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41-12-MSWLF
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1

PERMIT MODIFICATION

for

PHASE III

of the

WHITE STREET LANDFILL
GREENSBORO, NORTH CAROLINA

Prepared for:
City of Greensboro, North Carolina

GREENSBORO®

Prepared by:

HDR

HDR Engineering, Inc. of the Carolinas
128 South Tryon St. Suite 1400
Charlotte, NC 28202

MARCH 2008

HDR ONE COMPANY | *Many Solutions* SM

March 20, 2008

Received
MAR 2008
Solid Waste Section

Mr. Edward Mussler, III
Section Chief, Permitting Branch
North Carolina Department of Environment and Natural Resources
Division of Waste Management
1628 Mail Service Center
Raleigh, NC 27699-1628

Re: White Street Landfill Phase III Permit Modification (Permit No. 41-12)
Greensboro, North Carolina
HDR Project No. 06770-67286-001

Dear Mr. Mussler:

On behalf of the City of Greensboro, HDR Engineering, Inc. of the Carolinas is pleased to submit two copies of the permit modification for White Street Landfill Phase III for your review.

If you have any questions regarding this, please feel free to contact me at (704) 338-6843.

Sincerely,

HDR Engineering, Inc. of the Carolinas

Michael D. Plummer, PE
Project Manager

Fac/Perm/Co ID #	Date	Doc ID#
Ming Chao	04/14/09	DIN 7278

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NORTH CAROLINA
PROFESSIONAL
SEAL
025495
ENGINEER
MICHAEL D. PLUMMER
3/20/08

TABLE OF CONTENTS

APPENDICES

1.0 PURPOSE

The purpose of this application is to gain approval for the following proposed Landfill modifications:

- Revision to the proposed final contours for the Landfill.
- Revision to the Closure Plan for the Landfill.
- Revision to the Post-Closure Plan for the Landfill.

2.0 BACKGROUND

2.1. General History

The City of Greensboro, North Carolina (City), owns and operates the White Street Landfill Facility (Facility) located east of U.S. Highway 29, at the east end of White Street, under NCDENR permit 41-12.

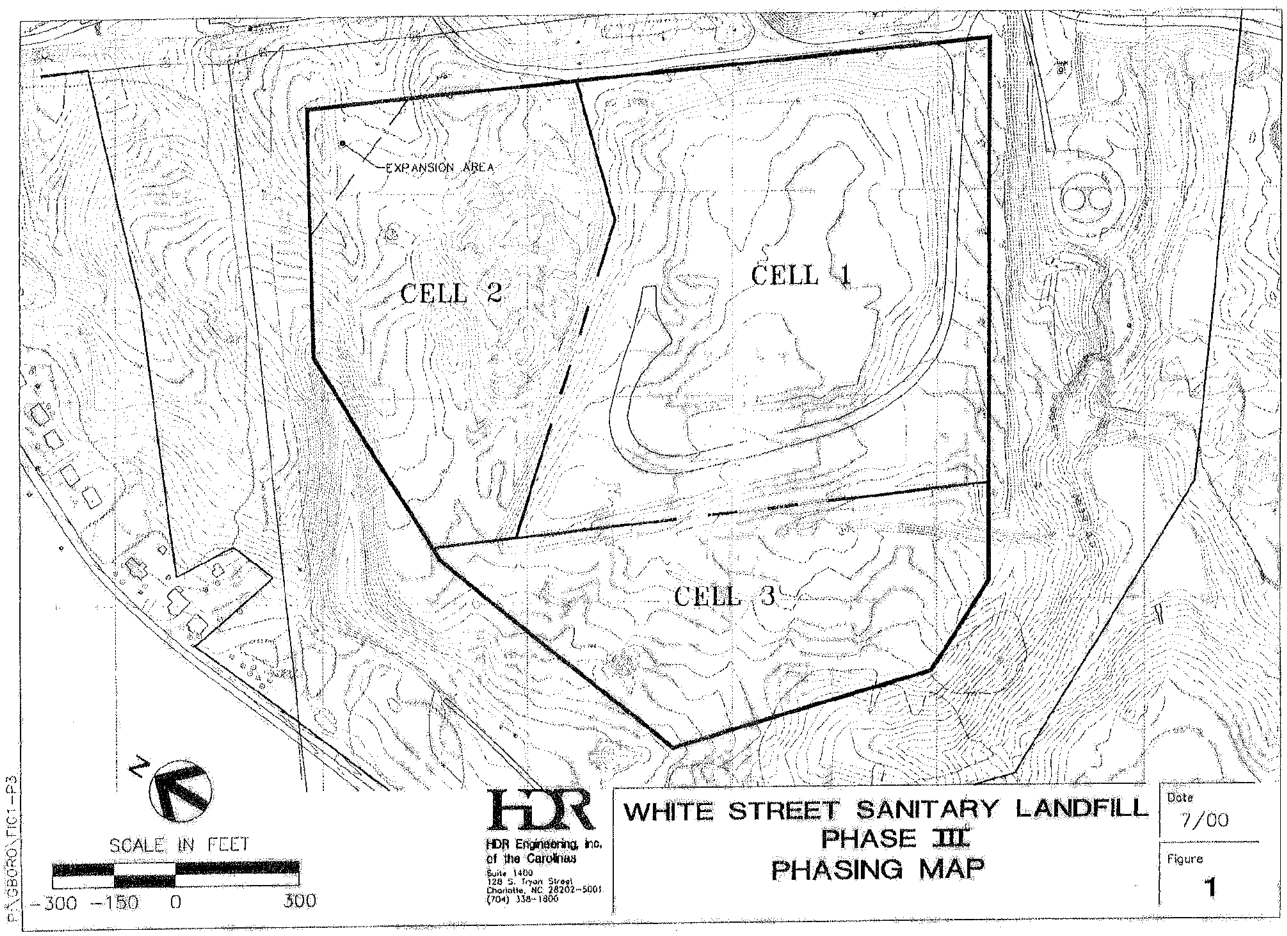
Waste disposal activities in the area now known as the White Street Sanitary Landfill began in 1943, and primarily consisted of the burning of garbage and trash on the site. Burning operations ceased in the mid-1960s, and since that time waste has been buried on site. The current landfill property covers an area of approximately 767 acres. As constructed, the City of Greensboro's White Street Sanitary Landfill is divided into three Phases. Phase I is an 85-acre site that stopped receiving waste prior to 1978. Phase II consists of approximately 135 acres, which received municipal solid waste until the end of 1997. Phase III is the first area to be lined and consists of three cells totaling approximately 51 acres. Waste placement began in Cell 1 in December 1997.

2.2. Landfill Configuration

Phase III is located south of the scale house. All three cells have been constructed and granted a Permit to Operate by NCDENR. The general layout begins with Cell 1 (approximately 25.5 acres) in the northeast corner of Phase 1. Cell 2 (approximately 14 acres) is located to the west of Cell 1, and Cell 3 (approximately 12 acres) is located south of Cells 1 and 2 (see Figure 1). The proposed subgrade ranges between 2 to 6 percent slope. Based on information submitted with the Construction Permit Application, groundwater generally flows in a north-northeast direction. The long axis of Cell 2 is roughly parallel to groundwater flow. A minimum separation of 4 feet is required (by regulation) between the bottom of the liner and the estimated long-term seasonal high water table; however, the Design Hydrogeologic Report submitted for Phase III estimates a 5-foot separation. Cells 2 and 3 were constructed with an approved alternate liner system which varies from the standard Subtitle D design by replacing the 2-foot thick

$1x10^{-7}$ cm/sec compacted clay liner with a geosynthetic clay (bentonite) liner (GCL) and 18 inches of $1x10^{-5}$ cm/sec soil.

Figure 1



3.0 REVISED FINAL COVER GRADES

According to Rule 15A NCAC 13B .1627, post-settlement surface slopes shall be a minimum of 5% and a maximum of 25% (4H:1V). Historically, NCDENR has allowed permit modifications to go to a 33%, a 3 horizontal to 1 vertical (3H:1V), slope if adequate stability can be demonstrated. The purpose of this permit modification is to demonstrate the stability of Phase III at 3H:1V slopes. The following text addresses engineering concerns related to the modification.

3.1. Slope Stability Analysis

In accordance with the EPA guidance document EPA/600/R-95/051, slope stability analyses were performed on the proposed revised final cover grades of the Facility. The EPA guidance document requires minimum factors of safety against slope failures of 1.5 statically and 1.0 dynamically for completed landfills. The computer program PCStable6H was used to evaluate the slope stability of the revised final grades. Two types of analyses were performed on two sections through the final refuse contours. First, a block failure was assumed for the analysis of the liner system such that the failure surface block encompassed the liner system components. Second, circular failure surfaces were assumed to occur through the refuse.

Two sections through the proposed revised final refuse contours were evaluated for slope stability. The sections were selected at locations of maximum refuse height and minimum perimeter berm height to produce minimum factors of safety.

With a couple of exceptions, the stability model input parameters were kept fairly consistent with the original stability analysis performed by G. N. Richardson & Associates submitted in the approved Construction Permit Application. The two exceptions were the change to a 3H:1V slope and an increase in the very conservative cohesion for waste from 200 psf to 400 psf. A cohesion value of 400 psf is consistent with the recommendation from "Waste Containment Systems, Waste Stabilization, and Landfills" authored by Hari D. Sharma and Sangeeta P. Lewis.

Table 1 presents the results of the slope stability analyses for the two sections. The lowest factors of safety for dynamic and static conditions for the revised Phase III contours occurred in cross-section A-A'. Cross-section A-A' resulted in minimum factors of safety of 1.04 for dynamic conditions and 1.55 for static conditions. Both factors of safety are satisfactory and meet EPA guidelines.

Table 1 Results of the Slope Stability Analyses

Cross Section	Failure Type	Factor of Safety	
		Static Conditions	Dynamic Conditions
A-A'	Block	1.55	1.04
	Circular	1.57	1.32
B-B'	Block	2.35	1.85
	Circular	1.84	1.55

A final cover veneer stability analysis was performed to determine the minimum interface friction angle required for the final cover system. The final cover slope of 25% presented in the Construction Permit Application required a minimum friction angle of 25 degrees. The analysis performed for the proposed revised final slope of 33% (3H:1V) resulted in a minimum friction angle of 27.3 degrees. A friction angle of 27.3 degrees is appropriate for geotextile/soil or geotextile/textured geomembrane surfaces. However, the materials used for final cover construction should be tested to verify the necessary minimum friction angle for all layers of the final cap system.

3.2. Final Cover Drainage

Drawing C-7A has been revised to show the proposed revised final cover slope of 33%. Design of the drainage control features for the original permitted contours were based on guidelines and procedures as set forth in the North Carolina Erosion and Sediment Control Planning and Design Manual (E&SCP&DM) and "Elements of Urban Stormwater Design" (EOUSD), by H. Rooney Malcom, P.E. This system included a series of diversion berms, downchutes, benches, and channels which will convey stormwater runoff from the cover system to multiple sediment basins located adjacent to the sanitary landfill. Drawing C-7A has been revised to show drainage consistent with the new location of benches on the 3H:1V slope. The area of drainage to each sediment basin was kept consistent with the original design and therefore no new erosion and sedimentation calculations have been included.

3.3. Total Operating Capacity

By increasing the final cover slope, the proposed revised final cover slope results in an increase in Landfill volume. In the approved 1996 Construction Permit Application Drawing Set, the final cover contours broke from a 25% slope to an 8% slope at elevation 910 feet, resulting in a maximum Landfill height at approximate elevation 920 feet. To maintain the same landfill height the break point to 8% was modified to elevation 898 feet above MSL.

The current permitted 4H:1V final contours as modified and approved in October 6, 2000 for Facility Permit No. 41-12, generates an anticipated total municipal solid waste disposal capacity of 5,645,000 cubic yards. Using AutoCAD 14 to determine the revised capacity, the 3H:1V final contours shown on Drawing C-1 were compared against the 4H:1V permitted surface which resulted in an additional 1,024,000 cubic yards of disposal capacity or an 18.1% increase in volume. This results in a revised total municipal solid waste disposal capacity of approximately 6,669,000 cubic yards. Under General Statute 130A.294 (b) (1) a. the City of Greensboro is required to conduct a public hearing for an increase of ten percent or more in the quantity of solid waste to be disposed of in the sanitary landfill if sufficient public interest exists.

4.0 CONCLUSIONS

This permit modification proposes to revise the final cover grades for the Phase III landfill located at the White Street Landfill from 25% side slopes to 33% side slopes. The revised final cover grades maximize the available capacity of lined landfill space on-site. With the increase in slope and landfill height, an analysis of slope stability was conducted. The results of the slope stability analyses indicated that the revised final cover grades meet the EPA recommended minimum factors of safety for completed landfills. Additionally, the proposed revised final cover grades resulted in an increase in total operating capacity of 18.1%. The final grade revision is consistent with the concept of the original final grade.

CALCULATIONS

3 to 1 Volume Calculations

3 to 1 Global Stability Calculations

Permitted 4 to 1 Global Stability Calculations (for reference)

3 to 1 Veneer Stability Calculations

Project:	City of Greensboro, North Carolina	Computed: SPF	Date: 3-04-08
Subject:	White Street Landfill Phase III Permit Modification	Checked:	Date:
Task:	Volume Calculations	Sheet:	Of:

Objective: Evaluate the potential volume gain by revising the sideslopes of Phase III from 4:1 to 3:1.

Given:

A 5,645,000 cy, Phase III Total Operating Volume Permitted 4:1 (AutoCADD, 123r vs 4 to 1 permitted Phase III)

B 6,669,000 cy, Phase III Total Operating Volume Proposed 3:1 (AutoCADD, 123r vs 3 to 1 Phase III)

C 1,024,000 cy, Increase from Phase III 4:1 and 3:1 (AutoCADD, 4 to 1 permitted Phase III vs 3 to 1 Phase III)

Evaluation of Volumes:

D **18.1% volume increase from Phase III 4:1 to 3:1** **(C/A)**

*If greater than 10%, the City would be required to conduct a public hearing if sufficient public interest exists.

AutoCAD Volume Report

Surface 1	Surface 2	Method	Cut (yd^3)	Fill (yd^3)	Net (yd^3)	Avg. Fill Volume (yd3)
4 to 1 permitted phase 3	3 to 1 phase 3	Grid	13	1,024,165	1,024,151	1,024,000
		Composite	47	1,024,263	1,024,216	
		End Area	43	1,024,268	1,024,225	
		Prismoidal	40	1,024,220	1,024,180	
123-r	4 to 1 permitted phase 3	Grid	54	5,644,014	5,643,960	5,645,000
		Composite	122	5,645,288	5,645,165	
		End Area	123	5,645,369	5,645,246	
		Prismoidal	118	5,645,169	5,645,051	
123-r	3 to 1 phase 3	Grid	39	6,667,541	6,667,503	6,669,000
		Composite	112	6,669,301	6,669,189	
		End Area	108	6,669,207	6,669,099	
		Prismoidal	104	6,668,944	6,668,840	

Greensboro Landfill - Section A - A' Block Stability Static

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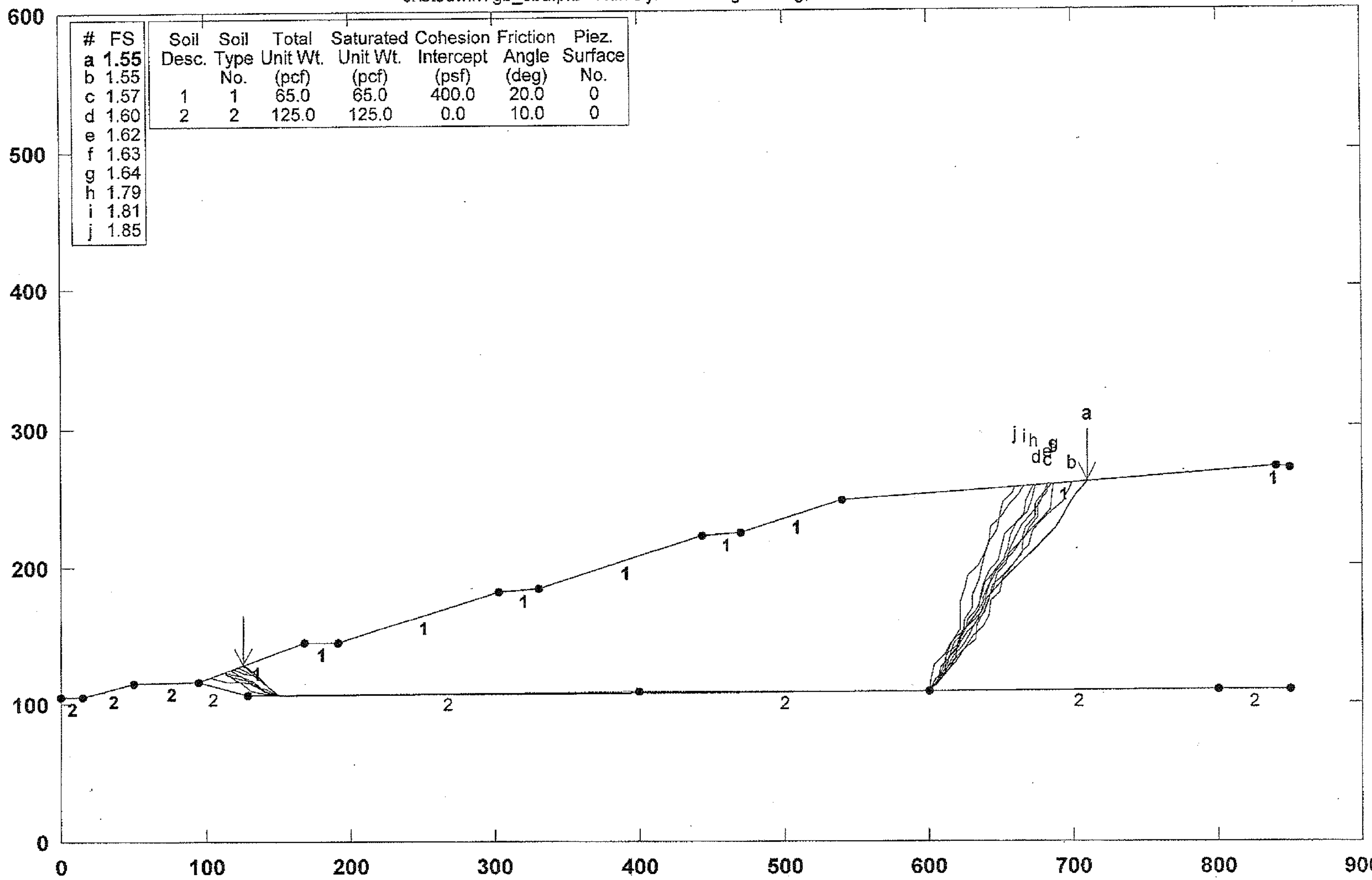

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Safety Factors Are Calculated By The Modified Janbu Method

STED

Greensboro Landfill - Section A - A' Block Stability Dynamic

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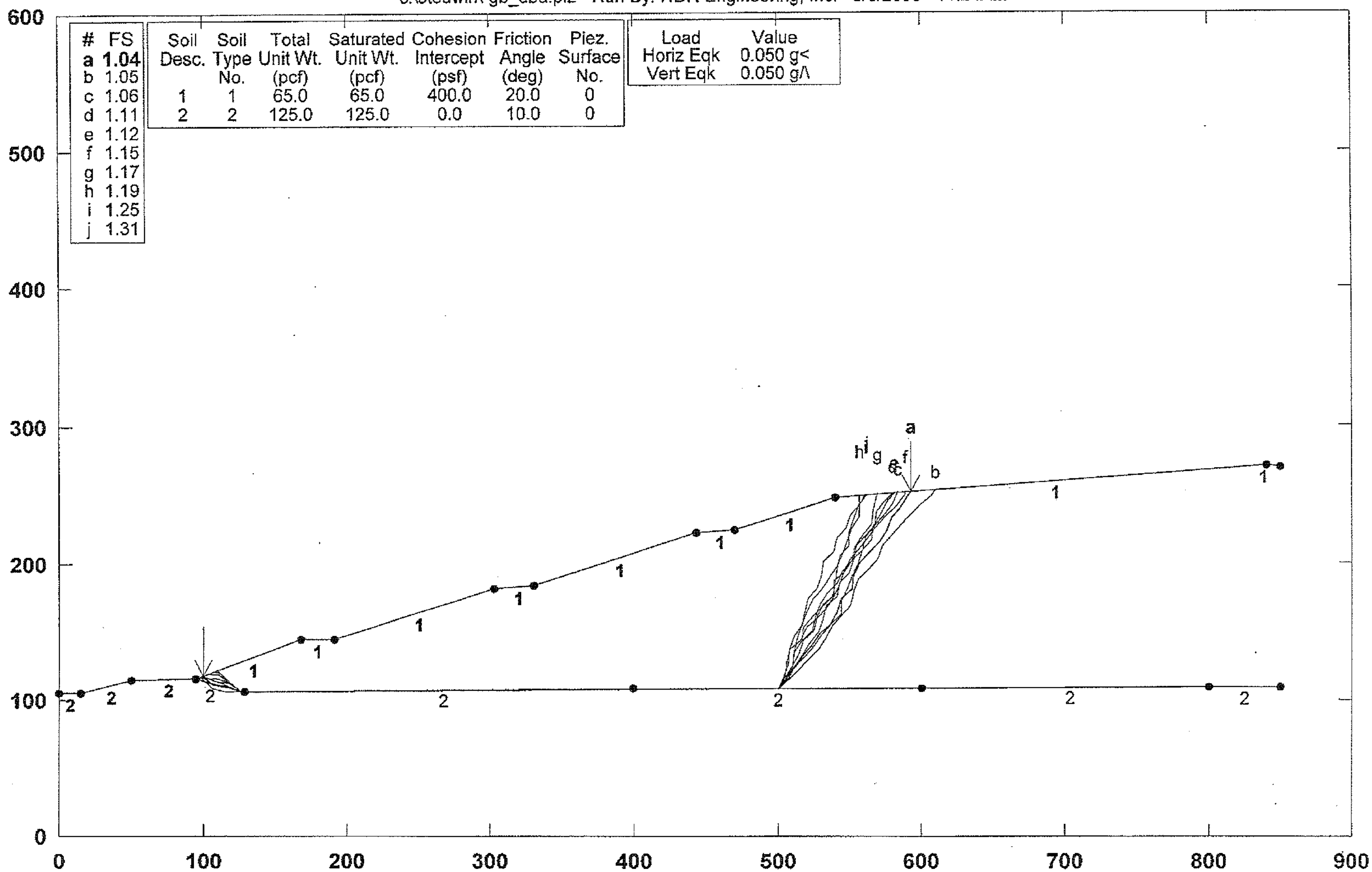

STABL6H FSmin=1.04

Safety Factors Are Calculated By The Modified Janbu Method

STED

Greensboro Landfill - Section A - A' Circular Stability Static

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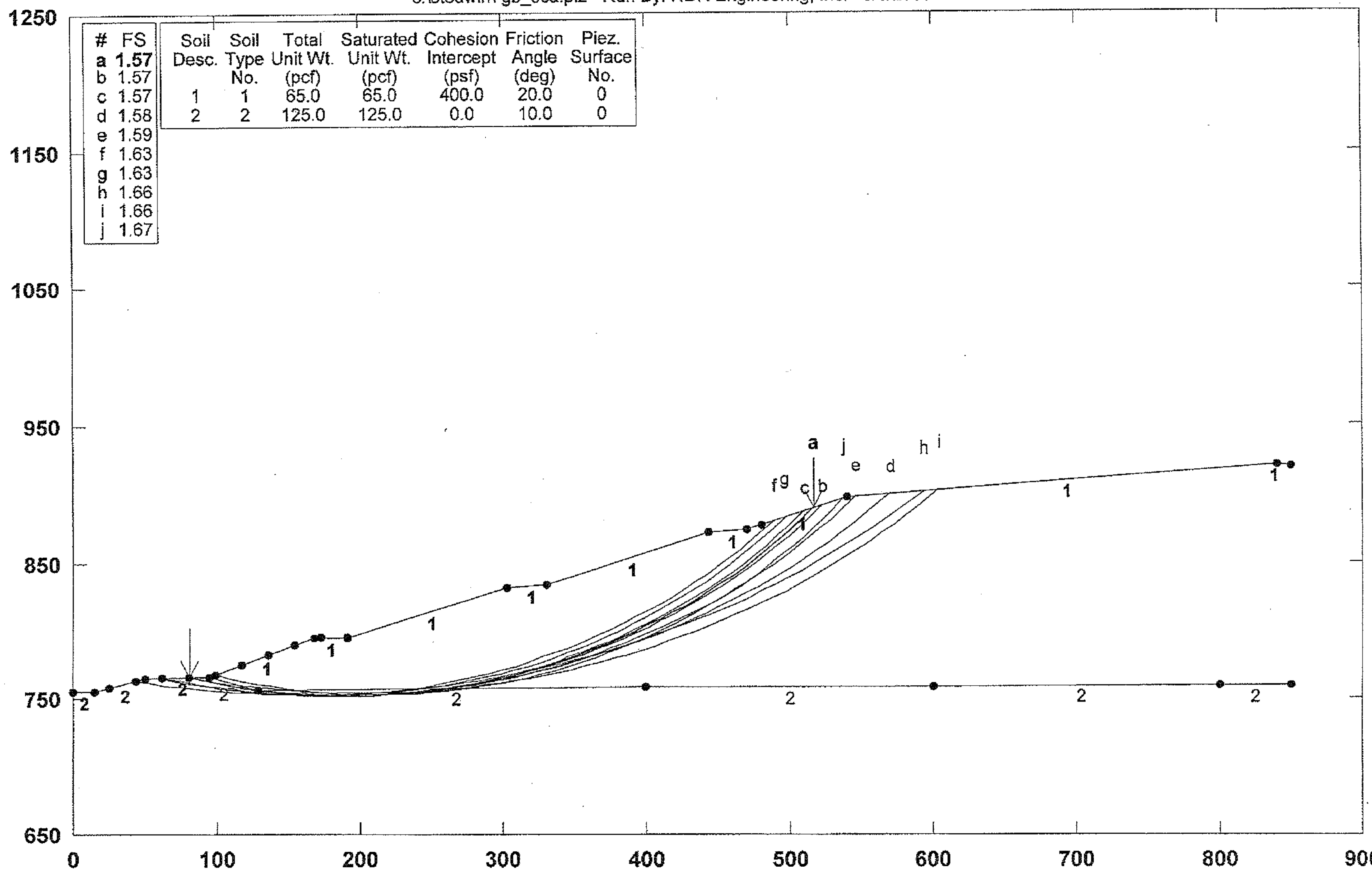
a	**1.57**
b	1.57
c	1.57
d	1.58
e	1.59
f	1.63
g	1.63
h	1.66
i	1.66
j	1.67

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
1	1	65.0	65.0	400.0	20.0	0
2	2	125.0	125.0	0.0	10.0	0



STABL6H FSmin=1.57
Safety Factors Are Calculated By The Modified Bishop Method

STED

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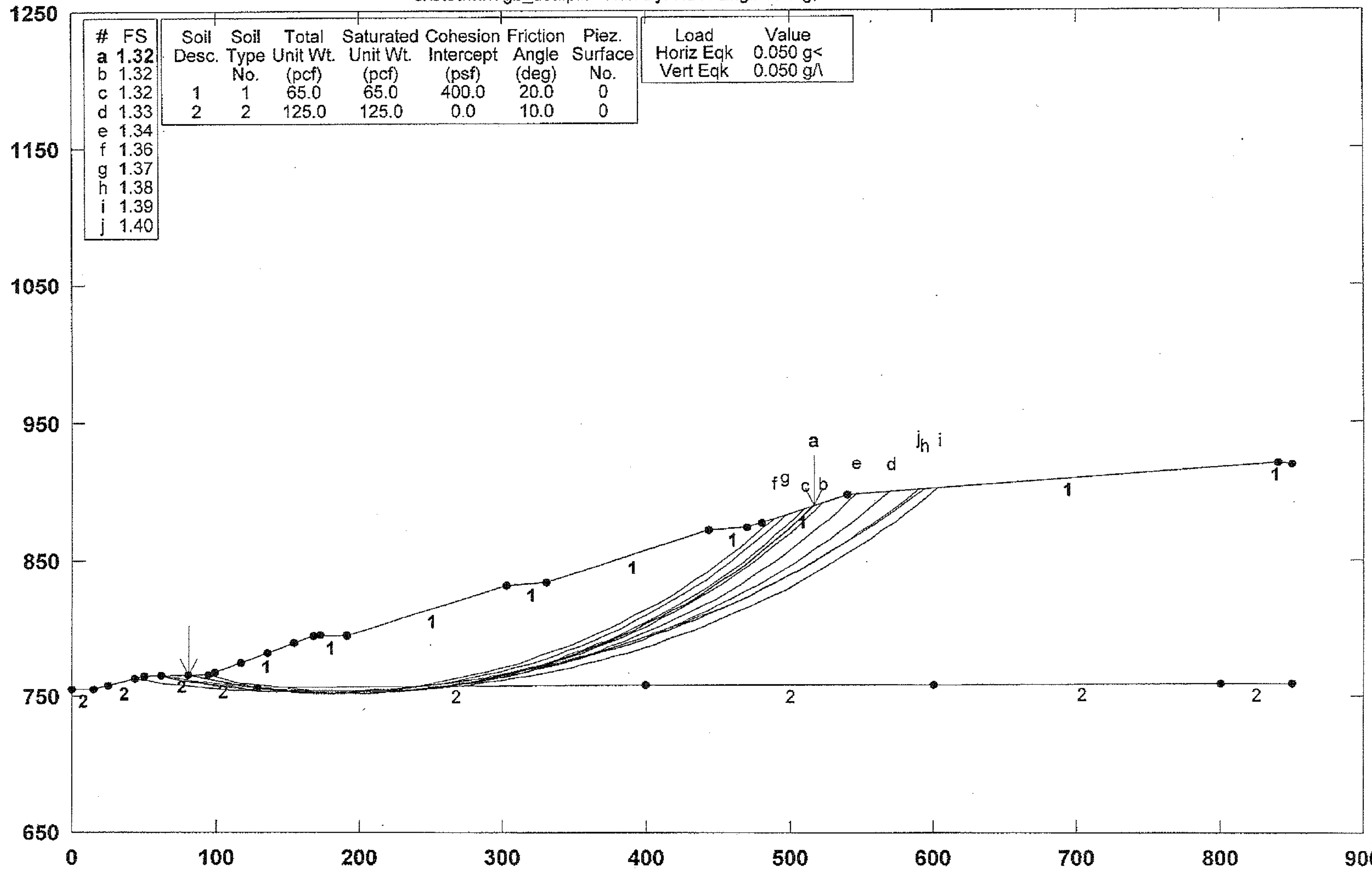

STABL6H FSmin=1.32

Safety Factors Are Calculated By The Modified Bishop Method

STED

Greensboro Landfill Section B-B' Block Stability Static

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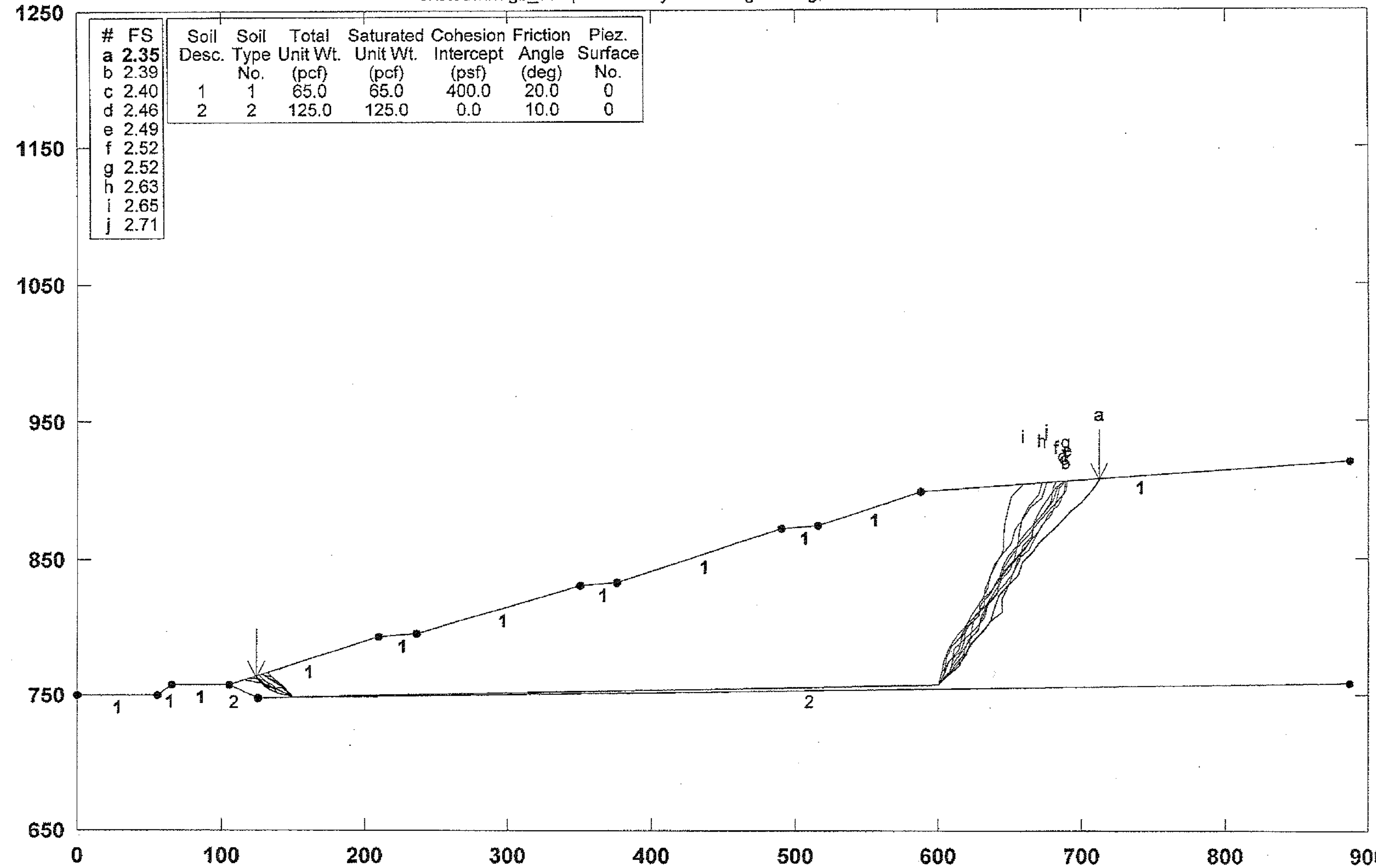

#	FS
a	**2.35**
b	2.39
c	2.40
d	2.46
e	2.49
f	2.52
g	2.52
h	2.63
i	2.65
j	2.71

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
1	1	65.0	65.0	400.0	20.0	0
2	2	125.0	125.0	0.0	10.0	0

STABL6H FSmin=2.35

Safety Factors Are Calculated By The Modified Janbu Method

STED

Greensboro Landfill Section B-B' Block Stability Dynamic

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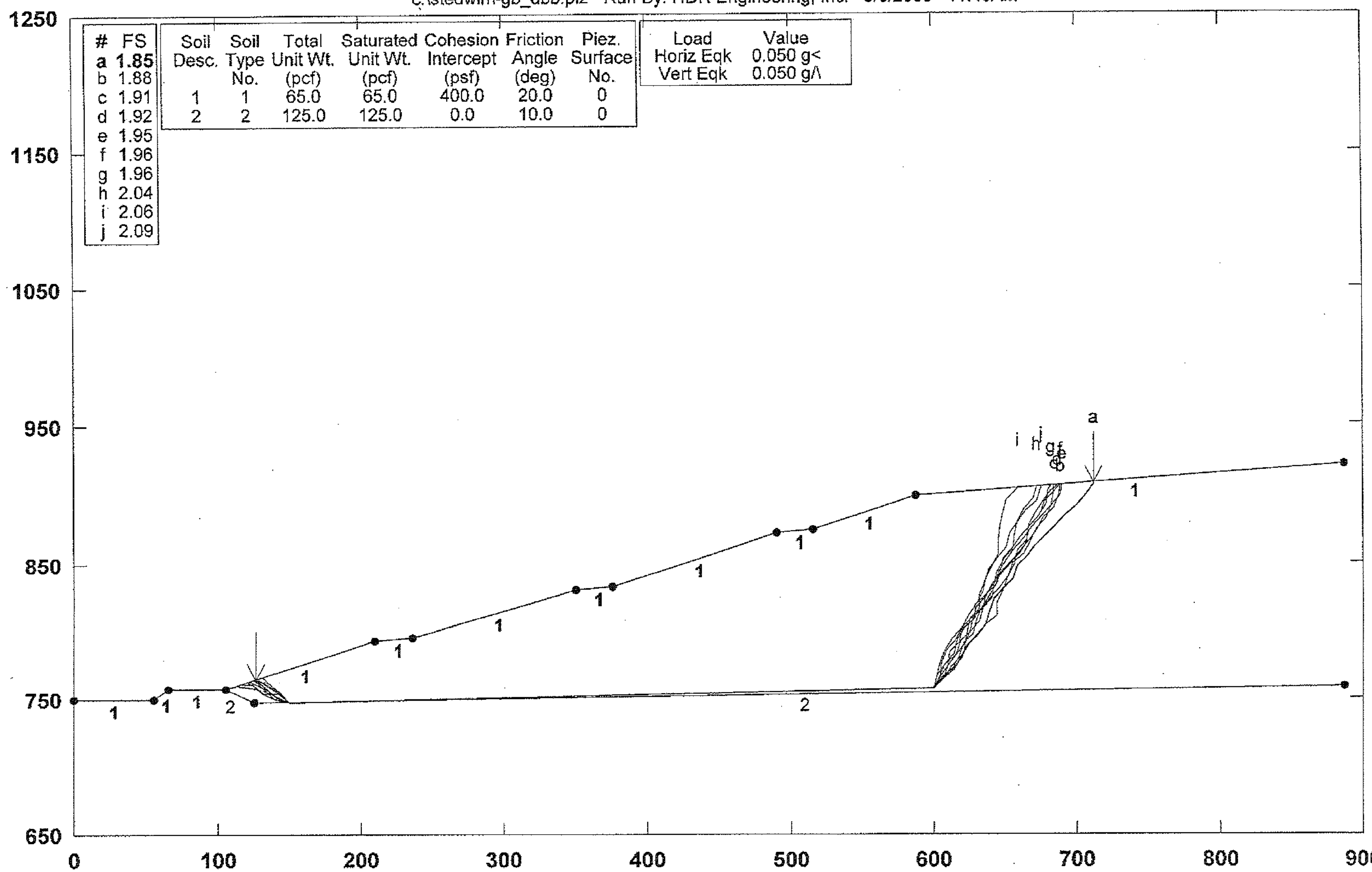

STABL6H FSmin=1.85

Safety Factors Are Calculated By The Modified Janbu Method

STED

Greensboro Landfill Section B-B' Circular Stability Static

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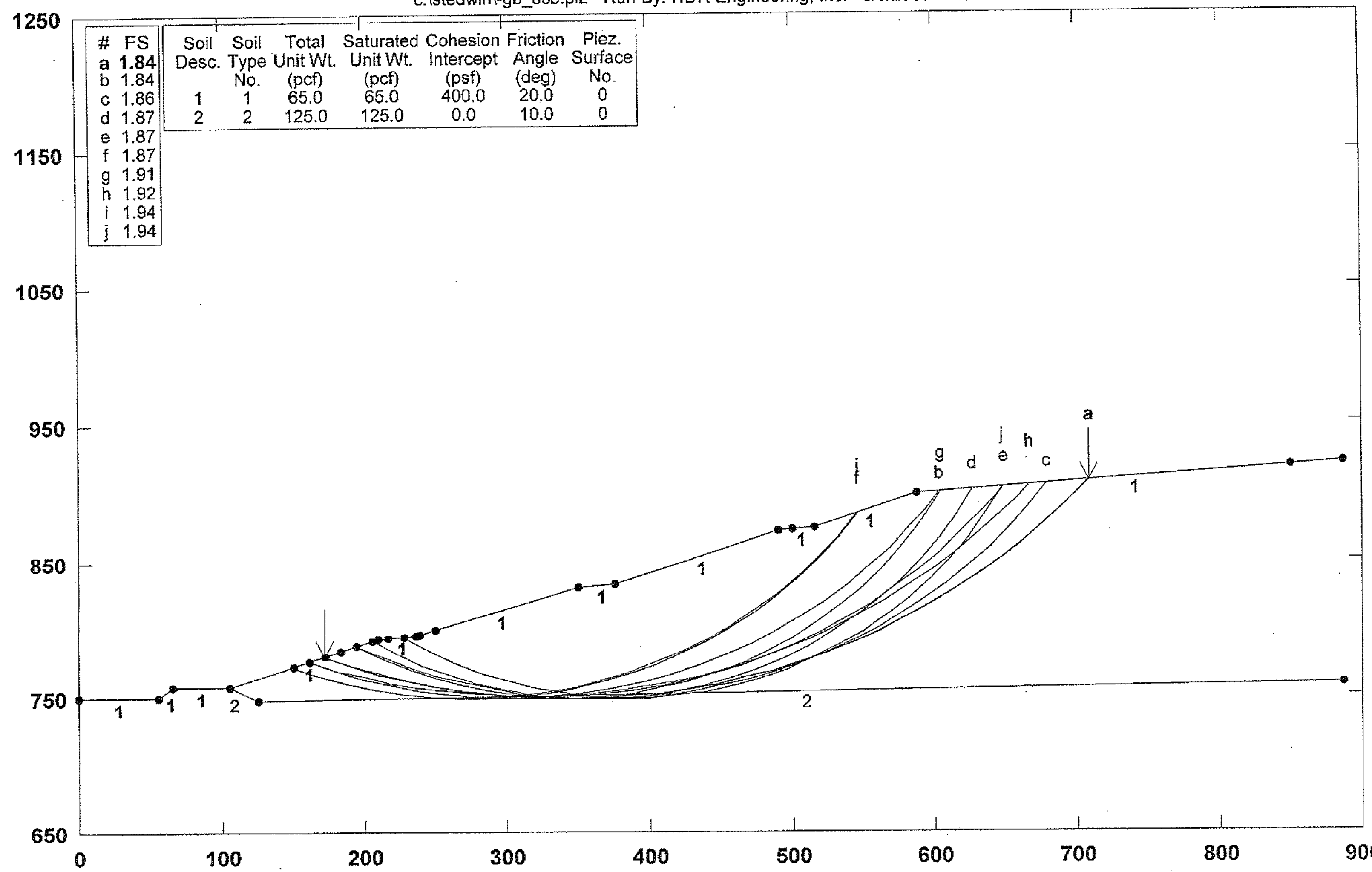

#	FS
a	**1.84**
b	1.84
c	1.86
d	1.87
e	1.87
f	1.87
g	1.91
h	1.92
i	1.94
j	1.94

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
1	1	65.0	65.0	400.0	20.0	0
2	2	125.0	125.0	0.0	10.0	0

STABL6H FSmin=1.84

Safety Factors Are Calculated By The Modified Bishop Method

STED

Greensboro Landfill Section B-B' Circular Stability Dynamic

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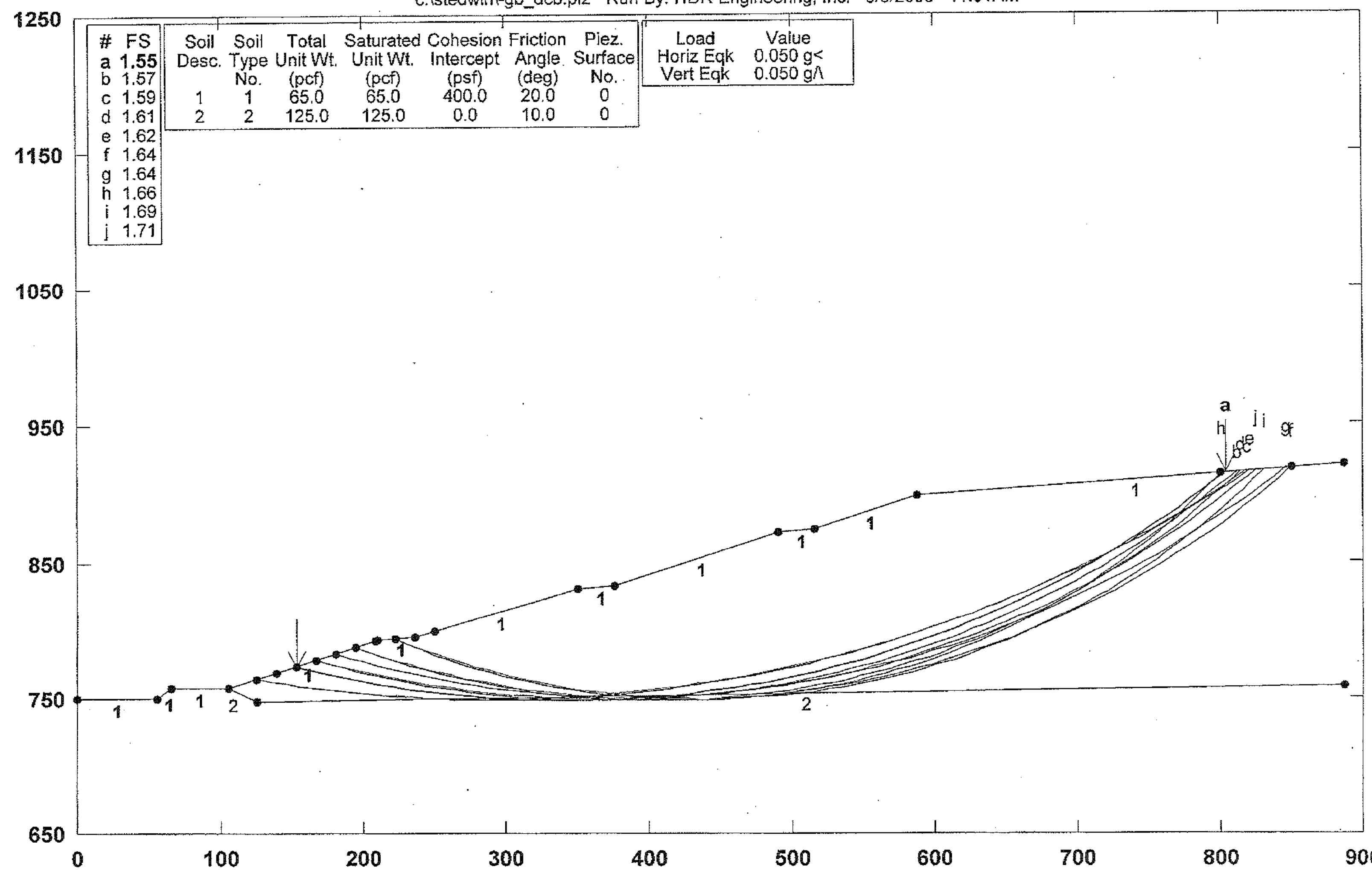


#	FS
a	**1.55**
b	1.57
c	1.59
d	1.61
e	1.62
f	1.64
g	1.64
h	1.66
i	1.69
j	1.71

Soil Desc.	Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Piez. Surface No.
1	1	65.0	65.0	400.0	20.0	0
2	2	125.0	125.0	0.0	10.0	0

Load	Value
Horiz Eqk	0.050 g<
Vert Eqk	0.050 g/\

STABL6H FSmin=1.55

Safety Factors Are Calculated By The Modified Bishop Method

STED

recommended zone in this figure is close to the line for c–ϕ information obtained from full-scale field tests by Converse et al. (1975).

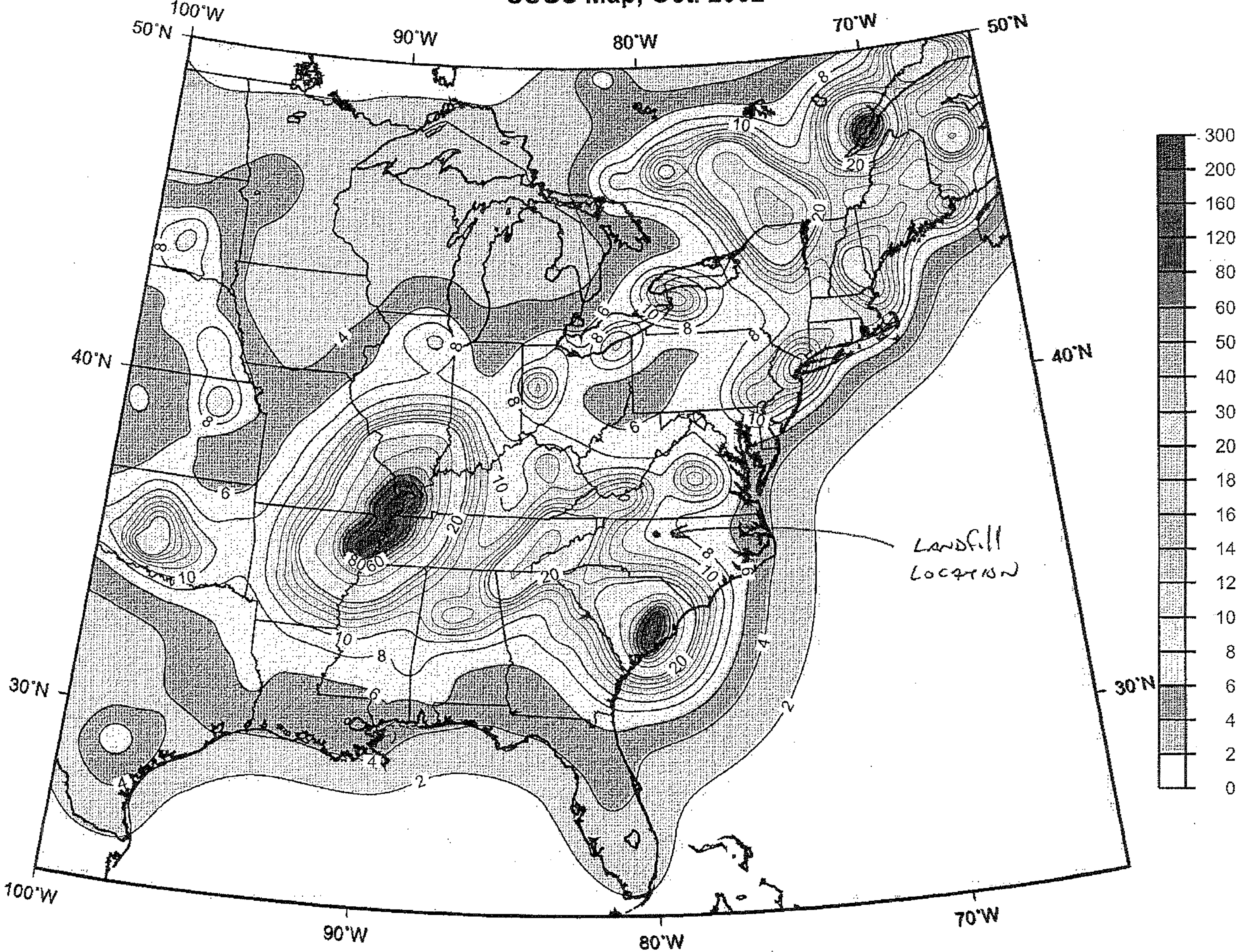
Various data points, presented in Figure 2.15, represent interpretations from vane shear tests, SPT tests, and back-calculated c–ϕ values from field load tests, failures, and performance records. Due to scatter in the data, definitive conclusions regarding c–ϕ relationships cannot be presented. In view of the scatter in data and nonhomogenity of landfill material, it is generally recommended that strength properties that fall toward the lower bound of test results (summarized in Figure 2.15) can be used in slope stability analysis. The authors generally use values of $c = 400$ lb/ft^2 and $\phi = 20°$ in preliminary slope stability analyses, followed by a sensitivity analysis if the preliminary results require such an analysis.

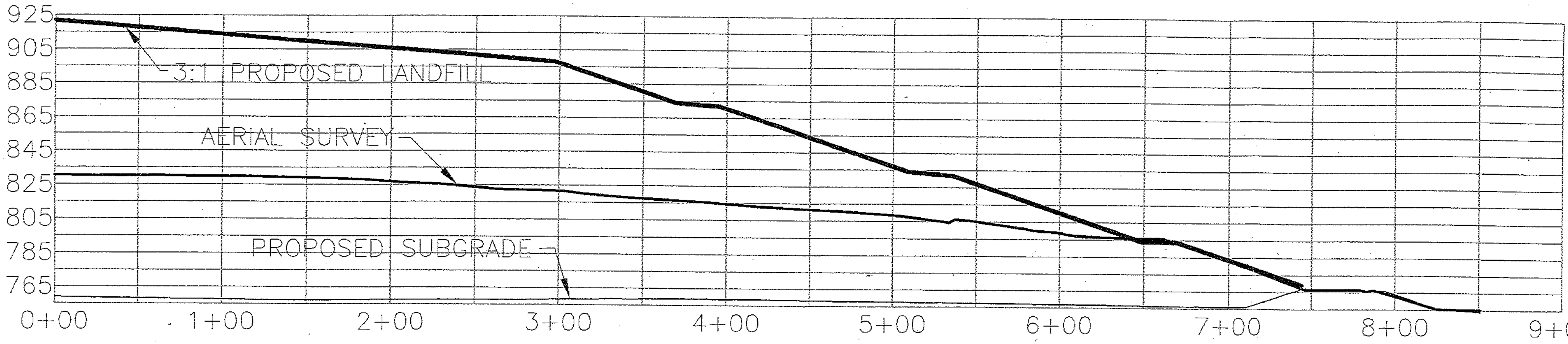
TABLE 2.23 Strength Properties of Mineral Waste

Description	Cohesion, c (kPa)	Friction Angle, ϕ (deg)	Undrained Compressive Strength, q_u (kPa)	Water Content, w (%)
Coal refuse				
Undrained condition	10–40	10–28		
Effective stress	0–40	25–43		
Fly ash, Arizona 7-day				
Unit wt. 12.6 kN/m^3			223	
Unit wt. 13.4 kN/m^3			331	
Unit wt. 13.8 kN/m^3			587	
Fly ash (silica 46%, aluminum 34%, calcium 7%)				
Slurry samples	0	37		
Compacted, undrained effective stress	0	41		
Compacted, drained	0	37		
West Virginia fly ash				
Shelby tube samples (consolidated, undrained)	0	34		
Shelby tube samples (consolidated, drained)	0	37.5		
West Virginia bottom ash		38–43		
Flue-gas desulfurization (FGD) sludge				
Consolidated, drained test	0	41.5		
Compacted	0–40	10–40		
Red mud (bauxite residue)				
Unleached			63	52
Leached			0	49
Mud: sand (5:1)			38	41

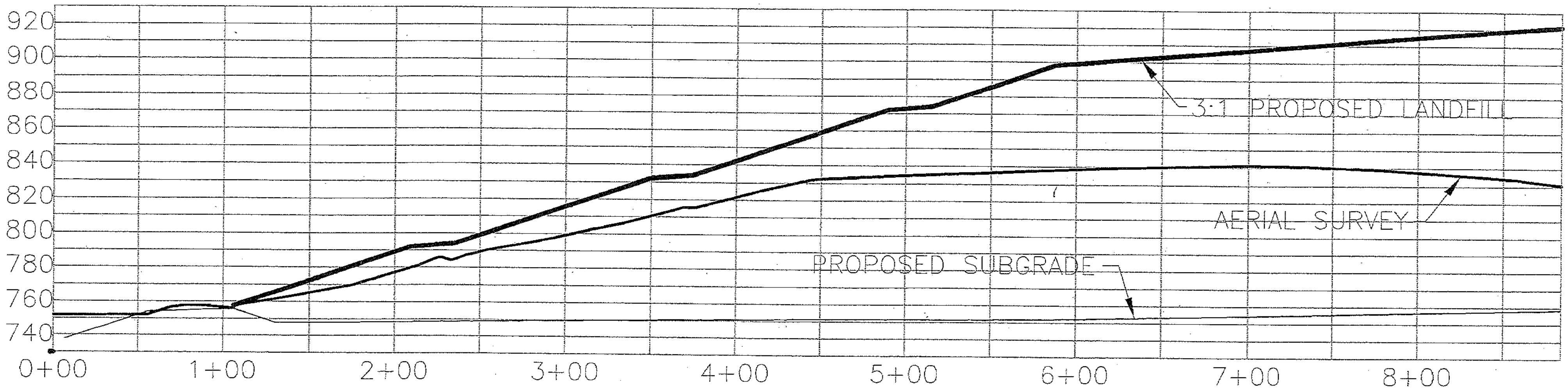
Source: Weis and Khera (1990). Reproduced by permission of Butterworth-Heinemann.

Peak Acceleration (%g) with 2% Probability of Exceedance in 50 Years
USGS Map, Oct. 2002





SECTION A
SCALE 1"=60'



SECTION B
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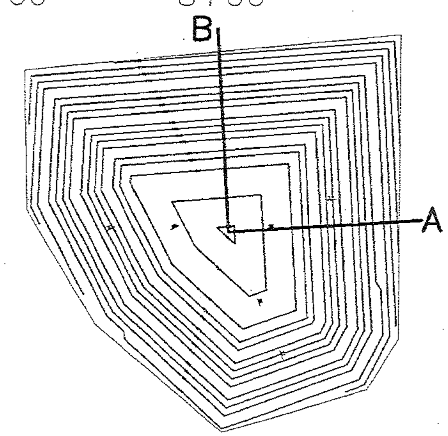


G · N · Richardson & Associates
CONSULTING ENGINEERING

December 7, 1995

Joseph C. Readling, P.E.
HDR Engineering, Inc.
128 South Tryon Street, Suite 1400
Charlotte, NC 28202-5001

RE: **Seismic and Slope Stability Analysis**
White Street Landfill
Greensboro, North Carolina

Dear Joe:

This report was prepared in response to your request. The report is consistent with our letter proposal dated November 3, 1995 and meets 40 CFR 258 requirements as expressed in the EPA guidance document EPA/600/R-95/051.

Site Specific Seismic Considerations

On October 9, 1993, RCRA Subtitle D regulations (40 CFR Part 258) governing landfills receiving municipal solid waste (MSW) went into effect. These regulations require that

- Section 258.13 : landfills cannot be sited within 200-feet of a fault that has been active during the Holocene Epoch (past 11,000 years) unless it can be demonstrated that a lesser set back is safe.

- Section 258.14 : landfills must be designed for seismic conditions if they are within a seismic impact zone defined as having a peak bedrock acceleration exceeding 0.1 g based on a 90% probability of non-exceedance over a 250 year time period.

The recent EPA guidance for seismic design guidance for municipal solid waste landfills (EPA/600/R-95/051) clearly indicates that only two faults east of the Rocky Mountains have been shown to be active. The region of capable faults is shown on Figure 1 and extends eastward only to the Meers fault in Oklahoma. Thus the Greensboro site satisfies the requirements of 258.13.

The peak bedrock acceleration at the Greensboro site is obtained from USGS MF-2120 which is partially reproduced on Figure 2. This indicates that a peak bedrock acceleration of 0.10g can be assigned to the Greensboro site. This peak acceleration represents a 90% probability of not being exceeded in 250 years. This corresponds to a site earthquake having a return period exceeding 2400 years.

piles resting on sand layers up to 100 ft (30 m) below the ground surface have been reported, surface effects from liquefaction is generally not likely to occur more than 50 ft (15 m) below the ground surface.

- Soil Penetration Resistance. According to the data presented in Seed and Idriss (1985), liquefaction has not been observed in soil deposits having normalized Standard Penetration Test (SPT) blowcount larger than 22. Marcuson, et al. (1990) suggest a normalized SPT value of 30 as the threshold value above which liquefaction will not occur. However, Chinese experience, as quoted in Seed et al. (1983), suggests that in extreme conditions liquefaction is possible in soils having normalized SPT blowcounts as high as 40.

  Based on the work performed by Engineering Tectonics, normalized blowcounts in the soils underlying the landfill are generally in excess of 30. Soils where normalized blowcounts were less than 30 were found to be above the water table.

If three or more of the above criteria indicate that liquefaction is not likely, the potential for liquefaction may be considered to be small. If, however, based on the above initial screening criteria, the potential for liquefaction of a cohesionless soil layer beneath the site of a planned landfill (new construction or lateral expansion) cannot be dismissed, more rigorous analysis of liquefaction potential is needed.

Based on the above screening criteria it is apparent that liquefaction is not likely at the White Street Landfill and a more rigorous analysis of this potential is not necessary.

Slope Stability Evaluation

EPA guidance, EPA/600/R-95/051, requires that the completed landfill have minimum factors of safety against slope failures of 1.5 statically and 1.0 dynamically. The slope stability evaluations for the Greensboro Landfill were obtained using the computer program STABL5. A block failure was assumed for the analysis such that the liner formed a major portion of the block. The STABL5 search algorithm looked for the lowest factor of safety for a failure block defined by the geomembrane surface and a plane up through the refuse. Additional slope stability analyses were performed assuming circular failure surfaces through the refuse.

Slope stability evaluations were performed at three sections through the final proposed refuse contours. The sections were selected at locations of maximum steepness of final cover combined with liner slopes to produce minimum slope factors of safety. The locations of the slope stability cuts are shown on Figure 4.

Computer output for the STABL5 studies is presented in Attachment 1 for static and dynamic

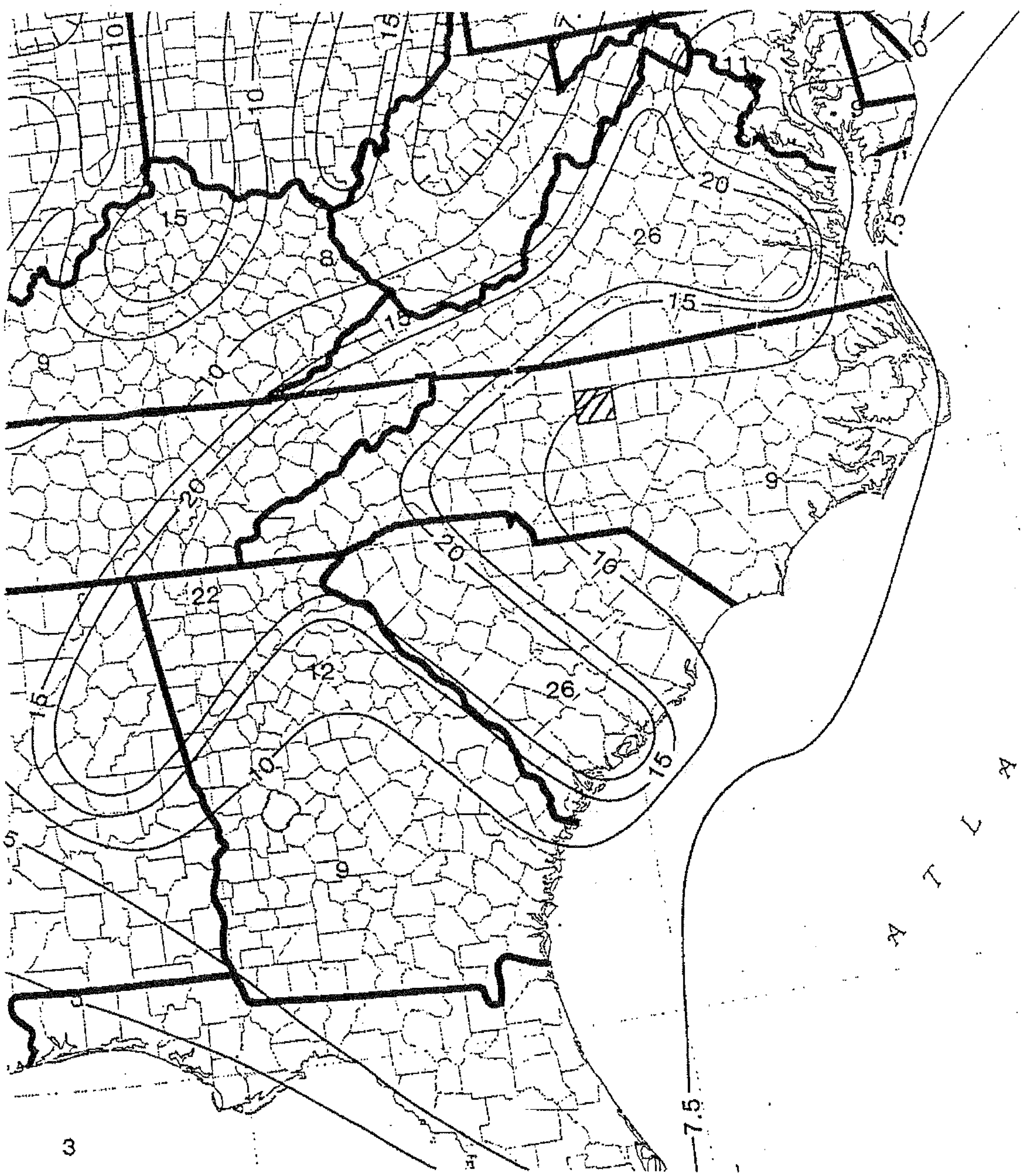
References

Algermissen, S.T., Perkins, D.M., P.C. Thenhaus, S.L. Hanson, and B.L. Bender (1990), "Probabilistic Earthquake Acceleration and Velocity Maps for the United States and Puerto Rico," U.S. Geological Survey Map MF-2120.

Krinitzsky, E.L., Gould, J.P., and P.H. Edinger (1993), Fundamentals of Earthquake-Resistant Construction, John Wiley & Sons, New York.

Richardson, G.N., Kavazanjian, E., and N. Matasovi (1995), RCRA Subtitle D (258) Seismic Design Guidance for Municipal Solid Waste Landfill Facilities, EPA/600/R-95/051, U.S. Environmental Protection Agency, Washington, D.C.

Seed, H.B. and Idriss, I.M. (1982), "Ground Motions and Soil Liquefaction During Earthquakes," Monograph No. 5, Earthquake Engineering Research Institute, Berkeley, California.

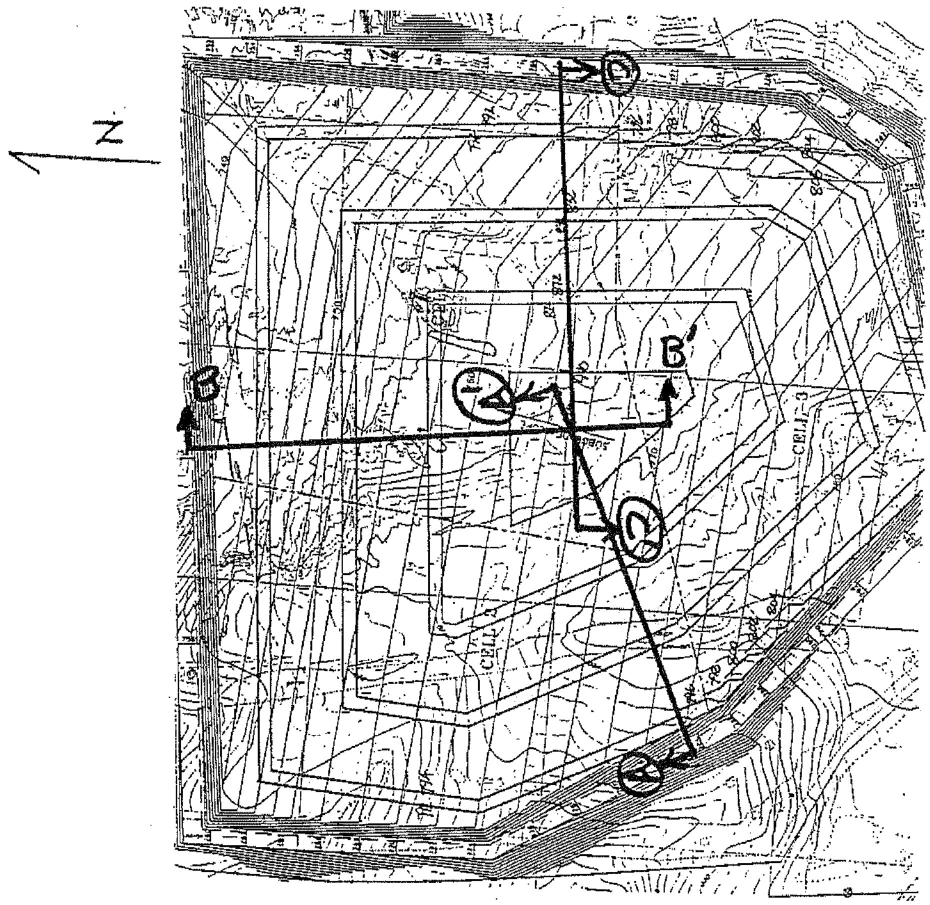


USGS MF-2120
PEAK BEDROCK ACCELERATIONS AS A PERCENT OF GRAVITY (90% PROBABILITY OF NOT BEING EXCEEDED IN 250 YEARS)

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services

417 N. Boylan Avenue Raleigh, North Carolina
(919) 828-0577 Fax 828-3899

SCALE:	DRAWN BY:	CHECKED BY:	DATE:	PROJECT NO.	FIGURE NO.
1"=625,000 FT		PKS	12/6/95	HDRGN-2	2



LOCATION OF SLOPE STABILITY
CROSS SECTIONS

G.N. RICHARDSON & ASSOCIATES, INC.
Engineering and Geological Services
417 N. Boylan Avenue Raleigh, North Carolina
(919) 828-0577 Fax 828-3899

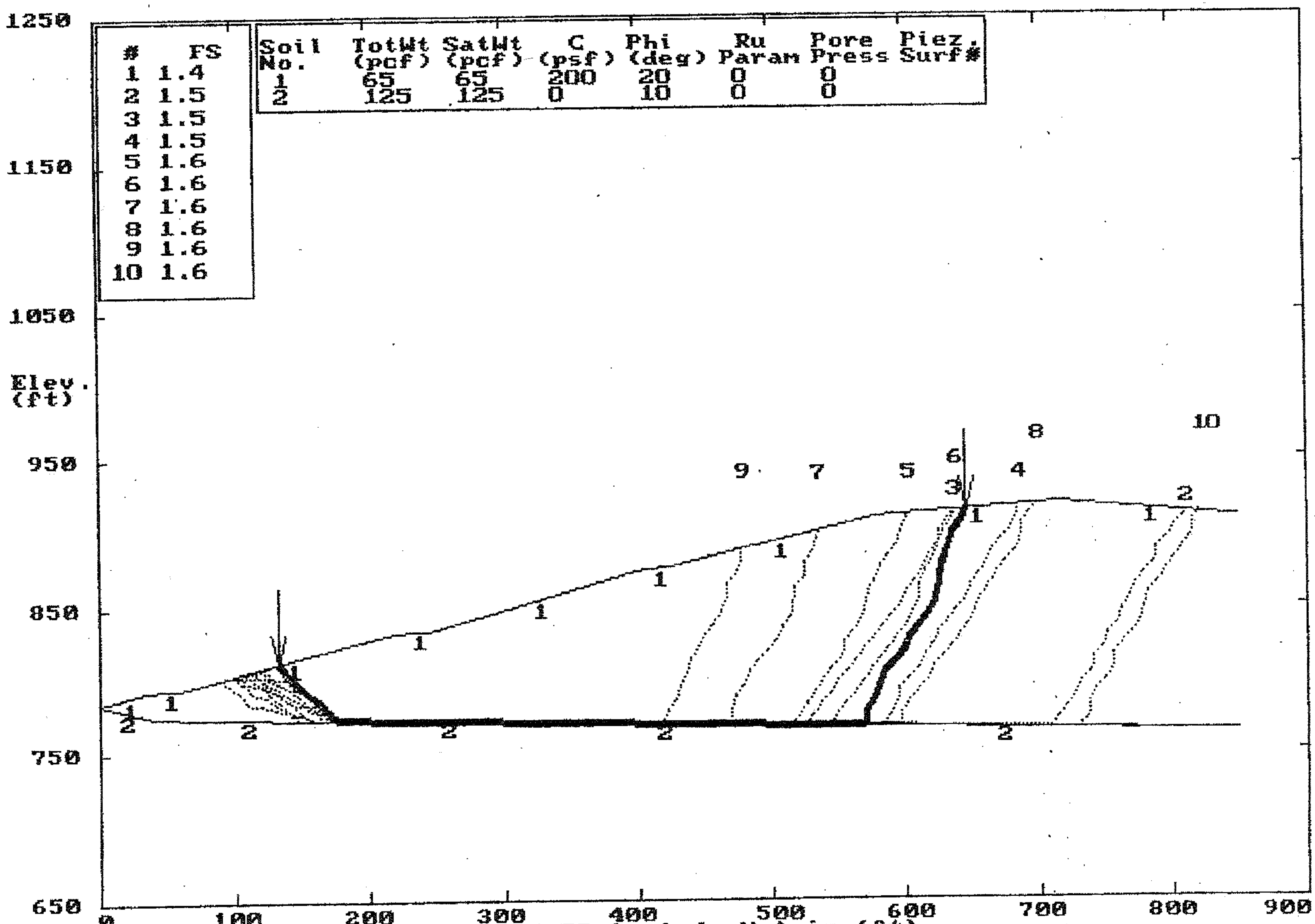
SCALE:	DRAWN BY:	CHECKED BY:	DATE:	PROJECT NO.	FIGURE NO.
1"=400'		PKS	12/6/95	HDRGN-2	4

Attachment 1

Computer Output

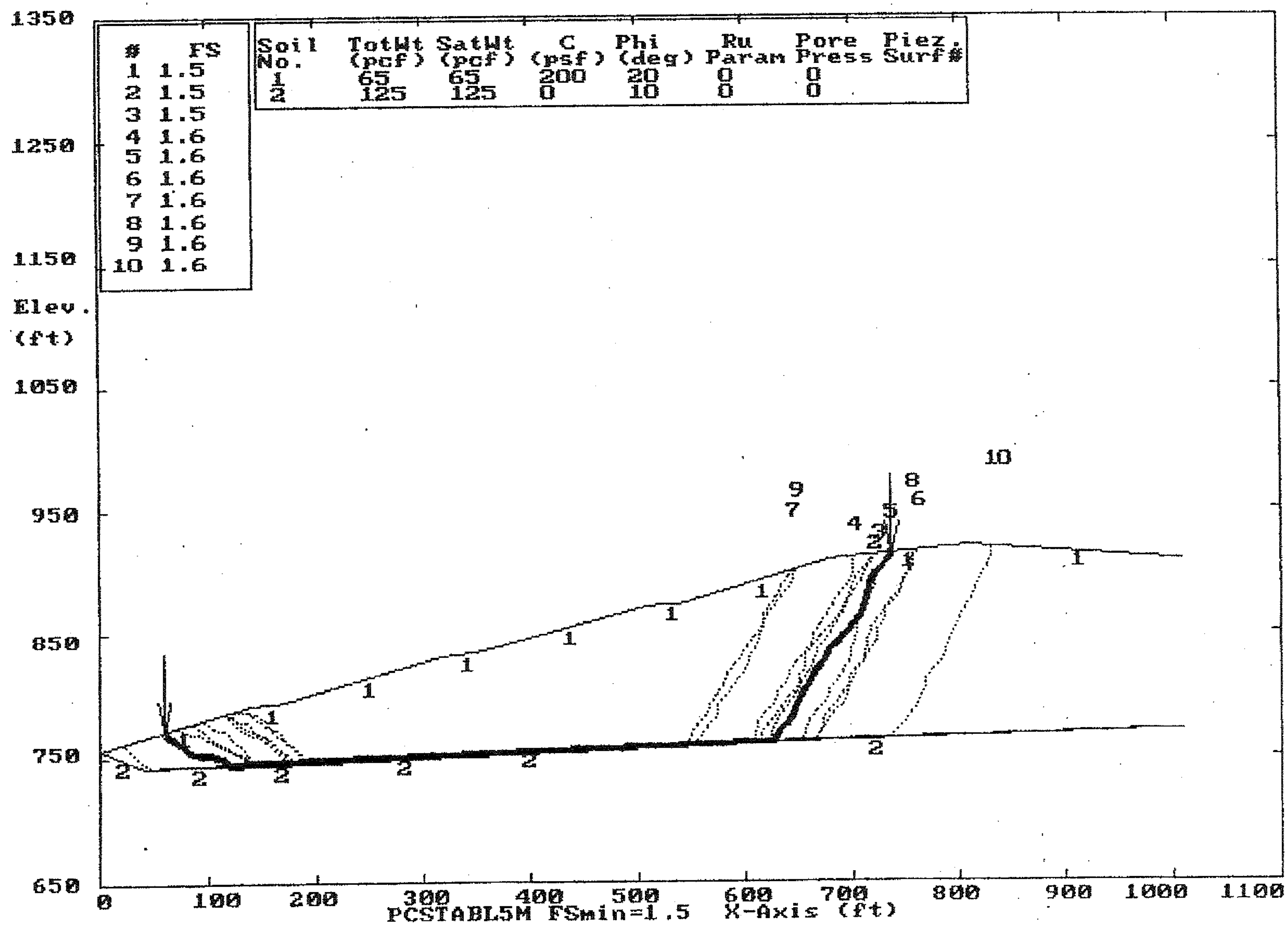
Static and Dynamic Loadings

Greensboro Landfill - Section A-A' Block Stability Along Liner - EQUAKE
Ten Most Critical. A:GNAAE.PLT By: PKS 12-07-95 1:31pm

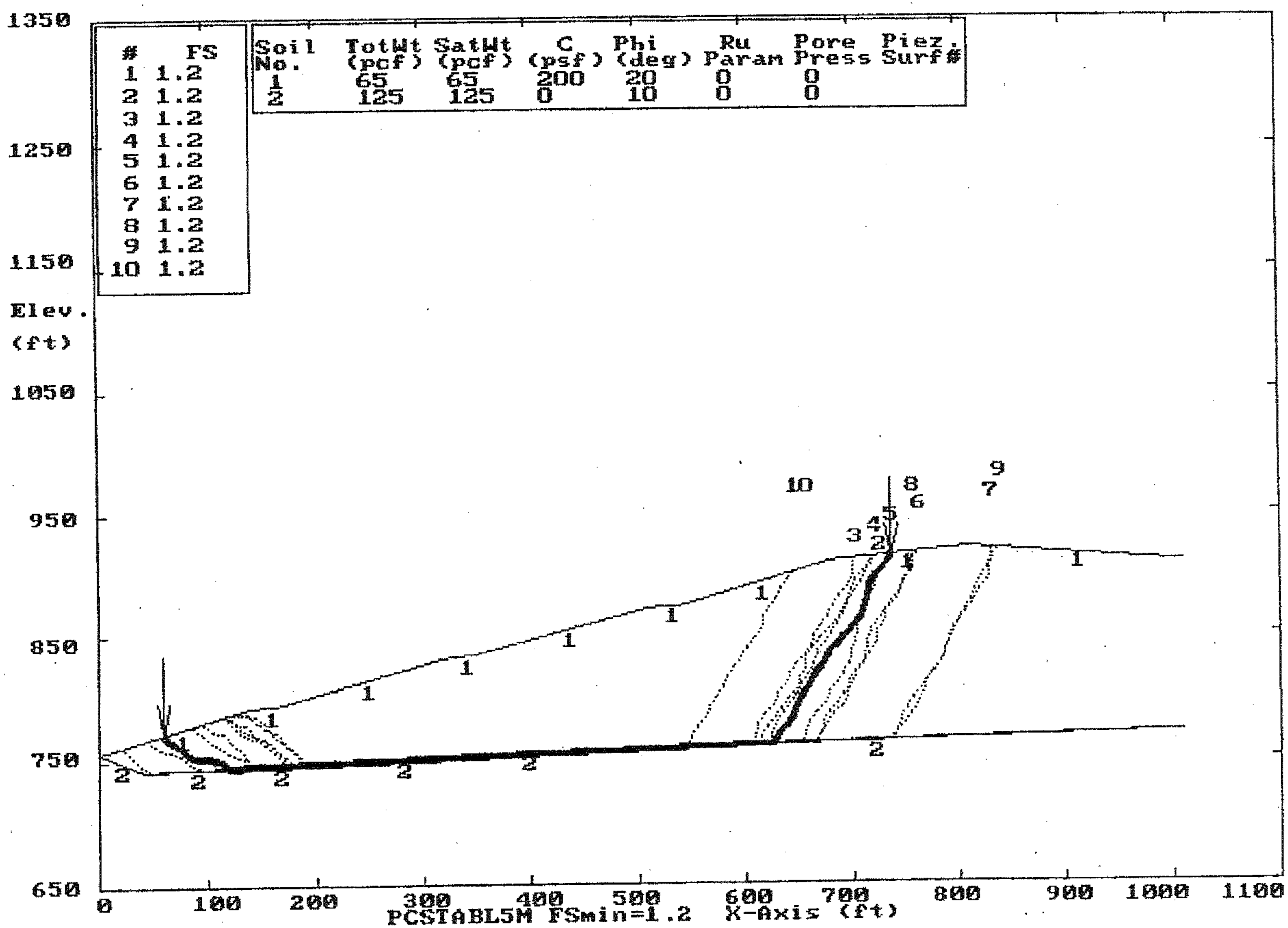


PCSTABL5M FSmin=1.4

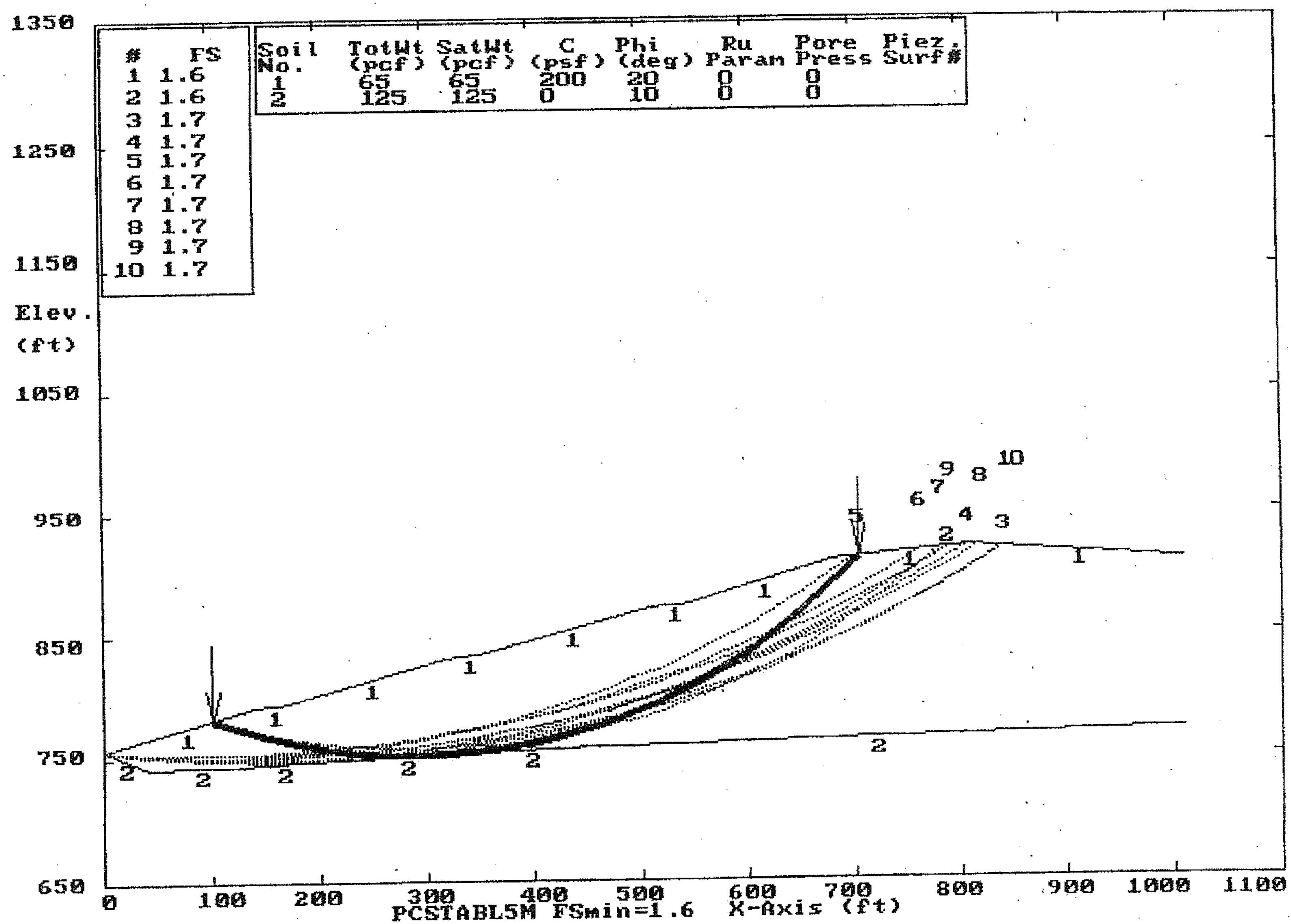
Greensboro Landfill - Section B-B' Block Stability Along Liner - STATIC
Ten Most Critical. A:GNBB.PLT By: PKS 12-07-95 2:06pm



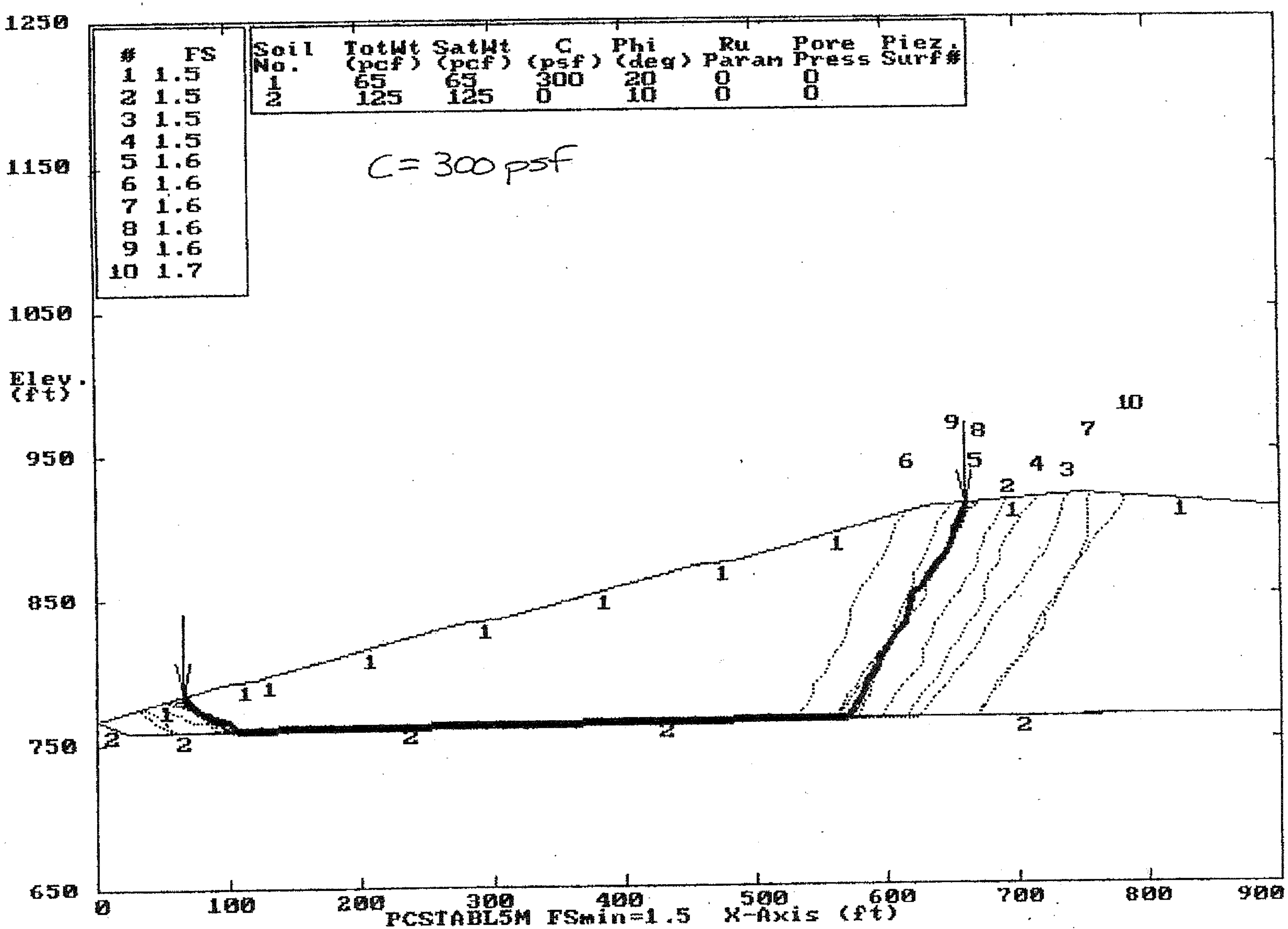
Greensboro Landfill - Section B-B' Block Stability Along Liner - EQUAKE
Ten Most Critical. A:GNBBE.PLT By: PKS 12-07-95 2:09pm



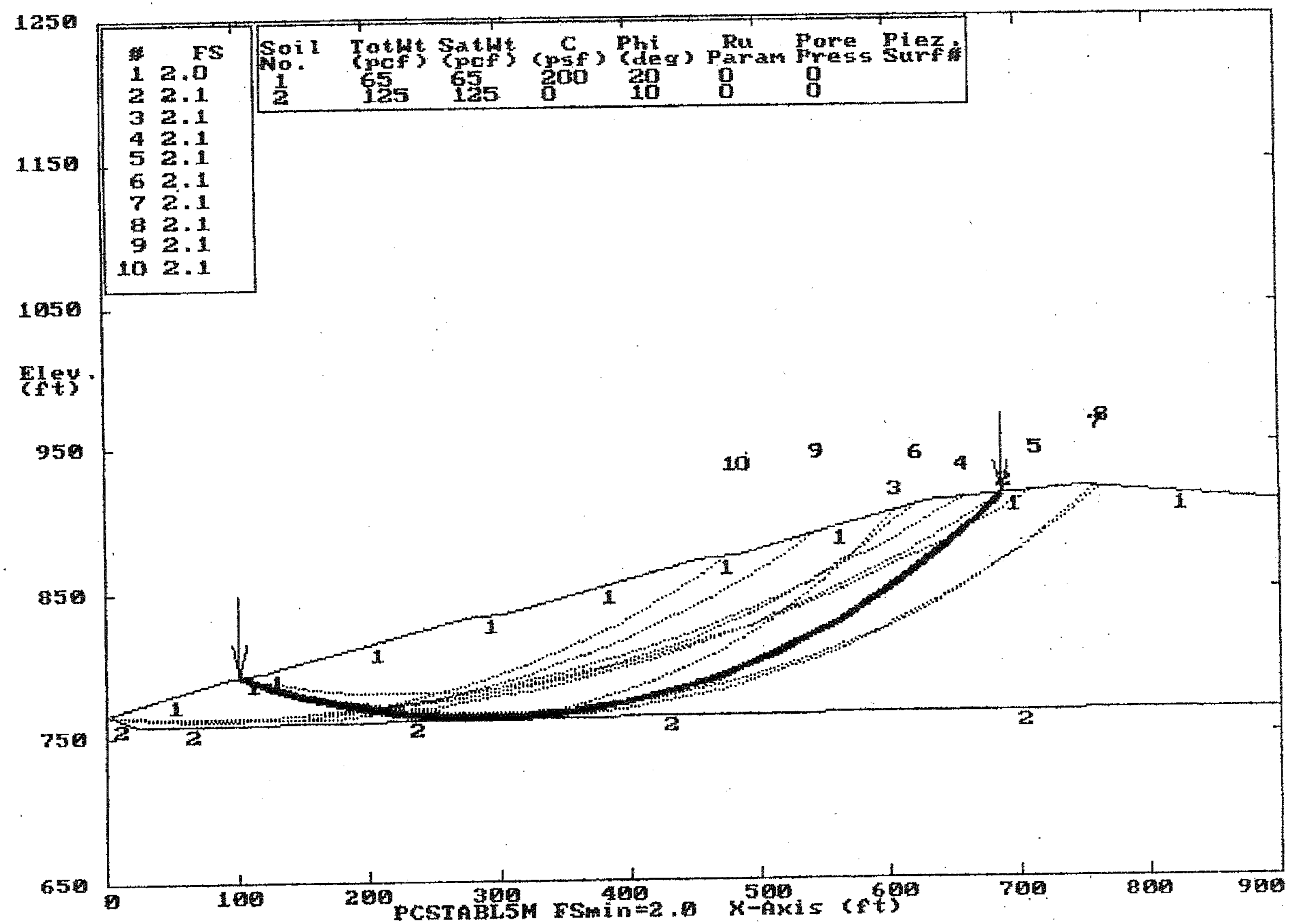
Greensboro Landfill - Section B-B' Circular Stability - EQUAKE
Ten Most Critical. A:GNBBCE.PLT By: PKS 12-07-95 2:00pm



Greensboro Landfill - Section C-C' Block Stability Along Liner - STATIC
Ten Most Critical. A:GNCC1.PLT By: PKS 12-07-95 4:17pm



Greensboro Landfill - Section C-C' Circular Stability - STATIC
Ten Most Critical. A:GNCCC.PLT By: PKS 12-07-95 2:34pm



Attachment 2

Veneer Stability Analysis of Final Cover

G.N. Richardson & Associates

ENGINEERING AND GEOLOGICAL SERVICES

SHEET: 2/2
JOB #: HDRGN-2
DATE: 12/7/95
BY: PKS
CHKD BY:

HDR - Greensboro Landfill
Analysis of Final Cover Stability

Input Parameters: (User Input)

Sideslope Angle (Beta):		14	degrees	
Final Cover:	Thickness (z):	2	ft	
	Unit Weight:	110	pcf	
	Cohesion:	0	psf	
	Water Depth:	2	ft	(= z if Slope is Dry)
Seismic Coefficient (ks):		0	Static FS	
		0.10	Dynamic FS	(= Peak Ground Acceleration For The Site)

Calculate Static FS Against Sliding:

Interface Fric. Angle	Resisting Force	Driving Force	FS slide	Comment
10	0.18	0.25	0.71	NO GOOD
15	0.27	0.25	1.07	NO GOOD
20	0.36	0.25	1.46	NO GOOD
25	0.47	0.25	1.87	OK

Calculate Dynamic FS Against Sliding:

Interface Fric. Angle	Resisting Force	Driving Force	FS slide	Comment
10	0.15	0.35	0.43	NO GOOD
15	0.24	0.35	0.70	NO GOOD
20	0.34	0.35	0.97	NO GOOD
25	0.44	0.35	1.26	OK

HDR Computation

Job Number 06770-67257-018	No.

Project	White Street Landfill	Computed		Date	
Subject	Phase III Closure	Checked		Date	
Task	Final Cover Veneer Stability	Sheet	1	Of	

Calculations: Infinite slope:

$$FS = \frac{\text{Resisting Moment (RM)}}{\text{Driving Moment (DM)}}$$

$$FS = \frac{[c/(\gamma z \cos^2\beta) + \tan\delta[1 - \gamma_w(z - d_w)/(\gamma z)] - k_g \tan\beta]}{k_g + \tan\beta}$$

Where:
FS = Factor of Safety
k_g = seismic coefficient (=0 for static stability)
γ = unit weight of cover soil
c = cohesion of cover soil
γ_w = unit weight of water
z = depth to failure surface (thickness of soil layer)
d_w = depth to seepage surface (=z if slope is dry)
β = slope angle of cover
δ = interface friction angle

FS_{min} = 1.5 Static conditions
FS_{min} = 1.0 Dynamic conditions

Given:

γ =	110	lb/ft^3	
γ_w =	62.4	lb/ft^3	
z =	2.0	ft	
Slope, M =	3	H:1V	
c =	0.0	lb/ft^2	assumed value, actual soil anticiapted to be higher
d_w =	1.90	ft	
β =	18.4	degrees	

Ground surface acceleration = 0.10 (seismic coefficient)
= 0 (static)

Dynamic FS Against Sliding:

δ	RM	DM	FS	
5	0.052	0.4333	0.12	Not Okay
10.0	0.138	0.4333	0.32	Not Okay
15	0.227	0.4333	0.52	Not Okay
20	0.320	0.4333	0.74	Not Okay
25	0.420	0.4333	0.97	Not Okay
27.3	0.468	0.4333	1.08	Okay
28	0.483	0.4333	1.12	Okay

Static FS Against Sliding:

δ	RM	DM	FS	
10	0.171	0.3333	0.51	Not Okay
15	0.260	0.3333	0.78	Not Okay
20	0.354	0.3333	1.06	Not Okay
25	0.453	0.3333	1.36	Not Okay
27.3	0.501	0.3333	1.50	Okay
28	0.517	0.3333	1.55	Okay

Conclusion: A minimum interface friction angle of 27.3 degrees between geotextile /soil and geotextile / textured geomembrane is necessary for stability.

DRAWING

N

-100 0 50 100 200

SCALE: 1"=100'

LEGEND

PROPERTY LINE

DRAINAGE DIVIDE

DRAINAGE DITCH

NOTES:

1. TOPOGRAPHY PROVIDED BY THE CITY OF GREENSBORO MARCH 2007.
2. PLANIMETRIC FEATURES PROVIDED BY GUILFORD CO. MAPS DATED 1991.
3. BOUNDARY SURVEY PROVIDED BY CITY OF GREENSBORO DATED DECEMBER 27, 1994.
4. CONTOURS DEPICT TOP OF FINAL COVER.
5. TERRACES ARE DEPICTED SCHEMATICALLY; INDICATOR ARROWS SHOW DIRECTION OF FLOW.
6. CATCH BASINS TO BE AREA DRAIN TYPE, NCDOT APPROVED.
7. CULVERTS TO BE CORRUGATED METAL OR REINFORCED CONCRETE.
8. DOWNCHUTES TO BE GABION LINED, TRAPEZOIDAL.
9. REFER TO DRAWING C-12 FOR DRAINAGE DETAILS.

HDR

HDR Engineering, Inc. of North Carolina
Suite 1400
128 S. Tryon Street
Charlotte, NC 28202-5001
(704) 338-1800

Issue No.	Description	Date	Drwn.	Chkd.	Resp. Engr.	Proj. Mgr.
A2	REVISED FINAL CONTOURS TO A 3H:1V SLOPE AND UPDATED THE EXISTING TOPOGRAPHY	3/6/08	JEG	DTD	JCR	JCR
A1	REVISED AS PER NCDEHNR COMMENTS DATED 2/25/97	2/26/97	JEG	DTD	JCR	JCR
A	ISSUED FOR DEHNR APPROVAL	11/28/95	JEG	EAW	JCR	JCR

NORTH CAROLINA PROFESSIONAL SEAL ENGINEER MICHAEL D. PLUMMER

Project Manager: J. READLING, P.E.
Architect:
I&C/Process:
Civil: E. WRIGHT, P.E.
Mechanical:
Electrical:
Structural:
Geology:
Drawn By: JEG

SEDIMENT AND EROSION CONTROL PLAN FOR THE
WHITE STREET SANITARY LANDFILL
PHASE III EXPANSION
CONSTRUCTION PERMIT APPLICATION

CITY OF GREENSBORO NORTH CAROLINA

FINAL CONTOURS AND DRAINAGE PLAN

Date	Project No.	Fig No.	Issue
MARCH 2008	6770-021-018	C-7A	A2

Scale: 1"=100'

REVISED CLOSURE PLAN

SECTION 6.0
CLOSURE PLAN

6.1 Cap System Background

In compliance with the Solid Waste Management Rules, the landfill will place a final cap system over all waste placed in the Phase III expansion. The cap system will be designed and constructed in accordance with Rule .1624 (b) (8), (9), and (15), to minimize infiltration and erosion. It is estimated that the total landfill volume at completion will be 6,669,000 ~~4,960,000~~ cubic yards. The maximum area requiring a cap at any one time is approximately 51 acres.

6.2 Cap System Design

The cap system designed will be checked prior to closure and revised and updated as appropriate. Compacted clay liners will be incorporated in the cap system design to provide protection throughout the 30-year post-closure period and beyond. The system will consist of, from bottom up; an 18-inch compacted clay liner (1×10^{-5} cm/sec); a geomembrane; a drainage layer (geonet); an 18-inch vegetative support layer; and, a 6-inch erosion layer.

The landfill may use on-site or off-site borrow material for the low permeability layer. The low-permeability layer will consist of no less than 18 inches of clay material having permeability no greater than 1×10^{-5} cm/sec. In order to assure that the material meets the established criteria, the material will be tested prior to use and after placement. Testing requirements will be outlined in the final closure plan. Construction methods for the compacted clay liner shall be based upon the type and quality of the borrow source and shall be verified in the field by constructing test pad(s). A Professional Engineer shall certify that the compacted clay liner installation conforms with the plans approved by the NC DEHNR Division of Solid Waste Management.

The erosion layer shall consist of 24 inches of cover soil of which no less than six inches of earthen material that is capable of sustaining native plant growth. The landfill anticipates use of on-site borrow material suitable for the erosion layer.

The material of the erosion layer will be selected considering: soil type, nutrient levels, pH, erodibility, and other factors. The vegetation should be selected based upon:

- Species of grasses which are locally adapted and resistant to drought or temperature extremes;
- Having roots which will not disrupt the low permeability layer;
- Ability to thrive in low nutrient soil and develop a good stand to resist erosion;
- Survive and function with little or no maintenance.

All cover material will be free of putresible material, solid waste, vegetation, rocks, construction debris, frozen soil, and other deleterious materials.

6.3 Final Contour Requirements

The final contour requirements for closure are shown on the drawings. These contours have been established to reflect all municipal solid waste expected to be received, intermediate cover material (representing a total of 12 inches), and the final cover system (representing a total of three and one-half feet).

6.4 Cap System Material Requirements

Based on 18 inches of clay placed over the 51 acres that require final closure, 126,000 cubic yards of low-permeability clay are required for the first layer of the cap system. Additionally, 126,000 cubic yards is required for the vegetative support soil. An estimated 42,000 cubic yards of earthen material is required for the 6 inches of top soil layer. An estimated 2,270,000 square feet of geomembrane will be used in final cover of this phase.

6.5 Drainage Control Measures

The landfill is designed to have top slopes of 8 percent and side slopes of 33~~25~~ percent. Final contours have been established to allow the landfill to drain while limiting erosion potential and maintaining post settlement slopes greater than 5 percent. Surface water will sheet flow down each of the sideslopes, and into terrace perimeter drainage ditches which will direct flow via down chutes to sedimentation basins located around the unit.

6.6 Permanent Erosion Control Measures

The landfill is situated near North Buffalo Creek at the northern side of the property, which is a tributary to the Haw River. As shown in the Drawings, a system of drainage channels and sedimentation basins will be used to protect the North Buffalo Creek from sediment laden runoff. The sedimentation basins are designed to control the 24-hour/25-year storm event and achieve a minimum of 70 percent efficiency in settling a sediment particle with a diameter of 40 microns. The sedimentation basin design calculations may be found at the end of this application.

6.7 Settlement Subsidence and Displacement

Landfill compaction methods which include the use of steel-wheeled compaction equipment to spread and compact in layers not to exceed two feet in thickness, combined with an adequate number of passes over each layer of waste, will be utilized to reduce voids and minimize differential settlement. Proper placement of daily, intermediate, and final cover will reduce the moisture content of the waste prior to site closure and further reduce settlement. Final slopes of the landfill have been developed to allow for this anticipated subsidence so that positive drainage of the fill will not be hindered.

6.8 Leachate Control

The installation of the final cap system over the fill area will greatly reduce infiltration of surface water and lessen the potential for leachate generation. The landfill has a comprehensive surface and groundwater monitoring program to detect any potential leachate migration problems. This program will be continued throughout the post-closure care period.

6.9 Gas Collection/Venting System

A passive gas venting system will be installed under the cap to allow movement of gas generated from the completed fill area to the gas management area.

6.10 Schedule for Closure

The closure will begin after completion of a portion of the final grades but no later than 30 days after the final receipt of waste. The design of the landfill in combination with the maintenance plan should assure a fairly uncomplicated closure period. The closure of the entire unit, or portions thereof, will be completed within 180 days unless an extension has been requested and received due to changes in the anticipated schedule.

6.11 Notice of Closure and Date of Final Waste Acceptance

A sign indicating the anticipated date of closure and the date of final waste acceptance will be conspicuously posted at the facility at least 30 days in advance of closure. The landfill may take other steps to notify the public of the planned closure. Prior to beginning closure of the unit or portions thereof, the Department of Solid Waste Management will be notified that a notice of intent to close has been placed in the operating record.

6.12 Implementation of Closure Plan

The closure plan will be implemented no more than 30 days from the date of final waste acceptance and completed in accordance with State regulations.

6.13 Closure Verification

The following procedures will be implemented following closure.

- A Construction Quality Assurance (CQA) report shall be submitted to the NC DEHNR Division of Solid Waste Management. This report shall describe the observations and tests used before, during, and upon completion of construction to ensure that the construction materials meet the cap design specifications and the construction and certification requirements. The CQA report shall contain as-built drawings.

- A signed certification from an independent registered professional engineer verifying that closure has been completed in accordance with the closure plan will be submitted to the NC DEHNR Division of Solid Waste Management.

- At least one sign notifying all persons of the closing of the phase and that wastes are no longer accepted will be posted. Suitable barriers will be installed as necessary at former accesses to prevent new waste from being deposited.

- Within 90 days, a survey plat, prepared by a professional land surveyor registered by the State, indicating the location and dimensions of landfill disposal areas, will be submitted to the circuit court clerk of the City of Greensboro.

- A notation shall be recorded on the deed notifying any potential purchaser of the property that the land has been used as a solid waste management unit and that future use is restricted under Paragraph (8) of Rule .1627. A copy of the deed notation as recorded shall be filed with the operating record.

REVISED POST-CLOSURE PLAN

SECTION 7.0
POST-CLOSURE PLAN

7.1 Introduction

This Post-Closure Plan has been developed to outline steps to be taken to ensure the environmental soundness of the landfill during its post-closure care period. The post-closure care period will last at least 30 years after closure completion and at a minimum will consist of the following:

- Maintaining integrity and effectiveness of final cover system
- Performing groundwater and surface water monitoring
- Maintaining and operating a gas monitoring system
- Maintaining run-on/run-off controls

No wastes will remain exposed after closure of the unit. Access to the closed site by the public or domestic livestock will not pose a health hazard.

7.2 Post-Closure Contact

All correspondence and questions concerning the post-closure care of the unit should be directed to:

~~Mr. Dale James~~
~~Solid Waste Manager~~Director of Environmental Services

City of Greensboro
P.O. Box 3136
Greensboro, NC 27402
(910) 373-2035

7.3 Description of Use

After filling operations cease at Phase III of the White Street Sanitary Landfill and the unit is officially closed in accordance with the Plan described in Section 7.0, the area will be allowed to return to its natural vegetative state.

7.4 Maintenance

7.4.1 Repair of Security Control Devices

All security control devices will be inspected and maintained as necessary to ensure access to the site is controlled. Locks, vehicular gates and fencing will be replaced if functioning improperly. Warning signs will be kept legible at all times and will be replaced if damaged by inclement weather or vandalism.

7.4.2 Erosion Damage Repair

If erosion of the final cover occurs during post-closure, the affected area will be repaired and reseeded as necessary. Excessive slopes will be flattened if possible by adding clean fill material. If necessary, erosion control fabrics will be used to expedite rapid re-vegetation of slopes and to secure topsoil in place. Rough surfaces which cause isolated erosion areas will be smooth and reseeded as necessary.

7.4.3 Correction of Settlement, Subsidence and Displacement

Minimum slopes of five percent will be maintained after settlement in order to prevent ponding and allow for proper drainage without infiltration. If vertical or horizontal displacement occurs due to differential settlement, cracks will be filled with appropriate material and final cover will be reestablished. Excessive vertical displacement is not anticipated.

7.4.4 Repair of Run-On/Run-Off Control Structures

All terraces, ditches, and perimeter channels will be repaired, cleaned, or realigned in order to maintain original condition. Any culverts that are damaged will be replaced.

7.4.5 Gas Collection/Venting System

The landfill gas collection and venting system is anticipated to be maintained by Greensboro personnel~~a third party~~. Proper operation of the systems will be verified through testing at the landfill gas monitoring wells and probes.

If methane gas recovery wells do not function as a result of irregular settlement, accumulation of liquids (condensate, leachate, water), binding or corrosion, replacement wells can be installed if necessary. Non-functioning vents will be reset if necessary.

7.4.6 Groundwater Monitoring System

All groundwater monitoring wells have been installed with concrete pads and protective casings to prevent accidental damage by vehicles and equipment. The wells are also equipped with a locking cap to discourage vandalism. Groundwater wells will be inspected regularly (at the time of sampling) to ensure integrity. Persons inspecting a well should look for signs of well tampering, cracking or degradation, and determine whether the well needs to be replaced. If the decision is made to replace and abandon a well, the replacement well should be installed 5-10 feet from the abandoned well in accordance with previous well specifications. Well abandonment should be accomplished by pulling the casing out and grouting the hole.

7.4.7 Leachate Collection System

The leachate collection system will be monitored. The leachate production rates are expected to be reduced significantly following capping. After six months of minimal flows the storage tank system may be evaluated for decommissioning and leachate will be pumped directly into the discharge line from the pump station. The tanks and pipe system will be annually inspected and repaired as necessary.

After closure of the landfill areas has been achieved, the generation of leachate will eventually curtail. The flow rate immediately after closure should decrease to 20 gallons/acre/day (gpad) which for all disposal areas yield approximately 800 gallons/day. Toward the end of the 30-year post-closure period, the flow should approach zero, at which time the storage tank will not be required. The following procedures will be followed to properly close the storage tank:

- Completely drain and remove all liquids, sludges, sediments, etc., from the storage tank.

- Disassemble the tank, piping, and appurtenances and dispose of the contents in a manner approved by NC DEHNR.

- Sample and analyze the soil for appropriate constituents inherent to leachate. Assess the results for evidence of contaminant migration.

- If contamination of underlying soil is exhibited, perform an assessment as to the degree of contamination and develop remedial actions.

- Obtain approval from NC DEHNR for the assessment and associated remedial measures.

- Perform the remedial actions as necessary to limit any threats to public health and the environment.

- Restore the area to closely match pre-existing conditions in the vicinity of the impoundment. Activities may include: filling, grading, topsoiling, and seeding.

7.5 Monitoring Plan

The closed unit shall be monitored for a minimum of 30 years. A series of inspections shall be scheduled to ensure the integrity and effectiveness of the cap system, storm water control system, groundwater monitoring system, gas collection system, leachate collection system, and to protect human health and the environment.

7.5.1 <u>Inspection Frequencies</u>

Inspections to be conducted during the post-closure care period will occur regularly as follows:

Inspection	Frequency
Security Control Devices	Quarterly
Cover drainage system functioning	Semi-annually
Gas collection/venting system	Semi-annually
Groundwater monitoring system	Semi-annually
Erosion damage	Quarterly
Cover settlement, subsidence and	Semi-annually
displacement	Quarterly
Vegetative cover condition	Quarterly
Stormwater control system	Quarterly
Benchmark Integrity	Quarterly
Leachate Collection System	

A copy of the Post-Closure Inspection Checklist is shown as Figure 7-1.

7.5.2 Quarterly Inspections

Quarterly inspections of the closed site will include examining –the security control devices for signs of deterioration or vandalism to ensure access to the site is limited to authorized persons. The previous disposal area will be checked to ensure that the integrity of the final cover system is maintained, erosion damage is repaired, vegetative cover persists, and that cover settlement, subsidence and displacement are minimal. Drainage ditches will be cleared of litter and debris and benchmark integrity will be noted and maintained.

7.5.3 Semi-Annual Inspections

Semi-annual inspections of the site during the post-closure period will be conducted by the City of Greensboro's consultant engineer and/or the City's waste disposal engineer with detail attention paid to integrity and drainage of the final cover system and proper functioning of the groundwater and gas monitoring systems.

FIGURE 7-1

POST-CLOSURE INSPECTION CHECKLIST

Date: ____________________ Time: ____________________

Weather: ____________________ Completed By: ____________________

	Yes	No
I. Security Control Devices:		
Are security control devices in place and functioning?	☐	☐
Are all warning signs prominent and legible?	☐	☐
Are there any signs of unauthorized entry on the site?	☐	☐
Are there signs of illegal dumping on site?	☐	☐
II. Final Cover System:		
Is the final cover free of erosion and depressions?	☐	☐
Is there leachate seeping from the final cover? (If yes, make note of location on comment section below.)	☐	☐
Is the vegetative cover continuous and in good condition, free of bare spots?	☐	☐
Does the site require mowing? (If yes, mow grass and note in comment section below.)	☐	☐
Is there ponding of water on final cover system?	☐	☐
III. Gas Collection System:		
Are the casings in good repair and secure?	☐	☐
IV. Groundwater Monitoring Wells:		
Is the casing upright and unobstructed?	☐	☐
Is the outer casing secure and locked?	☐	☐
Is the ID tag present and legible?	☐	☐
V. Leachate Collection System:		
Are the cleanouts accessible and secured?	☐	☐
Are the valves operational?	☐	☐
Are the tanks and pipelines free of signs of leakage?	☐	☐
VI. Miscellaneous:		
Are all benchmarks visible and intact?	☐	☐
Are all ditches free of debris and litter?	☐	☐
Are any odors present which may indicate landfill gas migration?	☐	☐

Comments

Please use the section below to comment on any area not covered above and also note any areas of concern or needing immediate attention.

Groundwater monitoring will continue on a regular basis throughout the post-closure care period. The parameters chosen for analysis will be no less than the requirements of regulatory agencies. Groundwater monitoring wells will be inspected in accordance with the Ground-water Monitoring Plan. A report of the findings will be sent to City of Greensboro representative via the Post-Closure Inspection Checklist including any recommendations for actions necessary to ensure the site continues to meet the closure performance standard. The engineer will also receive copies of the quarterly inspections reports and respond to any comments that demand immediate attention.

Gas migration will be monitored using an explosimeter around the perimeter of the fill area and between the fill and adjacent buildings and property lines. Monitoring will take place at least quarterly for safety purposes. If it is determined that an active gas venting system is required to control migration, a system including final gas treatment and disposal will be incorporated.

7.6 Engineering Certification

Based on the City's monitoring reports and an engineer's quarterly site visits, annual certifications by the engineer will be placed in the operating record. They will certify that the closure plan has been followed, noting discrepancies along with the corrective actions undertaken. At the end of the post closure period, the individual certifications will be compiled into a final document and forwarded to the Division.