NORTH TEXAS MUNICIPAL WATER DISTRICT

Regional. Reliable. Everyday.

June 19, 2019

Executive Director, c/o Mr. Chance Goodin, MSW Permits Section
MC-124
Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Re: Limited Scope Permit Amendment Application; NTMWD 121 Regional Disposal Facility; TCEQ Permit No. MSW 2294; Collin County; RN101308781 / CN601365448

Dear Mr. Goodin:

On behalf of the North Texas Municipal Water District (NTMWD), Biggs & Mathews Environmental has prepared the enclosed limited scope permit amendment application for the above referenced Type I municipal solid waste facility. Included are one signed original and three copies of the application for your review and approval. Only portions that are proposed to change are included as required by 30 TAC Chapter 305.62.

The NTMWD is fully committed to operating this landfill site consistent with applicable TCEQ regulations which will protect human health and the environment while providing needed landfill disposal capability for the communities and businesses in and around Collin County, Texas. If you or your staff have any questions please do not hesitate to contact Mr. David Clark with Biggs & Mathews Environmental at (817) 563-1144 or Mr. Mike Friesen with NTMWD at (469) 626-4339.

Sincerely,

JEFFREY D. MAYFIELD
Assistant Deputy – Solid Waste

/JDM

Attachments: CD – Electronic Copy of Land Owners List
Permit Amendment Application (One Original and Three Copies)

cc: Mike Friesen, Solid Waste System Manager, NTMWD
NTMWD Central File 121 RDF 9.0
121 RDF Site Operating Record 9.0
Jeff Reed, Lloyd Gosselink Rochelle & Townsend, P.C.
Erin Gorman, TCEQ Region IV

501 E. Brown Street, P.O. Box 2408, Wylie, Texas 75098-2408 | Phone: 972-442-5405 | Fax: 972-295-6440 | www.ntmwd.com

NTMWD 121 REGIONAL DISPOSAL FACILITY
COLLIN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 2294

LIMITED SCOPE
PERMIT AMENDMENT APPLICATION

Prepared for

NORTH TEXAS MUNICIPAL WATER DISTRICT

June 2019

Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road ◆ Mansfield, Texas 76063 ◆ 817-563-1144

CORRESPONDENCE COVER SHEET
WASTE PERMITS DIVISION
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Date: 06/19/2019
Facility Name: NTMWD 121 Regional Disposal Facility
Permit or Registration No.: 2294

Nature of Correspondence:
☒ Initial/New
☐ Response/Revision*

*If Response/Revision, please provide previous TCEQ Tracking No.:
(Previous TCEQ Tracking No. can be found in the Subject line of the TCEQ's response letter to your original submittal.)

This cover sheet should accompany all correspondences submitted to the Waste Permits Division and should be affixed to the front of your submittal as a cover page. Please check the appropriate box for the type of correspondence being submitted. For questions regarding this form, please contact the Waste Permits Division at (512) 239-2335.

Table 1 - Municipal Solid Waste

APPLICATIONS	REPORTS and RESPONSES
☐ New Notification	☐ Closure Report
☐ New Permit (including Subchapter T)	☐ Groundwater Alternate SRC Demonstration
☐ New Registration (including Subchapter T)	☐ Groundwater Corrective Action
☐ Major Amendment	☐ Groundwater Monitoring Report
☐ Minor Amendment	☐ Groundwater Statistical Evaluation
☒ Limited Scope Major Amendment	☐ Landfill Gas Corrective Action
☐ Notice Modification	☐ Landfill Gas Monitoring
☐ Non-Notice Modification	☐ Liner Evaluation Report
☐ Transfer/Name Change Modification	☐ Soil Boring Plan
☐ Temporary Authorization	☐ Special Waste Request
☐ Voluntary Revocation	☐ Other:
☐ Subchapter T Workplan	
☐ Other:	

Table 2 - Industrial & Hazardous Waste

APPLICATIONS	REPORTS and RESPONSES
☐ New	☐ Annual/Biennial Site Activity Report
☐ Renewal	☐ CfPT Plan/Result
☐ Post-Closure Order	☐ Closure Certification/Report
☐ Major Amendment	☐ Construction Certification/Report
☐ Minor Amendment	☐ CPT Plan/Result
☐ Class 3 Modification	☐ Extension Request
☐ Class 2 Modification	☐ Groundwater Monitoring Report
☐ Class 1 ED Modification	☐ Interim Status Change
☐ Class 1 Modification	☐ Interim Status Closure Plan
☐ Endorsement	☐ Soil Core Monitoring Report
☐ Temporary Authorization	☐ Treatability Study
☐ Voluntary Revocation	☐ Trial Burn Plan/Result
☐ 335.6 Notification	☐ Unsaturated Zone Monitoring Report
☐ Other:	☐ Waste Minimization Report
	☐ Other:

NTMWD 121 REGIONAL DISPOSAL FACILITY
COLLIN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 2294

LIMITED SCOPE
PERMIT AMENDMENT APPLICATION

Prepared for

NORTH TEXAS MUNICIPAL WATER DISCTRICT

June 2019

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

Prepared by

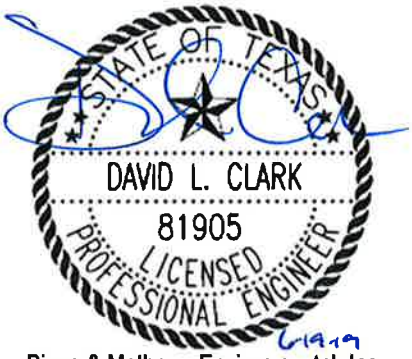
BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road, Suite 100 • Mansfield, Texas 76063 • 817-563-1144

TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NO. F-256

TEXAS BOARD OF PROFESSIONAL GEOSCIENTISTS
FIRM REGISTRATION NO. 50222

NTMWD 121 REGIONAL DISPOSAL FACILITY
COLLIN COUNTY, TEXAS
TCEQ PERMIT NO. MSW 2294

LIMITED SCOPE
PERMIT AMENDMENT APPLICATION



Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

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Facility Name: NTMWD 121 REGIONAL DISPOSAL FACILITY
Permittee/Registrant Name: NORTH TEXAS MUNICIPAL WATER DISTRICT
MSW Authorization #:2294
Initial Submittal Date: 06/19/2019
Revision Date:

Texas Commission on Environmental Quality

Part I Form for New Permit/Registration and Amendment Applications for an MSW Facility

1. Reason for Submittal

☒ Initial Submittal ☐ Notice of Deficiency (NOD) Response

2. Authorization Type

☒ Permit ☐ Registration

3. Application Type

☐ New ☐ Major Amendment
☒ Major Amendment (Limited Scope)

4. Application Fees

☐ Pay by Check ☒ Online Payment

If paid online, e-Pay Confirmation Number:

5. Application URL

Is the application submitted for Type I Arid Exempt (AE) and/or Type IV AE facility?

☐ Yes ☒ No

If the answer is "No", provide the URL address of a publicly accessible internet web site where the application and all revisions to that application will be posted.
http://

6. Application Publishing

Party Responsible for Publishing Notice:

☒ Applicant ☐ Agent in Service ☐ Consultant

Contact Name: Title:

7. Alternative Language Notice

Is an alternative language notice required for this application? (For determination refer to Alternative Language Checklist on the Public Notice Verification Form TCEQ-20244-Waste)

☐ Yes ☒ No

8. Public Place Location of Application

Name of the Public Place: **Melissa Public Library**

Physical Address: **3411 Barker Avenue**

City: **Melissas** County: **Collin** State: **TX** Zip Code: **75454**

(Area code) Telephone Number: **972-837-4540**

9. Consolidated Permit Processing

Is this submittal part of a consolidated permit processing request, in accordance with 30 TAC Chapter 33?

☐ Yes ☒ No ☐ Not Applicable

If "Yes", state the other TCEQ program authorizations requested:

10. Confidential Documents

Does the application contain confidential documents?

☐ Yes ☒ No

If "Yes", cross-reference the confidential documents throughout the application and submit as a separate attachment in a binder clearly marked "CONFIDENTIAL."

11. Permits and Construction Approvals

Permit or Approval	Received	Pending	Not Applicable
Hazardous Waste Management Program under the Texas Solid Waste Disposal Act	☐	☐	☒
Underground Injection Control Program under the Texas Injection Well Act	☐	☐	☒
National Pollutant Discharge Elimination System Program under the Clean Water Act and Waste Discharge Program under Texas Water Code, Chapter 26	☒	☐	☐
Prevention of Significant Deterioration Program under the Federal Clean Air Act (FCAA). Nonattainment Program under the FCAA	☐	☐	☒
National Emission Standards for Hazardous Air Pollutants Preconstruction Approval under the FCAA	☐	☐	☒
Ocean Dumping Permits under the Marine Protection Research and Sanctuaries Act	☐	☐	☒

Permit or Approval	Received	Pending	Not Applicable
Dredge or Fill Permits under the CWA	☐	☐	☒
Licenses under the Texas Radiation Control Act	☐	☐	☒
Other (describe)	☐	☐	☐
Other (describe)	☐	☐	☐
Other (describe)	☐	☐	☐
Other (describe)	☐	☐	☐

12. General Facility Information

Facility Name: **NTMWD 121 REGIONAL DISPOSAL FACILITY**

Contact Name: **Jeff Mayfield** Title: **Assistant Deputy**

MSW Authorization No. (if available): **2294**

Regulated Entity Reference No. (if issued)*: RN**101308781**

Physical or Street Address (if available): **3820 Sam Rayburn Hwy**

City: **Melissa** County: **Collin** State: **TX** Zip Code: **75454**

(Area Code) Telephone Number: **972-442-5405**

Latitude (Degrees, Minutes Seconds): **N33° 17' 26.74556"**

Longitude (Degrees, Minutes Seconds): **W96° 30' 51.22736"**

Benchmark Elevation (above mean sea level): **657.45**ft.

Provide a description of the location of the facility with respect to known or easily identifiable landmarks: **Approximately 2 miles northeast of the intersection of State Highway 121 and Farm to Market 545.**

Detail access routes from the nearest United States or state highway to the facility: **Approximately 4 miles northeast of the intersection of US Highway 75 and State Highway 121.**

*If this number has not been issued for the facility, complete a TCEQ Core Data Form (TCEQ-10400) and submit it with this application. List the Facility as the Regulated Entity.

13. Facility Type(s)

☒ Type I	☐ Type IV	☐ Type V
☐ Type I AE	☐ Type IV AE	☐ Type VI

14. Activities Conducted at the Facility

☐ Storage	☒ Processing	☒ Disposal

15. Facility Waste Management Unit(s)

☒ Landfill Unit(s)	☐ Incinerator(s)
☐ Class 1 Landfill Unit(s)	☐ Autoclave(s)
☐ Process Tank(s)	☐ Refrigeration Unit(s)
☒ Storage Tank(s)	☐ Mobile Processing Unit(s)
☐ Tipping Floor	☐ Type VI Demonstration Unit
☐ Storage Area	☒ Compost Pile(s) and/or Vessel(s)
☒ Container(s)	☐ Other (Specify)
☒ Roll-off Boxes	☐ Other (Specify)
☐ Surface Impoundment	☐ Other (Specify)

16. Description of Proposed Facility or Changes to Existing Facility

Provide a brief description of the proposed activities if application is for a new facility, or the proposed changes to an existing facility or permit conditions if the application is for an amendment.
Permit amendment application for an alternate liner system consistent with 30 TAC 305.62(j)(2)(C), and 330.335.

17. Facility Contact Information

Site Operator (Permittee/Registrant) Name: North Texas Municipal Water District

Customer Reference No. (if issued)*: CN**601365448**

Contact Name: **Jeff Mayfield** Title: **Assistant Deputy**

Mailing Address: **P.O. Box 2408**

City: **Wylie** County: **Collin** State: **TX** Zip Code: **75098**

(Area Code) Telephone Number: **972-442-5405**

Email Address: **jmayfield@ntmwd.com**

TX Secretary of State (SOS) Filing Number:

*If the Site Operator (Permittee/Registrant) does not have this number, complete a TCEQ Core Data Form (TCEQ-10400) and submit it with this application. List the Site Operator (Permittee/Registrant) as the Customer.

Operator Name[1]: "Same as "Site Operator (Permitee/Registrant)"

Customer Reference No. (if issued)*:

Contact Name: Title:

Mailing Address:

City: County: State: Zip Code:

(Area Code) Telephone Number:

Email Address:

TX SOS Filing Number:

[1]If the Operator is the same as Site Operator/Permittee type "Same as "Site Operator (Permittee/Registrant)".
*If the Operator does not have this number, complete a TCEQ Core Data Form (TCEQ-10400) and submit it with this application. List the Operator as the customer.

Consultant Name (if applicable): Biggs and Mathews Environmental, Inc. F-256

Texas Board of Professional Engineers Firm Registration Number:

Contact Name: **David Clark, P.E.** Title: **Senior Engineer**

Mailing Address: **1700 Robert Road**

City: **Mansfield** County: **Tarrant** State: **TX** Zip Code: **76063**

(Area Code) Telephone Number: **(817)563-1144**

E-Mail Address: **dclark@biggsandmathews.com**

Agent in Service Name (required only for out-of-state):

Mailing Address:

City: County: State: Zip Code:

(Area Code) Telephone Number:

E-Mail Address:

18. Facility Supervisor's License

Select the Type of License that the Solid Waste Facility Supervisor, as defined in 30 TAC Chapter 30, Occupational Licenses and Registrations, will obtain prior to commencing facility operations.

☒ Class A ☐ Class B

19. Ownership Status of the Facility

☐ Corporation	☐ Limited Partnership	☐ Federal Government
☐ Individual	☐ City Government	☐ Other Government
☐ Sole Proprietorship	☐ County Government	☐ Military
☐ General Partnership	☐ State Government	☒ Other (Specify):

Does the Site Operator (Permittee/Registrant) own all the facility units and all the facility property?

☒ Yes ☐ No

If "No", provide the information requested below for any additional ownership.

Owner Name:

Street or P.O. Box:

City: County: State: Zip Code:

(Area Code) Telephone Number:

Email Address (optional):

20. Other Governmental Entities Information

Texas Department of Transportation District: Dallas

District Engineer's Name: **Mohamed Mo Bur, P.E.**

Street Address or P.O. Box: **4777 E. Highway 80**

City: **Mesquite** County: **Dallas** State: **TX** Zip Code: **75150**

(Area Code) Telephone Number: **214-320-6100**

E-Mail Address (optional):

The Local Governmental Authority Responsible for Road Maintenance (if applicable):

Contact Person's Name:

Street Address or P.O. Box:

City: County: State: Zip Code:

(Area Code) Telephone Number:

E-Mail Address (optional):

City Mayor Information

City Mayor's Name: **Reed Greer**

Office Address: **3411 Barker Avenue**

City: **Melissa** County: **Collin** State: **TX** Zip Code: **75454**

(Area Code) Telephone Number: **972-838-2520**

E-Mail Address (optional):

City Health Authority:

Contact Person's Name:

Street Address or P.O. Box:

City: County: State: Zip Code:

(Area Code) Telephone Number:

E-Mail Address (optional):

County Judge Information

County Judge's Name: **Chris Hill**

Street Address or P.O. Box: **2300 Bloomdale Rd., Suite 4192**

City: **McKinney** County: **Collin** State: **TX** Zip Code: **75071**

(Area Code) Telephone Number: **972-424-1460 ext. 4631**

E-Mail Address (optional):

County Health Authority: Collin County Health Care

Contact Person's Name: **Candy Blair, R.N.**

Street Address or P.O. Box: **825 N. McDonald St., Suite 130**

City: **McKinney** County: **Collin** State: **TX** Zip Code: **75069**

(Area Code) Telephone Number: **972-548-5500**

E-Mail Address (optional):

State Representative Information

District Number: **70**

State Representative's Name: **Scott Sanford**

District Office Address: **115 W. Virginia, Suite 103**

City: **McKinney** County: **Collin** State: **TX** Zip Code: **75069**

(Area Code) Telephone Number: **972-548-7500**

E-Mail Address (optional):

State Senator Information

District Number: **30**

State Senator's Name: **Pat Fallon**

District Office Address: **P.O. Box 12068**

City: **Austin** County: **Travis** State: **TX** Zip Code: **78711**

(Area Code) Telephone Number: **512-463-0130**

E-Mail Address (optional):

Council of Government (COG) Name: NCTCOG

COG Representative's Name: **Edith Marvin**

COG Representative's Title: **Director of Environment & Development**

Street Address or P.O. Box: **616 Six Flags Dr., STE 200**

City: **Arlington** County: **Tarrant** State: **TX** Zip Code: **76011**

(Area Code) Telephone Number: **817-695-9211**

E-Mail Address (optional):

River Basin Authority Name: Trinity River Authority

Contact Person's Name: **Kevin Ward**

Watershed Sub-Basin Name: **Stiff Creek-Sister Grove Creek**

Street Address or P.O. Box: **P.O. Box 60**

City: **Arlington** County: **Tarrant** State: **TX** Zip Code: **76004**

(Area Code) Telephone Number: **817-467-4343**

E-Mail Address (optional):

Coastal Management Program

Is the facility within the Coastal Management Program boundary?

☐ Yes ☒ No

U.S. Army Corps of Engineers

The facility is located in the following District of the U.S. Army Corps of Engineers:

☐ Albuquerque, NM ☐ Galveston, TX

☒ Ft. Worth, TX ☐ Tulsa, OK

Local Government Jurisdiction

Within City Limits of: **Melissa**

Within Extraterritorial Jurisdiction of:

Is the facility located in an area in which the governing body of the municipality or county has prohibited the storage, processing or disposal of municipal or industrial solid waste?

☐ Yes ☒ No

(If "Yes", provide a copy of the ordinance or order as an attachment):

Facility Name: NTMWD 121 REGIONAL DISPOSAL FACILITY Initial Submittal Date: 06/19/2019
MSW Authorization #: 2294 Revision Date:

Signature Page

I, Thomas Kula, Executive Director,
(Site Operator (Permittee/Registrant)'s Authorized Signatory) (Title)

certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Signature: Thomas Kula Date: 6/19/19

TO BE COMPLETED BY THE OPERATOR IF THE APPLICATION IS SIGNED BY AN AUTHORIZED REPRESENTATIVE FOR THE OPERATOR

I, _____, hereby designate _____
(Print or Type Operator Name) (Print or Type Representative Name)

as my representative and hereby authorize said representative to sign any application, submit additional information as may be requested by the Commission; and/or appear for me at any hearing or before the Texas Commission on Environmental Quality in conjunction with this request for a Texas Water Code or Texas Solid Waste Disposal Act permit. I further understand that I am responsible for the contents of this application, for oral statements given by my authorized representative in support of the application, and for compliance with the terms and conditions of any permit which might be issued based upon this application.

_____
Printed or Typed Name of Operator or Principal Executive Officer

_____
Signature

SUBSCRIBED AND SWORN to before me by the said Thomas W. Kula
On this 19th day of June, 2019
My commission expires on the 18th day of May, 2020
LeAnn Bumpus
Notary Public in and for
Collin County, Texas
(Note: Application Must Bear Signature & Seal of Notary Public)

LEANN BUMPUS
Notary Public, State of Texas
Comm. Expires 05-18-2020
Notary ID 10188600

Part I Attachments

(See Instructions for P.E. seal requirements.)

Required Attachments	**Attachment No.**
Supplementary Technical Report	
Property Legal Description	
Property Metes and Bounds Description	
Facility Legal Description	
Facility Metes and Bounds Description	
Metes and Bounds Drawings	
On-Site Easements Drawing	
Land Ownership Map	**Following Narrative**
Land Ownership List	**Following Narrative**
Electronic List or Mailing Labels	**Following Narrative**
Texas Department of Transportation (TxDOT) County Map	
General Location Map	
General Topographic Map	
Verification of Legal Status	
Property Owner Affidavit	
Evidence of Competency	

Additional Attachments as Applicable- Select all those apply and add as necessary

- ☐ TCEQ Core Data Form(s)
- ☐ Signatory Authority Delegation
- ☐ Fee Payment Receipt
- ☐ Confidential Documents
- ☐ Waste Storage, Processing and Disposal Ordinances
- ☐ Final Plat Record of Property
- ☐ Certificate of Fact (Certificate of Incorporation)
- ☐ Assumed Name Certificate

LIMITED SCOPE PERMIT AMENDMENT NARRATIVE

Introduction

The purpose of this limited scope permit amendment is to provide an alternate liner design demonstration. These revisions include a new option for excavation and liner. This limited scope permit amendment has been prepared consistent with the applicable provisions of 30 Texas Administrative Code (TAC) §305.62 (j) for permit amendments where *"only the portions of the permit and attachments to which changes are being proposed are required to be submitted;" and* §330.335 for Alternative Liner Design. The proposed limited scope permit amendment for the NTMWD 121 Regional Disposal Facility meets this definition.

The following section identifies each limited scope permit amendment requirement, identifies the revisions within this limited scope permit amendment, and states how the proposed revisions meet the specific permit modification requirements:

Proposed Limited Scope Permit Amendment

The proposed limited scope permit amendment requirements are established in 30 TAC §305.62(j)(2)(C), §330.335, and included in this submittal are identified below. The specific rule is stated in the following narrative in *"italics"* with the proposed revision justification stated. The following describes the proposed permit modification.

30 TAC §305.62(j)(2)(C) *– For all other major amendment applications for MSW facilities, only the portions of the permit and attachments to which changes are being proposed are required to be submitted. Addition of an alternative liner design, in accordance with §330.335 of this title (relating to Alternative Liner Design).*

30 TAC §330.335 *– Alternative liner designs, which for Type I landfills must include a leachate management system, may be authorized by the executive director if the owner or operator provides a demonstration by computerized design modeling that the maximum contaminant levels detailed in §330.331 of this title (relating to Design Criteria), Table 1 will not be exceeded at the point of compliance.*

Per the September 19, 2018 meeting between Biggs & Mathews Environmental, Inc., North Texas Municipal Water District, and TCEQ; this limited scope permit amendment will be presented in a non-traditional format.

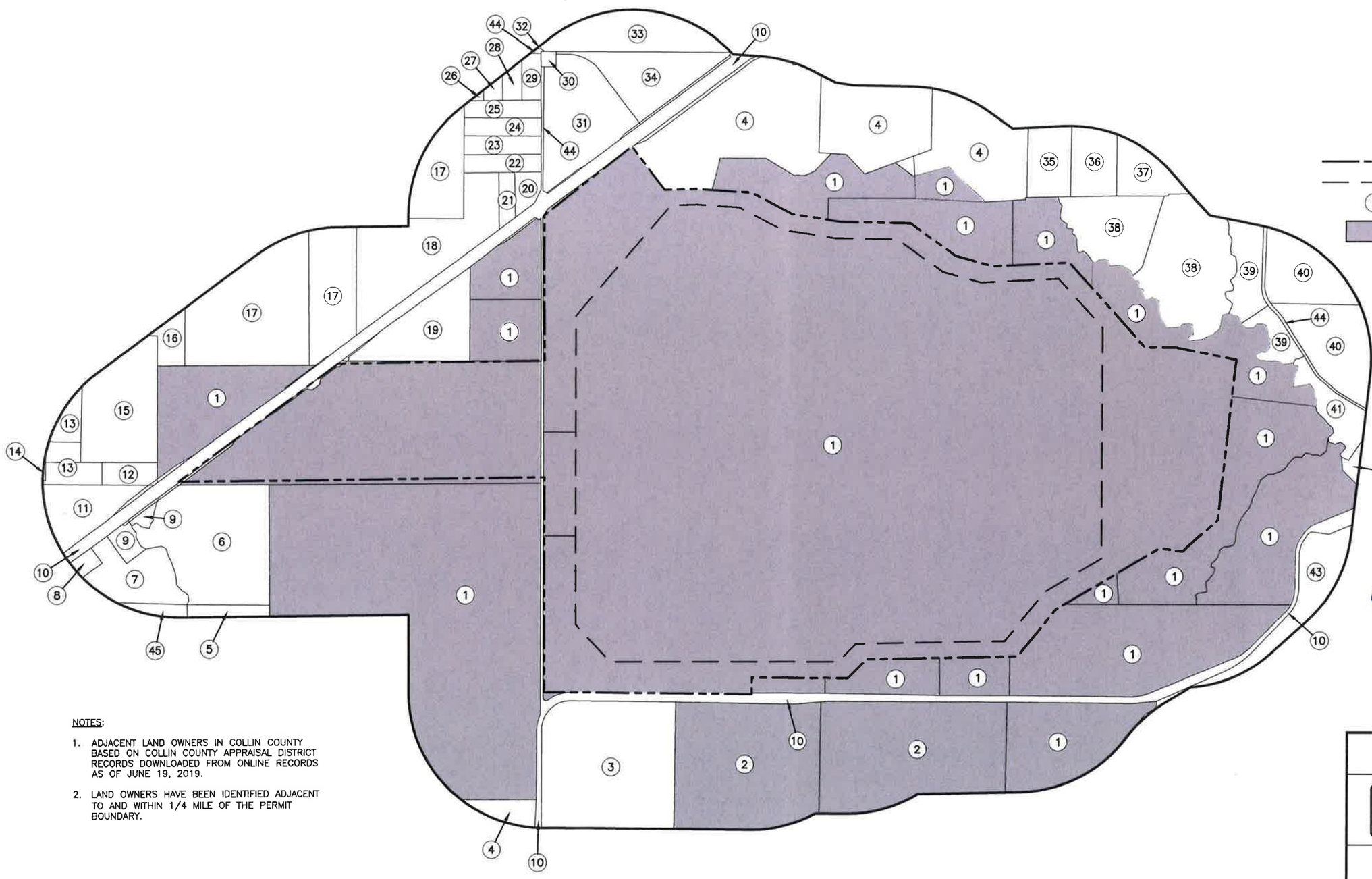
The current approved permit has Parts I and II in a combined fashion, therefore the required Part I Form and Landowners List and Map will be included as part of this narrative, and the existing Parts I/II will remain intact. Following the rules and regulations for submitting an ALD, a MultiMed model is required. For the 121 RDF, there is no aquifer, as the site is entirely confined within the Austin Chalk. For modeling

purposes, an aquifer was assumed to exist within the Austin Chalk to satisfy the MultiMed modeling requirements. This resulted in a very large DAF of 4.85×10^8, as shown in Attachment 16, page 16-C-5.

Because this alternate liner design demonstration is a new addition to the Site Development Plan, there will be limited redline/strikeout revisions. As such, the formatting for this limited scope permit amendment will be presented as "Attachment 1 – Marked (Redline/Strikeout) Pages" and "Attachment 2 – Unmarked Revised Pages."

This alternate liner design demonstration is submitted as a redline/strikeout copy to the Part III – Site Development Plan which was approved in January 2004 and last modified in 2007. This alternate liner design demonstration includes only the pages within Part III – Site Development Plan that are revised and/or added with this limited scope permit amendment.

LANDOWNERS LIST AND MAP



NOTES:

1. ADJACENT LAND OWNERS IN COLLIN COUNTY BASED ON COLLIN COUNTY APPRAISAL DISTRICT RECORDS DOWNLOADED FROM ONLINE RECORDS AS OF JUNE 19, 2019.
2. LAND OWNERS HAVE BEEN IDENTIFIED ADJACENT TO AND WITHIN 1/4 MILE OF THE PERMIT BOUNDARY.

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER

6/19/2019

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

LANDOWNERS MAP & LIST
1/4 MILE RADIUS

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN.	DLC	DATE : 06/19	DRAWING 1
DWN.	SRC	SCALE : GRAPHIC	
CHK.	DLC	DWG : AdjacentOwners_6-20-19.dwg	

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North Texas Municipal Water District 121 RDF
Land Owners List
(Based on Collin County Appraisal District Records – June 19, 2019)

1 NORTH TEXAS MUNICIPAL WATER DISTRICT
P.O. BOX 2408
WYLIE TX 75094-2408

2 NORTH TEXAS MUNICIPAL WATER DISTRICT
P. O. BOX 2408
WYLIE TX 75094-2408

3 MELISSA INDEPENDENT SCHOOL DISTRICT
1904 COOPER ST
MELISSA TX 75454-9555

4 CITY OF MELISSA
3411 BARKER AVE
MELISSA TX 75454-9569

5 MILRANEY R A
3603 GRAMERCY ST
HOUSTON TX 77025-1320

6 JANOW PROPERTIES LLC
P.O. BOX 175
McKINNEY TX 75070-8133

7 MCKINNEY LUMBER COMPANY LLC
3510 SAM RAYBURN HWY
MELISSA TX 75454-2665

8 HJR INVESTMENTS LTD
P.O. BOX 190
MESLISSA TX 75454-0190

9 EST PROPERTIES LLC
615 N. HUDSON AVE STE 300
OKLAHOMA CITY OK 73102-3091

10 STATE OF TEXAS
ATTN: RIGHT OF WAY SECTION
P.O. BOX 133067
DALLAS TX 75313-3067

11 BLOOMFIELD HOMES LP
1050 E STATE HWY 114 STE 210
SOUTHLAKE TX 76092-5255

12 GAUS DWAIN D & CAROLINE
3840 CAROL D LANE
MELISSA TX 75454-2590

13 AMERITEK GROUP LLC
PO BOX 490
McKINNEY, TX 75070-8138

14 HOWARD CHARLES T ETAL
P.O. BOX 112
MELISSA TX 75454-0112

15 HIBBARD LELAND J JR
3639 KARNAGHAN LN
MELISSA TX 75454-2682

16 WICKERSHAM JOSHUA J & SHELLY M
3902 SHERLEY LN
MELISSA TX 75454-8920

17 HARLAN PROPERTIES INC
2404 TEXAS DR STE 103
IRVING TX 75062-7011

18 KHAMASH FAYEZ AHMED &
QATTAN HUSSEIN A
7008 MARBLE CANYON DR
PLANO TX 75074-8948

19 THE JAMES ROY PRESCOTT & LISA
McGUIRE PRESCOTT REV LIV TRUST
150 ANNA CADE RD
ROCKWALL TX 75087-7477

20 SMITH RAYMOND J & MAGIC
8533 COUNTY ROAD 419
ANNA TX 75409-8230

21 ROBERTS KYLE LYNN & JENNIFER BROOKE
P O BOX 673
MELISSA TX 75454-0673

22 RAINE JAMES JAY & MARTHA
8563 COUNTY ROAD 419
ANNA TX 75409-8230

23 BARBOSA ROBERTO
8583 COUNTY ROAD 419
ANNA TX 75409-8230

24 DONAHUE MICHAEL E
8607 COUNTY ROAD 419
ANNA TX 75409-8232

25 CHRISTIANSEN ROGER L ETAL
8645 COUNTY ROAD 419
ANNA TX 75409-8232

26 HOLDEN MARY J
13100 BARBAROSA DR
FRISCO TX 75035-6479

North Texas Municipal Water District 121 RDF
Land Owners List
(Based on Collin County Appraisal District Records – June 19, 2019)

27 LINZMAIER RICHARD & JANETTE C
3632 COUNTY ROAD 417
ANNA TX 75409-8228

28 GEIS WILLIAM & VIRGINIA
3656 COUNTY ROAD 417
ANNA TX 75409-8228

29 ELLIS THOMAS DYLAN
8719 COUNTY ROAD 419
ANNA TX 75409-8219

30 NORTH COLLIN SPECIAL UTILITY DISTRICT
2333 SAM RAYBURN HWY
PO BOX 343
MELISSA, TX 75454-0343

31 MANSOOR SHAHID
6229 WINDY OAKS
ALEXANDRIA LA 71301-2857

32 BARAKAH TEXAS PROPERTIES LLC
6229 WINDY OAKS
ALEXANDRIA LA 71301-2857

33 ROLLINS JAMES D JR & QUINCY SHERLEY - QJR PARTNERSHIP LTD
9262 COUNTY ROAD 419
ANNA TX 75409-8205

34 SKY TREASURES RANCH LLC
3225 TURTLE CREEK BLVD APT 708B DALLAS TX 75219-5463

35 REID NANCY M & BYRON T STEWART
3706 GUTHRIE RD
GARLAND TX 75043-6221

36 STEWART BYRON T
4030 COCHISE DR
BALCH SPRINGS TX 75180-2562

37 CLARK SUSAN ANN & JEANA K CUNNINGHAM
602 TANBARK CT
COPPELL TX 75019-2200

38 STEWART JOHN ROBERT & DEBY M
11201 PATTI LN
BALCH SPRINGS TX 75180-2009

39 ROPER AMON BURL
107 COUNTY ROAD 915
ANNA TX 75409-4411

40 FULLER ALBERT M
PO BOX 547
BLUE RIDGE TX 75424-0547

41 LASHLEY JULIA C
8543 COUNTY ROAD 472
ANNA TX 75409-8445

42 AIRHART ROBERT & SANDRA
8441 COUNTY ROAD 472
ANNA TX 75409-8447

43 CHAMBLISS LAND LLC
1340 S MAIN ST STE 300
GRAPEVINE TX 76051-7512

44 COUNTY OF COLLIN
825 N MCDONALD ST STE 143
MCKINNEY TX 75069-2178

45 HINES MILRANY RANCH LLC
C/O HINES INTERESTS LMTD PARTNERSHIP
2200 ROSS AVE. STE 4200W
DALLAS TX 75201-2763

MSW PERMIT APPLICATION CHECKLIST

Administrative and Technical Review Checklist for Municipal Solid Waste (MSW) Permits, Registrations and Amendments

This checklist is designed to provide guidance for the Municipal Solid Waste (MSW) rules found in Title 30 Texas Administrative Code (30 TAC) Chapter 330, for Type I, IV and V registration, permit, and permit amendment applications. Areas of the checklist that are shaded in gray are for information purposes only.

Please fill out application information before selecting and filling out a checklist.

Applicant Information

Company:	NORTH TEXAS MUNICIPAL WATER DISTRICT				
First name:	THOMAS	Last name	KULA		
Applicant Title:	EXECUTIVE DIRECTOR			Prefix:	
Street Address:	P.O. BOX 2408				
City:	WYLIE	State:	TX	Zip code:	75098

Consultant Information

First name:	DAVID	Last name:	CLARK		
Consultant Title:	SENIOR ENGINEER			Prefix:	
Consultant Firm:	BIGGS AND MATHEWS ENVIRONMENTAL, INC.				
Consultant Address:	1700 ROBERT ROAD				
City:	MANSFIELD	State:	TX	Zip code:	76063

Application Information

Facility Name:	NTMWD 121 REGIONAL DISPOSAL FACILITY		
Application Date	6/13/2019		
CN:	601365448	MSW ID:	2294
RN:	101308781	Authorization Type:	Permit
County:	COLLIN	Application Type:	Permit Amendment

ID	App. Pa	Checklist Item	Item Type	Citation	Complete?	Location	Comments	plication Area
1	General	Submit all four parts of the permit, permit amendment or registration application	Required	330.57(a) & (b)	Yes	N/A	LIMITED SCOPE PERMIT AMENDMENT	Format-Application
2	General	Submit TCEQ Part I Form (Form No. 0650)	Required	330.57(c)(1)	Yes	FOLLOWING COVER LETTER		Format-Application
3	General	Part II of the application contains location and coordination information.	Informational	330.57(c)(2)				Format-Application
4	General	Part III of the application contains design information	Informational	330.57(c)(3)				Format-Application
5	General	Part IV of the application contains the site operating plan	Informational	330.57(c)(4)				Format-Application
6	General	The application should address all aspects of application and design requirements, even to show why not applicable (N/A)	Informational	330.57(d)				Format-Application
7	General	Submit data of sufficient completeness, accuracy and clarity	Required	330.57(d)	Yes	N/A	SEE SUBMITTAL	Format-Application
8	General	Failure to provide complete information may be cause for ED to return application.	Informational	330.57(d)				Format-Application
9	General	Provide 4 Copies for Initial Submittal (1 original and 3 copies)	Required	330.57(e)	Yes	N/A	COPIES PROVIDED AS REQUIRED	Format-Application
10	General	Provide 4 copies for NOD Responses including 1 copy with marked revisions (redline/strikeout)	Required	330.57(g)(6)	Yes	N/A	INITIAL SUBMITTAL	Format-Application
11	General	Application must be prepared in accordance with Texas Occupations Code, Texas Engineering Practice Act, Chapter 1001 and Texas Geoscience Practice Act, Chapter 1002	Informational	330.57(f)				Format-Application
12	General	Provide a PE signature, seal and date on the title page of each bound engineering report or individual engineering plan, and on each engineering drawing	Required	330.57(f)(1)	Yes	N/A	LOCATIONS VARY THROUGHOUT DOCUMENT	Format-Application
13	General	Provide PG sign, seal, & date for applicable items	Required	330.57(f)(2)	Yes	N/A	NO PG SEALS APPLICABLE FOR SUBMITTAL	Format-Application
14	General	Applications that are not sealed are incomplete and shall be returned	Informational	330.57(f)(3)				Format-Application
15	General	Submit the application in three ring-binders	Required	330.57(g)(1)	Yes	N/A	BINDERS USED AS REQUIRED	Format-Application
16	General	Submit Title Page with Name, Application No., Site Operator Name, Operator Name (if applicable), Location, Date Prepared and Revision Date(s)	Required	330.57(g)(2)	Yes	COVER		Format-Application
17	General	Provide Table of Contents with PE seal	Required	330.57(g)(3)	Yes	N/A	LOCATED THROUGHOUT	Format-Application
18	General	Use 8.5x11 inch or 11x17 paper (folded to 8.5x11 inch)	Required	330.57(g)(4)	Yes	N/A	LOCATED THROUGHOUT	Format-Application
19	General	Provide pages with date (original and revised) and sequential page numbers	Required	330.57(g)(5)	Yes	N/A	LOCATED THROUGHOUT	Format-Application
20	General	Provide legible drawings/maps	Required	330.57(h)(1)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
21	General	Provide color coding on all figures and drawings that is legible and distinct after copying in black & white	Required	330.57(h)(2)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
22	General	Provide a standard engineering scale on each figure or drawing	Required	330.57(h)(3)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
23	General	Provide a dated title block on each figure or drawing	Required	330.57(h)(4)(A)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
24	General	Provide a bar scale at least 1 inch on all figures and drawings	Required	330.57(h)(4)(B)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
25	General	Provide a revision block on all figures and drawings	Required	330.57(h)(4)(C)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
26	General	Provide a PE or PG seal ,if required, on all figures and drawings	Required	330.57(h)(4)(D)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings
27	General	Include drawing number and a page number on each drawing and figure	Required	330.57(h)(4)(E)	Yes	N/A	LCCATED THNCUGHCUT	Format-Maps/Drawings
28	General	Include a north arrow on each map or plan drawing	Required	330.57(h)(5)(A)	Yes	N/A	LCCATED THNCUGHCUT	Format-Maps/Drawings
29	General	Include a reference to base map & date of most current base map used, if the map is based upon another map	Required	330.57(h)(5)(B)	Yes	N/A	LCCATED THNCUGHCUT	Format-Maps/Drawings
30	General	Include a legend on each map or plan drawing	Required	330.57(h)(5)(C)	Yes	N/A	LCCATED THNCUGHCUT	Format-Maps/Drawings
31	General	Provide match lines and section lines that reference the drawing where the match or section is shown.	Required	330.57(h)(6)	Yes	N/A	LOCATED THROUGHOUT	Format-Maps/Drawings

349	Part III	Provide sufficient number of cross-section w/ inset key map gas vents or wells, groundwater monitoring wells, initial and static levels of any groundwater encountered	Required	330.63(d)(4)(E)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Management Unit Design
350	Part III	Provide sufficient number of cross-section w/ inset key map showing the top of the levee, top of the proposed fill, top of the wastes, maximum elevation of proposed fill, existing ground, bottom of the excavations, side slopes of trenches and fill areas, gas vents or wells, groundwater monitoring wells, initial and static levels of any groundwater encountered	Required	330.63(d)(4)(E)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
351	Part III	Provide cross-sections so as to accurately depict the existing and proposed depths of all fill areas within the site. The fill cross-sections shall go through or very near the soil borings in order to show boring logs on the profile.	Required	330.63(d)(4)(E)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
352	Part III	Provide cross-sections to depict construction and design details of proposed compacted perimeter or toe berms and aerial-fill waste disposal areas	Required	330.63(d)(4)(F)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
353	Part III	Submit a Liner Quality Control Plan, prepared by a PE to include construction methods, engineering practices & the installation & testing of geomembrane (if used)	Required	330.63(d)(4)(G)	Yes	ATT. 10B		Waste Management Unit Design
354	Part III	Submit a liner design for Type I units constructed that ensures that the concentration values listed in Table 1 (Figure: 30 TAC§330.331(a)(1)) will not be exceeded in the uppermost aquifer at the point of compliance	Required	330.331(a)(1)	Yes	ATT. 16		Waste Management Unit Design
355	Part III	Submit a liner design constructed with a composite liner, and a leachate collection system that is designed and constructed to maintain less than a 30-centimeter depth of leachate over the liner	Required	330.331(a)(2)	Yes	ATT. 16		Waste Management Unit Design
356	Part III	Submit a liner design that considers the hydrogeologic characteristics of the facility and surrounding land	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
357	Part III	Submit a liner design that considers the climatic factors of the area	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
358	Part III	Submit for a liner design that considers the volume and physical and chemical characteristics of the leachate	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
359	Part III	Submit for a liner design that considers the quantity, quality, and direction of flow of groundwater	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
363	Part III	Submit for a liner design that considers the public health, safety, and welfare effects; and	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
364	Part III	Submit for a liner design that considers the practicable capability of the owner or operator.	Required	330.331(c)	Yes	ATT. 16		Waste Management Unit Design
365	Part III	Submit a design for a liner system that includes at least four feet of in-situ soil between the deposited waste and groundwater. This in-situ soil liner must meet all the physical properties for a constructed liner as detailed in §330.339(c)(5) of this title (relating to Liner Quality Control Plan)	Required	330.331(d)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
366	Part III	Submit a design for a liner system that includes at least a three-foot thick re-compacted clay liner between the deposited waste and groundwater. The constructed liner must meet all the criteria detailed in §330.339	Required	330.331(d)(2)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
367	Part III	Submit a design for a liner system that includes an alternative liner system, in accordance with §330.335 of this title (relating to Alternative Liner Design).	Required if Requested	330.331(d)(3)	Yes	ATT. 10B & 16		Waste Management Unit Design

368	Part III	Landfill units that accept Class 1 industrial solid wastes, other than asbestos-containing material, must provide dedicated cells that meet the requirements prescribed under 30 TAC 330.331(e) through (e)(2)(C)	Informational	330.331(e)		N/A		Management Unit Design
369	Part III	Demonstrate location compliance for a new landfill cell or an aerial expansion of an existing landfill cell as prescribed under 335.584(b)(1) and (2) relating to Location Restrictions.	Required if Requested	330.331(e)(3)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
370	Part III	Provide a design for a leachate-collection and associated leachate-removal systems to be constructed of materials that are chemically resistant to the leachate expected to be generated	Required	330.333	Yes	ATT. 0B		Waste Management Unit Design
371	Part III	Provide a design for a leachate-collection and associated leachate-removal systems to be constructed of sufficient strength and thickness to prevent collapse under the pressures exerted by overlying wastes, waste cover materials, and by any equipment used at the landfill	Required	330.333	Yes	ATT. 16		Waste Management Unit Design
372	Part III	Provide a design for a leachate-collection and associated leachate-removal systems to be designed and operated to function through the scheduled closure and post-closure care period of the landfill considering the factors prescribed under 30 TAC 330.333(A) through (G)	Required	330.333(A)-(G)	Yes	ATT. 16		Waste Management Unit Design
373	Part III	Submit an alternative liner designs that include a leachate management system, a demonstration by computerized design modeling that the maximum contaminant levels detailed in 30 TAC §330.331 of this title (relating to Design Criteria), Table 1 will not be exceeded at the point of compliance	Required if Requested	330.335	Yes	ATT. 16	LIMITED SCOPE PERMIT AMENDMENT FOR AN ALD	Waste Management Unit Design
374	Part III	Type IV landfills may be required to meet one or more provisions under 330.337 at ED's discretion	Informational	330.337(a)				Waste Management Unit Design
375	Part III	Submit calculations to demonstrate that the weight of liner & any ballast will offset uplift by a factor of 1.2	Required	330.337(b)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
376	Part III	Submit calculations to demonstrate that an active or passive dewatering system will reduce hydrostatic forces by a factor of 1.2	Required	330.337(b)(2)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
377	Part III	Provide evidence to demonstrate that the soil surrounding the facility is so poorly permeable that GW cannot exert force on liner	Required if Requested	330.337(b)(3)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
378	Part III	Submit evidence that the seasonal high GW is below planned excavation	Required if Requested	330.337(b)(4)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
379	Part III	Provide for liner stability during filling through dewatering &/or ballasting approved by ED	Required	330.337(c)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
380	Part III	Provide a leachate collection system capable of handling leachate and groundwater inflow. Submit the calculations for maximum GW inflow	Required	330.337(d)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
381	Part III	Provide a foundation evaluation that considers the stability, settlement, and constructability prior to excavating below the seasonal high water table	Required	330.337(e)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
382	Part III	Provide a liner quality control plan to include methods & tests to verify liner will not uplift during construction & ballast placement	Required	330.337(f)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
383	Part III	Provide measurements & test results verifying that the ballast meets criteria including inspections, compaction, weight, density, thickness, & top elevation	Required	330.337(f)(2)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
384	Part III	Provide designs for any dewatering systems used for liner construction and filling, and indicate that the system will be operated until the ED determines it is no longer required	Required if Requested	330.337(g)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design

385	Part III	Submit (if waste is to be used as ballast) an operating plan that provides for no brush or rge items in first 5 ft. of thickness	Required if Requested	330.337(h)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
386	Part III	.'rovide (if waste is to be used as ballast) for the use of a 40,000 lb. compactor or equivalent to achieve a 1,200 lbs. per cubic yard density	Required if Requested	330.337(h)(2)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
387	Part III	Submit (if waste is to be used as ballast) methods for verifying waste as ballast compaction density not less than 1200 lbs. per cubic yard, No method is required if a 40,000 lb. compactor is used	Required if Requested	330.337(h)(3)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
388	Part III	Submit a ballast evaluation report that verifies the use of a 40,000 lb. compactor or that 1,200 lbs. per cubic yard density was achieved and must be sufficient to offset hydrostatic forces by a factor of 1.5	Required if Requested	330.337(h)(4)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
389	Part III	Provide for the adjustment of seasonal high water table, if necessary, as new data is collected	Required	330.337(i)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
390	Part III	Acknowledge that a ballast evaluation report will be submitted upon completion of placement. If ED does not respond within 14 days, discontinue dewatering or ballasting	Acknowledgement	330.337(j)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
391	Part III	Acknowledge that a ballast evaluation report will be submitted to verify that the liner did not undergo uplift	Acknowledgement	330.337(j)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
392	Part III	Acknowledge that a certification that ballasting met the criteria will be submitted and signed and sealed by a P.E, and signature of permittee	Acknowledgement	330.337(j)(2)-(3)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
393	Part III	Provide a liner quality control plan prepared under the direction of a licensed professional engineer.	Informational	330.339(a)				Waste Management Unit Design
394	Part III	Provide in the liner quality control plan procedures that address the installation and testing of a geomembrane liner, if used	Required	330.339(a)	Yes	ATT. 10B		Waste Management Unit Design
395	Part III	Submit constructed liner details, depicted on cross-sections of a typical cell showing the slope, widths, and thicknesses for compaction lifts	Required	330.339(a)(1)	Yes	ATT. 10B		Waste Management Unit Design
396	Part III	Provide soil and liner quality-control testing procedures, to include sampling frequency, all field sampling and testing, both during construction and after completion	Required	330.339(a)(2)	Yes	ATT. 10B		Waste Management Unit Design
397	Part III	Acknowledge that the professional of record who signs the soil liner evaluation report or his representative should be on site during all liner construction.	Acknowledgement	330.339(a)(2)	Yes	ATT. 10B		Waste Management Unit Design
398	Part III	Acknowledge that quality control of construction and quality assurance of sampling and testing procedures shall follow the latest technical guidelines of the executive director.	Acknowledgement	330.339(a)(2)	Yes	ATT. 10B		Waste Management Unit Design
399	Part III	Provide testing and reporting evaluation procedures to prepare the soil liner evaluation reports for the facility	Required	330.339(b)(1)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
400	Part III	Submit information to specify materials, equipment, and construction methods for the compaction of clay soils and depict on a drawing	Required	330.339(b)(2)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
401	Part III	Submit details and drawings for the over excavation and recompaction of the in-situ soils, or the compaction of soils from a borrow source, and cross-sections of a typical cell showing the slope, widths, and thicknesses for compaction lifts	Required	330.339(b)(2)(A)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
402	Part III	Submit procedures to be followed when excavations, cells, or disposal areas extend into or have the potential to extend into the groundwater; in accordance with 30 TAC 330.337	Required	330.339(b)(2)(B)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design
403	Part III	Provide a description of installation methods, quality control testing, reporting, following the placement of geomembrane liners	Required	330.339(b)(3)	Yes	ATT. 10B		Waste Management Unit Design
404	Part III	Provide quality control testing frequencies and procedures that are in accordance with the executive director's most recent guidelines	Required	330.339(c)	Yes	N/A	NOT REQUIRED IN SUBMITTAL	Waste Management Unit Design

ATTACHMENT 1

MARKED (REDLINE/STRIKEOUT) PAGES

PART III
SITE DEVELOPMENT PLAN

121 REGIONAL DISPOSAL FACILITY
TCEQ PERMIT NO. MSW 2294
COLLIN COUNTY, TEXAS

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

Prepared for

NORTH TEXAS MUNICIPAL WATER DISTRICT

Permit Issued January 8, 2004
Revised June 2004
Revised June 30, 2004
Rev. 3 March 28, 2007

Revised June 2019

Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road • Mansfield, Texas 76063 • 817-563-1144

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 REGIONAL DISPOSAL FACILITY
PART III, SITE DEVELOPMENT PLAN
INTRODUCTION

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

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APPENDICES

III-0A Reports by Dr. David Daniel and Dr. Robert Koerner

III-0B TNRCC and EPA Letters Concerning the Liner and Final Cover Systems Designs

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

INTRODUCTION

The following Site Development Plan (SDP) contains information regarding the proposed landfilling method, all-weather operation, access control, solid waste deposition and site life, ground (subsurface) water protection design and operation, drainage information, and final cover design. The SDP also contains the Attachments listed below:

Attachment 1 -	Site Layout Plan (Drawings)
Attachment 2-	Typical Fill Cross Sections
Attachment 3-	Existing Contour Map
Attachment 4-	Geology Report
Attachment 5-	Ground (Subsurface) Water Characterization Report
Attachment 6-	Subsurface Water and Surface Water Protection Plans and Drainage Plan
Attachment 7-	Final Contour Map
Attachment 8-	Cost Estimate for Closure and Post-Closure Care
Attachment 9-	Applicant's Statement
Attachment 10-	Soil and Liner Quality Control Plan
Attachment 11-	Ground (Subsurface) Water Sampling and Analysis Plan
Attachment 12-	Final Closure Plan
Attachment 13-	Post-Closure Care Plan
Attachment 14-	Landfill Gas Management Plan
Attachment 15-	Leachate and Contaminated Water Plan
Attachment 16-	Alternate Liner (Option 3) Geotechnical Design

LEGEND

- TREES/VEGETATION
- WATERCOURSE
- MAXIMUM IMPOUNDMENT
- 4 — 10 FT CONTOUR (PROPOSED)
- STRUCTURES
- SECURITY FENCE
- PERMIT BOUNDARY

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL DATA COLLECTED BY BIGGS AND MATHEWS ENVIRONMENTAL, INC., ON MARCH 21, 2018. THE GRID SYSTEM SHOWN IS BASED ON TEXAS STATE PLANE COORDINATE SYSTEM, NAD 83.
2. SECTOR 8 WILL BE FILLED BEFORE SECTOR 7, AND SECTOR 12 WILL BE FILLED BEFORE SECTOR 11.

0 400 800
SCALE IN FEET

11 46.9 AC.
12 26.8 AC.
10 37.9 AC.
9 37.7 AC.
7 37.9 AC.
8 37.9 AC.
6 37.9 AC.
5 37.9 AC.
3 37.9 AC.
4 37.3 AC.
2 46.7 AC.
1 27.6 AC.

LEACHATE HOLDING POND (TYP)

DETENTION POND

LIMIT OF EXCAVATION

LANDFILL GRID ORIGIN A.O. AT STATE PLANE GRID INTERSECTION N 7158500, E 2571500. PERMANENT BENCHMARK TO BE PLACED AT GRID ORIGIN.

FM 545 (80' ROW)

REVISIONS:

1. UPDATED CONTOURS.
2. ADDED NOTE 2 FOR SECTOR DEVELOPMENT.

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED PROFESSIONAL ENGINEER
6-19-19

ISSUED FOR PERMITTING PURPOSES ONLY

REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

ATTACHMENT 1
SECTORIZED FILL LAYOUT PLAN

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

DSN. FAW	DATE : 06/19	DRAWING	
DWN. BBB	SCALE : GRAPHIC	1.3	
CHK. FAW	DWG : 1.3 SectorFill.dwg		

J:\211\01\126\1.3 SectorFill.dwg Layout: 1.3RL User: mwelch

ATTACHMENT 2

UNMARKED REVISED PAGES

PART III
SITE DEVELOPMENT PLAN

121 REGIONAL DISPOSAL FACILITY
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Prepared by

BIGGS & MATHEWS ENVIRONMENTAL
1700 Robert Road • Mansfield, Texas 76063 • 817-563-1144

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 REGIONAL DISPOSAL FACILITY
PART III, SITE DEVELOPMENT PLAN
INTRODUCTION

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

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Biggs & Mathews Environmental, Inc.
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INTRODUCTION

The following Site Development Plan (SDP) contains information regarding the proposed landfilling method, all-weather operation, access control, solid waste deposition and site life, ground (subsurface) water protection design and operation, drainage information, and final cover design. The SDP also contains the Attachments listed below:

Attachment 1 -	Site Layout Plan (Drawings)
Attachment 2-	Typical Fill Cross Sections
Attachment 3-	Existing Contour Map
Attachment 4-	Geology Report
Attachment 5-	Ground (Subsurface) Water Characterization Report
Attachment 6-	Subsurface Water and Surface Water Protection Plans and Drainage Plan
Attachment 7-	Final Contour Map
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Attachment 9-	Applicant's Statement
Attachment 10-	Soil and Liner Quality Control Plan
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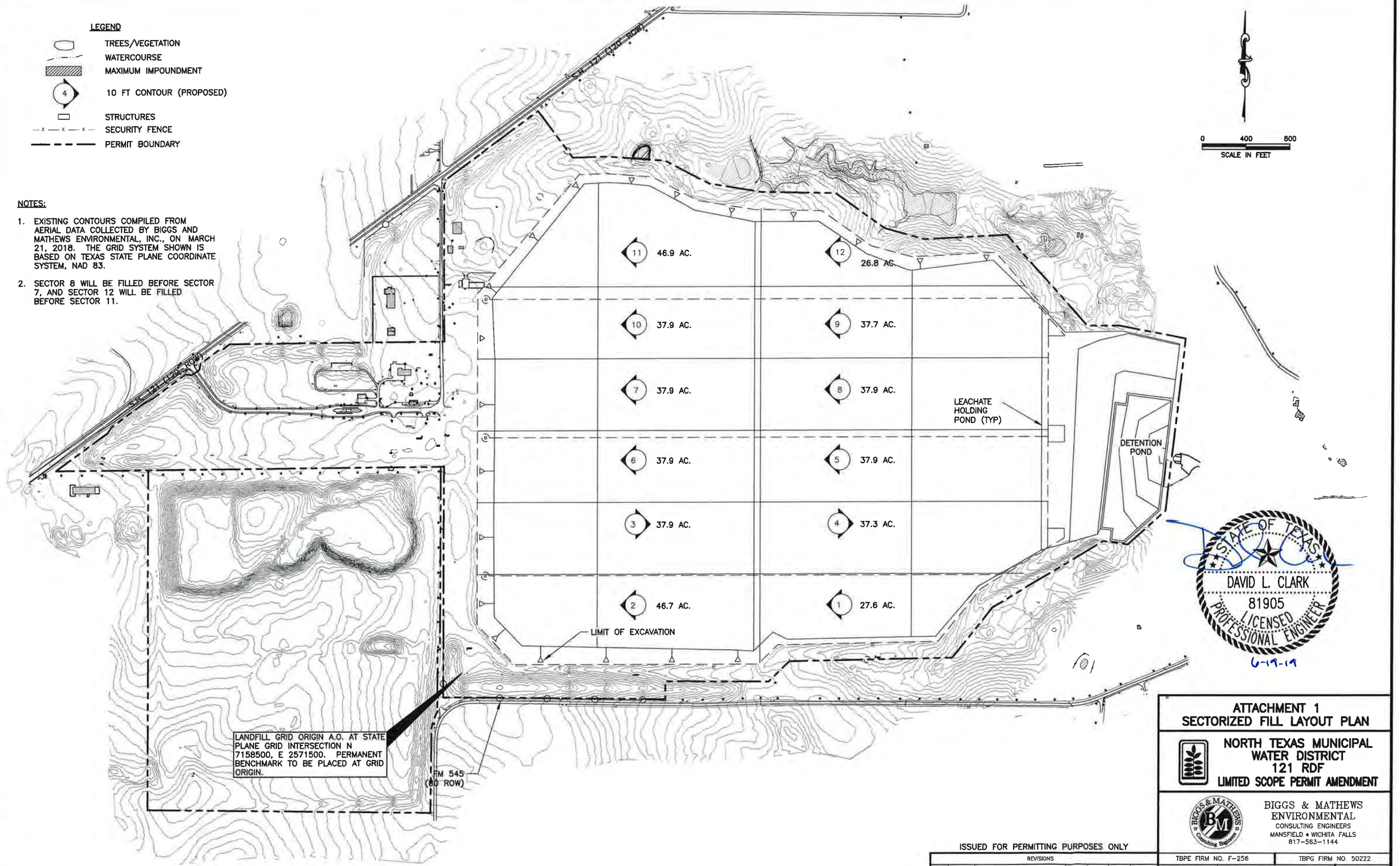
Attachment 15-	Leachate and Contaminated Water Plan
Attachment 16-	Alternate Liner (Option 3) Geotechnical Design

LEGEND

- TREES/VEGETATION
- WATERCOURSE
- MAXIMUM IMPOUNDMENT
- 10 FT CONTOUR (PROPOSED)
- STRUCTURES
- SECURITY FENCE
- PERMIT BOUNDARY

NOTES:

1. EXISTING CONTOURS COMPILED FROM AERIAL DATA COLLECTED BY BIGGS AND MATHEWS ENVIRONMENTAL, INC., ON MARCH 21, 2018. THE GRID SYSTEM SHOWN IS BASED ON TEXAS STATE PLANE COORDINATE SYSTEM, NAD 83.
2. SECTOR 8 WILL BE FILLED BEFORE SECTOR 7, AND SECTOR 12 WILL BE FILLED BEFORE SECTOR 11.



STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED PROFESSIONAL ENGINEER
6-19-19

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

ATTACHMENT 1
SECTORIZED FILL LAYOUT PLAN

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144
TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

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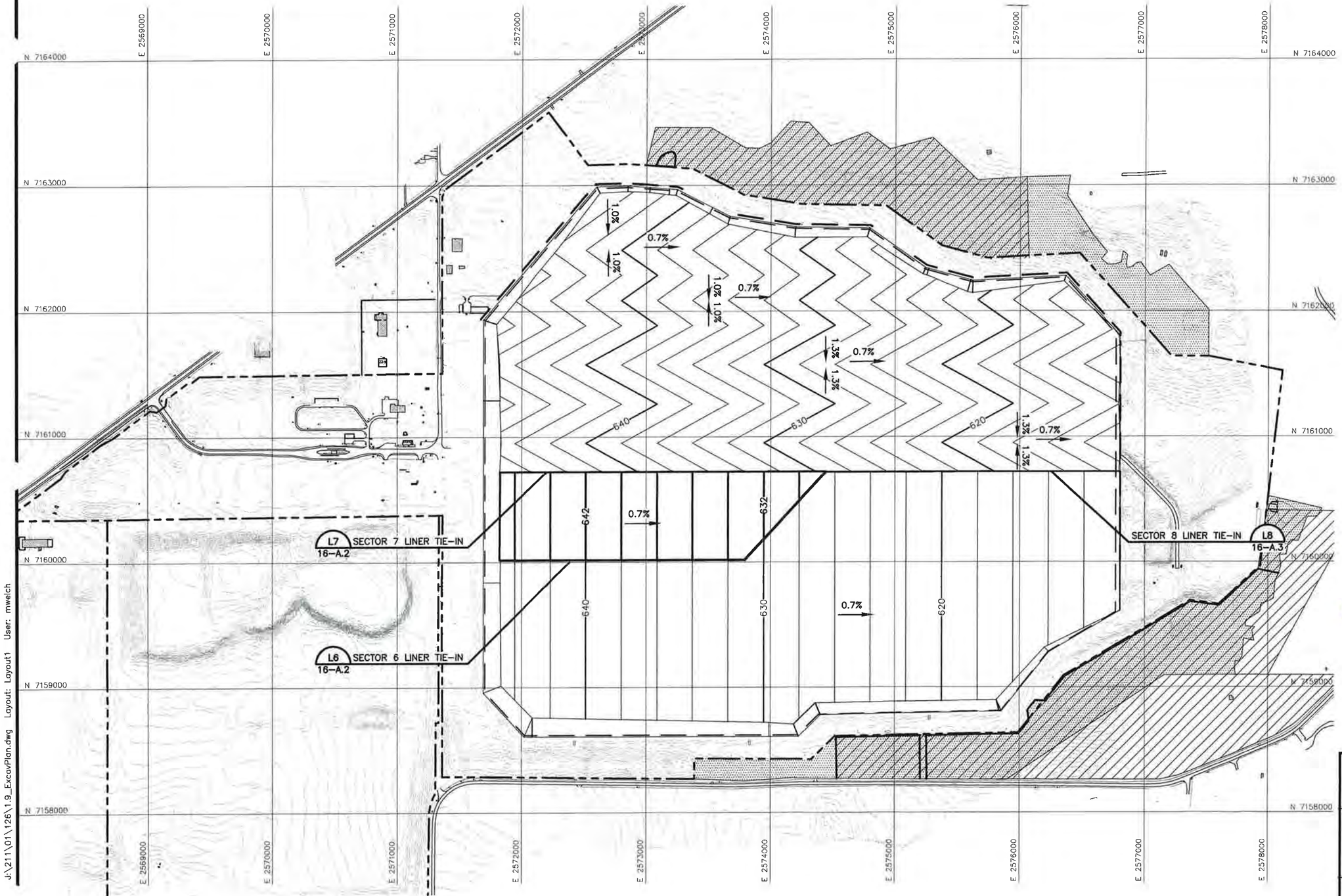

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SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- 630 SUBGRADE CONTOUR
- N 7160000 STATE PLANE GRID
- EXISTING CONTOUR

NOTE:

1. EXISTING CONTOURS COMPILED FROM AERIAL DATA COLLECTED BY BIGGS AND MATHEWS ENVIRONMENTAL, INC., ON MARCH 21, 2018. THE GRID SYSTEM SHOWN IS BASED ON TEXAS STATE PLANE COORDINATE SYSTEM, NAD 83.

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ATTACHMENT 1
EXCAVATION PLAN
(OPTION 3)

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE AMENDMENT

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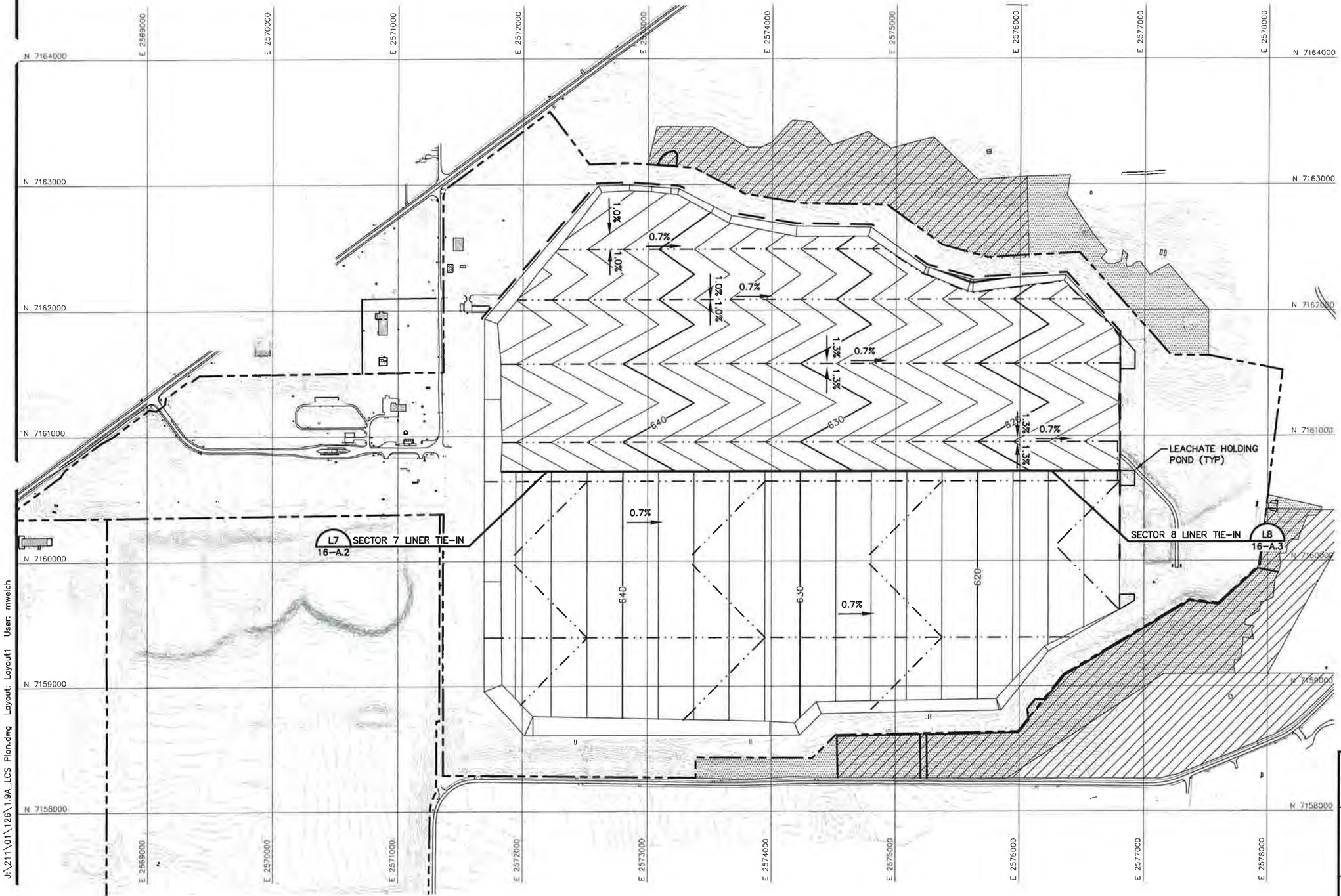

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SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- 630 — TOP OF PROTECTIVE COVER CONTOUR
- N 7160000 — STATE PLANE GRID
- LEACHATE HEADER/LATERAL
- EXISTING CONTOUR

NOTE:

1. EXISTING CONTOURS COMPILED FROM AERIAL DATA COLLECTED BY BIGGS AND MATHEWS ENVIRONMENTAL, INC., ON MARCH 21, 2018. THE GRID SYSTEM SHOWN IS BASED ON TEXAS STATE PLANE COORDINATE SYSTEM, NAD 83.

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ATTACHMENT 1
LINER/LCS PLAN
(OPTION 3)

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE AMENDMENT

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PART III

ATTACHMENT 10

SOIL AND LINER QUALITY CONTROL PLAN

121 REGIONAL DISPOSAL FACILITY
TCEQ PERMIT NO. MSW 2294
COLLIN COUNTY, TEXAS

Prepared for

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

North Texas Municipal Water District

Permit Issued January 8, 2004
Revised June 2004
Revised March 2006
Revised July 2007

Revised June 2019

Prepared by

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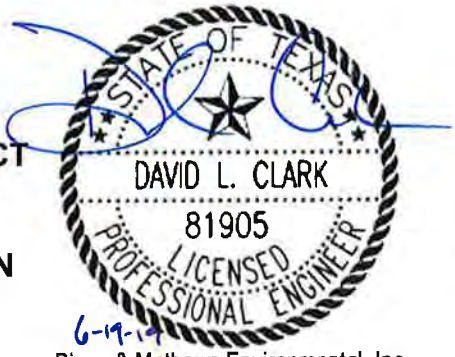
NORTH TEXAS MUNICIPAL WATER DISTRICT
121 REGIONAL DISPOSAL FACILITY
PART III, ATTACHMENT 10
SOIL AND LINER QUALITY CONTROL PLAN



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Soils and Liner Quality Control Plan (Option 3)

121 REGIONAL DISPOSAL FACILITY
COLLIN COUNTY, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 2294

LIMITED SCOPE PERMIT AMENDMENT APPLICATION

PART III – SITE DEVELOPMENT PLAN
ATTACHMENT 10B
SOILS AND LINER QUALITY CONTROL PLAN
(OPTION 3)

Prepared for

NORTH TEXAS MUNICIPAL SOLID WASTE DISTRICT

June 2019

Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

Prepared by

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TEXAS BOARD OF PROFESSIONAL ENGINEERS
FIRM REGISTRATION NO. F-256

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FIRM REGISTRATION NO. 50222

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30 TAC §§330.63(d)(4)(G), 330.331, 330.337, 330.339, 330.341

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1 INTRODUCTION

30 TAC §330.339

1.1 Purpose

This Soils and Liner Quality Control Plan (SLQCP) has been prepared in accordance with Subchapter H – Liner System Design and Operation to establish procedures to assure compliance with Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste (MSW) rules. This appendix is a stand-alone SLQCP for liner system Option 3 that provides guidance for the design, construction, testing and documentation of the liner and leachate collection system construction.

1.2 Definitions

Specific terms and acronyms that are used in this SLQCP are defined below.

ASTM. American Society for Testing and Material.

Construction Quality Assurance (CQA). CQA is a planned system of activities that provides the owner and permitting agency assurance that the facility was constructed as specified in the design. CQA includes the observations, evaluations, and testing necessary to assess and document the quality of the constructed facility. CQA includes measures taken by the CQA organization to assess whether the work is in compliance with the plans, specifications, and permit requirements for a project.

Construction Quality Assurance (CQA) Monitors. CQA monitors are representatives of the GP who work under direct supervision of the GP. The CQA monitor is responsible for quality assurance monitoring and performing on-site tests and observations. The CQA monitor must be NICET-certified at level 2 for soils and geosynthetics, an engineering technician with a minimum of four years directly related experience, or a graduate engineer or geologist with one year of directly related experience.

Geomembrane Liner (GM). This is an essentially impermeable geomembrane synthetic lining material, also referred to as geomembrane, membrane liner, or sheet.

Geomembrane Liner Evaluation Report (GLER). This is a construction report for geomembrane liner that is submitted to the TCEQ for approval.

Geosynthetic Materials. Manufactured materials that include geomembranes, geogrids, geofilters, geocomposites, geodrainage nets, and geotextiles.

Geosynthetic Clay Liner (GCL). A synthetic liner material that consists of bentonite encapsulated between two geotextiles.

Geosynthetic Clay Liner Evaluation Report (GCLER). This is a construction report for geosynthetic clay liner that is submitted to the TCEQ for approval.

Geotechnical Professional (GP). The GP is the authorized representative of the owner who is responsible for all CQA activities for the project. The GP must be licensed as a professional engineer in Texas. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance and quality control testing, and hydrogeology. The GP must also have competency and experience in certifying similar projects. The GP may also be known in applicable regulations and guidelines as the CQA engineer, resident project representative, geotechnical quality control/quality assurance professional (GQCP), or professional of record (POR).

Geotechnical Professional's (GP's) Representative. The GP's Representative is a person who works under the supervision of the GP. The GP's Representative may include the CQA Monitor and third party testing laboratory, but excludes employees of the manufacturer and contractor.

Panel. This is a unit area of the GM or GCL, which will be seamed in the field.

Quality Assurance. Quality assurance is a planned program, or system of activities that is designed to assure that the work meets the requirements of plans, specifications, and permit for a construction project. Quality assurance includes procedures, quality control activities and documentation that are performed by the GP and CQA monitor.

Quality Control. Quality control is a planned system of inspections and activities that implement, monitor, and control the quality of a construction project. The GP, CQA monitor, and contractor will perform quality control.

2 LINER SYSTEM

30 TAC §330.331

2.1 Liner and Leachate Collection Systems

The North Texas Municipal Water District (NTMWD) will have the option to construct two liner systems. The Option 2 liner system is detailed in Attachment 10A and depicted on Attachments 6J.1, 6J.2, 6K.1, and 6K.2. The Option 3 liner system is defined in Table 10B-1 from top to bottom. Details of the Option 3 liner system are provided in Appendix 16-A. The alternate liner design demonstration for the Option 3 liner system is provided in Attachment 16.

Table 10B-1
Components of the Option 3 Liner System

Liner System Component	Description	Thickness
Protective Cover	General earthfill	24 inches
Leachate Collection Layer	Double-sided geocomposite on floor and sideslopes	0.25 inches
Geomembrane (GM)	Textured HDPE geomembrane on floor and sideslopes	60 mils (0.06 in)
Geosynthetic Clay Liner (GCL)	Non-reinforced GCL on floor Reinforced GCL on sideslopes GCL with a maximum coefficient of permeability of less than 5.0×10^{-9} cm/sec	0.24 inches

The leachate collection layer will drain to collection trenches along the centerline of each cell. The leachate collection trenches will consist of perforated HDPE pipes encased in aggregate filled trenches. The leachate collection trenches will convey leachate to the leachate collection sumps located along the toe of the sideslopes. The leachate collection sumps will be lined with geomembrane. A description of the leachate collection system is provided in Attachment 15 – Leachate and Contaminated Water Plan and details of the leachate collection system are provided in Attachment 16, Appendix 16-A.

2.2 Construction Monitoring

Continuous on-site monitoring is necessary to ensure that all the components of the liner and leachate collection systems are constructed in accordance with this SLQCP. At a minimum, the CQA monitor shall provide continuous on-site observation during all construction activities including the following:

- Subgrade preparation
- Geosynthetic clay liner (GCL) deployment, seaming, and repairing
- Geomembrane liner deployment, trial welds, seaming, testing, and repairing
- Anchor trench backfill
- Leachate collection layer deployment and seaming
- Protective cover layer placement
- Any work that could damage the installed components of the liner system

The GP will document and certify that the liner system was constructed in accordance with this SLQCP. The GP shall make sufficient site visits to observe critical construction activities and to verify that the construction and quality assurance activities are performed with this SLQCP.

3 EARTHWORK

30 TAC §§330.337, 330.339

3.1 General

The excavation plan for NTMWD when liner Option 3 is utilized (see Part III, Attachment 1) provides for the landfill floor to slope at a minimum of 1.22 percent and the perimeter sidewalls to slope at 3H:1V. The landfill floor for Sectors 7 through 12 will be divided into four areas, which will have a minimum 1 percent cross slope from the ridge to a leachate collection trench along the sector centerline. Collection trenches will slope at a minimum of 0.7 percent to sumps located along the east perimeter of the landfill. The excavation will range from ground surface to about 60 feet deep. Earthwork activities and testing will be documented in the GCLER and GLER in accordance with Section 8.

3.2 Materials

The following material classifications will be encountered in excavations, or will be required for landfill construction.

Liner Subgrade. Liner subgrade consists of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than 4 inches in diameter. The top 6 inches of liner subgrade will consist of soil that is free from debris, rubbish, solid waste, organic matter, and particles larger than ¾-inch in diameter.

Protective Cover. Protective cover materials shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, solid waste, organic materials, and meets the requirements of Section 7.2.

Daily and Intermediate Cover. Daily and intermediate cover materials consist of soils that have not been previously mixed with solid waste.

Topsoil. Topsoil consists of soil that is capable of sustaining vegetation and is free of debris, rubbish, and solid waste.

Drainage Aggregate. Drainage aggregate consists of natural or manufactured granular material meeting the gradation that is required by the specifications. Drainage aggregate shall have a coefficient of permeability of 1.0×10^{-2} cm/sec or greater. Additional requirements for drainage aggregate that is used in the leachate collection system are provided in Section 6.2.4.

Anchor Trench Backfill. Anchor trench backfill consists of general fill that is free of particles larger than 1 inch in diameter.

Unsuitable Materials. Unsuitable materials consist of any material that is determined by the Engineer to not be suitable for use as classified above.

3.3 Excavation

Based on the subsurface exploration, it is anticipated that the excavation can be achieved with excavation equipment such as dozers with rippers and trackhoes.

3.4 Testing and Verification

A minimum of one standard Proctor test (ASTM D 698) shall be performed on each representative soil used as general fill material. Atterberg limits tests (ASTM D 4318) and percent passing the 1-inch and No. 200 sieve (ASTM D 422) shall be performed with each Proctor test. Moisture-density testing shall be performed by the CQA monitor at a rate of one field density test per lift for each 20,000 square feet of lift area.

4 GEOSYNTHETIC CLAY LINER

30 TAC §330.339

4.1 General

The geosynthetic clay liner (GCL) consists of a sodium bentonite contained between two geotextiles that is placed over the liner subgrade. Reinforced GCL will be placed over the sidewalls, and non-reinforced GCL will be placed on the landfill floor. The CQA monitor shall provide continuous on-site observation during GCL deployment, seaming, and repairing. The GP shall make sufficient site visits during the GCL installation to document the installation in the GCLER, in accordance with Section 8.

4.2 Materials

4.2.1 Properties

The GCL shall consist of sodium bentonite contained between two geotextiles. A certificate of analysis for each clay lot shall be submitted as part of the quality control documentation. The finished GCL must have a permeability no greater than $5x10^{-9}$ cm/sec (test method ASTM D 5084 or GRI GCL-3), have a free swell (test method ASTM D 5890) of at least 24 ml/g, and a fluid loss (test method ASTM D 5891) no greater than 18 mL.

Manufacturer quality control testing procedures and frequencies for GCL are listed in Section 4.5.1. Conformance samples may be taken at the manufacturing plant or at the project site by the GP or his representative and will be forwarded to a third party laboratory for testing. Third party conformance testing procedures and frequencies for GCL are listed in Section 4.5.2.

4.2.2 Delivery and Storage

The GCL shall be shipped in rolls that are wrapped individually in relatively impermeable and opaque protective covers. The rolls may be stacked only as allowed by manufacturer's recommendations. The GCL rolls must be stored aboveground and protected from moisture.

Upon delivery of the GCL, the CQA monitor will observe that:

- Equipment used to unload and store the rolls or pallets does not damage the GCL.
- The GCL is stored in an acceptable location and not stacked more than five rolls high.

- The GCL is protected from puncture, dirt, grease, water, moisture, and excessive heat, or other damage.

- All manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications.

4.3 Preparation

Prior to installation of the GCL, the liner subgrade shall be surveyed and verified. Surveying will be performed to verify that the finished subgrade is to the lines and grades specified in the design with a vertical tolerance of ±0.1 feet.

Before installation of GCL, the CQA monitor or geosynthetics contractor will observe the following:

- All lines and grades of the prepared subgrade have been verified.
- The prepared subgrade is free of irregularities and protrusions.
- The top of the prepared subgrade shall be free of particles larger than ¾-inch in diameter.
- The prepared subgrade is not saturated and no standing water is present.
- The geosynthetics contractor has certified in writing that the prepared subgrade on which the GCL will be installed is acceptable.

4.4 Installation

4.4.1 Deployment and Placement

Equipment used to deploy GCL over soil shall not cause rutting of the subgrade. The GCL should be unrolled, not dragged, across the subgrade. Where the GCL cannot be unrolled, a geosynthetic rub sheet must be placed under the GCL to protect it during deployment. Deployed GCL panels shall contain no folds or excessive slack. Generators, gasoline or solvent cans, tools, or supplies shall not be placed directly on GCL. Installation personnel shall not smoke or wear damaging shoes when working on GCL.

GCL on sideslopes shall not be unrolled perpendicular (across) to the slope. No horizontal seams will be allowed on side slopes unless the full roll length is too short to extend from the anchor trench to 5 feet past the toe of the slope. If horizontal seams are necessary, they will be constructed only in the lower half of the slope with a minimum end lap of 3 feet, shingled in the down slope direction, and staggered at least 20 feet apart vertically. GCL will be temporarily anchored at the top of the slope and then be unrolled downslope with appropriate construction equipment to prevent wrinkles and folds.

During GCL placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe the condition of the liner subgrade and note any deficiencies. All deficiencies shall be repaired and be approved by the CQA monitor.
- Observe the condition of the GCL and note any defects. All defects must be repaired in accordance with the requirements of Section 4.4.4.
- Observe that people working on the GCL do not smoke, wear shoes that could damage the GCL, or engage in activities that could damage the GCL.
- Observe that no more panels are deployed than can be covered on the same day.
- Observe that overlaps are constructed in accordance with the manufacturer's recommendations, but in no case will the overlaps be less than 6 inches on the edges (longitudinal) and 2 feet on the ends.
- Observe that seams are constructed per manufacturer's recommendations. Horizontal and vertical seams for reinforced and non-reinforced GCLs will be amended with granular dry bentonite between the overlapped panels in accordance with the manufacturer's recommendations. In absence of other guidelines, a rate of ¼ pound per linear foot will be used where bentonite amendment is required.
- Observe that defects are patched and overlapped properly.
- Observe that on sideslopes, the GCL is anchored at the top and then unrolled.
- Observe the GCL for premature hydration. All GCL that has prematurely hydrated shall be removed and replaced with new GCL.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and be repaired in accordance with Section 4.4.4 or be removed and replaced by the installer.

4.4.2 Protection

Construction equipment on the GCL shall be minimized to reduce the potential for damage or puncture. Small equipment such as generators shall be placed on scrap GM material (rub sheets). Vehicle and equipment traffic other than only low contact pressure vehicles must not be allowed on the deployed GCL. The CQA monitor will verify that GCL (or overlying geosynthetics) are not displaced or damaged while

overlying materials are being placed. Drainage aggregates and protective cover shall be placed in lifts using low ground pressure equipment.

4.4.3 Anchor Trenches

The top corner of the anchor trenches shall be rounded to prevent crimping the GCL. The bottom of the anchor trench shall be dry, stable and be free of loose particles and rocks. Anchor trenches shall be backfilled with compacted general fill that is free of particles larger than 1 inch in diameter. General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture density tests will be taken at the discretion of the CQA monitor to evaluate the quality of the backfill.

4.4.4 Repairs

Repairs shall be constructed in accordance with the manufacturer's recommendations. Damaged non-reinforced GCL (landfill floor) will be repaired by completely exposing the affected area, removing all foreign objects or soil, and placing a patch cut from unused GCL over the damaged area with a minimum overlap of 12 inches on all edges. Dry bentonite will be placed between the patch edges and the repair material at a rate of a quarter pound per linear foot. Reinforced GCL material damaged on the side slopes will be repaired by the same procedure as the non-reinforced GCL.

4.5 Testing and Verification

4.5.1 Manufacturer's Quality Control Testing

The manufacturer shall test the GCL and raw materials in accordance with the most current GRI Standard GCL3 and Table 10B-2 to assure the quality of the GCL. The most current GRI Standard GCL3 (as of the date of this SLQCP) is provided in Appendix 10B-B.

Table 10B-2
GCL Manufacturer Tests

Test	Type of Test	Standard Test Method	Frequency of Testing
Bentonite[1]	Free Swell	ASTM D 5890	per 50 tons and every truck or railcar
	Fluid Loss	ASTM D 5891	
Geotextile	Mass Unit/Unit Area	ASTM D 5261	per 200,000 ft^2
	Grab Tensile Strength	ASTM D 4632	
GCL Product	Clay Mass/Unit Area @ 0% moisture	ASTM D 5993	per 40,000 ft^2
	Bentonite Moisture Content	ASTM D 5993	
	Grab Tensile Strength	ASTM D 4632	per 200,000 ft^2
	Permeability[2]	GRI GCL-3 or ASTM D 5084	per week for each production line
	Lap Joint Permeability	Flow box or other suitable device	per GCL adjoining material and lap type

[1] Tests to be performed on bentonite before incorporation into GCL.
[2] Report last 20 permeability values, ending on production date of supplied GCL.

4.5.2 Conformance Testing

Conformance testing requirements are provided in Table 10B-3.

Table 10B-3
GCL Conformance Tests

Property	Standard Test Method	Frequency of Testing
Clay Mass/Unit Area @ 0% moisture	ASTM D 5993	per 40,000 ft^2
Permeability[1]	GRI GCL-3 or ASTM D 5084	per 100,000 ft^2
Internal Shear Strength	ASTM D 6243	per 100,000 ft^2

[1] Test at confining/consolidating pressures simulating field conditions for ASTM D 5084.

4.5.3 Required Manufacturer's Specifications

Table 10B-4
Manufacturer's Specifications for Non-Reinforced and Reinforced GCL Materials

Property	Required Values	
	Non-reinforced GCL	Reinforced GCL
Free Swell (millimeters)	24 (minimum)	24 (minimum)
Fluid Loss (millimeters)	18 (minimum)	18 (minimum)
Bentonite Mass per Unit Area (lb/sf)	0.75 (minimum)	0.75 (minimum)
Grab Tensile Strength (lbs)	80 (minimum)	90 (minimum)
GCL Hydrated Internal Shear Strength (psf)	50 (minimum)	500 (minimum)
GCL Permeability (cm/s)	$5x10^{-9}$ (maximum)	$5x10^{-9}$ (maximum)
Lap Joint Permeability (cm/s)	$5x10^{-9}$ (maximum)	$5x10^{-9}$ (maximum)

5 GEOMEMBRANE LINER

30 TAC §§330.331, 330.339

5.1 General

The geomembrane liner (GM) consists of a 60-mil thick HDPE geomembrane placed over the geosynthetic clay liner. Textured GM will be placed on the floor and GM that is textured on both sides will be placed over the sidewalls. The CQA monitor shall provide continuous on-site observation during GM deployment, trial welds, seaming, testing, and repairing. The GP shall make sufficient site visits during the GM installation to document the installation and testing in the GLER, in accordance with Section 8.

5.2 Materials

5.2.1 Properties

GM shall consist of textured high-density polyethylene (HDPE) geomembrane produced from virgin raw materials. Recycled materials are not acceptable. The GM shall not be manufactured from resin from differing suppliers. The GM shall meet the requirements of the Geosynthetics Research Institute (GRI) - GM13 Standard Specification. A copy of GRI - GM13 Standard Specification (as of the date of this SLQCP) is included in Appendix 10B-A for informational purposes and will be superseded as newer versions are adopted. This SLQCP incorporates the most current version of GRI - GM13 Standard Specification.

Manufacturer quality control testing procedures and frequencies for GM are listed in Section 5.5.1. Third party conformance testing procedures and frequencies for GM are listed in Section 5.5.2.

5.2.2 Delivery and Storage

GM shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site.

Upon delivery of the geomembrane, the CQA monitor will observe that:

- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location and not stacked more than five rolls high.

- The geomembrane is protected from puncture, dirt, grease, water, moisture, and excessive heat, or other damage.

- All manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications.

- The geomembrane receipt log form has been completed for all materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane.

5.3 Preparation

The surface of the GCL shall be protected in accordance with Section 4.4.2 until the GM is installed. Prior to installation of any geomembrane, the installed GCL surface shall be inspected by the CQA monitor and the geosynthetics contractor. Before installation of the GM, the GP or CQA monitor will observe the following:

- The GCL surface is free of surface irregularities and protrusions.

- The anchor trenches are free of sharp objects and stones.

- The GCL is not saturated, and no water is present above the GCL.

- The geosynthetics contractor has certified in writing that the GCL surface on which geomembrane will be installed is acceptable.

5.4 Installation

5.4.1 Deployment and Placement

The following activities must take place prior to GM deployment:

- The manufacturer's quality control and third party conformance tests will be completed and approved by the GP in accordance with the requirements of Section 5.5.

- The GP and geosynthetics installer shall approve the subgrade in accordance with the requirements of Section 5.3.

- The geosynthetic installer shall sign the subgrade acceptance form.

GM shall be deployed by equipment that will unroll the GM without damaging, crimping or stretching it and deployment equipment must not damage the underlying geosynthetic clay liner (GCL). Only low contact pressure equipment shall be allowed on the GCL.

GM must not be deployed during periods of rain, freezing temperatures, or high winds. The installer must only deploy the amount of GM that can be seamed on the same day.

Upon deployment, each panel shall be assigned a unique identification number. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and damaging shoes shall not be permitted on the GM and only low-ground pressure supporting equipment shall be allowed on the GM. Textured GM shall be placed on sideslopes and shall extend to a minimum of 5 feet beyond the toe of the slope.

During GM placement, the CQA monitor must:

- Provide full-time observation.
- Record panel numbers, panel dimensions, and roll numbers on the panel layout drawing.
- Record weather conditions.
- Observe the condition of the GM and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the deployment method minimizes wrinkles and that the GM is anchored to prevent movement from wind.
- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that there are no horizontal seams on sideslopes and that the textured material extends a minimum of 5 feet past the toe of the slope.
- Observe that the underlain GCL is not damaged by geomembrane installation equipment or activities. These observations will be visual and when the GM deems it necessary other testing methods may be used.
- Observe that the geomembrane panels are deployed only by low ground pressure equipment to prevent damage to the underlain GCL.
- Observe that the geomembrane is not dragged across a surface that could damage the geomembrane.
- Observe that the geomembrane panel is placed in a manner to ensure direct and uniform contact between GM and GCL. The geomembrane panels will be observed for crimping, stretching, and wrinkling to ensure uniform contact.

Any panels that are not deployed in accordance with this section shall be marked by the CQA monitor and be repaired in accordance with Section 5.4.4 or be removed and replaced by the installer.

5.4.2 Seaming

Only welding apparatus and operators that have completed approved trial welds, in accordance with Section 5.5.3, shall be allowed to weld panel seams. Each seam shall be assigned a unique number, which is preferably consistent with the panel numbering system. Sidewall seams shall be oriented downslope. Prior to welding, the proper panel overlap shall be provided. Dirt, grease, and free moisture shall be cleaned from the panel contact area, and wrinkles shall be removed as much as practical. For extrusion welds, oxidation shall be ground from the seam area within one hour of the welding operation and the extrudiate shall be purged from the extrusion welding apparatus. Seaming operations shall not be allowed when the ambient temperature is below 40° F or above 104° F unless trial welds have demonstrated that adequate welds can be achieved outside these limits.

During GM seaming operations, the CQA monitor must:

- Provide full-time observation.
- Record seam numbers on the panel layout drawing.
- Record weather conditions.
- Observe that the only approved welding apparatus and operators are allowed to weld seams.
- Observe the condition of the seams and note any defects. All defects must be repaired in accordance with the requirements of Section 5.4.4.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the seams are free of grease, dirt, moisture and wrinkles.
- Observe that welding operations take place within the approved ambient temperature range.
- Observe that seam grinding has been completed less that one hour before extrusion welding and the extrudiate has been purged from extrusion welders.

5.4.3 Anchor Trenches

The GM anchor trench shall be left open until the seaming is completed. Expansion and contraction of the GM will be accounted for during deployment. The top corner of the anchor trenches shall be rounded to prevent crimping the GM. The bottom of the

anchor trench shall be dry, stable and be free of loose particles and rocks. Anchor trenches shall be backfilled with compacted general fill that is free of particles larger than 1 inch in diameter. The anchor trenches shall be backfilled and compacted in a manner that does not damage or induce stress to the GM.

5.4.4 Repairs

Defects in the GM, defects in seams, failing destructive tests, failing nondestructive tests, holes from nondestructive tests, and destructive test sample locations shall be repaired by one of the following repair techniques:

- Patching - used to repair large holes, tears, large GM defects, and destructive test locations.
- Extrusion - used to repair small GM defects, cuts, holes from nondestructive tests, and seam defects less than ½ inch long.
- Capping - used to repair failed seams or seams where nondestructive tests cannot be performed.
- Removal - used to replace areas with large defects where other repair techniques are not appropriate.

Repair procedures include the following:

- Abrade geomembrane surfaces to be repaired (extrusion welds only) no more than one hour prior to the repair.
- Clean and dry all surfaces at the time of repair.
- Extend patches or caps at least 6 inches beyond the edge of the defect, and round all corners of material to be patched and the patches to a radius of at least 3 inches. Bevel the top edges of patches prior to extrusion welding.

Destructive and non-destructive testing will be performed on all repairs in accordance with Section 5.5.4.

5.5 Testing and Verification

5.5.1 Manufacturer's Quality Control Testing

The GM manufacturer shall test the geomembrane and raw materials in accordance with the most current GRI - GM13 Standard Specification to assure the quality of the GM. The GRI - GM13 Standard Specification (as of the date of this SLQCP) is provided in Appendix 10B-A.

5.5.2 Conformance Testing

Conformance samples of the GM shall be cut across the full width of selected rolls in accordance with the test frequency specified in Table 10B-5. Conformance samples may be taken at the manufacturing plant or at the project site by the GP or his representative and will be forwarded to a third party laboratory for testing. Minimum conformance testing requirements are provided in Table 10B-5 and criteria are provided in GRI - GM13.

Table 10B-5
GM Conformance Tests

Test	Standard	Frequency
Sheet Thickness[1]	ASTM D 5994 (textured)	1 per 50,000 sf and every resin lot
Specific Gravity	ASTM D 1505	1 per 100,000 sf and every resin lot
Carbon Black Content	ASTM D 1603	1 per 100,000 sf and every resin lot
Carbon Black Dispersion	ASTM D 3015 ASTM D 5596	1 per 100,000 sf and every resin lot
Tensile Properties	ASTM D 638 / GRI GM13	1 per 100,000 sf and every resin lot
Direct Shear	ASTM D 5321	Per GM/adjoining material type

[1] The average thickness shall be no less than the specified thickness and no individual measurement shall be less than 90 percent of the specified thickness.

5.5.3 Trial Welds

Each operator and welding apparatus must be tested to verify that seam welds that meet the specifications can be achieved under the site conditions. Trial welds, must be performed at the beginning and midpoint of each day for each operator and apparatus used that day. If welding continues past 6:00 p.m., additional trial welds may be required.

The trial weld samples shall be 3 feet long and 12 inches wide, with the seam centered lengthwise. At least four one-inch wide coupons will be cut from each trial weld sample.

Two coupons from each sample will be tested for shear and two samples will be tested for peel. Peel test coupons for dual-track welds shall be tested on both sides of the air channel. Each coupon must meet the minimum strength requirements listed in Table 10B-6 and exhibit a Film Tear Bond (FTB). If the trial weld fails, two more trial seams must be welded and tested. This process will continue until passing trial welds are achieved.

The CQA monitor must observe the trial welding operations and document the operator's initials, apparatus number, time, date, air temperature, apparatus temperature, and peel and shear test results. If the CQA monitor believes that an operator or apparatus is not functioning properly, or if the weather conditions have substantially changed since the trial welds were performed, new trial welds must be performed.

5.5.4 Construction Testing

Nondestructive Tests

Nondestructive seam tests include vacuum testing and air pressure testing. Nondestructive testing shall be performed for the entire length of each seam by the GM installer.

Vacuum testing shall be used to test extrusion-welded seams and fusion welded seams that cannot be tested by air pressure methods. The vacuum box shall be placed over a seam section, which has been thoroughly saturated with a soapy water solution. The rubber gasket on the bottom of the vacuum box must seal against the GM to prevent leaks. The vacuum box pressure shall be reduced to about 3 to 5 inches of Hg. Soap bubbles will indicate the presence of holes or non-bonded seams. The vacuum box dwell time shall be at least 10 seconds.

Air pressure testing shall be used to test fusion-welded seams that have an air channel. Both ends of the air channel shall be sealed and air shall be pumped into the channel to at least 30 psi or ½ psi per mil of thickness, whichever is greater. With the air pump shut off, the air channel must sustain the pressure for at least five minutes, without more than a 4-psi pressure drop. Following a passing pressure test, the pressure shall be released from the end of the seam that is opposite of the pressure gauge. The pressure gauge must return to zero, if not, the seam is probably blocked. After the blockage has been located, the seam shall be pressure tested on both sides of the blockage. If the pressure drop is greater than 4 psi after 5 minutes, this indicates a seam leak that must be isolated and repaired. All penetration holes shall be sealed after the air pressure testing is completed.

During the nondestructive testing, the CQA monitor must:

- Observe that equipment and operators are performing the tests properly.
- Observe that the entire length of each seam is tested and record the results of the test on the appropriate log.
- Identify failed seams and inform the installer of any required repairs.
- Record all completed and tested repairs on the repair log.

Destructive Tests

Destructive testing shall be performed at a frequency of one test location per 500 linear feet of seam. Repairs over 10-feet long shall be included in the total seam length. Destructive test samples will be 45-inches long by 12-inches wide with the seam centered along the length of the sample. At a minimum, a destructive test must be done for each welding machine used for seaming or repair.

Two coupons will be cut from each end of the sample and the installer must test these coupons with a tensiometer capable of measuring the seam strength. The installer shall

test two coupons in shear and two coupons in peel. For double wedge-welded seams, both sides of the air channel shall be tested in peel. The CQA monitor must observe the tests and record the results on the destructive testing log. The minimum requirements for destructive testing are provided in Table 10B-6. If one of the coupons fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established.

If the field test results are satisfactory, the remaining sample shall be divided into three parts: one third for the installer, one third for third party laboratory testing, and one third for the owner to archive. The laboratory shall test five coupons from each sample in shear and test five coupons from each sample in peel (ten when testing both inner and outer welds of dual-track fusion welds). The minimum requirements for destructive testing are provided in Table 10B-6. If the laboratory test fails in either peel or shear, the installer shall reconstruct the entire seam between passed test locations, or take additional samples 10 feet in both directions of the failed test. If the additional tests pass, the contractor shall reconstruct or cap the seam between the passing test locations. If the additional tests fail, the sampling and testing procedure shall be repeated until the length of the faulty seam is established. All seams shall be bracketed by passing laboratory tests; field tests results shall not be used for final acceptance.

Table 10B-6
Geomembrane Seam Properties

Test	Standard	Frequency	Minimum Criteria
Shear	ASTM D 4437	1 sample per 500 feet of seam	4 of 5 specimens from each sample must have a shear strength greater than or equal to 95% of sheet strength but not less than 120 ppi. The average shear strength value of all 5 specimens must be greater than or equal to 95% of sheet strength but not less than 120 ppi. 4 of 5 specimens shall exhibit Film Tear Bond.
Peel	ASTM D 4437	1 sample per 500 feet of seam	4 of 5 specimens from each sample must have a peel strength greater than or equal to 62% of sheet strength but not less than 78 ppi. The average peel strength value of all 5 specimens must be greater than or equal to 62% of sheet strength but not less than 78 ppi. Both sides of dual track seams shall meet the minimum criteria. Each track is considered a separate sample. 4 of 5 specimens shall exhibit Film Tear Bond.

[1] The manufacturer's sheet strength valves must be provided in order to determine if the test result is adequate.

During destructive seam testing, the CQA monitor must:

- Select sample locations and observe sample cutting.

- Assign sample numbers and label samples.
- Observe installer-performed tests.
- Record sample locations, sample number, sample purpose, and field test results.

6 LEACHATE COLLECTION SYSTEM

30 TAC §330.333

6.1 General

The leachate collection system consists of the collection layer, collection trenches, piping, and the sumps. Refer to Attachment 15 for design calculations for the leachate collection systems. Material properties are described in Section 6.2. The CQA monitor shall provide on-site observation during leachate collection layer and piping installation. The GP shall make sufficient site visits during the leachate collection system installation to document the installation in the GLER, in accordance with Section 8.

6.2 Materials

6.2.1 Geocomposite (Drainage Layer)

The leachate collection layer consists of geocomposite drainage net installed above the GM. Double-sided geocomposite (nonwoven geotextile bonded to the top of HDPE drainage net) will be installed on the floor and sidewalls. The geocomposite shall have the minimum properties listed in Table 10B-7.

Table 10B-7
Geocomposite Properties

Material	Test	Standard	Required Property
Geotextile	Material		Nonwoven polypropylene or polyester
	Apparent Opening Size	ASTM D 4751	70 sieve maximum
	Unit Weight	ASTM D 5261	6 oz/yd^2
	Grab Strength	ASTM D 4632	150 lb
	Tear Strength	ASTM D 4533	70 lb
	Puncture Strength	ASTM D 4833	80 lb
	Burst Strength	ASTM D 3786	330 lb/in^2
HDPE Drainage Net	Specific Gravity	ASTM D 1505	0.93 g/cm^3
	Thickness	ASTM D 5199	0.25 inch
	Carbon Black	ASTM D 1603	Minimum 2% Maximum 3%
	Tensile Strength	ASTM D 5035	40 lb/in
Geocomposite	Transmissivity	ASTM D 4716	0.5x10^{-4} m^2/sec (double-sided)

Manufacturer quality control testing procedures and frequencies for geocomposite are listed in Section 6.5.1.

6.2.2 Geotextile

The leachate aggregate that is placed in the collection trenches and sumps shall be wrapped in a geotextile filter fabric. The geotextile shall have the minimum properties listed in Table 10B-8.

Table 10B-8
Geotextile Properties

Test	Standard	Required Property
Material		Nonwoven polypropylene or polyester
Apparent Opening Size	ASTM D 4751	70 sieve maximum
Unit Weight	ASTM D 5261	6 oz/yd^2
Grab Strength	ASTM D 4632	160 lb
Tear Strength	ASTM D 4533	70 lb
Puncture Strength	ASTM D 4833	80 lb
Burst Strength	ASTM D 3786	330 lb/in^2

Manufacturer quality control testing procedures and frequencies for geotextile are listed in Section 6.5.1.

6.2.3 Leachate Pipe

The leachate piping includes perforated collection trench pipes and the solid sidewall riser pipes. The leachate piping shall meet the cell classification PE345434C in accordance with ASTM D 3350. The pipe shall have the minimum SDR rating and meet the design requirements provided in Attachment 15.

6.2.4 Leachate Aggregate

Leachate aggregate will be placed in the collection trenches and in the sumps. The aggregate shall consist of manufactured or natural materials having the properties listed in Table 10B-9. Alternate gradations may be approved by the GP.

Table 10B-9
Leachate Aggregate Properties

Test	Standard	Required Property	
Gradation	ASTM D 422	Sieve 1½" ½" ⅜"	% Passing 90-100 20-50 <15
Hydraulic Conductivity	ASTM D 2434	≥ 1.0×10^{-2} cm/sec	
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	Maximum 15% loss	

[a] Use an HCL solution having a pH of 5 or lower.

Conformance testing procedures and frequencies for leachate aggregate are listed in Section 6.5.2.

6.2.5 Delivery and Storage

Geocomposite and geotextile shall be shipped in rolls labeled with the manufacturer's name, roll number, and lot or batch number. The CQA monitor shall inspect the rolls for shipping damage and complete a geosynthetics receipt log for all materials delivered to the site. Damaged rolls shall be rejected. Pipe shall be shipped in bundles labeled with the manufacturer's name and cell classification number.

The geocomposite, geotextile and pipe shall be unloaded and handled with equipment that does not cause damage. Rolls will not be pushed, slid, or be dragged to the storage location. The geocomposite and geotextile must not be stored on wet, soft, or rocky subgrade but must be stored on a stable subgrade. Geocomposite and geotextile must not be stacked more than 5 rolls high to avoid crushing the roll cores. The stored geocomposite, geotextile and pipe must be protected from puncture, grease, dirt, excessive heat, or other damage.

6.3 Preparation

Prior to installation of the leachate collection layer the GM shall be tested and verified in accordance with Section 5.5. The CQA monitor shall observe that the surface to receive the geocomposite is free of debris, stones and dirt and verify that the geocomposite conformance documentation has been submitted and approved.

6.4 Installation

6.4.1 Geocomposite

Double-sided geocomposite shall be installed on sidewalls and single-sided geocomposite shall be installed on the floor. Geocomposite shall be deployed by equipment that will

unroll the geocomposite without damaging, crimping or stretching it and deployment equipment must not damage the underlying GM. All panels must be anchored with adequate ballast to prevent uplift from wind. Smoking and damaging shoes shall not be permitted on the geocomposite and only low-ground pressure supporting equipment shall be allowed on the geocomposite or GM. Adjacent rolls of geocomposite shall be securely tied through the drainage net with plastic fasteners every 5 feet along the length of the panel and every 6 inches along the ends of the panels. The top geotextile of adjacent rolls shall be overlapped and be sewn or heat bonded together.

During geocomposite placement, the CQA monitor must:

- Provide full time observation.
- Record weather conditions.
- Observe that the geocomposite was installed with the HDPE drainage net placed downward.
- Observe the condition of the geocomposite and note any defects. All defects must be repaired or replaced.
- Observe that people working on the GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.
- Observe that the deployment method minimizes wrinkles in the GM and the geocomposite.
- Observe that the geocomposite panels have been properly tied and seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be removed and replaced by the installer.

6.4.2 Geotextile

Geotextile shall be placed around the leachate aggregate in the collection trenches and the sumps in accordance with the plans. Geotextile shall be deployed by equipment that will unroll the geotextile without damaging or stretching it and deployment equipment must not damage the underlying geosynthetics. Smoking and damaging shoes shall not be permitted on the geotextile and only low-ground pressure supporting equipment shall be allowed on the geotextile. Adjacent rolls shall be overlapped and be sewn or heat bonded together.

During geotextile placement, the CQA monitor must:

- Provide full-time observation.
- Observe the condition of the geotextile and note any defects. All defects must be repaired or replaced.

- Observe that people working on the geocomposite and GM do not smoke, wear shoes that could damage the GM, or engage in activities that could damage the GM.

- Observe that the deployment method minimizes wrinkles in the GM and the geocomposite.

- Observe that the geotextile panels have been properly seamed.

Any panels that are not installed in accordance with this section shall be marked by the CQA monitor and be removed and replaced by the installer.

6.4.3 Pipe

Leachate pipe shall be placed to the lines and grades shown on the plans. The pipe shall be joined in accordance with the manufacturer's recommendations and the project specifications.

Construction equipment shall not be allowed to travel directly over the leachate pipes to prevent crushing or excessive deflection until aggregates and protective cover have been placed.

During leachate pipe placement, the CQA monitor must:

- Provide full-time observation.

- Observe the condition of the pipes and note any defects. All defective pipes must be replaced.

- Observe that people working on the geocomposite and GM do not smoke, wear shoes that could damage the GM or geocomposite, or engage in activities that could damage the GM or geocomposite.

- Observe that construction equipment does not damage pipes.

- Observe that the perforations and pipe orientation are in accordance with the plans and specifications.

- Observe that the pipes and fittings are joined in accordance with the project specifications and the manufacturer's recommendations.

Any pipes that are not installed in accordance with this section shall be marked by the CQA monitor and be repaired or be removed and replaced by the installer.

6.4.4 Leachate Aggregate

Leachate aggregate shall be placed in the collection trenches and sumps to the lines and grades shown on the plans. During leachate aggregate placement, the CQA monitor must:

- Observe that leachate aggregate is placed in accordance with the plans and specifications.
- Observe that the leachate aggregate is consistent with the conformance test samples.
- Observe that leachate aggregate placement activities do no dislodge or damage leachate pipes or underlying geosynthetics.

6.5 Testing and Verification

6.5.1 Manufacturer's Testing

The geocomposite manufacturer shall test the geocomposite to assure the quality of the geocomposite. Geocomposite property requirements are provided in Section 6.2.1. Minimum manufacturer's testing requirements are provided in Table 10B-10. The manufacturer's testing shall be conducted at a minimum frequency of one test per 100,000 sf of material.

Table 10B-10
Geocomposite Manufacturer's Tests

Material	Test	Standard
Geotextile	Unit Weight	ASTM D 5261
	Apparent Opening Size	ASTM D 4751
	Grab Strength	ASTM D 4632
	Tear Strength	ASTM D 4533
	Puncture Strength	ASTM D 4833
	Burst Strength	ASTM D 3786
HDPE Drainage Net	Specific Gravity	ASTM D 1505
	Thickness	ASTM D 5199
	Carbon Black	ASTM D 1603
Geocomposite	Transmissivity	ASTM D 4716

The geotextile manufacturer shall test the geotextile to assure the quality of the geotextile. Geotextile property requirements are provided in Section 6.2.2. Minimum manufacturer's testing requirements are provided in Table 10B-11. The manufacturer's testing shall be conducted at a minimum frequency of one test per 100,000 sf of material.

Table 10B-11
Geotextile Manufacturer's Tests

Test	Standard
Unit Weight	ASTM D 5261
Apparent Opening Size	ASTM D 4751
Grab Strength	ASTM D 4632
Tear Strength	ASTM D 4533
Puncture Strength	ASTM D 4833
Burst Strength	ASTM D 3786

The leachate piping manufacturer shall provide a certification that the pipe meets the cell classification PE345434C in accordance with ASTM D 3350, and the minimum SDR rating and perforation schedule shown on the plans and specifications.

The leachate aggregate shall be tested at the source to assure that the aggregate meets the specifications. Material property requirements are provided in Section 6.2.4. Minimum source testing requirements are provided in Table 10B-12.

Table 10B-12
Leachate Aggregate Source Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per source
Hydraulic Conductivity	ASTM D 2434	1 per source
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per source

[a] Use an HCL solution having a pH of 5 or lower.

6.5.2 Construction Testing

The leachate aggregate shall be tested to assure that the aggregate meets the specifications. Material property requirements are provided in Section 6.2.4. Minimum construction testing requirements are provided in Table 10B-13.

Table 10B-13
Leachate Aggregate Construction Tests

Test	Standard	Frequency
Gradation	ASTM D 422	1 per 3,000 cy
Hydraulic Conductivity	ASTM D 2434	1 per 3,000 cy
Carbonate Content	JLT-S-105-89 or ASTM D 3042[a]	1 per 3,000 cy

[a] Use an HCL solution having a pH of 5 or lower.

6.5.3 Verification

The as-built location of the leachate piping shall be determined and reported in the GLER. All components of the leachate collection system will be documented in the GLER as stated in Section 8.

7 PROTECTIVE COVER

30 TAC §330.339

7.1 General

The protective cover consists of a 24-inch thick layer of soils. The drainage aggregate around the leachate collection pipes will extend through the protective cover to form a chimney drain for the leachate collection system. The CQA monitor shall provide continuous on-site observation during protective cover placement to assure that protective cover placement does not damage underlying geosynthetics. The GP shall make sufficient site visits during protective cover placement to document the construction activities, testing, and thickness verification in the GLER in accordance with Section 8.

7.2 Materials

Protective cover material shall consist of soil that is free from debris, rubbish, frozen materials, foreign objects, solid waste, and organic material, or any material that could damage the underlying geosynthetics. The protective cover material will not contain rocks larger than 4 inches in diameter. Since drainage aggregate chimneys will be provided above the LCS trenches, there are no permeability requirements for protective cover materials.

7.3 Preparation

Prior to placing the protective cover material, the liner subgrade elevations shall be verified in accordance with the requirements of Section 3.5 and all testing on the underlying geosynthetics shall be completed.

7.4 Placement

The protective cover shall be placed in a manner that minimizes the potential to damage the underlying geosynthetics. Hauling equipment shall be restricted to haul roads of sufficient thickness to protect the underlying geosynthetics. The protective cover shall be dumped from the haul road and spread by low ground pressure equipment in a manner that minimizes wrinkles and stress in the geosynthetics. On sidewalls, protective cover shall be placed from the bottom to the top, not across or down. Bridge slope transitions occur when cold weather causes the geomembrane to contract. Protective cover shall not be placed over geosynthetics until the geosynthetics have expanded to maintain contact with the liner subgrade. The minimum separation distance between construction equipment and the geosynthetics are listed in Table 10B-14.

Table 10B-14
Minimum Separation Distance

Equipment Ground Pressure (psi)	Minimum Separation Distance (in)
< 4	12
4 - 8	18
8 - 16	24
> 16	36

Any geosynthetic material that in the opinion of the CQA monitor has been damaged by the protective cover placement must be repaired and retested in accordance with Sections 4.4.4 and 5.4.4.

7.5 Testing and Verification

The as-built thickness of the protective cover shall be determined by standard survey methods. Prior to the placement of geosynthetics, the top of liner subgrade elevations will be determined at a minimum rate of 1 survey point per 5,000 sf of lined area. After the protective cover is completed, the top of the protective cover elevations will be determined at the same locations as the top of liner subgrade elevations. The as-built vertical thickness will be the difference between the top of liner subgrade elevations and the top of protective cover elevations, reported to the nearest 0.1 foot and shall not be less than 2.0 feet.

8 DOCUMENTATION

30 TAC §330.341

After construction of the liner system, the GP will submit a GCLER and GLER in triplicate to the TCEQ on behalf of the owner. The GCLER and GLER may be combined into a single report. These reports will be submitted to the TCEQ prior to the disposal of solid waste over the specified constructed area. If no response, either written or verbal is provided within 14 days, the GLER or GCLER shall be considered approved and solid waste placement may proceed. Testing, evaluation, and submission of the GCLERs and GLERs for liner system construction will be in accordance with the requirements of this SLQCP prepared for the provisions of current TCEQ rules.

At a minimum, the GCLER and GLER will contain the following:

- TCEQ Form 10070 – Municipal Solid Waste Landfill Site Geomembrane / Geosynthetic Clay Liner Evaluation Report
- A summary of all construction activities in accordance with the SLQCP.
- A detailed description of the liner and leachate collection systems.
- All laboratory and field test results.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- Record drawings.
- The GP will sign and seal a statement of compliance with the SLQCP and construction plans.
- The data and other information must be sufficient to support the conclusions in the reports.
- The seal and signature of the GP in accordance with the Texas Engineering Practice Act.

Markers shall be placed on site so that the disposal areas for which the GCLER and GLER have been submitted and approved are readily determinable. The markers are to provide site workers immediate knowledge at all times of the extent of approved disposal areas. These markers shall be located so that they are not destroyed during operations and shall be in accordance with Part IV, Section 13.

The surface of the liner will be covered with a layer of solid waste within a period of six months to mitigate the effects of surface erosion and rutting due to traffic. Liner surfaces not covered with waste within six months shall be checked by the GP, who shall then submit a letter report on his findings to the TCEQ. Any required repairs shall be performed promptly. An addendum to the GLER shall be submitted on the new construction for all liners that need repair due to damage.

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APPENDIX 10B-A

GEOSYNTHETIC RESEARCH INSTITUTE STANDARD GM13

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Revision 14: January 6, 2016
Revision schedule on pg. 11

GRI - GM13 Standard Specification*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes" SM

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers high density polyethylene (HDPE) geomembranes with a formulated sheet density of 0.940 g/ml, or higher, in the thickness range of 0.75 mm (30 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, physical, mechanical and chemical properties that must be met, or exceeded by the geomembrane being manufactured. In a few cases a range is specified.

1.3 In the context of quality systems and management, this specification represents manufacturing quality control (MQC).

Note 1: Manufacturing quality control represents those actions taken by a manufacturer to ensure that the product represents the stated objective and properties set forth in this specification.

1.4 This standard specification is intended to ensure good quality and performance of HDPE geomembranes in general applications, but is possibly not adequate for the complete specification in a specific situation. Additional tests, or more restrictive

*This GRI standard specification is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version and it is kept current on the Institute's Website <<geosynthetic-institute.org>>.

values for test indicated, may be necessary under conditions of a particular application.

Note 2: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 3895 Test Method for Oxidative Induction Time of Polyolefins by Thermal Analysis
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5397 Procedure to Perform a Single Point Notched Constant Tensile Load – (SP-NCTL) Test: Appendix
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
D 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus
D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes

2.2 GRI Standards

GM10 Specification for the Stress Crack Resistance of Geomembrane Sheet

2.3 U. S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Definitions

Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications.
ref. EPA/600/R-93/182

Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project.
ref. EPA/600/R-93/182

Formulation - The mixture of a unique combination of ingredients identified by type, properties and quantity. For HDPE polyethylene geomembranes, a formulation is defined as the exact percentages and types of resin(s), additives and carbon black.

Nominal - Representative value of a measurable property determined under a set of conditions, by which a product may be described. Abbreviated as nom. in Tables 1 and 2.

4. Material Classification and Formulation

4.1 This specification covers high density polyethylene geomembranes with a formulated sheet density of 0.940 g/ml, or higher. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.932 g/ml or higher, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be a similar HDPE as the parent material.

4.4 No post consumer resin (PCR) of any type shall be added to the formulation.

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth HDPE geomembranes and Table 2 is for single and double sided textured HDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is soft.

Note 3: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of 23°C ± 2°C. Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of 21°C ± 2°C. The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of 23°C ± 2°C should be utilized for testing purposes.

Note 4: There are several tests often included in other HDPE specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693)
- Wide Width Tensile
- Water Vapor Transmission
- Water Absorption
- Ozone Resistance
- Modulus of Elasticity
- Hydrostatic Resistance
- Tensile Impact
- Field Seam Strength
- Multi-Axial Burst
- Various Toxicity Tests

Note 5: There are several tests which are included in this standard (that are not customarily required in other HDPE specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet (see Note 6)

Note 6: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

Note 7: There are other tests in this standard, focused on a particular property, which are updated to current standards. The following are in this category:

- Thickness of Textured Sheet
- Puncture Resistance
- Stress Crack Resistance
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

5.2 The values listed in the tables of this specification are to be interpreted according to the designated test method. In this respect they are neither minimum average roll values (MARV) nor maximum average roll values (MaxARV).

5.3 The properties of the HDPE geomembrane shall be tested at the minimum frequencies shown in Tables 1 and 2. If the specific manufacturer's quality control guide is more stringent and is certified accordingly, it must be followed in like manner.

Note 8: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively.

6. Workmanship and Appearance

6.1 Smooth geomembrane shall have good appearance qualities. It shall be free from such defects that would affect the specified properties of the geomembrane.

6.2 Textured geomembrane shall generally have uniform texturing appearance. It shall be free from agglomerated texturing material and such defects that would affect the specified properties of the geomembrane.

6.3 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Tables 1 and 2. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Tables 1 and 2.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave."

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marketing

9.1 The geomembrane shall be rolled onto a substantial core or core segments and held firm by dedicated straps/slings, or other suitable means. The rolls must be adequate for safe transportation to the point of delivery, unless otherwise specified in the contract or order.

10. Certification

10.1 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

ENGLISH UNITS

Table 1(a) – High Density Polyethylene (HDPE) Geomembrane -Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.)	D5199	nom.	nom.	nom.	nom.	nom.	nom.	nom.	Per roll
• lowest individual of 10 values		-10%	-10%	-10%	-10%	-10%	-10%	-10%	
Formulated Density mg/l (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties *(1)* (min. ave.)	D 6693 Type IV								20,000 lb
• yield strength		63 lb/in.	84 lb/in.	105 lb/in.	126 lb/in.	168 lb/in.	210 lb/in.	252 lb/in.	
• break strength		114 lb/in.	152 lb/in.	190 lb/in.	228 lb/in.	304 lb/in.	380 lb/in.	456 lb/in.	
• yield elongation		12%	12%	12%	12%	12%	12%	12%	
• break elongation		700%	700%	700%	700%	700%	700%	700%	
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	54 lb	72 lb	90 lb	108 lb	144 lb	180 lb	216 lb	45,000 lb
Stress Crack Resistance *(2)*	D5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI-GM10
Carbon Black Content (range)	D 4218 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	20,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)*									200,000 lb
(a) Standard OIT	D 3895	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	100 min.	
— or —									
(b) High Pressure OIT	D 5885	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	400 min.	
Oven Aging at 85°C *(5), (6)*	D 5721								
(a) Standard OIT (min. ave.) - % retained after 90 days	D 3895	55%	55%	55%	55%	55%	55%	55%	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5885	80%	80%	80%	80%	80%	80%	80%	
UV Resistance *(7)*	D 7238								
(a) Standard OIT (min. ave.)	D 3895	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	N.R. *(8)*	per each formulation
— or —									
(b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 5885	50%	50%	50%	50%	50%	50%	50%	

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 in.

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (METRIC) UNITS

Table 1(b) – High Density Polyethylene (HPDE) Geomembrane - Smooth

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness - mils (min. ave.) • lowest individual of 10 values	D5199	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	nom. (mil) -10%	per roll
Formulated Density (min.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties *(1)* (min. ave.) • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 11 kN/m 20 kN/m 12% 700%	 15 kN/m 27 kN/m 12% 700%	 18 kN/m 33 kN/m 12% 700%	 22 kN/m 40 kN/m 12% 700%	 29 kN/m 53 kN/m 12% 700%	 37 kN/m 67 kN/m 12% 700%	 44 kN/m 80 kN/m 12% 700%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	240 N	320 N	400 N	480 N	640 N	800 N	960 N	20,000 kg
Stress Crack Resistance *(2)*	D 5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI GM-10
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	2.0-3.0%	9,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(5)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(5), (6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 3895 D 5885	 N. R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	 N.R. *(8)* 50%	per each formulation

(1) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(2) The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

ENGLISH UNITS

Table 2(a) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.)	D 7466	16 mil	16 mil	16 mil	16 mil	16 mil	16 mil	16 mil	every 2nd roll *(1)*
Formulated Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	200,000 lb
Tensile Properties (min. ave.) *(2)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 63 lb/in. 45 lb/in. 12% 100%	 84 lb/in. 60 lb/in. 12% 100%	 105 lb/in. 75 lb/in. 12% 100%	 126 lb/in. 90 lb/in. 12% 100%	 168 lb/in. 120 lb/in. 12% 100%	 210 lb/in. 150 lb/in. 12% 100%	 252 lb/in. 180 lb/in. 12% 100%	20,000 lb
Tear Resistance (min. ave.)	D 1004	21 lb	28 lb	35 lb	42 lb	56 lb	70 lb	84 lb	45,000 lb
Puncture Resistance (min. ave.)	D 4833	45 lb	60 lb	75 lb	90 lb	120 lb	150 lb	180 lb	45,000 lb
Stress Crack Resistance *(3)*	D 5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(4)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	20,000 lb
Carbon Black Dispersion	D 5596	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(6)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	200,000 lb
Oven Aging at 85°C *(6), (7)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(8)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(10)*	D 7238 D 3895 D 5885	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	per each formulation

(1) Alternate the measurement side for double sided textured sheet

(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 1.3 inches
Break elongation is calculated using a gage length of 2.0 inches

(3) SP-NCTL per ASTM D5397 Appendix, is not appropriate for testing geomembranes with textured or irregular rough surfaces. Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.

(9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

(10) UV resistance is based on percent retained value regardless of the original HP-OIT value.

Table 2(b) – High Density Polyethylene (HDPE) Geomembrane - Textured

Properties	Test Method	Test Value							Testing Frequency (minimum)
		0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness mils (min. ave.) • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	nom. (-5%) -10% -15%	per roll
Asperity Height mils (min. ave.)	D 7466	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	0.40 mm	every 2nd roll *(1)*
Formulated Density (min. ave.)	D 1505/D 792	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	0.940 g/cc	90,000 kg
Tensile Properties (min. ave.) *(2)* • yield strength • break strength • yield elongation • break elongation	D 6693 Type IV	 11 kN/m 8 kN/m 12% 100%	 15 kN/m 10 kN/m 12% 100%	 18 kN/m 13 kN/m 12% 100%	 22 kN/m 16 kN/m 12% 100%	 29 kN/m 21 kN/m 12% 100%	 37 kN/m 26 kN/m 12% 100%	 44 kN/m 32 kN/m 12% 100%	9,000 kg
Tear Resistance (min. ave.)	D 1004	93 N	125 N	156 N	187 N	249 N	311 N	374 N	20,000 kg
Puncture Resistance (min. ave.)	D 4833	200N	267 N	333 N	400 N	534 N	667 N	800 N	20,000 kg
Stress Crack Resistance *(3)*	D 5397 (App.)	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	500 hr.	per GRI GM10
Carbon Black Content (range)	D 4218 *(4)*	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	2.0-3.0 %	90,000 kg
Carbon Black Dispersion	D 5596	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	note *(5)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(6)* (a) Standard OIT — or — (b) High Pressure OIT	 D 3895 D 5885	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	 100 min. 400 min.	90,000 kg
Oven Aging at 85°C *(6), (7)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 3895 D 5885	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	 55% 80%	per each formulation
UV Resistance *(8)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(10)*	D 7238 D 3895 D 5885	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	 N.R. *(9)* 50%	per each formulation

(1) Alternate the measurement side for double sided textured sheet

(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
Yield elongation is calculated using a gage length of 33 mm
Break elongation is calculated using a gage length of 50 mm

(3) The SP-NCTL test is not appropriate for testing geomembranes with textured or irregular rough surfaces Test should be conducted on smooth edges of textured rolls or on smooth sheets made from the same formulation as being used for the textured sheet materials.
The yield stress used to calculate the applied load for the SP-NCTL test should be the manufacturer's mean value via MQC testing.

(4) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.

(5) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
9 in Categories 1 or 2 and 1 in Category 3

(6) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

(7) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response

(8) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr condensation at 60°C

(9) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples

(10) UV resistance is based on percent retained value regardless of the original HP-OIT value

Adoption and Revision Schedule
for
HDPE Specification per GRI-GM13

"Test Methods, Test Properties, Testing Frequency for
High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"

Adopted:	June 17, 1997
Revision 1:	November 20, 1998; changed CB dispersion from allowing 2 views to be in Category 3 to requiring all 10 views to be in Category 1 or 2. Also reduced UV percent retained from 60% to 50%.
Revision 2:	April 29, 1999: added to Note 5 after the listing of Carbon Black Dispersion the following: "(In the viewing and subsequent quantitative interpretation of ASTM D5596 only near spherical agglomerates shall be included in the assessment)" and to Note (4) in the property tables.
Revision 3:	June 28, 2000: added a new Section 5.2 that the numeric table values are neither MARV or MaxARV. They are to be interpreted per the the designated test method.
Revision 4:	December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".
Revision 5:	May 15, 2003: Increased minimum acceptable stress crack resistance time from 200 hrs to 300 hrs.
Revision 6:	June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 2.
Revision 7:	February 20, 2006: Added Note 6 on Asperity Height clarification with respect to shear strength.
Revision 8:	Removed recommended warranty from specification.
Revision 9:	June 1, 2009: Replaced GRI-GM12 test for asperity height of textured geomembranes with ASTM D 7466.
Revision 10	April 11, 2011: Added alternative carbon black content test methods
Revision 11	December 13, 2012: Replaced GRI-GM11 with the equivalent ASTM D 7238.
Revision 12	November 14, 2014: Increased minimum acceptable stress crack resistance time from 300 to 500 hours. Also, increased asperity height of textured sheet from 10 to 16 mils (0.25 to 0.40 mm).
Revision 13	November 4, 2015: Removed Footnote (1) on asperity height from tables.
Revision 14	January 6, 2016: Removed Trouser Tear from Note 5.

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APPENDIX 10B-B

GEOSYNTHETIC RESEARCH INSTITUTE STANDARD GCL3

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Original - May 16, 2005
Rev. #2 – July 26, 2010
Rev. #3 - March 14, 2016
Rev. #4 - March 28, 2016
Revision Schedule on pg. 12

GRI-GCL3*

Standard Specification for

"Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)"

This specification was developed by the Geosynthetic Research Institute (GRI), with the cooperation of the member organizations for general use by the public. It is completely optional in this regard and can be superseded by other existing or new specifications on the subject matter in whole or in part. Neither GRI, the Geosynthetic Institute, nor any of its related institutes, warrant or indemnifies any materials produced according to this specification either at this time or in the future.

1. Scope

1.1 This specification covers the manufacturing quality control (MQC) of geosynthetic clay liners (GCLs), describing types of tests, the proper test methods, minimum and sometimes maximum values, and the minimum testing frequencies.

Note 1: Geosynthetic Clay Liners (GCLs) are also called Clay Geosynthetics Barriers (GBR-Cs).

1.2 There are two general categories of GCLs covered in this specification: reinforced and nonreinforced. Within each category there are geotextile, polymer coated geotextiles, and geomembrane/geofilm related types.

1.3 This specification is intended to aid manufacturers, suppliers, purchasers and users of GCLs in establishing an acceptable level of effort for manufacturing quality control.

*This GRI standard is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This specification will be reviewed at least every 2-years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

1.4 This specification does not address manufacturing quality assurance (MQA), product acceptance testing, or conformance testing. These are independent activities taken by organizations other than the GCL manufacturer.

1.5 The values stated in SI (metric) units are to be regarded as the standard. The U.S. (English) units are calculated values using a "soft" conversion accuracy.

1.6 This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

D 638 Test Method for Tensile Properties of Plastics
D 792 Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement
D 882 Test Method for Tensile Properties of Thin Plastic Sheeting
D 1141 Practice for Preparation of Substitute Ocean Water
D 1505 Test Method for Density of Plastics by the Density-Gradient Method
D 4354 Practice for Sampling of Geosynthetics for Testing
D 4439 Terminology for Geosynthetics
D 4632 Test Method for Grab Breaking Load and Elongation of Geotextiles
D 4759 Practice for Determining the Specification Conformance of Geosynthetics
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5261 Test Method for Measuring Mass per Unit Area of Geotextiles
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5887 Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using Flexible Wall Permeameter
D 5888 Practice for Storage and Handling of Geosynthetic Clay Liners
D 5889 Practice for Quality Control of Geosynthetic Clay Liners
D 5890 Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners
D 5891 Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners
D 5993 Test Method for Measuring the Mass Per Unit Area of Geosynthetic Clay Liners
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembrane
D 6102 Guide for Installation of Geosynthetic Clay Liners
D 6141 Guide for Screening the Clay Portion of a GCL for Chemical Compatibility to Liquids

D 6243 Method for Determining the Internal and Interface Shear Resistance of Geosynthetic Clay Liner by the Direct Shear Method
D 6495 Guide for Acceptance Testing Requirements for Geosynthetic Clay Liners
D 6496 Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 6766 Test Method for Evaluation of Hydraulic Properties of Geosynthetic Clay Liners Permeated with Potentially Incompatible Liquids
D 6768 Test Method for Tensile Strength of Geosynthetic Clay Liners

2.2 GRI Standards

GM13 Test Properties, Testing Frequency and Recommended Warrant for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GM17 Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GM18 Test Properties, Testing Frequency and Recommended Warrant for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes (Presently suspended as of May 3, 2004)

2.3 Government Document:

U.S. Environmental Protection Agency Technical Guidance Document "Quality Control Assurance and Quality Control for Waste Containment Facilities," EPA/600/R-93/182, September 1993, 305 pgs.

3. Terminology

3.1 Definition

3.1.1 Geosynthetic Definitions:

3.1.1.1 geotextile, n—a permeability geosynthetic comprised solely of textiles. (ASTM D 4439)
3.1.1.2 geomembrane, n—an essentially impermeable geosynthetic barrier composed of one or more synthetic sheets. (ASTM D 4439)
3.1.1.3 geofilm, n—a thin polymeric film which is essentially impermeable having a thickness no greater than 0.25 mm (10 mils).
3.1.1.4 geotextile-polymer, n—a geotextile which has been coated with, or impregnated by, a polymer such as polypropylene

3.1.1.5 geosynthetic clay liner, n—a manufactured hydraulic barrier consisting of clay bonded to a layer or layers of geosynthetic materials. (ASTM D 4439). Also recall Note 1.

Note 2: Geotextile Related GCL is one in which two geotextiles are used respectively as cap and carrier to the bentonite. Cap and carrier designations in this standard refer to respective orientations during manufacturing. This may or may not be the as-placed orientation in the field. It can be internally reinforced by needle punching or stitching, or be nonreinforced.
Geotextile Polymer Coated GCL is one in which two geotextiles are used respectively as cap and carrier to the encased bentonite, however, one of the geotextiles has been polymer coated in a manner that the permeability and flux are decreased. Within this context a bitumen coated geotextile can be considered as being a polymer. Cap and carrier designations refer to the as manufactured product and not necessarily to the as-placed orientation. It can be internally reinforced by needle punching or stitching, or be nonreinforced.
Geomembrane/Geofilm Related GCL is one in which a geomembrane or geofilm is included in the cross section either above or below the cap geotextile. It can be internally reinforced needle punching or be nonreinforced. Also in the nonreinforced category is bentonite adhesively bonded to a geomembrane.

3.1.2 Material Definitions

3.1.2.1 bentonite—a distinct type of fine-grained clay soil typically containing not less than 80% montmorillionite clay, usually characterized by high swelling upon wetting.

3.1.2.2 Formulation, n - The mixture of a unique combination of ingredients identified by type, properties and quantity. For geosynthetic materials, a formulation refers to the exact percentages of resin, additives, carbon black and/or other additives. It does not necessarily refer to individual suppliers of each ingredient. The individual suppliers must meet the manufacturer's internal quality control specification.

3.1.3 Organizational Definitions:

3.1.3.1 installer, n—the party who installs, or facilitates installation of, any materials purchased from manufacturers or suppliers.

3.1.3.2 manufacturer, n—the group, corporation, partnership, or individual that manufactures a product.

3.1.3.3 purchaser, n—the person, company, or organization that purchases any materials or work to be performed.

3.1.3.4 supplier, n—the party who supplies material or services.

3.1.4 Quality Definitions:

3.1.4.1 Manufacturing Quality Control (MQC) - A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of geosynthetic materials and is necessary to ensure minimum (or maximum) specified values in the manufactured product. MQC refers to measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications, ref. EPA/600/R-93/182

3.1.4.2 Manufacturing Quality Assurance (MQA) - A planned system of activities that provides assurance that the materials were constructed as specified in the certification documents and contract specifications. MQA includes manufacturing facility inspections, verifications, audits and evaluation of the raw materials (resins and additives) and geosynthetic products to assess the quality of the manufactured materials. MQA refers to measures taken by the MQA organization to determine if the manufacturer is in compliance with the product certification and contract specifications for the project, ref. EPA/600/R-93/182

3.1.4.3 Construction Quality Control (CQC) - A planned system of inspections that are used to directly monitor and control the quality of a construction project. Construction quality control is normally performed by the geosynthetics manufacturer or installer, or for natural soil materials by the earthwork contractor, and is necessary to achieve quality in the constructed or installed system. Construction quality control (CQC) refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project, ref. EPA/600/R-93/182

3.1.4.4 Construction Quality Assurance (CQA) - A planned system of activities that provide assurance that the facility was constructed as specified in the design. Construction quality assurance includes inspections, verification, audits, and evaluations of materials and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project, ref. EPA.600/R-93/182

4. Significance and Use

4.1 GCLs must be properly manufactured in a manner consistent with a minimum level of quality control as determined by in-house testing of the final product. This specification presents the types of tests, standard methods of the testing, required (usually minimum) test values, and minimum testing frequencies which should be embodied in the manufacturer's quality control documents. The quoted tests, test methods and test values in Table 1 must appear in the MQC plan and the MQC report.

4.2 It should be clearly recognized that manufacturers may perform additional tests or at greater frequency than required in this specification, or both. In this case, the manufacturer's quality control plan will then take precedence over this specification.

4.3 It should also be recognized that purchasers and installers of GCLs may require additional tests or at a great frequency than called for in this specification, or both. The organization(s) producing such project specific specification or quality assurance plan should recognize that such requirements are beyond the current state-of-the-practice. If such a request is made by purchasers or installers, they should clearly communicate the requirements to the manufacturer or supplier during the contract decisions in order that disputes do not arise at a subsequent time.

5. Procedure

5.1 The procedures embodied in this specification are contained in the respective test methods given in Table 1.

5.1.1 The minimum recommended quality control tests for the manufacture of GCLs are given in Table 1. Specific tests are performed on the bentonite, the geosynthetic component materials, and the finished GCL. Table 1(a) is in S.I. (Metric) units and Table 1(b) is in U.S. (English) units.

Note 3: The conversion from S.I. units into U.S. units is soft.

5.1.2 The individual properties in Table 1 are minimum values; except fluid loss, moisture content, and permeability (or flux). They are maximum values. The manner of taking specimens is described in the appropriate test method. When an average value is indicated, it is listed in the table as "min. ave.", or "max. ave.".

5.2 Bentonite (as received)
Two tests are required; swell index and fluid loss. The latter is a maximum value. These tests should be performed on the bentonite prior to fabrication into a GCL

or on bentonite taken from the manufactured product if the bentonite is modified in any way during manufacturing, e.g., if an adhesive is added.

5.3 Geotextile (as received)
Mass per unit area is required on the as-manufactured cap and carrier fabrics, with different values depending on the fabric being nonwoven or woven.

Note 4: These tests are to be performed on the geotextiles before manufacturing into the final GCL. Removal of the geotextiles from the manufactured product and subsequent testing will give erroneous values and is not an acceptable practice. The exception is polymer coated GCLs where the geotextile must be removed to determine its mass per unit area.

5.4 Geomembrane/Geofilm (as received)
The following tests are required; thickness, density, and tensile strength at break. All are minimum required values. Tensile strength at break is the lowest of machine direction and cross machine direction.

Note 5: These tests are to be performed on the geomembrane or geofilm before manufacturing into the final GCL. Removal of the geomembrane or geofilm from the manufactured product and subsequent testing will give erroneous values and is not an accepted practice.

5.5 GCL (as manufactured)
Six tests are required on the as-manufactured GCL with one having an alternative, i.e., hydraulic conductivity or flux. All are minimum values, with the exception of moisture content and hydraulic conductivity or flux.

5.6 GCL (long-term)
The purpose of these long-term or endurance tests is to provide confidence in the continuing acceptable performance of the bentonite and geosynthetic components of the installed GCL.

5.6.1 The durability of the bentonite is evaluated using a permeant consisting of 0.1 M calcium chloride solution. See ASTM D 6141 which is a guide for this particular aspect of the specification. The GCL is to be hydrated with distilled dionized water prior to conducting the tests with the calcium chloride solution. In this regard, ASTM D6766 Scenario 1 and Method C is the procedure to be used. Furthermore, this test is conducted twice at two different normal pressures, i.e., 35 and 500 kPa. The termination criterion at 500 kPa of eight (8) pore volumes does not apply and now becomes an outflow-to-inflow hydraulic conductivity within 25%. The maximum allowable values are listed in Table 1.

5.6.2 The geotextiles in their as-received condition are evaluated by incubation in a forced air oven per ASTM D5721 set at 60°C for 50 days. The minimum percent in tensile strength retained at break, as measured by ASTM D6768, is 65%. If individual yarns are used in reinforcing GCLs, they must also meet this same endurance criterion.

5.6.3 The geomembrane in its as-received condition is evaluated for durability via the appropriate GRI Specification. For high density polyethylene (HDPE), the specification is GRI GM13. For linear low density polyethylene (LLDPE), the specification is GRI GM17. For flexible polypropylene (fPP), the specification is GRI GM18.

5.6.4 The geofilm in its as-received condition is evaluated by incubation in a forced air oven per ASTM D5721 set at 60°C for 50 days. The minimum percent tensile strength retained at break for either MD or XMD, as measured by ASTM D882, is reported accordingly and must meet or exceed the specification value.

Note 6: It should be recognized that the above durability criterion for geofilms is not as stringent as the criteria for geomembranes stated in Section 5.6.3.

6. Workmanship and Appearance

6.1 Waterproof ink overlap lines should be printed on both edges of one of the surfaces (geotextile or geomembrane) of the manufactured GCL.

Note 7: The overlap lines are minimally 150 mm (6.0 in.) from the edges of the GCL. Other design-related situations may require greater overlap distances to be printed on the GCLs, e.g., when not backfilled in a timely manner.

6.2 Needle punched and stitch bonded GCLs shall be essentially free of broken needle and fragments that would negatively effect the performance of the final product. There must be continuous needle detection and removal devices, e.g., metal detectors and magnets, used during manufacture of GCL products.

6.3 The manufactured GCL shall have good appearance qualities. It shall be free from such defects that would affect the specified properties and integrity of the product.

6.4 General manufacturing procedures shall be performed in accordance with the manufacturer's internal quality control guide and/or documents. ASTM D5888 and D5889 should be followed in this regard.

7. MQC Sampling

7.1 Sampling shall be in accordance with the specific test methods listed in Table 1. If no sampling protocol is stipulated in the particular test method, then test specimens shall be taken evenly spaced across the entire roll width, see ASTM D 4354.

7.2 The number of tests shall be in accordance with the appropriate test methods listed in Table 1.

7.3 The average of the test results should be calculated per the particular standard cited and compared to the minimum value listed in these tables, hence the values listed are the minimum average values and are designated as "min. ave.". When the property is a maximum value, the designation is "max. ave.".

8. MQC Retest and Rejection

8.1 If the results of any test do not conform to the requirements of this specification, retesting to determine conformance or rejection should be done in accordance with the manufacturing protocol as set forth in the manufacturer's quality manual.

9. Packaging and Marking

9.1 The GCL shall be rolled onto a substantial core, clearly labeled, and enclosed in a waterproof wrapper. Packaging must be adequate for safe transportation to the point of delivery.

9.2 The label should include manufacturer, style, lot and/or roll number, weight, length and width.

10. Conformance and Certification

10.1 Conformance of the manufactured GCL to this specification, or agreed-upon variation thereof, shall be performed by the MQA organization or designated by the purchaser/owner. ASTM D 4759 can be used as a general guide, but individual test methods must be clearly stipulated and communicated to the parties involved.

10.2 Upon request of the purchaser in the contract or order, a manufacturer's certification that the material was manufactured and tested in accordance with this specification, together with a report of the test results, shall be furnished at the time of shipment.

Table 1(a) – Specification for Geosynthetic Clay Liners (GCLs)

Property	ASTM Test Method	Reinforced GCL			Non-Reinforced GCL			Testing Frequency
		GT-Related	GT Polymer Coated	GM-GF Related	GT-Related	GT Polymer Coated	GM-GF Related	
Clay (as received)								
swell index (ml/2g)	D5890	24	24	24	24	24	24	50 tonnes
fluid loss (ml)[1]	D5891	18	18	18	18	18	18	50 tonnes
Geotextiles (as received)								
cap fabric (nonwoven) - mass/unit area (g/m^2)[2]	D5261	200	200	200	100	100	n/a/100	20,000 m^2
cap fabric -(woven) - mass/unit area (g/m^2)	D5261	100	100	100	100	100	100	20,000 m^2
carrier fabric (nonwoven composite) - mass/(g/m^2)[2]	D5261	200	200	200	100	100	n/a/100	20,000 m^2
carrier fabric (woven) - mass/unit area (g/m^2)	D5261	100	100	100	-	-	-	20,000 m^2
coating - mass/unit area (g/m^2)[3]	D5261	n/a	200	n/a	n/a	200	n/a	4,000 m^2
Geomembrane/Geofilm (as received)								
thickness[4] (mm)	D5199/D5994	n/a	n/a	0.40/0.50/0.10	n/a	n/a	0.40/0.75/0.10	20,000 m^2
density (g/cc)	D1505/D792	n/a	n/a	0.92	n/a	n/a	0.92	20,000 m^2
break tensile strength, MD&XMD (kN/m)	D6693	n/a	n/a	n/a	n/a	n/a	6.0	20,000 m^2
break tensile strength, MD (kN/m)	D882	n/a	n/a	2.5	n/a	n/a	2.5	20,000 m^2
GCL (as manufactured)								
mass of GCL (g/m^2)[5]	D5993	4000	4050	4100	4000	4050	4100	4,000 m^2
mass of bentonite (g/m^2)[5]	D5993	3700	3700	3700	3700	3700	3700	4,000 m^2
moisture content[1] (%)	D5993	35	35	35	35	35	35	4,000 m^2
tensile str., MD (kN/m)	D6768	4.0	4.0	4.0	4.0	4.0	4.0	20,000 m^2
peel strength (N/m)	D6496	360	360	360	n/a	n/a	n/a	4,000 m^2
permeability[1] (m/sec), "or"	D5887	5×10^{-11}	n/a	n/a	5×10^{-11}	n/a	n/a	25,000 m^2
flux[1] ($m^3/sec\text{-}m^2$),	D5887	1×10^{-8}	n/a	n/a	1×10^{-8}	n/a	n/a	25,000 m^2
GCL permeability[1],[6],[7] (m/sec) (max. at 35 kPa)	D6766	1×10^{-8}	n/a	n/a	1×10^{-8}	n/a	n/a	yearly
GCL permeability[1],[6],[7] (m/sec) (max. at 500 kPa)	D6766 mod.	5×10^{-10}	n/a	n/a	5×10^{-10}	n/a	n/a	yearly
Component Durability								
geotextile and reinforcing yarns [8] (% strength retained)	See § 5.6.2	65	65	n/a	65	65	n/a	yearly
geomembrane	See § 5.6.3	n/a	n/a	GM Spec[9]	n/a	n/a	GM Spec[9]	yearly
geofilm/polymer treated[8] (% strength retained)	See § 5.6.4	n/a	85	80	n/a	85	80	yearly

n/a = not applicable with respect to this property :

(1) These values are maximum (all others are minimum)

(2) For both cap and carrier fabrics for nonwoven reinforced GCLs; one, or the other, must contain a scrim component of mass ≥ 100 g/m^2 for dimensional stability. This only applies to GM/GCL composites which are exposed to the atmosphere for several months or longer so as to mitigate panel separation.

(3) Calculated value obtained from difference of coated fabric to as-received fabric

(4) First value is for smooth geomembrane; second for textured geomembrane; third for geofilm

(5) Mass of the GCL and bentonite is measured after oven drying per the stated test method

(6) Value represents GCL permeability after permeation with a 0.1 M calcium chloride solution (11.1 g CaCl2 in 1-liter water); for termination criterion see § 5.6.1

(7) Test should be run on the pure bentonite only. Not on polymer modified bentonites.

(8) Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days

(9) Durability criteria should follow the appropriate specification for the geomembrane type used; i.e., GRI GM-13 for HDPE, GRI GM-17 for LLDPE or GRI GM-18 for fPP

Table 1(b) – Specification for Geosynthetic Clay Liners (GCLs)

Property	ASTM Test Method	Reinforced GCL			Non-Reinforced GCL			Testing Frequency
		GT-Related	GT Polymer Coated	GM-GF Related	GT-Related	GT Polymer Coated	GM-GF Related	
Clay (as received)								
swell index (ml/2g)	D5890	24	24	24	24	24	24	50 tonnes
fluid loss (ml)[1]	D5891	18	18	18	18	18	18	50 tonnes
Geotextiles (as received)								
cap fabric (nonwoven) - mass/unit area (oz/yd^2)[2]	D5261	5.9	5.9	5.9	3.0	3.0	n/a/3.0	25,000 yd^2
cap fabric (woven) - mass/unit area (oz/yd^2)	D5261	3.0	3.0	3.0	3.0	3.0	3.0	25,000 yd^2
carrier fabric (nonwoven composite) - mass/(oz/yd^2)[2]	D5261	5.9	5.9	5.9	3.0	3.0	n/a/3.0	25,000 yd^2
carrier fabric (woven) - mass/unit area (oz/yd^2)	D5261	3.0	3.0	3.0	-	-	-	25,000 yd^2
coating - mass/unit area (oz/yd^2)[3]	D5261	n/a	5.8	n/a	n/a	5.8	n/a	5,000 yd^2
Geomembrane/Geofilm (as received)								
thickness[4] (mils)	D5199/D5994	n/a	n/a	15/20/4	n/a	n/a	15/30/4	25,000 yd^2
density (g/cc)	D1505/D792	n/a	n/a	0.92	n/a	n/a	0.92	25,000 yd^2
break tensile strength, MD&XMD (lb/in.)	D6693	n/a	n/a	n/a	n/a	n/a	34	25,000 yd^2
break tensile strength, MD & XMD (lb/in.)	D882	n/a	n/a	14	n/a	n/a	14	25,000 yd^2
GCL (as manufactured)								
mass of GCL (lb/ft^2)[5]	D5993	0.81	0.83	0.84	0.81	0.83	0.84	5,000 yd^2
mass of bentonite (lb/ft^2)[5]	D5993	0.75	0.75	0.75	0.75	0.75	0.75	5,000 yd^2
moisture content[1] (%)	D5993	35	35	35	35	35	35	5,000 yd^2
tensile str., MD (lb/in.)	D6768	23	23	23	23	23	23	25,000 yd^2
peel strength (lb/in.)	D6496	2.1	2.1	2.1	1.0	1.0	1.0	5,000 yd^2
permeability[1] (cm/sec), "or"	D5887	5×10^{-9}	n/a	n/a	5×10^{-9}	n/a	n/a	30,000 yd^2
flux[1] ($cm^3/sec\text{-}cm^2$),	D5887	1×10^{-6}	n/a	n/a	1×10^{-6}	n/a	n/a	30,000 yd^2
GCL permeability[1],[6],[7] (cm/sec) (max. at 5 $lb/in.^2$)	D6766	1×10^{-6}	n/a	n/a	1×10^{-6}	n/a	n/a	yearly
GCL permeability[1],[6],[7] (cm/sec) (max. at 70 $lb/in.^2$)	D6766 mod.	5×10^{-8}	n/a	n/a	5×10^{-8}	n/a	n/a	yearly
Component Durability								
geotextile and reinforcing yarns[8] (% strength retained)	See § 5.6.2	65	65	n/a	65	65	n/a	yearly
geomembrane	See § 5.6.3	n/a	n/a	GM Spec[9]	n/a	n/a	GM Spec[9]	yearly
geofilm/polymer treated[8] (% strength retained)	See § 5.6.4	n/a	85	80	n/a	85	80	yearly

n/a = not applicable with respect to this property :

(1) These values are maximum (all others are minimum)

(2) For both cap and carrier fabrics for nonwoven reinforced GCLs; one, or the other, must contain a scrim component of mass > 2.9 oz/yd^2 for dimensional stability. This only applies to GM/GCL composites which are exposed to the atmosphere for several months or longer so as to mitigate panel separation.

(3) Calculated value obtained from difference of coated fabric to as-received fabric

(4) First value is for smooth geomembrane; second for textured geomembrane; third for geofilm

(5) Mass of the GCL and bentonite is measured after oven drying per the stated test method

(6) Value represents GCL permeability after permeation with a 0.1 M calcium chloride solution (11.1 g CaCl2 in 1-liter water); termination criterion see § 5.6.1.

(7) Test should be run on pure bentonite. Not on polymer modified bentonite.

(8) Value represents the minimum percent strength retained from the as-manufactured value after oven aging at 60°C for 50 days

(9) Durability criteria should follow the appropriate specification for the geomembrane used; i.e., GRI GM-13 for HDPE, GRI GM-17 for LLDPE or GRI GM-18 for fPP

Adoption and Revision Schedule

for

GCL Specification for GRI-GCL3

"Test Methods, Required Properties, and Testing Frequencies of Geosynthetic Clay Liners (GCLs)"

Adopted: May 16, 2005

Revision #1: March 30, 2009: Removed permeability testing requirement for GM back, GF backed, and polymer treated GCLs. Various editorial modifications.

Revision #2: July 26, 2010: (i) Increased cap fabric weights for nonreinforced GCL's from 90 to 100 g/m^2 (3.0 oz/yd^2); (ii) Included a maximum value for initial moisture content of 35% (previously it was "under investigation"); (iii) Termination criterion for D6766 test was modified per Section 5.6.1; and (iv) Added to Footnote #2, "This only applies to GM/GCL composites which are exposed to the atmosphere for months or longer so as to mitigate panel separation".

Revision #3: March 14, 2016: (i) Increased GT polymer coated mass/unit area from 2.9 oz/yd^2 to 5.8 oz/yd^2 (100 g/m^2 to 200 g/m^2); (ii) Increased termination criterion in Section 5.6.1 for ASTM D6141 from two (2) to ten (10) pore volumes; (iii) Introduced Footnote #7, which applies to ASTM D6766 testing. The test should be run on pure bentonite, not polymer modified bentonite. Indexed Footnotes 8 and 9 accordingly.

Revision #4: March 28, 2016: Decreased termination criterion in Section 5.6.1 for ASTM D6141 from ten (10) to eight (8) pore volumes.

121 REGIONAL DISPOSAL FACILITY
COLLIN COUNTY, TEXAS
TCEQ PERMIT APPLICATION NO. MSW 2294

PART III – SITE DEVELOPMENT PLAN

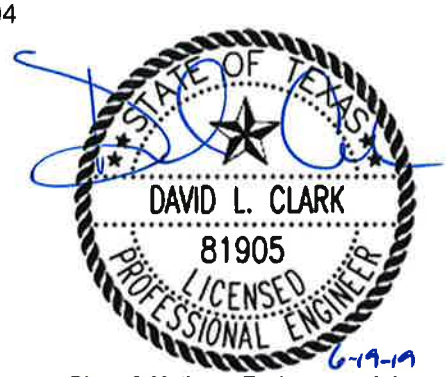
ATTACHMENT 16
ALTERNATE LINER (OPTION 3)
GEOTECHNICAL DESIGN

Prepared for

North Texas Municipal Water District

Permit Issued January 8, 2004

Revised June 2019



Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

Prepared by

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Firm Registration No. F-256

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ALTERNATE LINER (OPTION 3) DESIGN DETAILS

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1 PREVIOUS FIELD EXPLORATION

30 TAC §330.63(e)(5)

The geotechnical design of the alternate liner (Option 3) system is based on the previous field exploration included in Attachment 4 – Geology and Geotechnical Report, prepared by The Carel Corporation as part of the MSW permit application for the North Texas Municipal Water District (NTMWD) (TCEQ Permit No. MSW 2294, revised August 2010). Geotechnical tests included in Attachment 4 were performed on samples recovered from the borings to evaluate the physical and engineering properties of the subsurface materials.

Numerous Atterberg limits, gradation, and percent passing the number 200 sieve tests were performed during the previous field exploration. These test results were used to classify the soils according to the Unified Soil Classification System (USCS) and to evaluate the engineering properties of the soils.

Unit dry weight and natural moisture content tests were performed to determine the physical properties of the soils. In addition, direct shear tests were performed on selected samples to evaluate the shear strength of the soils. These test results were used in the evaluation of slope stability of the alternate liner (Option 3) system that is included in Appendix 16-B.

2 SUBSURFACE MATERIALS

30 TAC §330.63(e)(5)

The information from the previous field exploration included in Attachment 4 indicates that the subsurface materials at the site consists of Austin Chalk.

2.1 Material Properties

The laboratory test results are included in Attachment 4 – Geology and Geotechnical Report and are summarized on Table 16-1. These test results were reviewed along with the boring logs to develop generalized soil properties for use in the alternate liner (Option 3) slope stability analyses included in Appendix 16-B. As shown on the cross sections in Attachment 2, the landfill excavation will encounter mostly weathered Austin Chalk, and unweathered Austin Chalk.

2.2 Material Requirements

On-site soils will be required for construction of the protective cover components of the liner system. On-site soils will also be required for operational cover (daily and intermediate) and general earthfill. Typical material requirements for the various landfill components are summarized in Table 16-2.

Protective cover soils will not contain rocks larger than 4 inches in diameter. Operational cover soils will not have been previously mixed with waste materials. The test results and boring logs indicate that any of the soil material excavated from the site will be suitable for use as operational and protective cover.

General earthfill used to construct the site roads and embankments will consist of medium to low plasticity soils. The classification test results indicate that the on-site soils are suitable for use as structural fill material.

Table 16-1
NTMWD 121 RDF
Average Properties of On-Site Materials

Soil Description	Liquid Limit %	Plastic Limit %	Plasticity Index %	Passing 200 Sieve %	Moisture Content %	Unit Dry Weight (pcf)
Composite of Black Clay with Chalk	58	24	34	85.5	22.5	96.4
Composite of White Austin Chalk	43	23	20	79.1	19.4	106.6
Composite of Gray Austin Chalk	47	22	25	81.9	17.6	108.2

Table 16-2
NTMWD 121 RDF
Typical Soil Requirements for Protective Cover and Landfill Development

Landfill Component	Classification	LL	PI	% - 200	Hydraulic Conductivity cm/sec	Material Source
Protective Cover	SP, SW, SM, SC, CL, CH, ML, MH	No rocks larger than 4 inches in diameter				On-site
Operational Cover (Daily Cover, Intermediate Cover)	SP, SC, CL, CH, CL-ML, MH, ML	Not mixed with waste				
General Fill	SC, CL, CH, ML, CL-ML, MH	NA	5 min	15 min	NA	

3 EARTHWORK

30 TAC §330.337(e)

3.1 Excavation

The cross sections in Attachment 2 show that the excavation will be up to 60 feet below the surrounding ground surface. Because of the variability of the soil materials in the site profile, the excavated materials should be visually classified and then stockpiled separately according to the construction material properties outlined in Table 16-2. Prior to use the soils will be tested for suitability in accordance with Attachment 10.

3.2 Earthfill

General fill will be required to construct roads and perimeter berms. General fill should consist of on-site soils, which are free of organic or other objectionable materials. General fill should be spread in maximum 9-inch-thick loose lifts. General fill should be compacted to a minimum of 95 percent of maximum dry density as defined by the standard Proctor test (ASTM D698), within a range of 2 percentage points below to 4 percentage points above optimum moisture content. A minimum of one standard Proctor test should be performed on each representative soil used as general fill material.

4 SLOPE STABILITY ANALYSES

30 TAC §330.337(e)

Slope stability analyses were performed on representative sections to predict the stability of the liner slope, interim waste slope, and final waste slope. The geometry of the sections was developed from the proposed excavation and final cover plans and from data on logs of borings drilled in the vicinity of each section.

Table 16-3 summarizes the unit weights and strength parameters that were used for the stability analyses. The unit weights and strength parameters for the soils were selected based on a review of the historic boring logs and laboratory and field test results. The unit weights and strength parameters for the liner/cover material and solid waste were selected based on engineering judgment and published values. Site specific strength parameters for the liner geosynthetic materials will be verified prior to construction in accordance with Attachment 10.

Table 16-3
NTMWD 121 RDF
Summary of Material Weight and Strength Properties

Material	Wet Weight (pcf)	Total Stress		Effective Stress	
		Cohesion (psf)	Friction (deg)	Cohesion (psf)	Friction (deg)
Austin Chalk	140.6	10,000	0	0	0
Liner/Cover Floor Geosynthetics	N/A	40	16	40	16
Liner/Cover Sidewall Geosynthetics	N/A	40	16	40	16
Solid Waste	50.0	250	25	250	25

The interim waste slope was analyzed for short-term conditions using total stress parameters. The final waste slope was analyzed for long-term conditions using effective stress parameters. GEOSTASE4, a computer program developed to model the slope stability, was used to analyze the stability of the interim waste slopes and final waste slopes. The results of the stability analyses indicate that the proposed slopes are stable under the conditions analyzed. Table 16-4 summarizes the results of the stability analyses and compares the calculated factor of safety to the recommended minimum factor of safety. The recommended minimum factors of safety were selected from the Corps of Engineers "Design and Construction of Levees" manual (EM 1110-2-1913). The slope stability analyses are provided in Appendix 16-B.

Table 16-4
NTMWD 121 RDF
Summary of Slope Stability Analyses

Condition	Minimum Calculated Factor of Safety	Recommended Factor of Safety	Acceptable Factor of Safety
3H:1V Interim Waste Slope			
Sliding Block Failure	1.4	1.3	Yes
Final Waste Slope			
Sliding Block Failure	1.7	1.5	Yes

The stability of the composite liner system for the interim waste and final waste slopes was investigated by a sliding block analysis. This was accomplished by analyzing the resistance to failure within the liner system. The strength parameters assigned to the liner system (including protective cover) were selected based on the most conservative interface parameters of the geosynthetic liner system (geomembrane to geocomposite interface at the floor of the cell and GCL to geomembrane interface at the sidewall of the cell).

The slope stability analyses are only valid for the conditions that were analyzed. Any changes to the excavation plan, dewatering system, ballast system, liner system, final cover system or landfill completion plan will necessitate that the slope stability analyses be revised to reflect the actual conditions. Interim 3H:1V waste slope lengths must not exceed 320 feet based on the results of the interim waste slope sliding block analysis. Temporary construction slopes should not be steeper than the 3H:1V interim slopes and concentrated loadings such as heavy equipment and soil stockpiles should not be placed near the crest of slopes unless additional slope stability analyses are performed.

5 LINER CONSTRUCTION

30 TAC §330.331

5.1 Subgrade Preparation

The liner subgrade must be firm and stable. Prior to beginning liner construction, the subgrade should be proof-rolled with heavy, rubber-tired construction equipment to detect soft areas. Isolated soft areas should be undercut then backfilled with compacted earthfill in accordance with the requirements for general fill. Low areas should be brought to the design grades with general fill that is placed and compacted in accordance with the requirements in Section 3.

5.2 Alternate Liner System (Option 3)

The alternate liner system (Option 3) will consist of a geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane, a geocomposite drainage layer, and a 2-foot-thick layer of protective soil cover. The liner details are provided in Appendix 16-A.

5.3 Protective Cover

The protective cover should be constructed of sands, silts, or clays that are free of debris, large rock, plant materials, frozen materials, foreign objects, and organic material. Sand, silt, and clay will be available from proposed landfill excavations or on-site borrow sources to provide material for the protective cover.

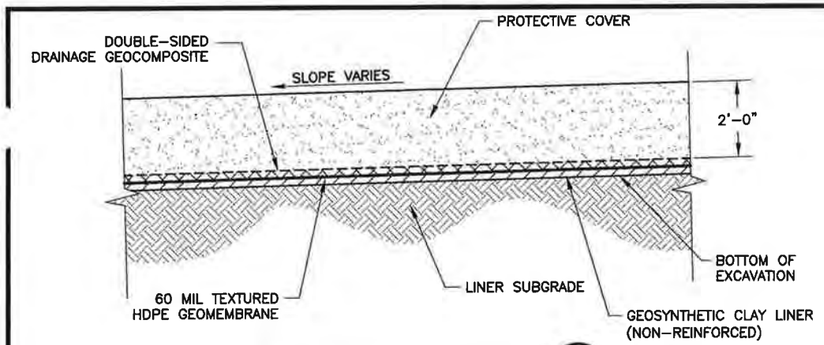
5.4 Liner Testing and Documentation

CQA testing of the soil liner must be performed as the liner is being constructed. Liner system testing is addressed in Attachment 10. The construction methods and test procedures documented in the GCLER and GLER must be consistent with the requirements of Attachment 10.

NTMWD 121 RDF

APPENDIX 16-A

ALTERNATE LINER (OPTION 3) DESIGN DETAILS



BOTTOM LINER OPTION 3 (L1)
16–A.1

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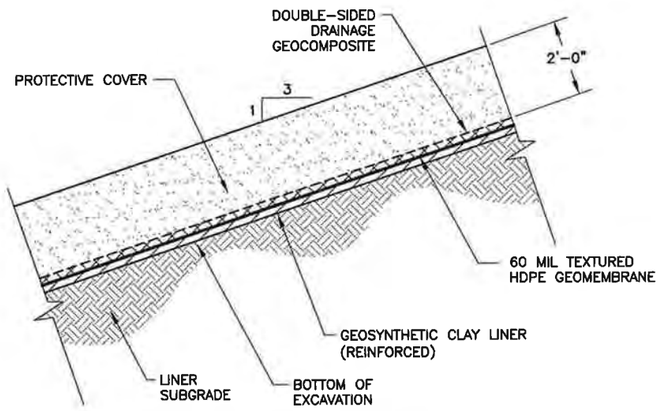
SCALE IN FEET



SIDEWALL LINER OPTION 3 (L2)
16–A.1

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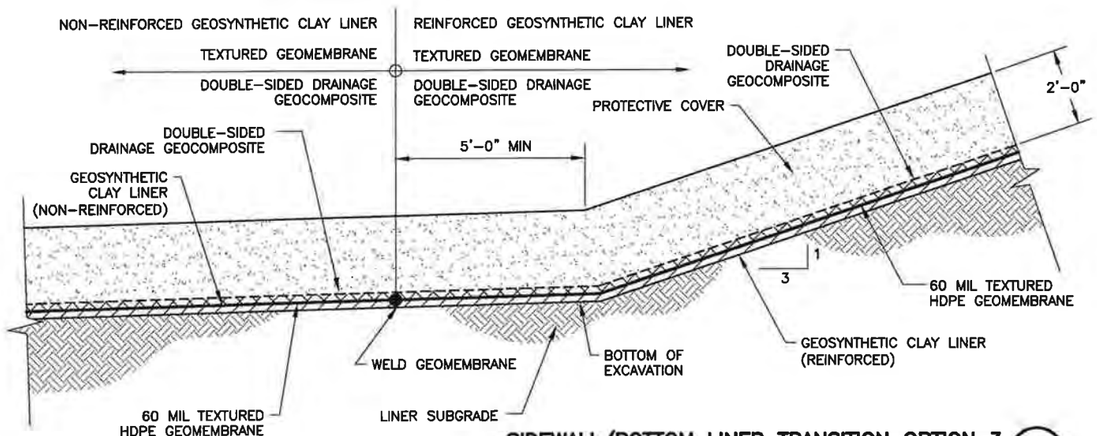
SCALE IN FEET



SIDEWALL/BOTTOM LINER TRANSITION OPTION 3 (L3)
16–A.1

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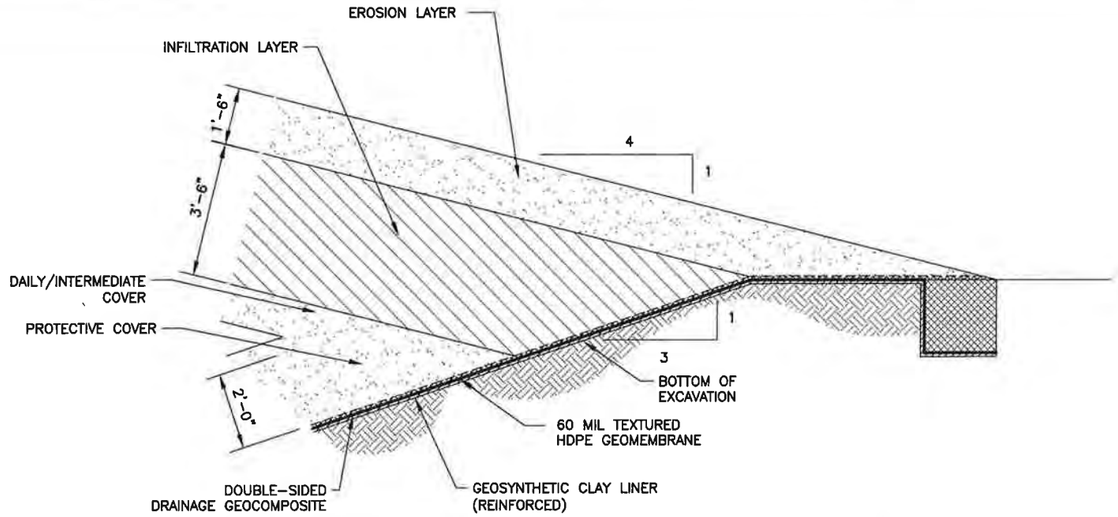
SCALE IN FEET



LINER/COVER TIE–IN OPTION 3 (L4)
16–A.1

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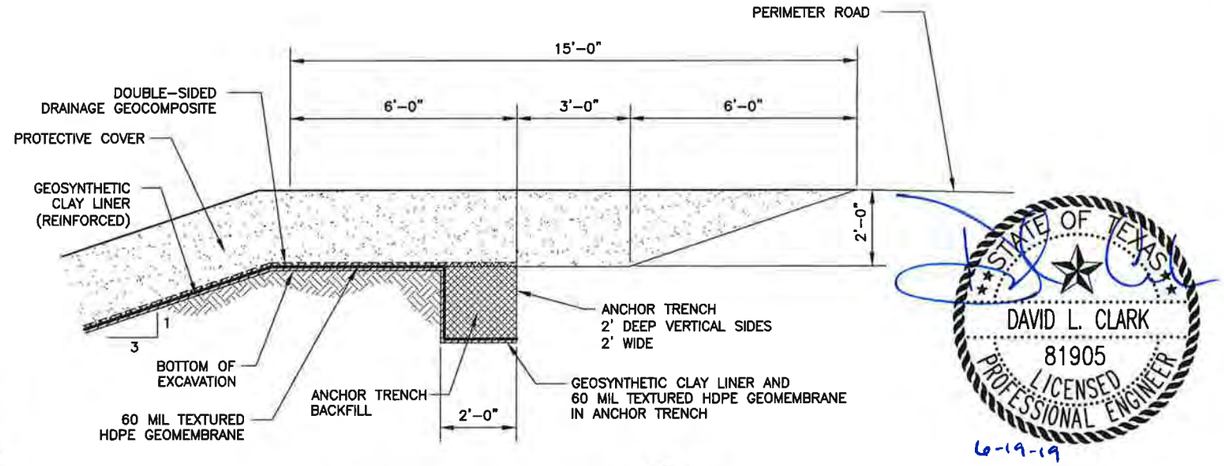
SCALE IN FEET



ANCHOR TRENCH OPTION 3 (L5)
16–A.1

0 2 4
SCALE IN FEET

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED PROFESSIONAL ENGINEER
6-19-19

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REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

LINER DETAILS OPTION 3

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817–563–1144
TBPE FIRM NO. F–256 | TBPG FIRM NO. 50222

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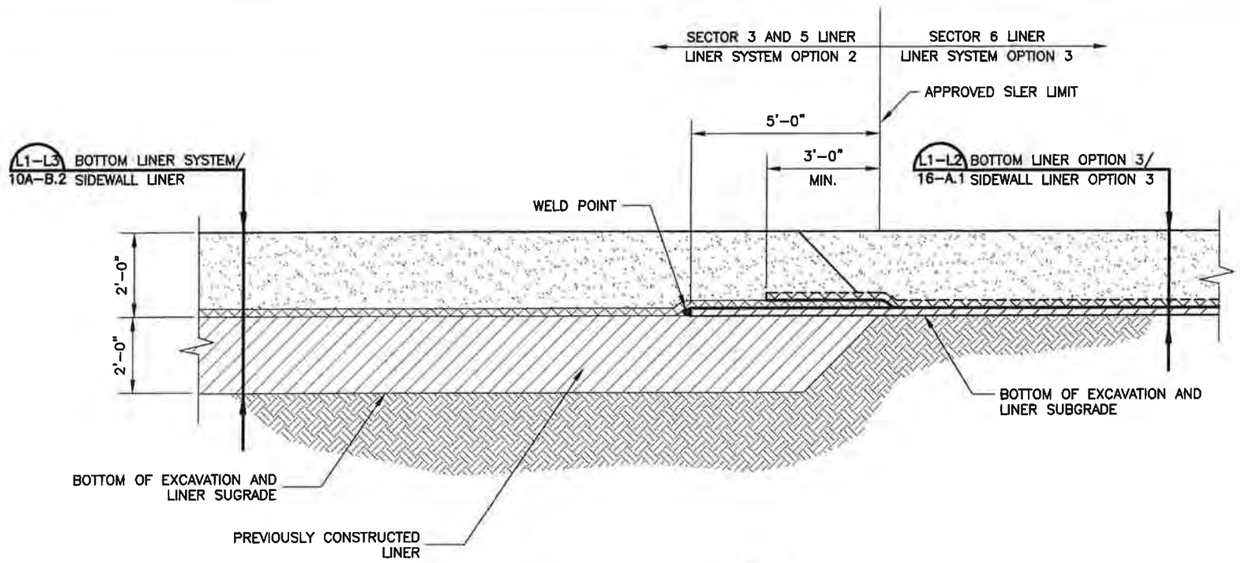
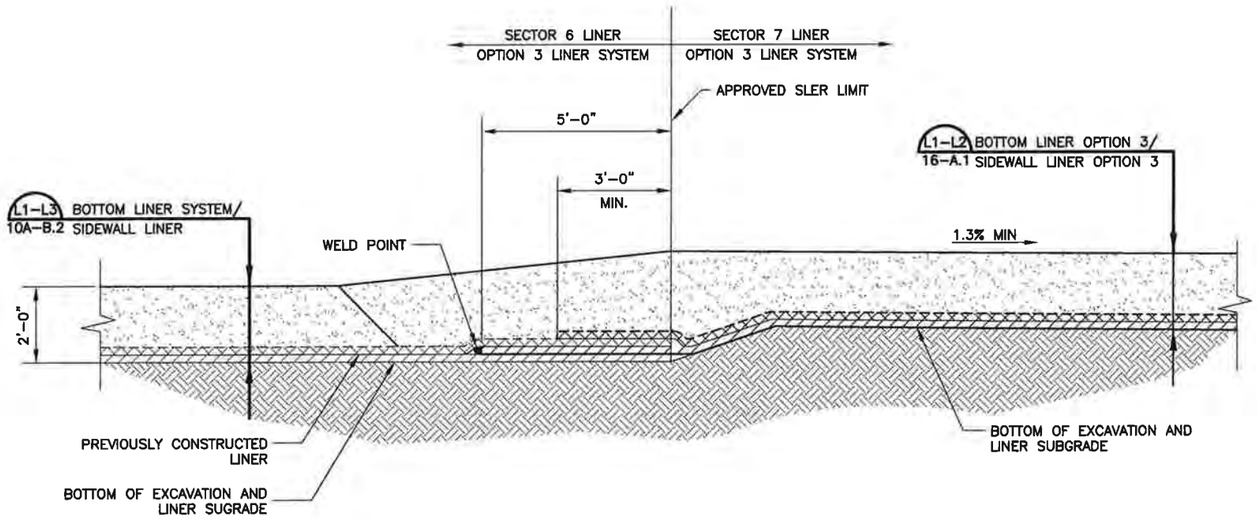


SECTOR 6 LINER TIE-IN L6
16-A.2

0 2 4
SCALE IN FEET

NOTES:

1. GCL AND FML WILL OVERLAP THE PREVIOUSLY CONSTRUCTED LINER A MINIMUM OF FIVE FEET.
2. REFER TO ATTACHMENT 1, DRAWING 1.3 FOR SECTOR SEQUENCING.



SECTOR 7 LINER TIE-IN L7
16-A.2

0 2 4
SCALE IN FEET

NOTES:

1. GCL AND FML WILL OVERLAP THE PREVIOUSLY CONSTRUCTED LINER A MINIMUM OF FIVE FEET.
2. REFER TO ATTACHMENT 1, DRAWING 1.3 FOR SECTOR SEQUENCING.

STATE OF TEXAS
DAVID L. CLARK
81905
LICENSED
PROFESSIONAL ENGINEER
6-19-19

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

LINER DETAILS OPTION 3

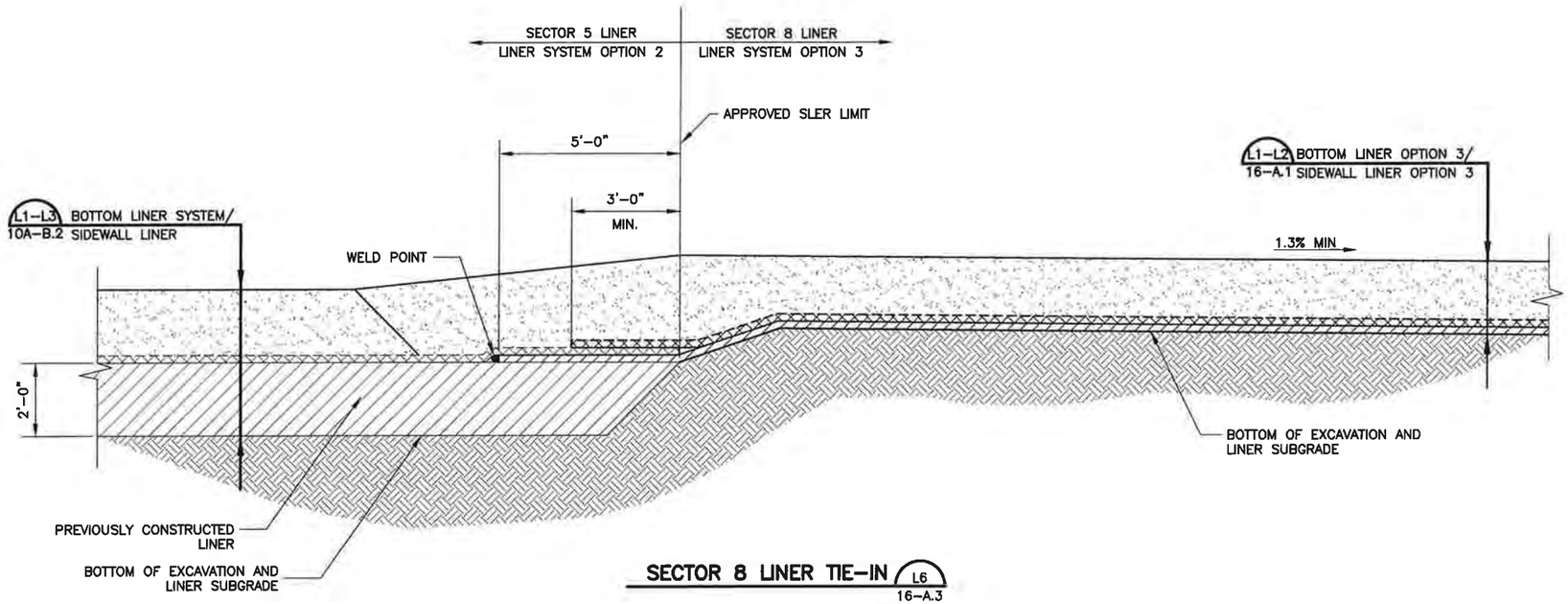
NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. FAW	DATE : 06/19	DRAWING	
DWN. MJW	SCALE : GRAPHIC	16-A.2	
CHK. FAW	DWG : 16-A_DEETS.dwg		

J:\211\01\126\16-A_DEETS.dwg Layout: 16-A.2 User: mwelch



SECTOR 8 LINER TIE-IN (L6 / 16-A.3)

0 2 4

SCALE IN FEET

NOTES:

1. GCL AND FML WILL OVERLAP THE PREVIOUSLY CONSTRUCTED LINER A MINIMUM OF FIVE FEET.
2. REFER TO ATTACHMENT 1, DRAWING 1.3 FOR SECTOR SEQUENCING.

J:\211\01\126\16-A_DEETS.dwg Layout: 16-A.3 User: mwelch

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

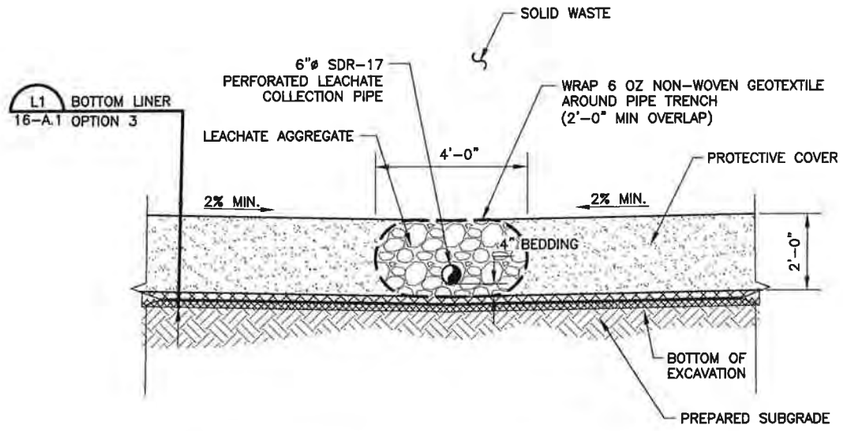
LINER DETAILS OPTION 3

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

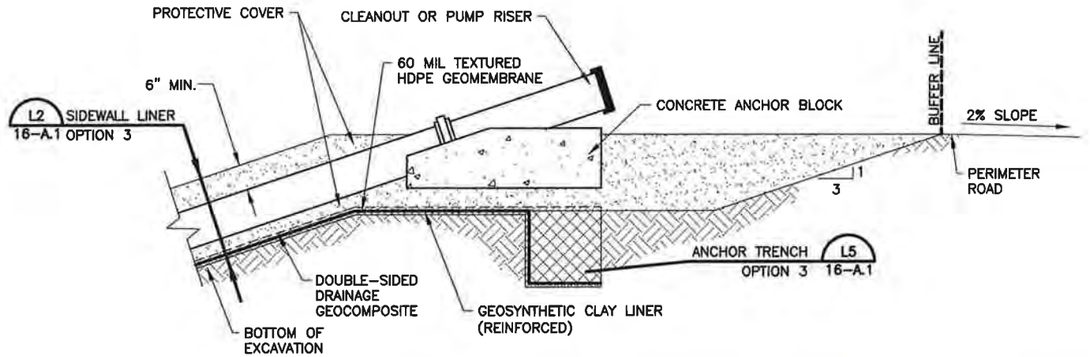
DSN. FAW	DATE : 06/19	DRAWING	16-A.3
DWN. MJW	SCALE : GRAPHIC		
CHK. FAW	DWG : 16-A_DEETS.dwg		



LEACHATE COLLECTION TRENCH OPTION 3 (LC1) 16-A.4

0 2 4

SCALE IN FEET



LEACHATE PIPE CLEANOUT OPTION 3 (LC2) 16-A.4

0 2 4

SCALE IN FEET

STATE OF TEXAS
DAVID L. CLARK
81905
REGISTERED
PROFESSIONAL ENGINEER
6-19-19

LEACHATE COLLECTION SYSTEM DETAILS – OPTION 3

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 TBPG FIRM NO. 50222

REVISIONS							
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY	

DSN. FAW	DATE : 06/19	ATTACHMENT
DWN. MJW	SCALE : GRAPHIC	16-A.4
CHK. FAW	DWG : 16-A_LCSDEETS.dwg	

J:\211\01\126\16-A_LCSDEETS.dwg Layout: LAYOUT 1 User: mwelch

NTMWD 121 RDF

APPENDIX 16-B

ALTERNATE LINER (OPTION 3) SLOPE STABILITY ANALYSES

APPENDIX 16-B
SLOPE STABILITY ANALYSES

The results of the stability analyses indicate that the proposed slopes are stable under the conditions analyzed. The Geostase output files are presented on pages 16-B-6 through 16-B-44. The liner veneer stability calculations are provided on pages 16-B-3 through 16-B-6. Table 16-B-1 summarizes the results of the stability analyses and compares the calculated factor of safety to the recommended minimum factor of safety. The recommended minimum factors of safety were selected from the Corps of Engineers "Design and Construction of Levees" manual (EM 1110-2-1913).

Table 16-B-1
Summary of Slope Stability Analyses

Condition	Minimum Calculated Factor of Safety	Recommended Factor of Safety	Acceptable Factor of Safety
3H:1V Interim Waste Slope[1]			
Sliding Block Failure	1.4	1.3	Yes
Final Waste Slope[1]			
Sliding Block Failure	1.7	1.5	Yes

[1]The stability of the composite liner system for the interim waste and final waste slopes was investigated by a sliding block analysis. This was accomplished by analyzing the resistance to failure within the liner system. The strength parameters assigned to the liner system (including protective cover) were selected based on the most conservative interface parameters of the geosynthetic liner system (geomembrane to geocomposite interface at the floor of the cell and GCL to geomembrane interface at the sidewall of the cell).

NTMWD 121 RDF
Slope Stability Analyses Parameters

Required: Select the appropriate soil parameters for the slope stability analyses.

References:
1) Emcon Associates, *Attachment 4 - Geology and Geotechnical Report,* City of Pampa Landfill Permit Application, Technically Complete August 1995.
2) Table 8-3.1 Typical Engineering Properties of Compacted Materials, *Geotechnical Engineering Procedures for Foundation Design of Buildings and Structures,* Naval Facilities Engineering Command, 2005.
3) Bouazza, A., Zornberg, J.G., and Adam, D., *Geosynthetics in Waste Containment Facilities: Recent Advances,* 2002.
4) Qian, X., Koerner, R.M., and Gray, Donald H., *Geotechnical Aspects of Landfill Design and Construction,* Prentice Hall, 2002.

Solution: The following materials may be included in the slope stability analyses.

Material	Moisture[a] %	Dry Wt[a] pcf	Wet Wt[b] pcf
Austin Chalk	12.7	124.8	140.6
Liner/Cover	N/A	N/A	N/A
Solid Waste	N/A	N/A	50.0

[a]Average laboratory test values
[b]Wet Wt = Dry Wt x (1 + Moisture)

Total stress parameters will be used to analyze short-term stability and effective stress parameters will be used to analyze long-term stability.

Material	Total Stress		Effective Stress	
	cohesion (psf)	friction (deg)	cohesion (psf)	friction (deg)
Austin Chalk	10,000[a]	0[a]	0[a]	0[a]
Liner/Cover Floor Geosynthetics	40[c]	16[d]	40[c]	16[d]
Liner/Cover Sidewall Geosynthetics	40[c]	16[d]	40[c]	16[d]
Solid Waste	250[e]	25[e]	250[e]	25[e]

[a]Reference 1.
[c]Assumed similar interface to textured geomembrane/compacted clay in Reference 3.
[d]Reference 3 for geosynthetic clay liner/clay.
[e]Reference 4.

Interface parameters for the sidewall geosynthetics will be used to evaluate the liner and cover veneer stability. The strength parameters shall be verified by conformance testing in accordance with Attachment 10B, Section 5.5.2.

Material Interface	Friction Angle (Degrees)	Cohesion (psf)
Soil/Geocomposite	25[a]	25[a]
Geocomposite/Geomembrane	18[a]	40[b]
Geomembrane/GCL	18[a]	40[b]
Austin Chalk	16[a]	40[b]

[a]Reference 3.
[b]Assumed.

NTMWD 121 RDF
Geosynthetic Stability Analyses

Required:

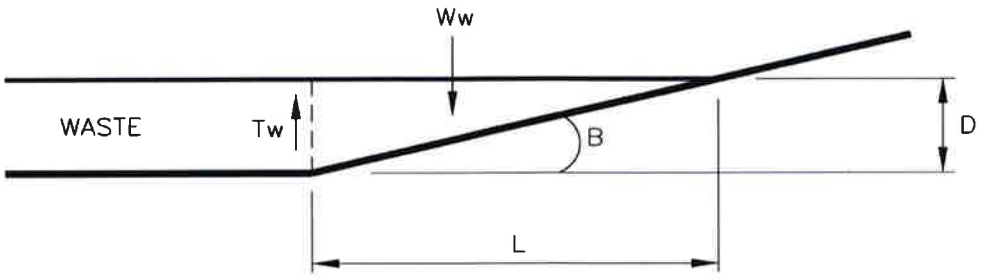
1) Check tensile stress in geomembrane.
2) Size geomembrane anchor trench.
3) Perform a veneer stability analysis of the liner system.

References:

1) *Designing with Geosynthetics,* 2nd Edition, Koerner, Prentice Hall.
2) *An Engineering Manual for Slope Stability Studies,* 2nd Edition, Duncan, Buchignani, Dept. of Civil Engineering, University of California.

Solution:

1) ***Tensile Stress in Geomembrane***
Forces on the liner are shown below:

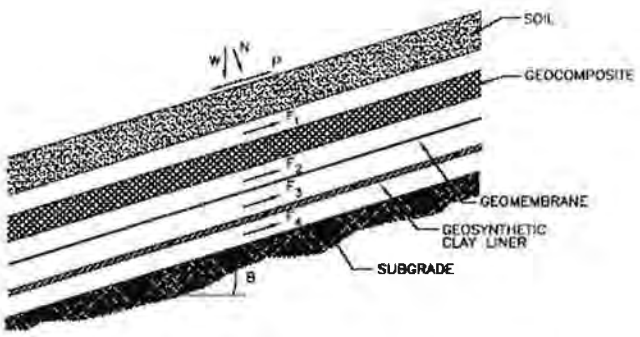


β =	slope angle =	18.4 deg
g_w =	unit weight of solid waste/daily cover =	50.0 pcf
Φ =	internal angle of friction for solid waste =	25.0 deg
D =	waste lift thickness =	15.0 ft
L =	length of lift =	45.0 ft
K_o =	$1 - \sin\Phi$ =	0.6

Calculate the forces on the liner:

W_w =	weight of solid waste = $DL\,g_w/2$ =	16,875 plf
T_w =	friction at edge of waste = $k_o(D^2\,g_w/2)\tan F$ =	1,514 plf
W =	net force of waste = $W_w - T_w$ =	15,361 plf

Forces within the liner system are shown below:



A_1 =	friction angle between protective cover soil/geocomposite =	25.0 deg
A_2 =	friction angle between geocomposite/geomembrane =	18.0 deg
A_3 =	friction angle between geomembrane/GCL =	18.0 deg
A_4 =	friction angle between GCL/soil subgrade =	16.0 deg
C_1 =	cohesion between protective cover soil/geocomposite =	25.0 psf
C_2 =	cohesion between geocomposite/geomembrane =	40.0 psf
C_3 =	cohesion between geomembrane/GCL =	40.0 psf
C_4 =	cohesion between GCL/soil subgrade =	40.0 psf

Calculate the forces within the liner system:

N =	normal force on liner = $W\cos b$ =	14,575 plf
P =	shearing force on liner = $W\sin b$ =	4,849 plf

Calculate the resistance in the liner system

$F_1 = N\tan A_1 + C_1 L/\cos b$ = 7,982 plf

Since $F_1 > P$ the soil is stable and the entire force P is transferred to the next layer.

$F_2 = N\tan A_2 + C_2 L/\cos b$ = 6,633 plf

Since $F_2 > P$ the geocomposite is stable and the entire force P is transferred to the next layer.

$F_3 = N\tan A_3 + C_3 L/\cos b$ = 6,633 plf

Since $F_3 > P$ the geomembrane is stable and the entire force P is transferred to the next layer.

$F_4 = N\tan A_4 + C_4 L/\cos b$ = 6,076 plf

Since $F_4 > P$ the GCL is stable and the entire force P is transferred to the next layer.

Therefore, there is no tensile stress in the gecomposite, geomembrane or geosynthetic clay liner.

2) *Anchor Trench*

Since there is no tensile stress in the geosynthetics an anchor trench will not be required for stability. Anchor trenches will be sized to meet construction needs.

3) ***Veneer Slope Analysis***

Use the procedures and charts from Reference 2 to evaluate the stability of the liner system.

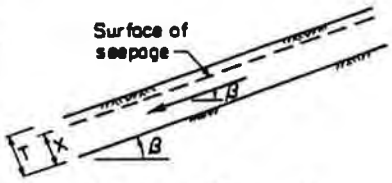
γ = total unit weight of soil

γ_w = unit weight of water

c' = cohesion intercept, ϕ' = friction angle } Effective Stress

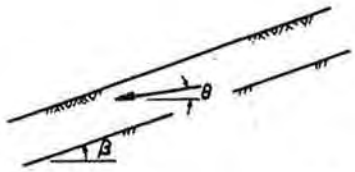
r_u = pore pressure ratio = $\frac{u}{\gamma H}$

u = pore pressure at depth H



Seepage parallel to slope

$r_u = \frac{X}{T}\frac{\gamma_w}{\gamma}\cos^2\beta$



Seepage emerging from slope

$r_u = \frac{\gamma_w}{\gamma}\frac{1}{1+\tan\beta\tan\theta}$

Steps:

① Determine r_u from measured pore pressures or formulas at right

② Determine a and b from charts below

③ Calculate $F = a\frac{\tan\phi'}{\tan\beta} + b\frac{c'}{\gamma H}$

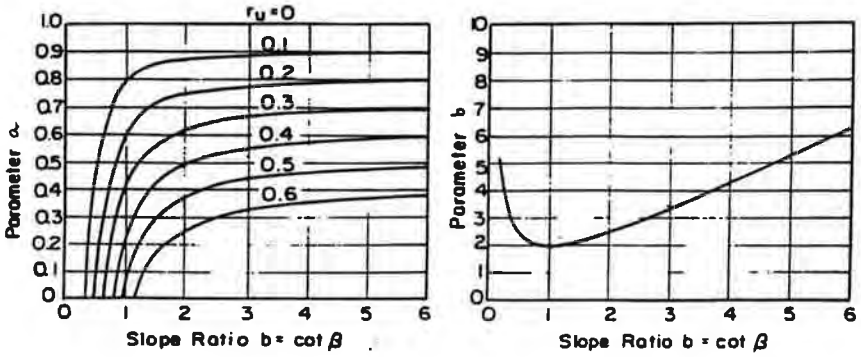


Fig. 10 STABILITY CHARTS FOR INFINITE SLOPES.

Calculate the factor of safety at each interface in the liner system. Assume typical values for interface strength parameters and the unit weight of soil. Assume that there is no pore water pressure because of the presence of the free draining layer of the geocomposite.

NTMWD 121 RDF
Geosynthetic Stability Analyses

Protective cover soil/geocomposite

Φ =	25.0	deg
β =	18.4	deg
C =	25.0	psf
u =	0.0	
γ =	120.0	pcf
r_u =	0.0	
H =	2.0	ft
a =	1.0	
b =	3.3	

FS @ soil/geocomposite =	1.7

Geocomposite/geomembrane

Φ =	18.0	deg
β =	18.4	deg
C =	40.0	psf
u =	0.0	
γ =	120.0	pcf
r_u =	0.0	
H =	2.0	ft
a =	1.0	
b =	3.3	

FS @ geocomposite/geomembrane =	1.5

Geomembrane/GCL

Φ =	18.0	deg
β =	18.4	deg
C =	40.0	psf
u =	0.0	
γ =	120.0	pcf
r_u =	0.0	
H =	2.0	ft
a =	1.0	
b =	3.3	

FS @ geomembrane/GCL =	1.5

GCL/Subgrade

Φ =	16.0	deg
β =	18.4	deg
C =	40.0	psf
u =	0.0	
γ =	120.0	pcf
r_u =	0.0	
H =	2.0	ft
a =	1.0	
b =	3.3	

FS @ GCL/soil subgrade =	1.4

3H:1V INTERIM WASTE SLOPE STABILITY – BLOCK ANALYSIS GEOSTASE INPUT PARAMETERS

This analysis evaluates the short term stability of the 3H:1V interim waste slope.

The geometry for the critical section is shown on page 16-B-8.

Total stress parameters were used to analyze the short term condition for the interim waste slope. Table 16-B-2 summarizes the material used for each soil type for purposes of this slope stability analysis. The unit weight and total stress parameters for the materials are from page 16-B-2.

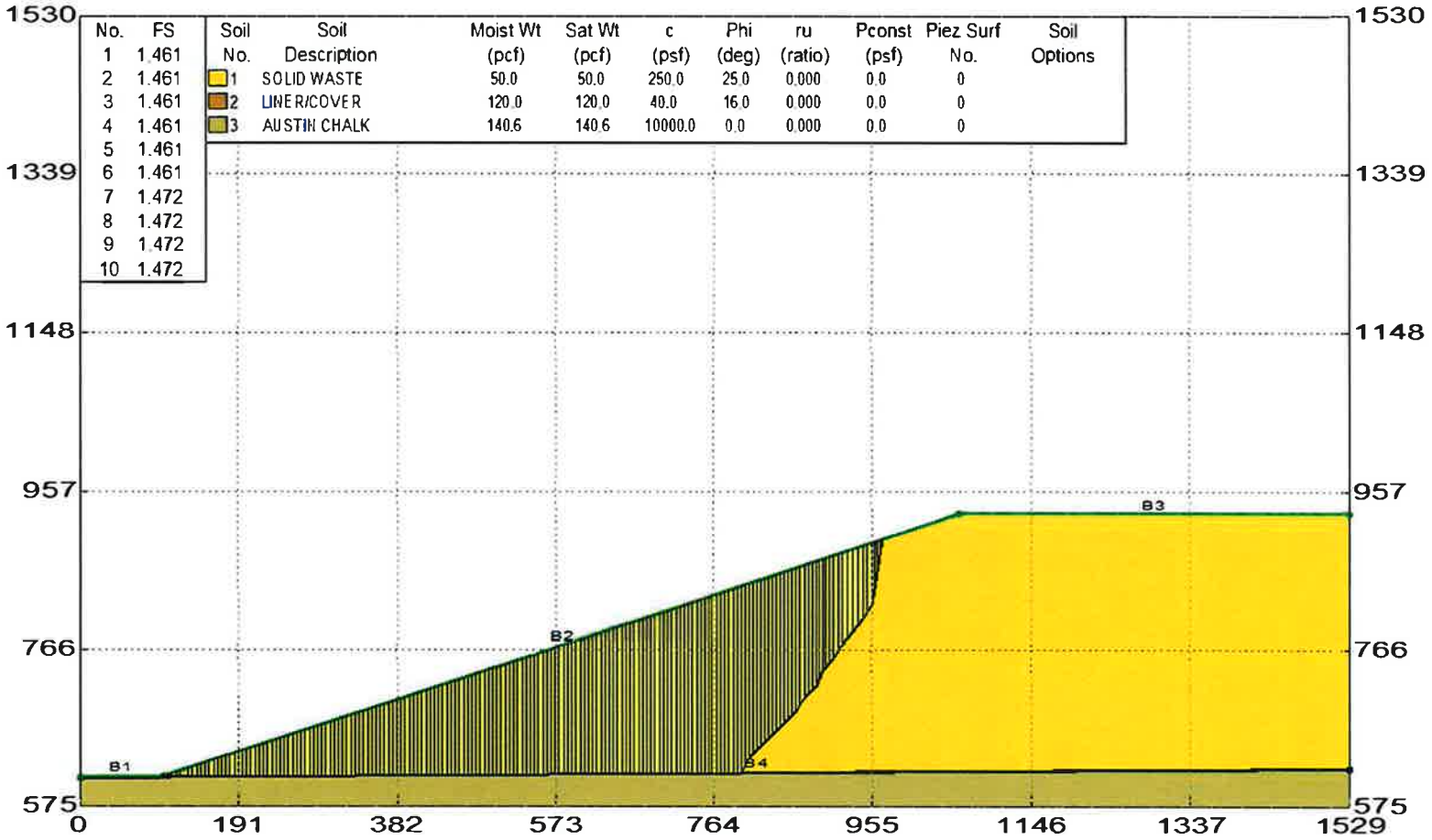
Table 16-B-2
3H:1V Interim Waste Analysis Material Inputs

Material	Soil Type
Solid Waste	1
Liner/Cover	2
Austin Chalk	3

NTMWD 121 RDF ALD
INTERIM 3:1

BIGGS AND MATHEWS ENVIRONMENTAL, INC -- FAW/MJW

\121 INTERIM 3TO1.gsd



GEOSTASE FS = 1.461

Simplified Janbu Method

GEOSTASE
Slope Stability
Analysis

GEOSTASE® by GREGORY GEOTECHNICAL SOFTWARE

PLATE C.1

*** GEOSTASE(R) ***

****

SLOPE STABILITY ANALYSIS SOFTWARE
Simplified Bishop, Simplified Janbu, or General Equilibrium (GE) Options.
(Spencer, Morgenstern-Price, USACE, and Lowe & Karafiath)
Including Pier/Pile, Planar Reinf, Nail, Tieback, Line Loads
Applied Forces, Fiber-Reinforced Soil (FRS), Distributed Loads
Nonlinear Undrained Shear Strength, Curved Strength Envelope,
Anisotropic Strengths, Water Surfaces, 3-Stage Rapid Drawdown
2- or 3-Stage Pseudo-Static & Simplified Newmark Seismic Analyses.

****

Analysis Date: 12/ 11/ 2018
Analysis Time:
Analysis By: BIGGS AND MATHEWS ENVIRONMENTAL, INC -- FAW/MJW

Input File Name: C:\GEOSTASE DATA\121 INTERIM 3TO1.gsd

Output File Name: C:\GEOSTASE DATA\121 INTERIM 3TO1.OUT

Unit System: English

PROJECT: NTMWD 121 RDF ALD

DESCRIPTION: INTERIM 3:1

BOUNDARY DATA

3 Surface Boundaries
5 Total Boundaries

Boundary No.	X - 1 (ft)	Y - 1 (ft)	X - 2 (ft)	Y - 2 (ft)	Soil Type Below Bnd
1	0.000	611.300	100.000	612.000	2
2	100.000	612.000	1060.000	930.000	1
3	1060.000	930.000	1529.000	930.000	1
4	100.000	612.000	1529.000	622.000	2
5	0.000	609.300	1529.000	620.000	3

User Specified X-Origin = 0.000(ft)

User Specified Y-Origin = 575.000(ft)

MOHR-COULOMB SOIL PARAMETERS

3 Type(s) of Soil Defined

Soil Number and Description	Moist Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Ratio(ru)	Pressure Constant (psf)	Water Surface No.	Water Option
1 SOLID WASTE	50.0	50.0	250.00	25.00	0.000	0.0	0	0
2 LINER/COVER	120.0	120.0	40.00	16.00	0.000	0.0	0	0
3 AUSTIN CHALK	140.6	140.6	10000.00	0.00	0.000	0.0	0	0

A Non-Circular Zone Search Has Been Selected For Analysis
Using Random Generation Within Specified Zones.

2 Zones Defined For Generation Of Non-Circular Surfaces

1000 Trial Surfaces Have Been Generated.

Length Of Line Segments For Active And Passive Portions Of
Non-Circular Zone Search = 20.00(ft)

Zone No.	X - 1 (ft)	Y - 1 (ft)	X - 2 (ft)	Y - 2 (ft)	Height (ft)
1	95.00	609.96	105.00	610.03	2.00
2	150.00	610.35	1200.00	618.40	2.00

The Simplified Janbu Method Was Selected for FS Analysis.

Total Number of Trial Surfaces Attempted = 1000

Number of Trial Surfaces With Valid FS = 1000

Statistical Data On All Valid FS Values:
FS Max = 44.701 FS Min = 1.461 FS Ave = 5.813
Standard Deviation = 7.046 Coefficient of Variation = 121.22 %

Critical Surface is Sequence Number 52 of Those Analyzed.

*****BEGINNING OF DETAILED GEOSTASE OUTPUT FOR CRITICAL SURFACE FROM A SEARCH*****

Factor Of Safety For The Critical or Specified Surface = 1.461

Table 1 - Geometry Data on the 179 Slices

Slice No.	Width (ft)	Height (ft)	X-Cntr (ft)	Y-Cntr-Base (ft)	Y-Cntr-Top (ft)	Alpha (deg)	Beta (deg)	Base Length (ft)
1	1.52	0.48	99.24	611.51	611.99	-32.07	0.40	1.79
2	0.37	1.14	100.19	610.92	612.06	-32.07	18.33	0.44
3	5.02	2.13	102.88	610.82	612.95	0.43	18.33	5.02
4	5.02	3.75	107.89	610.86	614.61	0.43	18.33	5.02
5	5.02	5.38	112.91	610.90	616.28	0.43	18.33	5.02
6	5.02	7.00	117.92	610.94	617.94	0.43	18.33	5.02
7	5.02	8.62	122.94	610.97	619.60	0.43	18.33	5.02
8	5.02	10.25	127.95	611.01	621.26	0.43	18.33	5.02
9	5.02	11.87	132.97	611.05	622.92	0.43	18.33	5.02
10	5.02	13.49	137.98	611.09	624.58	0.43	18.33	5.02
11	5.02	15.12	143.00	611.13	626.24	0.43	18.33	5.02
12	5.02	16.74	148.01	611.16	627.90	0.43	18.33	5.02
13	5.02	18.37	153.03	611.20	629.57	0.43	18.33	5.02
14	5.02	19.99	158.04	611.24	631.23	0.43	18.33	5.02
15	5.02	21.61	163.06	611.28	632.89	0.43	18.33	5.02
16	5.02	23.24	168.07	611.31	634.55	0.43	18.33	5.02
17	5.02	24.86	173.09	611.35	636.21	0.43	18.33	5.02
18	5.02	26.48	178.10	611.39	637.87	0.43	18.33	5.02
19	5.02	28.11	183.12	611.43	639.53	0.43	18.33	5.02
20	5.02	29.73	188.13	611.46	641.19	0.43	18.33	5.02
21	5.02	31.35	193.15	611.50	642.86	0.43	18.33	5.02
22	5.02	32.98	198.17	611.54	644.52	0.43	18.33	5.02
23	5.02	34.60	203.18	611.58	646.18	0.43	18.33	5.02
24	5.02	36.23	208.20	611.61	647.84	0.43	18.33	5.02
25	5.02	37.85	213.21	611.65	649.50	0.43	18.33	5.02
26	5.02	39.47	218.23	611.69	651.16	0.43	18.33	5.02
27	5.02	41.10	223.24	611.73	652.82	0.43	18.33	5.02
28	5.02	42.72	228.26	611.76	654.48	0.43	18.33	5.02
29	5.02	44.34	233.27	611.80	656.15	0.43	18.33	5.02

30	5.02	45.97	238.29	611.84	657.81	0.43	18.33	5.02
31	5.02	47.59	243.30	611.88	659.47	0.43	18.33	5.02
32	5.02	49.22	248.32	611.91	661.13	0.43	18.33	5.02
33	5.02	50.84	253.33	611.95	662.79	0.43	18.33	5.02
34	5.02	52.46	258.35	611.99	664.45	0.43	18.33	5.02
35	5.02	54.09	263.36	612.03	666.11	0.43	18.33	5.02
36	5.02	55.71	268.38	612.06	667.77	0.43	18.33	5.02
37	5.02	57.33	273.39	612.10	669.44	0.43	18.33	5.02
38	5.02	58.96	278.41	612.14	671.10	0.43	18.33	5.02
39	5.02	60.58	283.42	612.18	672.76	0.43	18.33	5.02
40	5.02	62.20	288.44	612.22	674.42	0.43	18.33	5.02
41	5.02	63.83	293.45	612.25	676.08	0.43	18.33	5.02
42	5.02	65.45	298.47	612.29	677.74	0.43	18.33	5.02
43	5.02	67.08	303.48	612.33	679.40	0.43	18.33	5.02
44	5.02	68.70	308.50	612.37	681.06	0.43	18.33	5.02
45	5.02	70.32	313.51	612.40	682.73	0.43	18.33	5.02
46	5.02	71.95	318.53	612.44	684.39	0.43	18.33	5.02
47	5.02	73.57	323.54	612.48	686.05	0.43	18.33	5.02
48	5.02	75.19	328.56	612.52	687.71	0.43	18.33	5.02
49	5.02	76.82	333.57	612.55	689.37	0.43	18.33	5.02
50	5.02	78.44	338.59	612.59	691.03	0.43	18.33	5.02
51	5.02	80.06	343.60	612.63	692.69	0.43	18.33	5.02
52	5.02	81.69	348.62	612.67	694.35	0.43	18.33	5.02
53	5.02	83.31	353.63	612.70	696.02	0.43	18.33	5.02
54	5.02	84.94	358.65	612.74	697.68	0.43	18.33	5.02
55	5.02	86.56	363.66	612.78	699.34	0.43	18.33	5.02
56	5.02	88.18	368.68	612.82	701.00	0.43	18.33	5.02
57	5.02	89.81	373.69	612.85	702.66	0.43	18.33	5.02
58	5.02	91.43	378.71	612.89	704.32	0.43	18.33	5.02
59	5.02	93.05	383.72	612.93	705.98	0.43	18.33	5.02
60	5.02	94.68	388.74	612.97	707.64	0.43	18.33	5.02
61	5.02	96.30	393.75	613.00	709.31	0.43	18.33	5.02
62	5.02	97.93	398.77	613.04	710.97	0.43	18.33	5.02
63	5.02	99.55	403.78	613.08	712.63	0.43	18.33	5.02
64	5.02	101.17	408.80	613.12	714.29	0.43	18.33	5.02
65	5.02	102.80	413.81	613.15	715.95	0.43	18.33	5.02
66	5.02	104.42	418.83	613.19	717.61	0.43	18.33	5.02
67	5.02	106.04	423.84	613.23	719.27	0.43	18.33	5.02
68	5.02	107.67	428.86	613.27	720.93	0.43	18.33	5.02
69	5.02	109.29	433.87	613.31	722.60	0.43	18.33	5.02
70	5.02	110.91	438.89	613.34	724.26	0.43	18.33	5.02
71	5.02	112.54	443.91	613.38	725.92	0.43	18.33	5.02
72	5.02	114.16	448.92	613.42	727.58	0.43	18.33	5.02
73	5.02	115.79	453.94	613.46	729.24	0.43	18.33	5.02
74	5.02	117.41	458.95	613.49	730.90	0.43	18.33	5.02
75	5.02	119.03	463.97	613.53	732.56	0.43	18.33	5.02
76	5.02	120.66	468.98	613.57	734.22	0.43	18.33	5.02
77	5.02	122.28	474.00	613.61	735.89	0.43	18.33	5.02
78	5.02	123.90	479.01	613.64	737.55	0.43	18.33	5.02
79	5.02	125.53	484.03	613.68	739.21	0.43	18.33	5.02
80	5.02	127.15	489.04	613.72	740.87	0.43	18.33	5.02
81	5.02	128.77	494.06	613.76	742.53	0.43	18.33	5.02
82	5.02	130.40	499.07	613.79	744.19	0.43	18.33	5.02
83	5.02	132.02	504.09	613.83	745.85	0.43	18.33	5.02
84	5.02	133.65	509.10	613.87	747.51	0.43	18.33	5.02
85	5.02	135.27	514.12	613.91	749.18	0.43	18.33	5.02
86	5.02	136.89	519.13	613.94	750.84	0.43	18.33	5.02
87	5.02	138.52	524.15	613.98	752.50	0.43	18.33	5.02
88	5.02	140.14	529.16	614.02	754.16	0.43	18.33	5.02
89	5.02	141.76	534.18	614.06	755.82	0.43	18.33	5.02
90	5.02	143.39	539.19	614.09	757.48	0.43	18.33	5.02
91	5.02	145.01	544.21	614.13	759.14	0.43	18.33	5.02
92	5.02	146.64	549.22	614.17	760.80	0.43	18.33	5.02
93	5.02	148.26	554.24	614.21	762.47	0.43	18.33	5.02
94	5.02	149.88	559.25	614.24	764.13	0.43	18.33	5.02
95	5.02	151.51	564.27	614.28	765.79	0.43	18.33	5.02
96	5.02	153.13	569.28	614.32	767.45	0.43	18.33	5.02
97	5.02	154.75	574.30	614.36	769.11	0.43	18.33	5.02
98	5.02	156.38	579.31	614.40	770.77	0.43	18.33	5.02
99	5.02	158.00	584.33	614.43	772.43	0.43	18.33	5.02
100	5.02	159.62	589.34	614.47	774.09	0.43	18.33	5.02
101	5.02	161.25	594.36	614.51	775.76	0.43	18.33	5.02
102	5.02	162.87	599.37	614.55	777.42	0.43	18.33	5.02
103	5.02	164.50	604.39	614.58	779.08	0.43	18.33	5.02

104	5.02	166.12	609.40	614.62	780.74	0.43	18.33	5.02
105	5.02	167.74	614.42	614.66	782.40	0.43	18.33	5.02
106	5.02	169.37	619.43	614.70	784.06	0.43	18.33	5.02
107	5.02	170.99	624.45	614.73	785.72	0.43	18.33	5.02
108	5.02	172.61	629.46	614.77	787.38	0.43	18.33	5.02
109	5.02	174.24	634.48	614.81	789.05	0.43	18.33	5.02
110	5.02	175.86	639.49	614.85	790.71	0.43	18.33	5.02
111	5.02	177.48	644.51	614.88	792.37	0.43	18.33	5.02
112	5.02	179.11	649.52	614.92	794.03	0.43	18.33	5.02
113	5.02	180.73	654.54	614.96	795.69	0.43	18.33	5.02
114	5.02	182.36	659.55	615.00	797.35	0.43	18.33	5.02
115	5.02	183.98	664.57	615.03	799.01	0.43	18.33	5.02
116	5.02	185.60	669.58	615.07	800.68	0.43	18.33	5.02
117	5.02	187.23	674.60	615.11	802.34	0.43	18.33	5.02
118	5.02	188.85	679.62	615.15	804.00	0.43	18.33	5.02
119	5.02	190.47	684.63	615.18	805.66	0.43	18.33	5.02
120	5.02	192.10	689.65	615.22	807.32	0.43	18.33	5.02
121	5.02	193.72	694.66	615.26	808.98	0.43	18.33	5.02
122	5.02	195.35	699.68	615.30	810.64	0.43	18.33	5.02
123	5.02	196.97	704.69	615.33	812.30	0.43	18.33	5.02
124	5.02	198.59	709.71	615.37	813.97	0.43	18.33	5.02
125	5.02	200.22	714.72	615.41	815.63	0.43	18.33	5.02
126	5.02	201.84	719.74	615.45	817.29	0.43	18.33	5.02
127	5.02	203.46	724.75	615.49	818.95	0.43	18.33	5.02
128	5.02	205.09	729.77	615.52	820.61	0.43	18.33	5.02
129	5.02	206.71	734.78	615.56	822.27	0.43	18.33	5.02
130	5.02	208.33	739.80	615.60	823.93	0.43	18.33	5.02
131	5.02	209.96	744.81	615.64	825.59	0.43	18.33	5.02
132	5.02	211.58	749.83	615.67	827.26	0.43	18.33	5.02
133	5.02	213.21	754.84	615.71	828.92	0.43	18.33	5.02
134	5.02	214.83	759.86	615.75	830.58	0.43	18.33	5.02
135	5.02	216.45	764.87	615.79	832.24	0.43	18.33	5.02
136	5.02	218.08	769.89	615.82	833.90	0.43	18.33	5.02
137	5.02	219.70	774.90	615.86	835.56	0.43	18.33	5.02
138	5.02	221.32	779.92	615.90	837.22	0.43	18.33	5.02
139	5.02	222.95	784.93	615.94	838.88	0.43	18.33	5.02
140	5.02	224.57	789.95	615.97	840.55	0.43	18.33	5.02
141	5.02	226.20	794.96	616.01	842.21	0.43	18.33	5.02
142	0.46	226.66	797.70	616.46	843.11	61.61	18.33	0.97
143	4.52	222.87	800.19	621.07	843.94	61.61	18.33	9.51
144	4.52	216.00	804.72	629.44	845.44	61.61	18.33	9.51
145	4.64	210.94	809.30	636.02	846.96	45.87	18.33	6.67
146	4.64	207.69	813.94	640.80	848.49	45.87	18.33	6.67
147	4.64	204.44	818.58	645.59	850.03	45.87	18.33	6.67
148	4.66	201.21	823.23	650.36	851.57	45.64	18.33	6.67
149	4.66	197.99	827.90	655.13	853.12	45.64	18.33	6.67
150	4.66	194.76	832.56	659.90	854.66	45.64	18.33	6.67
151	4.71	191.58	837.24	664.64	856.21	45.02	18.33	6.67
152	4.71	188.42	841.96	669.35	857.77	45.02	18.33	6.67
153	4.71	185.27	846.67	674.07	859.33	45.02	18.33	6.67
154	4.67	182.08	851.36	678.80	860.89	45.55	18.33	6.67
155	4.67	178.87	856.03	683.56	862.43	45.55	18.33	6.67
156	4.67	175.66	860.70	688.32	863.98	45.55	18.33	6.67
157	5.42	170.75	865.74	694.91	865.65	57.21	18.33	10.00
158	5.42	164.13	871.16	703.31	867.45	57.21	18.33	10.00
159	4.70	159.24	876.22	709.88	869.12	45.12	18.33	6.67
160	4.70	156.08	880.92	714.60	870.68	45.12	18.33	6.67
161	4.70	152.91	885.62	719.33	872.24	45.12	18.33	6.67
162	3.51	147.23	889.73	726.37	873.60	69.46	18.33	10.00
163	3.51	139.03	893.24	735.73	874.76	69.46	18.33	10.00
164	4.62	133.29	897.30	742.82	876.11	46.16	18.33	6.67
165	4.62	130.01	901.92	747.63	877.64	46.16	18.33	6.67
166	4.62	126.73	906.54	752.44	879.17	46.16	18.33	6.67
167	5.48	121.81	911.58	759.02	880.84	56.80	18.33	10.00
168	5.48	115.26	917.06	767.39	882.65	56.80	18.33	10.00
169	6.10	109.03	922.85	775.54	884.57	52.42	18.33	10.00
170	6.10	103.13	928.95	783.46	886.59	52.42	18.33	10.00
171	5.92	97.12	934.96	791.45	888.58	53.69	18.33	10.00
172	5.92	91.03	940.88	799.51	890.54	53.69	18.33	10.00
173	5.51	84.72	946.59	807.71	892.43	56.57	18.33	10.00
174	5.51	78.20	952.10	816.06	894.26	56.57	18.33	10.00
175	3.99	65.80	956.85	830.03	895.83	78.49	18.33	20.00
176	2.05	47.06	959.87	849.78	896.83	84.11	18.33	20.00
177	3.64	28.22	962.72	869.56	897.77	79.53	18.33	20.00

178	2.96	9.59	966.01	889.28	898.87	81.50	18.33	20.00
179	0.01	0.09	967.50	899.27	899.36	86.40	18.33	0.19

Table 2 - Force Data On The 179 Slices (Excluding Reinforcement)

Slice No.	Weight (lbs)	Ubeta Force Top (lbs)	Ualpha Force Bot (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Distributed Load (lbs)
1	87.7	0.0	0.0	0.0	0.0	0.0
2	49.1	0.0	0.0	0.0	0.0	0.0
3	953.6	0.0	0.0	0.0	0.0	0.0
4	1359.8	0.0	0.0	0.0	0.0	0.0
5	1766.1	0.0	0.0	0.0	0.0	0.0
6	2172.4	0.0	0.0	0.0	0.0	0.0
7	2578.6	0.0	0.0	0.0	0.0	0.0
8	2984.9	0.0	0.0	0.0	0.0	0.0
9	3391.2	0.0	0.0	0.0	0.0	0.0
10	3797.4	0.0	0.0	0.0	0.0	0.0
11	4203.7	0.0	0.0	0.0	0.0	0.0
12	4610.0	0.0	0.0	0.0	0.0	0.0
13	5016.3	0.0	0.0	0.0	0.0	0.0
14	5422.5	0.0	0.0	0.0	0.0	0.0
15	5828.8	0.0	0.0	0.0	0.0	0.0
16	6235.1	0.0	0.0	0.0	0.0	0.0
17	6641.3	0.0	0.0	0.0	0.0	0.0
18	7047.6	0.0	0.0	0.0	0.0	0.0
19	7453.9	0.0	0.0	0.0	0.0	0.0
20	7860.1	0.0	0.0	0.0	0.0	0.0
21	8266.4	0.0	0.0	0.0	0.0	0.0
22	8672.7	0.0	0.0	0.0	0.0	0.0
23	9078.9	0.0	0.0	0.0	0.0	0.0
24	9485.2	0.0	0.0	0.0	0.0	0.0
25	9891.5	0.0	0.0	0.0	0.0	0.0
26	10297.8	0.0	0.0	0.0	0.0	0.0
27	10704.0	0.0	0.0	0.0	0.0	0.0
28	11110.3	0.0	0.0	0.0	0.0	0.0
29	11516.6	0.0	0.0	0.0	0.0	0.0
30	11922.8	0.0	0.0	0.0	0.0	0.0
31	12329.1	0.0	0.0	0.0	0.0	0.0
32	12735.4	0.0	0.0	0.0	0.0	0.0
33	13141.6	0.0	0.0	0.0	0.0	0.0
34	13547.9	0.0	0.0	0.0	0.0	0.0
35	13954.2	0.0	0.0	0.0	0.0	0.0
36	14360.4	0.0	0.0	0.0	0.0	0.0
37	14766.7	0.0	0.0	0.0	0.0	0.0
38	15173.0	0.0	0.0	0.0	0.0	0.0
39	15579.2	0.0	0.0	0.0	0.0	0.0
40	15985.5	0.0	0.0	0.0	0.0	0.0
41	16391.8	0.0	0.0	0.0	0.0	0.0
42	16798.1	0.0	0.0	0.0	0.0	0.0
43	17204.3	0.0	0.0	0.0	0.0	0.0
44	17610.6	0.0	0.0	0.0	0.0	0.0
45	18016.9	0.0	0.0	0.0	0.0	0.0
46	18423.1	0.0	0.0	0.0	0.0	0.0
47	18829.4	0.0	0.0	0.0	0.0	0.0
48	19235.7	0.0	0.0	0.0	0.0	0.0
49	19641.9	0.0	0.0	0.0	0.0	0.0
50	20048.2	0.0	0.0	0.0	0.0	0.0
51	20454.5	0.0	0.0	0.0	0.0	0.0
52	20860.7	0.0	0.0	0.0	0.0	0.0
53	21267.0	0.0	0.0	0.0	0.0	0.0
54	21673.3	0.0	0.0	0.0	0.0	0.0
55	22079.5	0.0	0.0	0.0	0.0	0.0
56	22485.8	0.0	0.0	0.0	0.0	0.0
57	22892.1	0.0	0.0	0.0	0.0	0.0
58	23298.4	0.0	0.0	0.0	0.0	0.0
59	23704.6	0.0	0.0	0.0	0.0	0.0
60	24110.9	0.0	0.0	0.0	0.0	0.0
61	24517.2	0.0	0.0	0.0	0.0	0.0
62	24923.4	0.0	0.0	0.0	0.0	0.0

63	25329.7	0.0	0.0	0.0	0.0	0.0
64	25736.0	0.0	0.0	0.0	0.0	0.0
65	26142.2	0.0	0.0	0.0	0.0	0.0
66	26548.5	0.0	0.0	0.0	0.0	0.0
67	26954.8	0.0	0.0	0.0	0.0	0.0
68	27361.0	0.0	0.0	0.0	0.0	0.0
69	27767.3	0.0	0.0	0.0	0.0	0.0
70	28173.6	0.0	0.0	0.0	0.0	0.0
71	28579.8	0.0	0.0	0.0	0.0	0.0
72	28986.1	0.0	0.0	0.0	0.0	0.0
73	29392.4	0.0	0.0	0.0	0.0	0.0
74	29798.7	0.0	0.0	0.0	0.0	0.0
75	30204.9	0.0	0.0	0.0	0.0	0.0
76	30611.2	0.0	0.0	0.0	0.0	0.0
77	31017.5	0.0	0.0	0.0	0.0	0.0
78	31423.7	0.0	0.0	0.0	0.0	0.0
79	31830.0	0.0	0.0	0.0	0.0	0.0
80	32236.3	0.0	0.0	0.0	0.0	0.0
81	32642.5	0.0	0.0	0.0	0.0	0.0
82	33048.8	0.0	0.0	0.0	0.0	0.0
83	33455.1	0.0	0.0	0.0	0.0	0.0
84	33861.3	0.0	0.0	0.0	0.0	0.0
85	34267.6	0.0	0.0	0.0	0.0	0.0
86	34673.9	0.0	0.0	0.0	0.0	0.0
87	35080.2	0.0	0.0	0.0	0.0	0.0
88	35486.4	0.0	0.0	0.0	0.0	0.0
89	35892.7	0.0	0.0	0.0	0.0	0.0
90	36299.0	0.0	0.0	0.0	0.0	0.0
91	36705.2	0.0	0.0	0.0	0.0	0.0
92	37111.5	0.0	0.0	0.0	0.0	0.0
93	37517.8	0.0	0.0	0.0	0.0	0.0
94	37924.0	0.0	0.0	0.0	0.0	0.0
95	38330.3	0.0	0.0	0.0	0.0	0.0
96	38736.6	0.0	0.0	0.0	0.0	0.0
97	39142.8	0.0	0.0	0.0	0.0	0.0
98	39549.1	0.0	0.0	0.0	0.0	0.0
99	39955.4	0.0	0.0	0.0	0.0	0.0
100	40361.6	0.0	0.0	0.0	0.0	0.0
101	40767.9	0.0	0.0	0.0	0.0	0.0
102	41174.2	0.0	0.0	0.0	0.0	0.0
103	41580.5	0.0	0.0	0.0	0.0	0.0
104	41986.7	0.0	0.0	0.0	0.0	0.0
105	42393.0	0.0	0.0	0.0	0.0	0.0
106	42799.3	0.0	0.0	0.0	0.0	0.0
107	43205.5	0.0	0.0	0.0	0.0	0.0
108	43611.8	0.0	0.0	0.0	0.0	0.0
109	44018.1	0.0	0.0	0.0	0.0	0.0
110	44424.3	0.0	0.0	0.0	0.0	0.0
111	44830.6	0.0	0.0	0.0	0.0	0.0
112	45236.9	0.0	0.0	0.0	0.0	0.0
113	45643.1	0.0	0.0	0.0	0.0	0.0
114	46049.4	0.0	0.0	0.0	0.0	0.0
115	46455.7	0.0	0.0	0.0	0.0	0.0
116	46861.9	0.0	0.0	0.0	0.0	0.0
117	47268.2	0.0	0.0	0.0	0.0	0.0
118	47674.5	0.0	0.0	0.0	0.0	0.0
119	48080.8	0.0	0.0	0.0	0.0	0.0
120	48487.0	0.0	0.0	0.0	0.0	0.0
121	48893.3	0.0	0.0	0.0	0.0	0.0
122	49299.6	0.0	0.0	0.0	0.0	0.0
123	49705.8	0.0	0.0	0.0	0.0	0.0
124	50112.1	0.0	0.0	0.0	0.0	0.0
125	50518.4	0.0	0.0	0.0	0.0	0.0
126	50924.6	0.0	0.0	0.0	0.0	0.0
127	51330.9	0.0	0.0	0.0	0.0	0.0
128	51737.2	0.0	0.0	0.0	0.0	0.0
129	52143.4	0.0	0.0	0.0	0.0	0.0
130	52549.7	0.0	0.0	0.0	0.0	0.0
131	52956.0	0.0	0.0	0.0	0.0	0.0
132	53362.3	0.0	0.0	0.0	0.0	0.0
133	53768.5	0.0	0.0	0.0	0.0	0.0
134	54174.8	0.0	0.0	0.0	0.0	0.0
135	54581.1	0.0	0.0	0.0	0.0	0.0
136	54987.3	0.0	0.0	0.0	0.0	0.0

137	55393.6	0.0	0.0	0.0	0.0	0.0
138	55799.9	0.0	0.0	0.0	0.0	0.0
139	56206.1	0.0	0.0	0.0	0.0	0.0
140	56612.4	0.0	0.0	0.0	0.0	0.0
141	57018.7	0.0	0.0	0.0	0.0	0.0
142	5243.4	0.0	0.0	0.0	0.0	0.0
143	50407.2	0.0	0.0	0.0	0.0	0.0
144	48852.9	0.0	0.0	0.0	0.0	0.0
145	48957.2	0.0	0.0	0.0	0.0	0.0
146	48203.5	0.0	0.0	0.0	0.0	0.0
147	47449.8	0.0	0.0	0.0	0.0	0.0
148	46896.2	0.0	0.0	0.0	0.0	0.0
149	46145.3	0.0	0.0	0.0	0.0	0.0
150	45394.3	0.0	0.0	0.0	0.0	0.0
151	45141.4	0.0	0.0	0.0	0.0	0.0
152	44398.1	0.0	0.0	0.0	0.0	0.0
153	43654.9	0.0	0.0	0.0	0.0	0.0
154	42503.7	0.0	0.0	0.0	0.0	0.0
155	41753.8	0.0	0.0	0.0	0.0	0.0
156	41003.9	0.0	0.0	0.0	0.0	0.0
157	46232.4	0.0	0.0	0.0	0.0	0.0
158	44441.8	0.0	0.0	0.0	0.0	0.0
159	37455.9	0.0	0.0	0.0	0.0	0.0
160	36711.3	0.0	0.0	0.0	0.0	0.0
161	35966.8	0.0	0.0	0.0	0.0	0.0
162	25829.9	0.0	0.0	0.0	0.0	0.0
163	24390.9	0.0	0.0	0.0	0.0	0.0
164	30775.2	0.0	0.0	0.0	0.0	0.0
165	30018.2	0.0	0.0	0.0	0.0	0.0
166	29261.2	0.0	0.0	0.0	0.0	0.0
167	33347.3	0.0	0.0	0.0	0.0	0.0
168	31553.0	0.0	0.0	0.0	0.0	0.0
169	33250.1	0.0	0.0	0.0	0.0	0.0
170	31449.5	0.0	0.0	0.0	0.0	0.0
171	28757.8	0.0	0.0	0.0	0.0	0.0
172	26952.7	0.0	0.0	0.0	0.0	0.0
173	23338.1	0.0	0.0	0.0	0.0	0.0
174	21541.9	0.0	0.0	0.0	0.0	0.0
175	13125.6	0.0	0.0	0.0	0.0	0.0
176	4825.3	0.0	0.0	0.0	0.0	0.0
177	5129.8	0.0	0.0	0.0	0.0	0.0
178	1417.3	0.0	0.0	0.0	0.0	0.0
179	0.1	0.0	0.0	0.0	0.0	0.0

TOTAL WEIGHT OF SLIDING MASS = 5270984.82(lbs)

EFFECTIVE WEIGHT OF SLIDING MASS = 5270984.82(lbs)

TOTAL AREA OF SLIDING MASS = ********(ft2)

TABLE 2A - SOIL STRENGTH & SOIL OPTIONS DATA ON THE 179 SLICES

Slice No.	Soil Type	Cohesion (psf)	Phi(Deg)	Options
1	2	40.00	16.00	
2	2	40.00	16.00	
3	2	40.00	16.00	
4	2	40.00	16.00	
5	2	40.00	16.00	
6	2	40.00	16.00	
7	2	40.00	16.00	
8	2	40.00	16.00	
9	2	40.00	16.00	
10	2	40.00	16.00	
11	2	40.00	16.00	
12	2	40.00	16.00	
13	2	40.00	16.00	
14	2	40.00	16.00	
15	2	40.00	16.00	
16	2	40.00	16.00	
17	2	40.00	16.00	
18	2	40.00	16.00	
19	2	40.00	16.00	

20	2	40.00	16.00
21	2	40.00	16.00
22	2	40.00	16.00
23	2	40.00	16.00
24	2	40.00	16.00
25	2	40.00	16.00
26	2	40.00	16.00
27	2	40.00	16.00
28	2	40.00	16.00
29	2	40.00	16.00
30	2	40.00	16.00
31	2	40.00	16.00
32	2	40.00	16.00
33	2	40.00	16.00
34	2	40.00	16.00
35	2	40.00	16.00
36	2	40.00	16.00
37	2	40.00	16.00
38	2	40.00	16.00
39	2	40.00	16.00
40	2	40.00	16.00
41	2	40.00	16.00
42	2	40.00	16.00
43	2	40.00	16.00
44	2	40.00	16.00
45	2	40.00	16.00
46	2	40.00	16.00
47	2	40.00	16.00
48	2	40.00	16.00
49	2	40.00	16.00
50	2	40.00	16.00
51	2	40.00	16.00
52	2	40.00	16.00
53	2	40.00	16.00
54	2	40.00	16.00
55	2	40.00	16.00
56	2	40.00	16.00
57	2	40.00	16.00
58	2	40.00	16.00
59	2	40.00	16.00
60	2	40.00	16.00
61	2	40.00	16.00
62	2	40.00	16.00
63	2	40.00	16.00
64	2	40.00	16.00
65	2	40.00	16.00
66	2	40.00	16.00
67	2	40.00	16.00
68	2	40.00	16.00
69	2	40.00	16.00
70	2	40.00	16.00
71	2	40.00	16.00
72	2	40.00	16.00
73	2	40.00	16.00
74	2	40.00	16.00
75	2	40.00	16.00
76	2	40.00	16.00
77	2	40.00	16.00
78	2	40.00	16.00
79	2	40.00	16.00
80	2	40.00	16.00
81	2	40.00	16.00
82	2	40.00	16.00
83	2	40.00	16.00
84	2	40.00	16.00
85	2	40.00	16.00
86	2	40.00	16.00
87	2	40.00	16.00
88	2	40.00	16.00
89	2	40.00	16.00
90	2	40.00	16.00
91	2	40.00	16.00
92	2	40.00	16.00
93	2	40.00	16.00

94	2	40.00	16.00
95	2	40.00	16.00
96	2	40.00	16.00
97	2	40.00	16.00
98	2	40.00	16.00
99	2	40.00	16.00
100	2	40.00	16.00
101	2	40.00	16.00
102	2	40.00	16.00
103	2	40.00	16.00
104	2	40.00	16.00
105	2	40.00	16.00
106	2	40.00	16.00
107	2	40.00	16.00
108	2	40.00	16.00
109	2	40.00	16.00
110	2	40.00	16.00
111	2	40.00	16.00
112	2	40.00	16.00
113	2	40.00	16.00
114	2	40.00	16.00
115	2	40.00	16.00
116	2	40.00	16.00
117	2	40.00	16.00
118	2	40.00	16.00
119	2	40.00	16.00
120	2	40.00	16.00
121	2	40.00	16.00
122	2	40.00	16.00
123	2	40.00	16.00
124	2	40.00	16.00
125	2	40.00	16.00
126	2	40.00	16.00
127	2	40.00	16.00
128	2	40.00	16.00
129	2	40.00	16.00
130	2	40.00	16.00
131	2	40.00	16.00
132	2	40.00	16.00
133	2	40.00	16.00
134	2	40.00	16.00
135	2	40.00	16.00
136	2	40.00	16.00
137	2	40.00	16.00
138	2	40.00	16.00
139	2	40.00	16.00
140	2	40.00	16.00
141	2	40.00	16.00
142	2	40.00	16.00
143	1	250.00	25.00
144	1	250.00	25.00
145	1	250.00	25.00
146	1	250.00	25.00
147	1	250.00	25.00
148	1	250.00	25.00
149	1	250.00	25.00
150	1	250.00	25.00
151	1	250.00	25.00
152	1	250.00	25.00
153	1	250.00	25.00
154	1	250.00	25.00
155	1	250.00	25.00
156	1	250.00	25.00
157	1	250.00	25.00
158	1	250.00	25.00
159	1	250.00	25.00
160	1	250.00	25.00
161	1	250.00	25.00
162	1	250.00	25.00
163	1	250.00	25.00
164	1	250.00	25.00
165	1	250.00	25.00
166	1	250.00	25.00
167	1	250.00	25.00

168	1	250.00	25.00
169	1	250.00	25.00
170	1	250.00	25.00
171	1	250.00	25.00
172	1	250.00	25.00
173	1	250.00	25.00
174	1	250.00	25.00
175	1	250.00	25.00
176	1	250.00	25.00
177	1	250.00	25.00
178	1	250.00	25.00
179	1	250.00	25.00

SOIL OPTIONS: A = ANISOTROPIC, C = CURVED STRENGTH ENVELOPE (TANGENT PHI & C),
F = FIBER-REINFORCED SOIL (FRS), N = NONLINEAR UNDRAINED SHEAR STRENGTH,
R = RAPID DRAWDOWN OR RAPID LOADING (SEISMIC) SHEAR STRENGTH
NOTE: Phi and C in Table 4 are modified values based on specified
Soil Options (if any).

TABLE 3 - Effective and Base Shear Stress Data on the 179 Slices

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Effective Normal Stress (psf)	Available Shear Strength (psf)	Mobilized Shear Stress (psf)
1	-32.07	99.24	1.79	85.41	64.49	44.15
2	-32.07	100.19	0.44	170.72	88.95	60.90
3	0.43	102.88	5.02	189.65	94.38	64.62
4	0.43	107.89	5.02	270.54	117.58	80.50
5	0.43	112.91	5.02	351.43	140.77	96.38
6	0.43	117.92	5.02	432.32	163.97	112.26
7	0.43	122.94	5.02	513.21	187.16	128.14
8	0.43	127.95	5.02	594.10	210.36	144.02
9	0.43	132.97	5.02	674.99	233.55	159.90
10	0.43	137.98	5.02	755.88	256.75	175.79
11	0.43	143.00	5.02	836.77	279.94	191.67
12	0.43	148.01	5.02	917.66	303.14	207.55
13	0.43	153.03	5.02	998.55	326.33	223.43
14	0.43	158.04	5.02	1079.44	349.53	239.31
15	0.43	163.06	5.02	1160.33	372.72	255.19
16	0.43	168.07	5.02	1241.22	395.92	271.07
17	0.43	173.09	5.02	1322.11	419.11	286.95
18	0.43	178.10	5.02	1403.00	442.30	302.83
19	0.43	183.12	5.02	1483.89	465.50	318.71
20	0.43	188.13	5.02	1564.78	488.69	334.59
21	0.43	193.15	5.02	1645.67	511.89	350.47
22	0.43	198.17	5.02	1726.56	535.08	366.35
23	0.43	203.18	5.02	1807.45	558.28	382.23
24	0.43	208.20	5.02	1888.34	581.47	398.12
25	0.43	213.21	5.02	1969.23	604.67	414.00
26	0.43	218.23	5.02	2050.12	627.86	429.88
27	0.43	223.24	5.02	2131.01	651.06	445.76
28	0.43	228.26	5.02	2211.90	674.25	461.64
29	0.43	233.27	5.02	2292.79	697.45	477.52
30	0.43	238.29	5.02	2373.68	720.64	493.40
31	0.43	243.30	5.02	2454.57	743.84	509.28
32	0.43	248.32	5.02	2535.46	767.03	525.16
33	0.43	253.33	5.02	2616.35	790.23	541.04
34	0.43	258.35	5.02	2697.24	813.42	556.92
35	0.43	263.36	5.02	2778.13	836.62	572.80
36	0.43	268.38	5.02	2859.02	859.81	588.68
37	0.43	273.39	5.02	2939.91	883.01	604.57
38	0.43	278.41	5.02	3020.80	906.20	620.45
39	0.43	283.42	5.02	3101.69	929.40	636.33
40	0.43	288.44	5.02	3182.58	952.59	652.21
41	0.43	293.45	5.02	3263.47	975.79	668.09
42	0.43	298.47	5.02	3344.36	998.98	683.97
43	0.43	303.48	5.02	3425.25	1022.18	699.85
44	0.43	308.50	5.02	3506.14	1045.37	715.73
45	0.43	313.51	5.02	3587.03	1068.57	731.61
46	0.43	318.53	5.02	3667.92	1091.76	747.49
47	0.43	323.54	5.02	3748.81	1114.95	763.37

48	0.43	328.56	5.02	3829.70	1138.15	779.25
49	0.43	333.57	5.02	3910.59	1161.34	795.13
50	0.43	338.59	5.02	3991.48	1184.54	811.01
51	0.43	343.60	5.02	4072.37	1207.73	826.90
52	0.43	348.62	5.02	4153.26	1230.93	842.78
53	0.43	353.63	5.02	4234.15	1254.12	858.66
54	0.43	358.65	5.02	4315.04	1277.32	874.54
55	0.43	363.66	5.02	4395.93	1300.51	890.42
56	0.43	368.68	5.02	4476.82	1323.71	906.30
57	0.43	373.69	5.02	4557.71	1346.90	922.18
58	0.43	378.71	5.02	4638.60	1370.10	938.06
59	0.43	383.72	5.02	4719.49	1393.29	953.94
60	0.43	388.74	5.02	4800.38	1416.49	969.82
61	0.43	393.75	5.02	4881.27	1439.68	985.70
62	0.43	398.77	5.02	4962.16	1462.88	1001.58
63	0.43	403.78	5.02	5043.05	1486.07	1017.46
64	0.43	408.80	5.02	5123.94	1509.27	1033.34
65	0.43	413.81	5.02	5204.83	1532.46	1049.23
66	0.43	418.83	5.02	5285.72	1555.66	1065.11
67	0.43	423.84	5.02	5366.61	1578.85	1080.99
68	0.43	428.86	5.02	5447.50	1602.05	1096.87
69	0.43	433.87	5.02	5528.39	1625.24	1112.75
70	0.43	438.89	5.02	5609.28	1648.44	1128.63
71	0.43	443.91	5.02	5690.17	1671.63	1144.51
72	0.43	448.92	5.02	5771.06	1694.83	1160.39
73	0.43	453.94	5.02	5851.95	1718.02	1176.27
74	0.43	458.95	5.02	5932.84	1741.22	1192.15
75	0.43	463.97	5.02	6013.73	1764.41	1208.03
76	0.43	468.98	5.02	6094.62	1787.60	1223.91
77	0.43	474.00	5.02	6175.51	1810.80	1239.79
78	0.43	479.01	5.02	6256.40	1833.99	1255.67
79	0.43	484.03	5.02	6337.29	1857.19	1271.56
80	0.43	489.04	5.02	6418.18	1880.38	1287.44
81	0.43	494.06	5.02	6499.07	1903.58	1303.32
82	0.43	499.07	5.02	6579.96	1926.77	1319.20
83	0.43	504.09	5.02	6660.85	1949.97	1335.08
84	0.43	509.10	5.02	6741.74	1973.16	1350.96
85	0.43	514.12	5.02	6822.63	1996.36	1366.84
86	0.43	519.13	5.02	6903.52	2019.55	1382.72
87	0.43	524.15	5.02	6984.41	2042.75	1398.60
88	0.43	529.16	5.02	7065.30	2065.94	1414.48
89	0.43	534.18	5.02	7146.19	2089.14	1430.36
90	0.43	539.19	5.02	7227.08	2112.33	1446.24
91	0.43	544.21	5.02	7307.97	2135.53	1462.12
92	0.43	549.22	5.02	7388.86	2158.72	1478.00
93	0.43	554.24	5.02	7469.75	2181.92	1493.89
94	0.43	559.25	5.02	7550.64	2205.11	1509.77
95	0.43	564.27	5.02	7631.53	2228.31	1525.65
96	0.43	569.28	5.02	7712.42	2251.50	1541.53
97	0.43	574.30	5.02	7793.31	2274.70	1557.41
98	0.43	579.31	5.02	7874.20	2297.89	1573.29
99	0.43	584.33	5.02	7955.09	2321.09	1589.17
100	0.43	589.34	5.02	8035.98	2344.28	1605.05
101	0.43	594.36	5.02	8116.87	2367.48	1620.93
102	0.43	599.37	5.02	8197.76	2390.67	1636.81
103	0.43	604.39	5.02	8278.65	2413.87	1652.69
104	0.43	609.40	5.02	8359.54	2437.06	1668.57
105	0.43	614.42	5.02	8440.43	2460.25	1684.45
106	0.43	619.43	5.02	8521.32	2483.45	1700.33
107	0.43	624.45	5.02	8602.21	2506.64	1716.22
108	0.43	629.46	5.02	8683.10	2529.84	1732.10
109	0.43	634.48	5.02	8763.99	2553.03	1747.98
110	0.43	639.49	5.02	8844.88	2576.23	1763.86
111	0.43	644.51	5.02	8925.77	2599.42	1779.74
112	0.43	649.52	5.02	9006.66	2622.62	1795.62
113	0.43	654.54	5.02	9087.55	2645.81	1811.50
114	0.43	659.55	5.02	9168.44	2669.01	1827.38
115	0.43	664.57	5.02	9249.33	2692.20	1843.26
116	0.43	669.58	5.02	9330.22	2715.40	1859.14
117	0.43	674.60	5.02	9411.11	2738.59	1875.02
118	0.43	679.62	5.02	9492.00	2761.79	1890.90
119	0.43	684.63	5.02	9572.89	2784.98	1906.78
120	0.43	689.65	5.02	9653.78	2808.18	1922.66
121	0.43	694.66	5.02	9734.67	2831.37	1938.55

122	0.43	699.68	5.02	9815.56	2854.57	1954.43
123	0.43	704.69	5.02	9896.45	2877.76	1970.31
124	0.43	709.71	5.02	9977.34	2900.96	1986.19
125	0.43	714.72	5.02	10058.23	2924.15	2002.07
126	0.43	719.74	5.02	10139.12	2947.35	2017.95
127	0.43	724.75	5.02	10220.01	2970.54	2033.83
128	0.43	729.77	5.02	10300.90	2993.74	2049.71
129	0.43	734.78	5.02	10381.79	3016.93	2065.59
130	0.43	739.80	5.02	10462.68	3040.13	2081.47
131	0.43	744.81	5.02	10543.57	3063.32	2097.35
132	0.43	749.83	5.02	10624.46	3086.52	2113.23
133	0.43	754.84	5.02	10705.35	3109.71	2129.11
134	0.43	759.86	5.02	10786.24	3132.90	2145.00
135	0.43	764.87	5.02	10867.13	3156.10	2160.88
136	0.43	769.89	5.02	10948.02	3179.29	2176.76
137	0.43	774.90	5.02	11028.91	3202.49	2192.64
138	0.43	779.92	5.02	11109.80	3225.68	2208.52
139	0.43	784.93	5.02	11190.69	3248.88	2224.40
140	0.43	789.95	5.02	11271.58	3272.07	2240.28
141	0.43	794.96	5.02	11352.47	3295.27	2256.16
142	61.61	797.70	0.97	8296.58	2419.00	1656.21
143	61.61	800.19	9.51	6804.78	3423.12	2343.70
144	61.61	804.72	9.51	6588.81	3322.41	2274.75
145	45.87	809.30	6.67	7801.66	3887.97	2661.97
146	45.87	813.94	6.67	7679.51	3831.01	2622.97
147	45.87	818.58	6.67	7557.35	3774.05	2583.97
148	45.64	823.23	6.67	7451.86	3724.86	2550.29
149	45.64	827.90	6.67	7330.42	3668.23	2511.51
150	45.64	832.56	6.67	7208.98	3611.60	2472.74
151	45.02	837.24	6.67	7129.11	3574.36	2447.25
152	45.02	841.96	6.67	7009.59	3518.63	2409.09
153	45.02	846.67	6.67	6890.07	3462.89	2370.93
154	45.55	851.36	6.67	6736.38	3391.23	2321.86
155	45.55	856.03	6.67	6615.21	3334.72	2283.17
156	45.55	860.70	6.67	6494.03	3278.22	2244.48
157	57.21	865.74	10.00	5529.70	2828.54	1936.61
158	57.21	871.16	10.00	5308.65	2725.47	1866.03
159	45.12	876.22	6.67	5898.45	3000.49	2054.34
160	45.12	880.92	6.67	5778.61	2944.61	2016.08
161	45.12	885.62	6.67	5658.77	2888.73	1977.81
162	69.46	889.73	10.00	3727.33	1988.08	1361.17
163	69.46	893.24	10.00	3505.94	1884.85	1290.49
164	46.16	897.30	6.67	4867.35	2519.68	1725.14
165	46.16	901.92	6.67	4744.33	2462.32	1685.87
166	46.16	906.54	6.67	4621.31	2404.95	1646.59
167	56.80	911.58	10.00	3916.92	2076.49	1421.70
168	56.80	917.06	10.00	3696.70	1973.80	1351.40
169	52.42	922.85	10.00	3695.47	1973.22	1351.00
170	52.42	928.95	10.00	3486.83	1875.94	1284.39
171	53.69	934.96	10.00	3222.65	1752.74	1200.05
172	53.69	940.88	10.00	3010.17	1653.67	1132.21
173	56.57	946.59	10.00	2680.03	1499.72	1026.81
174	56.57	952.10	10.00	2460.31	1397.26	956.66
175	78.49	956.85	20.00	953.24	694.50	475.50
176	84.11	959.87	20.00	168.78	328.71	225.05
177	79.53	962.72	20.00	177.69	332.86	227.90
178	81.50	966.01	20.00	152.81	71.26	48.79
179	86.40	967.50	0.19	0.76	0.35	0.24

Table 4 - Base Force Data on the 179 Slices

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Effective Normal Force (lbs)	Available Shear Force (lbs)	Mobilized Shear Force (lbs)
1	-32.07	99.24	1.79	153.07	115.58	79.13
2	-32.07	100.19	0.44	74.64	38.89	26.63
3	0.43	102.88	5.02	951.16	473.35	324.09
4	0.43	107.89	5.02	1356.85	589.68	403.73
5	0.43	112.91	5.02	1762.53	706.01	483.38
6	0.43	117.92	5.02	2168.21	822.33	563.03
7	0.43	122.94	5.02	2573.90	938.66	642.67

8	0.43	127.95	5.02	2979.58	1054.99	722.32
9	0.43	132.97	5.02	3385.26	1171.32	801.96
10	0.43	137.98	5.02	3790.95	1287.65	881.61
11	0.43	143.00	5.02	4196.63	1403.97	961.25
12	0.43	148.01	5.02	4602.31	1520.30	1040.90
13	0.43	153.03	5.02	5007.99	1636.63	1120.55
14	0.43	158.04	5.02	5413.68	1752.96	1200.19
15	0.43	163.06	5.02	5819.36	1869.28	1279.84
16	0.43	168.07	5.02	6225.04	1985.61	1359.48
17	0.43	173.09	5.02	6630.73	2101.94	1439.13
18	0.43	178.10	5.02	7036.41	2218.27	1518.77
19	0.43	183.12	5.02	7442.09	2334.60	1598.42
20	0.43	188.13	5.02	7847.78	2450.92	1678.07
21	0.43	193.15	5.02	8253.46	2567.25	1757.71
22	0.43	198.17	5.02	8659.14	2683.58	1837.36
23	0.43	203.18	5.02	9064.83	2799.91	1917.00
24	0.43	208.20	5.02	9470.51	2916.23	1996.65
25	0.43	213.21	5.02	9876.19	3032.56	2076.29
26	0.43	218.23	5.02	10281.88	3148.89	2155.94
27	0.43	223.24	5.02	10687.56	3265.22	2235.59
28	0.43	228.26	5.02	11093.24	3381.55	2315.23
29	0.43	233.27	5.02	11498.92	3497.87	2394.88
30	0.43	238.29	5.02	11904.61	3614.20	2474.52
31	0.43	243.30	5.02	12310.29	3730.53	2554.17
32	0.43	248.32	5.02	12715.97	3846.86	2633.81
33	0.43	253.33	5.02	13121.66	3963.18	2713.46
34	0.43	258.35	5.02	13527.34	4079.51	2793.11
35	0.43	263.36	5.02	13933.02	4195.84	2872.75
36	0.43	268.38	5.02	14338.71	4312.17	2952.40
37	0.43	273.39	5.02	14744.39	4428.50	3032.04
38	0.43	278.41	5.02	15150.07	4544.82	3111.69
39	0.43	283.42	5.02	15555.76	4661.15	3191.33
40	0.43	288.44	5.02	15961.44	4777.48	3270.98
41	0.43	293.45	5.02	16367.12	4893.81	3350.63
42	0.43	298.47	5.02	16772.81	5010.13	3430.27
43	0.43	303.48	5.02	17178.49	5126.46	3509.92
44	0.43	308.50	5.02	17584.17	5242.79	3589.56
45	0.43	313.51	5.02	17989.85	5359.12	3669.21
46	0.43	318.53	5.02	18395.54	5475.45	3748.85
47	0.43	323.54	5.02	18801.22	5591.77	3828.50
48	0.43	328.56	5.02	19206.90	5708.10	3908.15
49	0.43	333.57	5.02	19612.59	5824.43	3987.79
50	0.43	338.59	5.02	20018.27	5940.76	4067.44
51	0.43	343.60	5.02	20423.95	6057.08	4147.08
52	0.43	348.62	5.02	20829.64	6173.41	4226.73
53	0.43	353.63	5.02	21235.32	6289.74	4306.37
54	0.43	358.65	5.02	21641.00	6406.07	4386.02
55	0.43	363.66	5.02	22046.69	6522.40	4465.67
56	0.43	368.68	5.02	22452.37	6638.72	4545.31
57	0.43	373.69	5.02	22858.05	6755.05	4624.96
58	0.43	378.71	5.02	23263.74	6871.38	4704.60
59	0.43	383.72	5.02	23669.42	6987.71	4784.25
60	0.43	388.74	5.02	24075.10	7104.03	4863.89
61	0.43	393.75	5.02	24480.79	7220.36	4943.54
62	0.43	398.77	5.02	24886.47	7336.69	5023.19
63	0.43	403.78	5.02	25292.15	7453.02	5102.83
64	0.43	408.80	5.02	25697.83	7569.35	5182.48
65	0.43	413.81	5.02	26103.52	7685.67	5262.12
66	0.43	418.83	5.02	26509.20	7802.00	5341.77
67	0.43	423.84	5.02	26914.88	7918.33	5421.41
68	0.43	428.86	5.02	27320.57	8034.66	5501.06
69	0.43	433.87	5.02	27726.25	8150.98	5580.71
70	0.43	438.89	5.02	28131.93	8267.31	5660.35
71	0.43	443.91	5.02	28537.62	8383.64	5740.00
72	0.43	448.92	5.02	28943.30	8499.97	5819.64
73	0.43	453.94	5.02	29348.98	8616.29	5899.29
74	0.43	458.95	5.02	29754.67	8732.62	5978.93
75	0.43	463.97	5.02	30160.35	8848.95	6058.58
76	0.43	468.98	5.02	30566.03	8965.28	6138.23
77	0.43	474.00	5.02	30971.72	9081.61	6217.87
78	0.43	479.01	5.02	31377.40	9197.93	6297.52
79	0.43	484.03	5.02	31783.08	9314.26	6377.16
80	0.43	489.04	5.02	32188.76	9430.59	6456.81
81	0.43	494.06	5.02	32594.45	9546.92	6536.45

82	0.43	499.07	5.02	33000.13	9663.24	6616.10
83	0.43	504.09	5.02	33405.81	9779.57	6695.75
84	0.43	509.10	5.02	33811.50	9895.90	6775.39
85	0.43	514.12	5.02	34217.18	10012.23	6855.04
86	0.43	519.13	5.02	34622.86	10128.56	6934.68
87	0.43	524.15	5.02	35028.55	10244.88	7014.33
88	0.43	529.16	5.02	35434.23	10361.21	7093.97
89	0.43	534.18	5.02	35839.91	10477.54	7173.62
90	0.43	539.19	5.02	36245.60	10593.87	7253.27
91	0.43	544.21	5.02	36651.28	10710.19	7332.91
92	0.43	549.22	5.02	37056.96	10826.52	7412.56
93	0.43	554.24	5.02	37462.65	10942.85	7492.20
94	0.43	559.25	5.02	37868.33	11059.18	7571.85
95	0.43	564.27	5.02	38274.01	11175.51	7651.49
96	0.43	569.28	5.02	38679.69	11291.83	7731.14
97	0.43	574.30	5.02	39085.38	11408.16	7810.79
98	0.43	579.31	5.02	39491.06	11524.49	7890.43
99	0.43	584.33	5.02	39896.74	11640.82	7970.08
100	0.43	589.34	5.02	40302.43	11757.14	8049.72
101	0.43	594.36	5.02	40708.11	11873.47	8129.37
102	0.43	599.37	5.02	41113.79	11989.80	8209.01
103	0.43	604.39	5.02	41519.48	12106.13	8288.66
104	0.43	609.40	5.02	41925.16	12222.46	8368.31
105	0.43	614.42	5.02	42330.84	12338.78	8447.95
106	0.43	619.43	5.02	42736.53	12455.11	8527.60
107	0.43	624.45	5.02	43142.21	12571.44	8607.24
108	0.43	629.46	5.02	43547.89	12687.77	8686.89
109	0.43	634.48	5.02	43953.58	12804.09	8766.53
110	0.43	639.49	5.02	44359.26	12920.42	8846.18
111	0.43	644.51	5.02	44764.94	13036.75	8925.83
112	0.43	649.52	5.02	45170.62	13153.08	9005.47
113	0.43	654.54	5.02	45576.31	13269.41	9085.12
114	0.43	659.55	5.02	45981.99	13385.73	9164.76
115	0.43	664.57	5.02	46387.67	13502.06	9244.41
116	0.43	669.58	5.02	46793.36	13618.39	9324.05
117	0.43	674.60	5.02	47199.04	13734.72	9403.70
118	0.43	679.62	5.02	47604.72	13851.04	9483.35
119	0.43	684.63	5.02	48010.41	13967.37	9562.99
120	0.43	689.65	5.02	48416.09	14083.70	9642.64
121	0.43	694.66	5.02	48821.77	14200.03	9722.28
122	0.43	699.68	5.02	49227.46	14316.36	9801.93
123	0.43	704.69	5.02	49633.14	14432.68	9881.57
124	0.43	709.71	5.02	50038.82	14549.01	9961.22
125	0.43	714.72	5.02	50444.51	14665.34	10040.87
126	0.43	719.74	5.02	50850.19	14781.67	10120.51
127	0.43	724.75	5.02	51255.87	14897.99	10200.16
128	0.43	729.77	5.02	51661.55	15014.32	10279.80
129	0.43	734.78	5.02	52067.24	15130.65	10359.45
130	0.43	739.80	5.02	52472.92	15246.98	10439.09
131	0.43	744.81	5.02	52878.60	15363.31	10518.74
132	0.43	749.83	5.02	53284.29	15479.63	10598.39
133	0.43	754.84	5.02	53689.97	15595.96	10678.03
134	0.43	759.86	5.02	54095.65	15712.29	10757.68
135	0.43	764.87	5.02	54501.34	15828.62	10837.32
136	0.43	769.89	5.02	54907.02	15944.94	10916.97
137	0.43	774.90	5.02	55312.70	16061.27	10996.62
138	0.43	779.92	5.02	55718.39	16177.60	11076.26
139	0.43	784.93	5.02	56124.07	16293.93	11155.91
140	0.43	789.95	5.02	56529.75	16410.26	11235.55
141	0.43	794.96	5.02	56935.44	16526.58	11315.20
142	61.61	797.70	0.97	8053.02	2347.99	1607.59
143	61.61	800.19	9.51	64745.32	32569.90	22299.52
144	61.61	804.72	9.51	62690.45	31611.71	21643.48
145	45.87	809.30	6.67	52011.09	25919.83	17746.44
146	45.87	813.94	6.67	51196.71	25540.09	17486.44
147	45.87	818.58	6.67	50382.34	25160.34	17226.44
148	45.64	823.23	6.67	49679.07	24832.39	17001.91
149	45.64	827.90	6.67	48869.47	24454.87	16743.43
150	45.64	832.56	6.67	48059.87	24077.35	16484.96
151	45.02	837.24	6.67	47527.43	23829.07	16314.97
152	45.02	841.96	6.67	46730.62	23457.51	16060.57
153	45.02	846.67	6.67	45933.80	23085.95	15806.18
154	45.55	851.36	6.67	44909.22	22608.18	15479.06
155	45.55	856.03	6.67	44101.38	22231.48	15221.15

156	45.55	860.70	6.67	43293.53	21854.77	14963.23
157	57.21	865.74	10.00	55296.99	28285.41	19366.07
158	57.21	871.16	10.00	53086.52	27254.65	18660.35
159	45.12	876.22	6.67	39323.02	20003.29	13695.58
160	45.12	880.92	6.67	38524.07	19630.73	13440.51
161	45.12	885.62	6.67	37725.12	19258.18	13185.43
162	69.46	889.73	10.00	37273.31	19880.83	13611.74
163	69.46	893.24	10.00	35059.43	18848.48	12904.92
164	46.16	897.30	6.67	32449.01	16797.89	11500.95
165	46.16	901.92	6.67	31628.89	16415.46	11239.11
166	46.16	906.54	6.67	30808.77	16033.03	10977.28
167	56.80	911.58	10.00	39169.21	20764.90	14217.03
168	56.80	917.06	10.00	36967.03	19738.01	13513.95
169	52.42	922.85	10.00	36954.67	19732.24	13510.01
170	52.42	928.95	10.00	34868.35	18759.38	12843.92
171	53.69	934.96	10.00	32226.47	17527.45	12000.46
172	53.69	940.88	10.00	30101.70	16536.65	11322.09
173	56.57	946.59	10.00	26800.31	14997.19	10268.07
174	56.57	952.10	10.00	24603.11	13972.62	9566.58
175	78.49	956.85	20.00	19064.88	13890.10	9510.09
176	84.11	959.87	20.00	3375.68	6574.10	4501.07
177	79.53	962.72	20.00	3553.72	6657.13	4557.91
178	81.50	966.01	20.00	3056.27	1425.16	975.76
179	86.40	967.50	0.19	0.14	0.07	0.05

Sum of the Resisting Forces = 1620308.37 (lbs)

Average Available Shear Strength = 1558.68(psf)

Sum of the Driving Forces = 1109370.89 (lbs)

Average Mobilized Shear Stress = 1067.18(psf)

Total length of the failure surface = 1039.54(ft)

Factor of Safety Balance Check: FS = 1.46057

**** END OF GEOSTASE OUTPUT ****

FINAL WASTE SLOPE STABILITY – BLOCK ANALYSIS GEOSTASE INPUT PARAMETERS

This analysis evaluates the long term stability of the final waste slope.

The geometry for the critical section is shown on page 16-B-25.

Effective stress parameters were used to analyze the long term condition for the final waste slope. Table 16-B-4 summarizes the material used for each soil type for purposes of this slope stability analysis. The unit weight and effective strength parameters for the materials are from page 16-B-2.

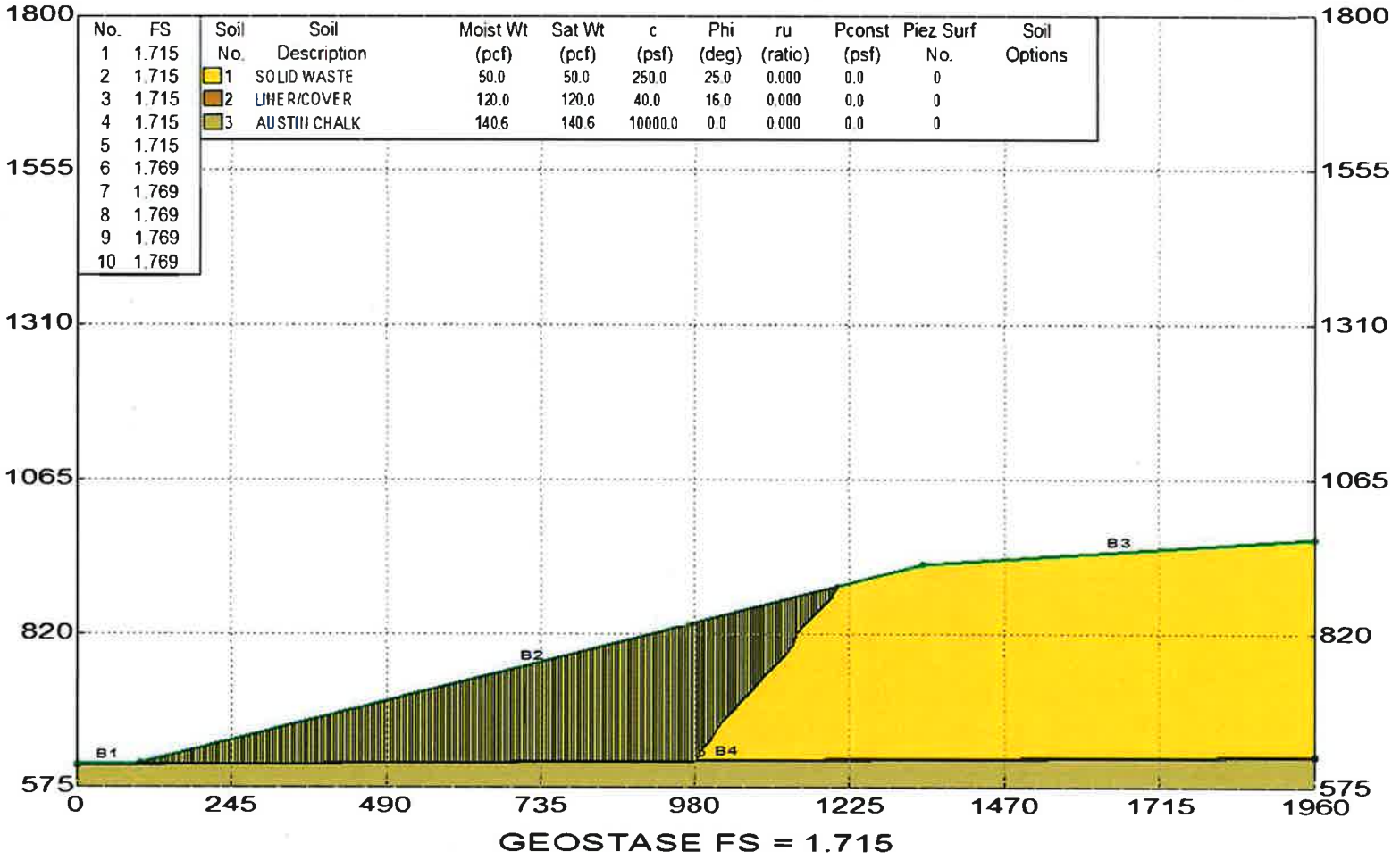
Table 16-B-4
Final Waste Analysis Material Inputs

Material	Soil Type
Solid Waste	1
Liner/Cover	2
Austin Chalk	3

NTMWD 121 RDF ALD
FINAL 4:1

BIGGS AND MATHEWS ENVIRONMENTAL, INC -- FAW/MJW

\121 FINAL 4TO1.gsd



No.	FS
1	1.715
2	1.715
3	1.715
4	1.715
5	1.715
6	1.769
7	1.769
8	1.769
9	1.769
10	1.769

Soil No.	Soil Description	Moist Wt (pcf)	Sat Wt (pcf)	c (psf)	Phi (deg)	ru (ratio)	Pconst (psf)	Piez Surf No.	Soil Options
1	SOLID WASTE	50.0	50.0	250.0	25.0	0.000	0.0	0	
2	LINER/COVER	120.0	120.0	40.0	16.0	0.000	0.0	0	
3	AUSTIN CHALK	140.6	140.6	10000.0	0.0	0.000	0.0	0	

GEOSTASE FS = 1.715

Simplified Janbu Method

GEOSTASE
Slope Stability Analysis

GEOSTASE® by GREGORY GEOTECHNICAL SOFTWARE

PLATE C.1

*** GEOSTASE(R) ***

****

SLOPE STABILITY ANALYSIS SOFTWARE
Simplified Bishop, Simplified Janbu, or General Equilibrium (GE) Options.
(Spencer, Morgenstern-Price, USACE, and Lowe & Karafiath)
Including Pier/Pile, Planar Reinf, Nail, Tieback, Line Loads
Applied Forces, Fiber-Reinforced Soil (FRS), Distributed Loads
Nonlinear Undrained Shear Strength, Curved Strength Envelope,
Anisotropic Strengths, Water Surfaces, 3-Stage Rapid Drawdown
2- or 3-Stage Pseudo-Static & Simplified Newmark Seismic Analyses.

****

Analysis Date: 12/ 11/ 2018
Analysis Time:
Analysis By: BIGGS AND MATHEWS ENVIRONMENTAL, INC -- FAW/MJW

Input File Name: C:\GEOSTASE DATA\121 FINAL 4TO1.gsd

Output File Name: C:\GEOSTASE DATA\121 FINAL 4TO1.OUT

Unit System: English

PROJECT: NTMWD 121 RDF ALD

DESCRIPTION: FINAL 4:1

BOUNDARY DATA

3 Surface Boundaries
5 Total Boundaries

Boundary No.	X - 1 (ft)	Y - 1 (ft)	X - 2 (ft)	Y - 2 (ft)	Soil Type Below Bnd
1	0.000	611.300	100.000	612.000	2
2	100.000	612.000	1340.000	930.000	1
3	1340.000	930.000	1960.000	970.000	1
4	100.000	612.000	1960.000	625.020	2
5	0.000	609.300	1960.000	623.020	3

User Specified X-Origin = 0.000(ft)

User Specified Y-Origin = 575.000(ft)

MOHR-COULOMB SOIL PARAMETERS

3 Type(s) of Soil Defined

Soil Number and Description	Moist Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Ratio(ru)	Pressure Constant (psf)	Water Surface No.	Water Option
1 SOLID WASTE	50.0	50.0	250.00	25.00	0.000	0.0	0	0
2 LINER/COVER	120.0	120.0	40.00	16.00	0.000	0.0	0	0
3 AUSTIN CHALK	140.6	140.6	10000.00	0.00	0.000	0.0	0	0

A Non-Circular Zone Search Has Been Selected For Analysis
Using Random Generation Within Specified Zones.

2 Zones Defined For Generation Of Non-Circular Surfaces

1000 Trial Surfaces Have Been Generated.

Length Of Line Segments For Active And Passive Portions Of
Non-Circular Zone Search = 20.00(ft)

Zone No.	X - 1 (ft)	Y - 1 (ft)	X - 2 (ft)	Y - 2 (ft)	Height (ft)
1	95.00	609.96	105.00	610.03	2.00
2	150.00	610.35	1200.00	618.40	2.00

The Simplified Janbu Method Was Selected for FS Analysis.

Total Number of Trial Surfaces Attempted = 1000

Number of Trial Surfaces With Valid FS = 1000

Statistical Data On All Valid FS Values:
FS Max = 69.941 FS Min = 1.715 FS Ave = 7.954
Standard Deviation = 10.105 Coefficient of Variation = 127.04 %

Critical Surface is Sequence Number 25 of Those Analyzed.

*****BEGINNING OF DETAILED GEOSTASE OUTPUT FOR CRITICAL SURFACE FROM A SEARCH*****

Factor Of Safety For The Critical or Specified Surface = 1.715

Table 1 - Geometry Data on the 230 Slices

Slice No.	Width (ft)	Height (ft)	X-Cntr (ft)	Y-Cntr-Base (ft)	Y-Cntr-Top (ft)	Alpha (deg)	Beta (deg)	Base Length (ft)
1	1.74	0.59	95.95	611.38	611.97	-34.06	0.40	2.10
2	3.18	1.19	98.41	610.80	611.99	0.42	0.40	3.18
3	5.01	1.81	102.51	610.83	612.64	0.42	14.38	5.01
4	5.01	3.06	107.52	610.87	613.93	0.42	14.38	5.01
5	5.01	4.31	112.53	610.90	615.21	0.42	14.38	5.01
6	5.01	5.56	117.54	610.94	616.50	0.42	14.38	5.01
7	5.01	6.81	122.55	610.98	617.78	0.42	14.38	5.01
8	5.01	8.06	127.56	611.01	619.07	0.42	14.38	5.01
9	5.01	9.30	132.58	611.05	620.35	0.42	14.38	5.01
10	5.01	10.55	137.59	611.09	621.64	0.42	14.38	5.01
11	5.01	11.80	142.60	611.12	622.92	0.42	14.38	5.01
12	5.01	13.05	147.61	611.16	624.21	0.42	14.38	5.01
13	5.01	14.30	152.62	611.20	625.49	0.42	14.38	5.01
14	5.01	15.55	157.63	611.23	626.78	0.42	14.38	5.01
15	5.01	16.80	162.64	611.27	628.07	0.42	14.38	5.01
16	5.01	18.04	167.66	611.31	629.35	0.42	14.38	5.01
17	5.01	19.29	172.67	611.34	630.64	0.42	14.38	5.01
18	5.01	20.54	177.68	611.38	631.92	0.42	14.38	5.01
19	5.01	21.79	182.69	611.42	633.21	0.42	14.38	5.01
20	5.01	23.04	187.70	611.45	634.49	0.42	14.38	5.01
21	5.01	24.29	192.71	611.49	635.78	0.42	14.38	5.01
22	5.01	25.54	197.73	611.53	637.06	0.42	14.38	5.01
23	5.01	26.78	202.74	611.56	638.35	0.42	14.38	5.01
24	5.01	28.03	207.75	611.60	639.63	0.42	14.38	5.01
25	5.01	29.28	212.76	611.64	640.92	0.42	14.38	5.01
26	5.01	30.53	217.77	611.67	642.20	0.42	14.38	5.01
27	5.01	31.78	222.78	611.71	643.49	0.42	14.38	5.01
28	5.01	33.03	227.80	611.75	644.77	0.42	14.38	5.01
29	5.01	34.28	232.81	611.78	646.06	0.42	14.38	5.01

30	5.01	35.52	237.82	611.82	647.34	0.42	14.38	5.01
31	5.01	36.77	242.83	611.86	648.63	0.42	14.38	5.01
32	5.01	38.02	247.84	611.89	649.91	0.42	14.38	5.01
33	5.01	39.27	252.85	611.93	651.20	0.42	14.38	5.01
34	5.01	40.52	257.87	611.97	652.48	0.42	14.38	5.01
35	5.01	41.77	262.88	612.00	653.77	0.42	14.38	5.01
36	5.01	43.01	267.89	612.04	655.06	0.42	14.38	5.01
37	5.01	44.26	272.90	612.08	656.34	0.42	14.38	5.01
38	5.01	45.51	277.91	612.11	657.63	0.42	14.38	5.01
39	5.01	46.76	282.92	612.15	658.91	0.42	14.38	5.01
40	5.01	48.01	287.93	612.19	660.20	0.42	14.38	5.01
41	5.01	49.26	292.95	612.22	661.48	0.42	14.38	5.01
42	5.01	50.51	297.96	612.26	662.77	0.42	14.38	5.01
43	5.01	51.75	302.97	612.30	664.05	0.42	14.38	5.01
44	5.01	53.00	307.98	612.33	665.34	0.42	14.38	5.01
45	5.01	54.25	312.99	612.37	666.62	0.42	14.38	5.01
46	5.01	55.50	318.00	612.41	667.91	0.42	14.38	5.01
47	5.01	56.75	323.02	612.44	669.19	0.42	14.38	5.01
48	5.01	58.00	328.03	612.48	670.48	0.42	14.38	5.01
49	5.01	59.25	333.04	612.52	671.76	0.42	14.38	5.01
50	5.01	60.49	338.05	612.55	673.05	0.42	14.38	5.01
51	5.01	61.74	343.06	612.59	674.33	0.42	14.38	5.01
52	5.01	62.99	348.07	612.63	675.62	0.42	14.38	5.01
53	5.01	64.24	353.09	612.66	676.90	0.42	14.38	5.01
54	5.01	65.49	358.10	612.70	678.19	0.42	14.38	5.01
55	5.01	66.74	363.11	612.74	679.47	0.42	14.38	5.01
56	5.01	67.99	368.12	612.77	680.76	0.42	14.38	5.01
57	5.01	69.23	373.13	612.81	682.05	0.42	14.38	5.01
58	5.01	70.48	378.14	612.85	683.33	0.42	14.38	5.01
59	5.01	71.73	383.16	612.88	684.62	0.42	14.38	5.01
60	5.01	72.98	388.17	612.92	685.90	0.42	14.38	5.01
61	5.01	74.23	393.18	612.96	687.19	0.42	14.38	5.01
62	5.01	75.48	398.19	612.99	688.47	0.42	14.38	5.01
63	5.01	76.73	403.20	613.03	689.76	0.42	14.38	5.01
64	5.01	77.97	408.21	613.07	691.04	0.42	14.38	5.01
65	5.01	79.22	413.22	613.10	692.33	0.42	14.38	5.01
66	5.01	80.47	418.24	613.14	693.61	0.42	14.38	5.01
67	5.01	81.72	423.25	613.18	694.90	0.42	14.38	5.01
68	5.01	82.97	428.26	613.21	696.18	0.42	14.38	5.01
69	5.01	84.22	433.27	613.25	697.47	0.42	14.38	5.01
70	5.01	85.47	438.28	613.29	698.75	0.42	14.38	5.01
71	5.01	86.71	443.29	613.32	700.04	0.42	14.38	5.01
72	5.01	87.96	448.31	613.36	701.32	0.42	14.38	5.01
73	5.01	89.21	453.32	613.40	702.61	0.42	14.38	5.01
74	5.01	90.46	458.33	613.43	703.89	0.42	14.38	5.01
75	5.01	91.71	463.34	613.47	705.18	0.42	14.38	5.01
76	5.01	92.96	468.35	613.51	706.46	0.42	14.38	5.01
77	5.01	94.21	473.36	613.54	707.75	0.42	14.38	5.01
78	5.01	95.45	478.38	613.58	709.03	0.42	14.38	5.01
79	5.01	96.70	483.39	613.62	710.32	0.42	14.38	5.01
80	5.01	97.95	488.40	613.65	711.61	0.42	14.38	5.01
81	5.01	99.20	493.41	613.69	712.89	0.42	14.38	5.01
82	5.01	100.45	498.42	613.73	714.18	0.42	14.38	5.01
83	5.01	101.70	503.43	613.76	715.46	0.42	14.38	5.01
84	5.01	102.95	508.44	613.80	716.75	0.42	14.38	5.01
85	5.01	104.19	513.46	613.84	718.03	0.42	14.38	5.01
86	5.01	105.44	518.47	613.87	719.32	0.42	14.38	5.01
87	5.01	106.69	523.48	613.91	720.60	0.42	14.38	5.01
88	5.01	107.94	528.49	613.95	721.89	0.42	14.38	5.01
89	5.01	109.19	533.50	613.98	723.17	0.42	14.38	5.01
90	5.01	110.44	538.51	614.02	724.46	0.42	14.38	5.01
91	5.01	111.69	543.53	614.06	725.74	0.42	14.38	5.01
92	5.01	112.93	548.54	614.09	727.03	0.42	14.38	5.01
93	5.01	114.18	553.55	614.13	728.31	0.42	14.38	5.01
94	5.01	115.43	558.56	614.17	729.60	0.42	14.38	5.01
95	5.01	116.68	563.57	614.20	730.88	0.42	14.38	5.01
96	5.01	117.93	568.58	614.24	732.17	0.42	14.38	5.01
97	5.01	119.18	573.60	614.28	733.45	0.42	14.38	5.01
98	5.01	120.43	578.61	614.31	734.74	0.42	14.38	5.01
99	5.01	121.67	583.62	614.35	736.02	0.42	14.38	5.01
100	5.01	122.92	588.63	614.39	737.31	0.42	14.38	5.01
101	5.01	124.17	593.64	614.42	738.60	0.42	14.38	5.01
102	5.01	125.42	598.65	614.46	739.88	0.42	14.38	5.01
103	5.01	126.67	603.67	614.50	741.17	0.42	14.38	5.01

104	5.01	127.92	608.68	614.53	742.45	0.42	14.38	5.01
105	5.01	129.17	613.69	614.57	743.74	0.42	14.38	5.01
106	5.01	130.41	618.70	614.61	745.02	0.42	14.38	5.01
107	5.01	131.66	623.71	614.64	746.31	0.42	14.38	5.01
108	5.01	132.91	628.72	614.68	747.59	0.42	14.38	5.01
109	5.01	134.16	633.73	614.72	748.88	0.42	14.38	5.01
110	5.01	135.41	638.75	614.75	750.16	0.42	14.38	5.01
111	5.01	136.66	643.76	614.79	751.45	0.42	14.38	5.01
112	5.01	137.91	648.77	614.83	752.73	0.42	14.38	5.01
113	5.01	139.15	653.78	614.86	754.02	0.42	14.38	5.01
114	5.01	140.40	658.79	614.90	755.30	0.42	14.38	5.01
115	5.01	141.65	663.80	614.94	756.59	0.42	14.38	5.01
116	5.01	142.90	668.82	614.97	757.87	0.42	14.38	5.01
117	5.01	144.15	673.83	615.01	759.16	0.42	14.38	5.01
118	5.01	145.40	678.84	615.05	760.44	0.42	14.38	5.01
119	5.01	146.65	683.85	615.08	761.73	0.42	14.38	5.01
120	5.01	147.89	688.86	615.12	763.01	0.42	14.38	5.01
121	5.01	149.14	693.87	615.16	764.30	0.42	14.38	5.01
122	5.01	150.39	698.89	615.19	765.59	0.42	14.38	5.01
123	5.01	151.64	703.90	615.23	766.87	0.42	14.38	5.01
124	5.01	152.89	708.91	615.27	768.16	0.42	14.38	5.01
125	5.01	154.14	713.92	615.30	769.44	0.42	14.38	5.01
126	5.01	155.39	718.93	615.34	770.73	0.42	14.38	5.01
127	5.01	156.63	723.94	615.38	772.01	0.42	14.38	5.01
128	5.01	157.88	728.95	615.41	773.30	0.42	14.38	5.01
129	5.01	159.13	733.97	615.45	774.58	0.42	14.38	5.01
130	5.01	160.38	738.98	615.49	775.87	0.42	14.38	5.01
131	5.01	161.63	743.99	615.52	777.15	0.42	14.38	5.01
132	5.01	162.88	749.00	615.56	778.44	0.42	14.38	5.01
133	5.01	164.13	754.01	615.60	779.72	0.42	14.38	5.01
134	5.01	165.37	759.02	615.63	781.01	0.42	14.38	5.01
135	5.01	166.62	764.04	615.67	782.29	0.42	14.38	5.01
136	5.01	167.87	769.05	615.71	783.58	0.42	14.38	5.01
137	5.01	169.12	774.06	615.74	784.86	0.42	14.38	5.01
138	5.01	170.37	779.07	615.78	786.15	0.42	14.38	5.01
139	5.01	171.62	784.08	615.82	787.43	0.42	14.38	5.01
140	5.01	172.87	789.09	615.85	788.72	0.42	14.38	5.01
141	5.01	174.11	794.11	615.89	790.00	0.42	14.38	5.01
142	5.01	175.36	799.12	615.93	791.29	0.42	14.38	5.01
143	5.01	176.61	804.13	615.96	792.57	0.42	14.38	5.01
144	5.01	177.86	809.14	616.00	793.86	0.42	14.38	5.01
145	5.01	179.11	814.15	616.04	795.15	0.42	14.38	5.01
146	5.01	180.36	819.16	616.07	796.43	0.42	14.38	5.01
147	5.01	181.61	824.18	616.11	797.72	0.42	14.38	5.01
148	5.01	182.85	829.19	616.15	799.00	0.42	14.38	5.01
149	5.01	184.10	834.20	616.18	800.29	0.42	14.38	5.01
150	5.01	185.35	839.21	616.22	801.57	0.42	14.38	5.01
151	5.01	186.60	844.22	616.26	802.86	0.42	14.38	5.01
152	5.01	187.85	849.23	616.29	804.14	0.42	14.38	5.01
153	5.01	189.10	854.24	616.33	805.43	0.42	14.38	5.01
154	5.01	190.35	859.26	616.37	806.71	0.42	14.38	5.01
155	5.01	191.59	864.27	616.40	808.00	0.42	14.38	5.01
156	5.01	192.84	869.28	616.44	809.28	0.42	14.38	5.01
157	5.01	194.09	874.29	616.48	810.57	0.42	14.38	5.01
158	5.01	195.34	879.30	616.51	811.85	0.42	14.38	5.01
159	5.01	196.59	884.31	616.55	813.14	0.42	14.38	5.01
160	5.01	197.84	889.33	616.59	814.42	0.42	14.38	5.01
161	5.01	199.09	894.34	616.62	815.71	0.42	14.38	5.01
162	5.01	200.33	899.35	616.66	816.99	0.42	14.38	5.01
163	5.01	201.58	904.36	616.70	818.28	0.42	14.38	5.01
164	5.01	202.83	909.37	616.73	819.56	0.42	14.38	5.01
165	5.01	204.08	914.38	616.77	820.85	0.42	14.38	5.01
166	5.01	205.33	919.40	616.81	822.14	0.42	14.38	5.01
167	5.01	206.58	924.41	616.84	823.42	0.42	14.38	5.01
168	5.01	207.83	929.42	616.88	824.71	0.42	14.38	5.01
169	5.01	209.07	934.43	616.92	825.99	0.42	14.38	5.01
170	5.01	210.32	939.44	616.95	827.28	0.42	14.38	5.01
171	5.01	211.57	944.45	616.99	828.56	0.42	14.38	5.01
172	5.01	212.82	949.47	617.03	829.85	0.42	14.38	5.01
173	5.01	214.07	954.48	617.06	831.13	0.42	14.38	5.01
174	5.01	215.32	959.49	617.10	832.42	0.42	14.38	5.01
175	5.01	216.57	964.50	617.14	833.70	0.42	14.38	5.01
176	5.01	217.81	969.51	617.17	834.99	0.42	14.38	5.01
177	5.01	219.06	974.52	617.21	836.27	0.42	14.38	5.01

178	5.01	220.31	979.53	617.25	837.56	0.42	14.38	5.01
179	0.42	220.53	982.25	617.72	838.25	65.44	14.38	1.00
180	3.95	216.32	984.43	622.50	838.81	65.44	14.38	9.50
181	3.95	208.69	988.38	631.14	839.83	65.44	14.38	9.50
182	4.65	203.09	992.68	637.84	840.93	45.73	14.38	6.67
183	4.65	199.51	997.33	642.62	842.12	45.73	14.38	6.67
184	4.65	195.93	1001.99	647.39	843.32	45.73	14.38	6.67
185	4.89	190.40	1006.76	654.14	844.54	60.74	14.38	10.00
186	4.89	182.93	1011.64	662.86	845.79	60.74	14.38	10.00
187	4.39	177.25	1016.28	669.73	846.98	48.76	14.38	6.67
188	4.39	173.36	1020.68	674.75	848.11	48.76	14.38	6.67
189	4.39	169.48	1025.07	679.76	849.24	48.76	14.38	6.67
190	4.50	165.65	1029.52	684.73	850.38	47.58	14.38	6.67
191	4.50	161.88	1034.02	689.65	851.53	47.58	14.38	6.67
192	4.50	158.11	1038.51	694.57	852.68	47.58	14.38	6.67
193	4.32	154.24	1042.92	699.57	853.81	49.66	14.38	6.67
194	4.32	150.27	1047.24	704.65	854.92	49.66	14.38	6.67
195	4.32	146.29	1051.55	709.73	856.03	49.66	14.38	6.67
196	4.69	142.54	1056.05	714.64	857.18	45.34	14.38	6.67
197	4.69	139.00	1060.74	719.39	858.38	45.34	14.38	6.67
198	4.69	135.46	1065.43	724.13	859.59	45.34	14.38	6.67
199	4.32	131.70	1069.93	729.04	860.74	49.59	14.38	6.67
200	4.32	127.74	1074.25	734.11	861.85	49.59	14.38	6.67
201	4.32	123.77	1078.57	739.19	862.96	49.59	14.38	6.67
202	4.23	119.75	1082.85	744.30	864.05	50.57	14.38	6.67
203	4.23	115.69	1087.09	749.45	865.14	50.57	14.38	6.67
204	4.23	111.63	1091.32	754.60	866.23	50.57	14.38	6.67
205	4.66	107.81	1095.77	759.56	867.37	45.71	14.38	6.67
206	4.66	104.23	1100.42	764.33	868.56	45.71	14.38	6.67
207	4.66	100.65	1105.08	769.10	869.75	45.71	14.38	6.67
208	4.71	97.11	1109.76	773.85	870.95	45.00	14.38	6.67
209	4.71	93.60	1114.48	778.56	872.16	45.00	14.38	6.67
210	4.71	90.10	1119.19	783.28	873.37	45.00	14.38	6.67
211	4.28	86.34	1123.69	788.19	874.53	50.02	14.38	6.67
212	4.28	82.33	1127.97	793.29	875.63	50.02	14.38	6.67
213	4.28	78.32	1132.26	798.40	876.72	50.02	14.38	6.67
214	3.25	72.00	1136.02	805.69	877.69	71.06	14.38	10.00
215	3.25	63.38	1139.27	815.14	878.52	71.06	14.38	10.00
216	4.40	57.12	1143.09	822.38	879.50	48.75	14.38	6.67
217	4.40	53.24	1147.48	827.39	880.63	48.75	14.38	6.67
218	4.40	49.35	1151.88	832.40	881.76	48.75	14.38	6.67
219	4.68	45.64	1156.42	837.28	882.92	45.38	14.38	6.67
220	4.68	42.09	1161.10	842.03	884.12	45.38	14.38	6.67
221	4.68	38.55	1165.78	846.77	885.32	45.38	14.38	6.67
222	4.69	35.01	1170.47	851.52	886.52	45.31	14.38	6.67
223	4.69	31.47	1175.16	856.26	887.73	45.31	14.38	6.67
224	4.69	27.93	1179.85	860.99	888.93	45.31	14.38	6.67
225	4.54	24.30	1184.46	865.81	890.11	47.12	14.38	6.67
226	4.54	20.58	1189.00	870.69	891.27	47.12	14.38	6.67
227	4.54	16.86	1193.53	875.58	892.44	47.12	14.38	6.67
228	5.13	11.36	1198.36	882.31	893.68	59.16	14.38	10.00
229	5.13	4.09	1203.49	890.90	894.99	59.16	14.38	10.00
230	0.25	0.23	1206.18	895.45	895.68	64.32	14.38	0.58

Table 2 - Force Data On The 230 Slices (Excluding Reinforcement)

Slice No.	Weight (lbs)	Ubeta Force Top (lbs)	Ualpha Force Bot (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Distributed Load (lbs)
1	124.2	0.0	0.0	0.0	0.0	0.0
2	454.2	0.0	0.0	0.0	0.0	0.0
3	870.7	0.0	0.0	0.0	0.0	0.0
4	1183.0	0.0	0.0	0.0	0.0	0.0
5	1495.3	0.0	0.0	0.0	0.0	0.0
6	1807.6	0.0	0.0	0.0	0.0	0.0
7	2119.9	0.0	0.0	0.0	0.0	0.0
8	2432.2	0.0	0.0	0.0	0.0	0.0
9	2744.5	0.0	0.0	0.0	0.0	0.0
10	3056.8	0.0	0.0	0.0	0.0	0.0
11	3369.1	0.0	0.0	0.0	0.0	0.0

12	3681.4	0.0	0.0	0.0	0.0	0.0
13	3993.7	0.0	0.0	0.0	0.0	0.0
14	4306.0	0.0	0.0	0.0	0.0	0.0
15	4618.3	0.0	0.0	0.0	0.0	0.0
16	4930.7	0.0	0.0	0.0	0.0	0.0
17	5243.0	0.0	0.0	0.0	0.0	0.0
18	5555.3	0.0	0.0	0.0	0.0	0.0
19	5867.6	0.0	0.0	0.0	0.0	0.0
20	6179.9	0.0	0.0	0.0	0.0	0.0
21	6492.2	0.0	0.0	0.0	0.0	0.0
22	6804.5	0.0	0.0	0.0	0.0	0.0
23	7116.8	0.0	0.0	0.0	0.0	0.0
24	7429.1	0.0	0.0	0.0	0.0	0.0
25	7741.4	0.0	0.0	0.0	0.0	0.0
26	8053.7	0.0	0.0	0.0	0.0	0.0
27	8366.0	0.0	0.0	0.0	0.0	0.0
28	8678.4	0.0	0.0	0.0	0.0	0.0
29	8990.7	0.0	0.0	0.0	0.0	0.0
30	9303.0	0.0	0.0	0.0	0.0	0.0
31	9615.3	0.0	0.0	0.0	0.0	0.0
32	9927.6	0.0	0.0	0.0	0.0	0.0
33	10239.9	0.0	0.0	0.0	0.0	0.0
34	10552.2	0.0	0.0	0.0	0.0	0.0
35	10864.5	0.0	0.0	0.0	0.0	0.0
36	11176.8	0.0	0.0	0.0	0.0	0.0
37	11489.1	0.0	0.0	0.0	0.0	0.0
38	11801.4	0.0	0.0	0.0	0.0	0.0
39	12113.7	0.0	0.0	0.0	0.0	0.0
40	12426.0	0.0	0.0	0.0	0.0	0.0
41	12738.4	0.0	0.0	0.0	0.0	0.0
42	13050.7	0.0	0.0	0.0	0.0	0.0
43	13363.0	0.0	0.0	0.0	0.0	0.0
44	13675.3	0.0	0.0	0.0	0.0	0.0
45	13987.6	0.0	0.0	0.0	0.0	0.0
46	14299.9	0.0	0.0	0.0	0.0	0.0
47	14612.2	0.0	0.0	0.0	0.0	0.0
48	14924.5	0.0	0.0	0.0	0.0	0.0
49	15236.8	0.0	0.0	0.0	0.0	0.0
50	15549.1	0.0	0.0	0.0	0.0	0.0
51	15861.4	0.0	0.0	0.0	0.0	0.0
52	16173.7	0.0	0.0	0.0	0.0	0.0
53	16486.0	0.0	0.0	0.0	0.0	0.0
54	16798.4	0.0	0.0	0.0	0.0	0.0
55	17110.7	0.0	0.0	0.0	0.0	0.0
56	17423.0	0.0	0.0	0.0	0.0	0.0
57	17735.3	0.0	0.0	0.0	0.0	0.0
58	18047.6	0.0	0.0	0.0	0.0	0.0
59	18359.9	0.0	0.0	0.0	0.0	0.0
60	18672.2	0.0	0.0	0.0	0.0	0.0
61	18984.5	0.0	0.0	0.0	0.0	0.0
62	19296.8	0.0	0.0	0.0	0.0	0.0
63	19609.1	0.0	0.0	0.0	0.0	0.0
64	19921.4	0.0	0.0	0.0	0.0	0.0
65	20233.7	0.0	0.0	0.0	0.0	0.0
66	20546.1	0.0	0.0	0.0	0.0	0.0
67	20858.4	0.0	0.0	0.0	0.0	0.0
68	21170.7	0.0	0.0	0.0	0.0	0.0
69	21483.0	0.0	0.0	0.0	0.0	0.0
70	21795.3	0.0	0.0	0.0	0.0	0.0
71	22107.6	0.0	0.0	0.0	0.0	0.0
72	22419.9	0.0	0.0	0.0	0.0	0.0
73	22732.2	0.0	0.0	0.0	0.0	0.0
74	23044.5	0.0	0.0	0.0	0.0	0.0
75	23356.8	0.0	0.0	0.0	0.0	0.0
76	23669.1	0.0	0.0	0.0	0.0	0.0
77	23981.4	0.0	0.0	0.0	0.0	0.0
78	24293.7	0.0	0.0	0.0	0.0	0.0
79	24606.1	0.0	0.0	0.0	0.0	0.0
80	24918.4	0.0	0.0	0.0	0.0	0.0
81	25230.7	0.0	0.0	0.0	0.0	0.0
82	25543.0	0.0	0.0	0.0	0.0	0.0
83	25855.3	0.0	0.0	0.0	0.0	0.0
84	26167.6	0.0	0.0	0.0	0.0	0.0
85	26479.9	0.0	0.0	0.0	0.0	0.0

86	26792.2	0.0	0.0	0.0	0.0	0.0
87	27104.5	0.0	0.0	0.0	0.0	0.0
88	27416.8	0.0	0.0	0.0	0.0	0.0
89	27729.1	0.0	0.0	0.0	0.0	0.0
90	28041.4	0.0	0.0	0.0	0.0	0.0
91	28353.7	0.0	0.0	0.0	0.0	0.0
92	28666.1	0.0	0.0	0.0	0.0	0.0
93	28978.4	0.0	0.0	0.0	0.0	0.0
94	29290.7	0.0	0.0	0.0	0.0	0.0
95	29603.0	0.0	0.0	0.0	0.0	0.0
96	29915.3	0.0	0.0	0.0	0.0	0.0
97	30227.6	0.0	0.0	0.0	0.0	0.0
98	30539.9	0.0	0.0	0.0	0.0	0.0
99	30852.2	0.0	0.0	0.0	0.0	0.0
100	31164.5	0.0	0.0	0.0	0.0	0.0
101	31476.8	0.0	0.0	0.0	0.0	0.0
102	31789.1	0.0	0.0	0.0	0.0	0.0
103	32101.4	0.0	0.0	0.0	0.0	0.0
104	32413.8	0.0	0.0	0.0	0.0	0.0
105	32726.1	0.0	0.0	0.0	0.0	0.0
106	33038.4	0.0	0.0	0.0	0.0	0.0
107	33350.7	0.0	0.0	0.0	0.0	0.0
108	33663.0	0.0	0.0	0.0	0.0	0.0
109	33975.3	0.0	0.0	0.0	0.0	0.0
110	34287.6	0.0	0.0	0.0	0.0	0.0
111	34599.9	0.0	0.0	0.0	0.0	0.0
112	34912.2	0.0	0.0	0.0	0.0	0.0
113	35224.5	0.0	0.0	0.0	0.0	0.0
114	35536.8	0.0	0.0	0.0	0.0	0.0
115	35849.1	0.0	0.0	0.0	0.0	0.0
116	36161.4	0.0	0.0	0.0	0.0	0.0
117	36473.8	0.0	0.0	0.0	0.0	0.0
118	36786.1	0.0	0.0	0.0	0.0	0.0
119	37098.4	0.0	0.0	0.0	0.0	0.0
120	37410.7	0.0	0.0	0.0	0.0	0.0
121	37723.0	0.0	0.0	0.0	0.0	0.0
122	38035.3	0.0	0.0	0.0	0.0	0.0
123	38347.6	0.0	0.0	0.0	0.0	0.0
124	38659.9	0.0	0.0	0.0	0.0	0.0
125	38972.2	0.0	0.0	0.0	0.0	0.0
126	39284.5	0.0	0.0	0.0	0.0	0.0
127	39596.8	0.0	0.0	0.0	0.0	0.0
128	39909.1	0.0	0.0	0.0	0.0	0.0
129	40221.4	0.0	0.0	0.0	0.0	0.0
130	40533.8	0.0	0.0	0.0	0.0	0.0
131	40846.1	0.0	0.0	0.0	0.0	0.0
132	41158.4	0.0	0.0	0.0	0.0	0.0
133	41470.7	0.0	0.0	0.0	0.0	0.0
134	41783.0	0.0	0.0	0.0	0.0	0.0
135	42095.3	0.0	0.0	0.0	0.0	0.0
136	42407.6	0.0	0.0	0.0	0.0	0.0
137	42719.9	0.0	0.0	0.0	0.0	0.0
138	43032.2	0.0	0.0	0.0	0.0	0.0
139	43344.5	0.0	0.0	0.0	0.0	0.0
140	43656.8	0.0	0.0	0.0	0.0	0.0
141	43969.1	0.0	0.0	0.0	0.0	0.0
142	44281.5	0.0	0.0	0.0	0.0	0.0
143	44593.8	0.0	0.0	0.0	0.0	0.0
144	44906.1	0.0	0.0	0.0	0.0	0.0
145	45218.4	0.0	0.0	0.0	0.0	0.0
146	45530.7	0.0	0.0	0.0	0.0	0.0
147	45843.0	0.0	0.0	0.0	0.0	0.0
148	46155.3	0.0	0.0	0.0	0.0	0.0
149	46467.6	0.0	0.0	0.0	0.0	0.0
150	46779.9	0.0	0.0	0.0	0.0	0.0
151	47092.2	0.0	0.0	0.0	0.0	0.0
152	47404.5	0.0	0.0	0.0	0.0	0.0
153	47716.8	0.0	0.0	0.0	0.0	0.0
154	48029.1	0.0	0.0	0.0	0.0	0.0
155	48341.5	0.0	0.0	0.0	0.0	0.0
156	48653.8	0.0	0.0	0.0	0.0	0.0
157	48966.1	0.0	0.0	0.0	0.0	0.0
158	49278.4	0.0	0.0	0.0	0.0	0.0
159	49590.7	0.0	0.0	0.0	0.0	0.0

160	49903.0	0.0	0.0	0.0	0.0	0.0
161	50215.3	0.0	0.0	0.0	0.0	0.0
162	50527.6	0.0	0.0	0.0	0.0	0.0
163	50839.9	0.0	0.0	0.0	0.0	0.0
164	51152.2	0.0	0.0	0.0	0.0	0.0
165	51464.5	0.0	0.0	0.0	0.0	0.0
166	51776.8	0.0	0.0	0.0	0.0	0.0
167	52089.1	0.0	0.0	0.0	0.0	0.0
168	52401.5	0.0	0.0	0.0	0.0	0.0
169	52713.8	0.0	0.0	0.0	0.0	0.0
170	53026.1	0.0	0.0	0.0	0.0	0.0
171	53338.4	0.0	0.0	0.0	0.0	0.0
172	53650.7	0.0	0.0	0.0	0.0	0.0
173	53963.0	0.0	0.0	0.0	0.0	0.0
174	54275.3	0.0	0.0	0.0	0.0	0.0
175	54587.6	0.0	0.0	0.0	0.0	0.0
176	54899.9	0.0	0.0	0.0	0.0	0.0
177	55212.2	0.0	0.0	0.0	0.0	0.0
178	55524.5	0.0	0.0	0.0	0.0	0.0
179	4606.8	0.0	0.0	0.0	0.0	0.0
180	42697.4	0.0	0.0	0.0	0.0	0.0
181	41191.9	0.0	0.0	0.0	0.0	0.0
182	47253.9	0.0	0.0	0.0	0.0	0.0
183	46420.8	0.0	0.0	0.0	0.0	0.0
184	45587.7	0.0	0.0	0.0	0.0	0.0
185	46525.6	0.0	0.0	0.0	0.0	0.0
186	44699.9	0.0	0.0	0.0	0.0	0.0
187	38949.7	0.0	0.0	0.0	0.0	0.0
188	38095.8	0.0	0.0	0.0	0.0	0.0
189	37241.9	0.0	0.0	0.0	0.0	0.0
190	37247.2	0.0	0.0	0.0	0.0	0.0
191	36400.0	0.0	0.0	0.0	0.0	0.0
192	35552.7	0.0	0.0	0.0	0.0	0.0
193	33283.4	0.0	0.0	0.0	0.0	0.0
194	32425.7	0.0	0.0	0.0	0.0	0.0
195	31568.1	0.0	0.0	0.0	0.0	0.0
196	33397.8	0.0	0.0	0.0	0.0	0.0
197	32568.4	0.0	0.0	0.0	0.0	0.0
198	31738.9	0.0	0.0	0.0	0.0	0.0
199	28460.7	0.0	0.0	0.0	0.0	0.0
200	27603.3	0.0	0.0	0.0	0.0	0.0
201	26746.0	0.0	0.0	0.0	0.0	0.0
202	25354.4	0.0	0.0	0.0	0.0	0.0
203	24494.1	0.0	0.0	0.0	0.0	0.0
204	23633.8	0.0	0.0	0.0	0.0	0.0
205	25094.2	0.0	0.0	0.0	0.0	0.0
206	24261.3	0.0	0.0	0.0	0.0	0.0
207	23428.4	0.0	0.0	0.0	0.0	0.0
208	22888.4	0.0	0.0	0.0	0.0	0.0
209	22062.2	0.0	0.0	0.0	0.0	0.0
210	21236.0	0.0	0.0	0.0	0.0	0.0
211	18492.7	0.0	0.0	0.0	0.0	0.0
212	17633.9	0.0	0.0	0.0	0.0	0.0
213	16775.0	0.0	0.0	0.0	0.0	0.0
214	11688.1	0.0	0.0	0.0	0.0	0.0
215	10287.9	0.0	0.0	0.0	0.0	0.0
216	12555.5	0.0	0.0	0.0	0.0	0.0
217	11701.6	0.0	0.0	0.0	0.0	0.0
218	10847.8	0.0	0.0	0.0	0.0	0.0
219	10684.6	0.0	0.0	0.0	0.0	0.0
220	9854.7	0.0	0.0	0.0	0.0	0.0
221	9024.8	0.0	0.0	0.0	0.0	0.0
222	8206.7	0.0	0.0	0.0	0.0	0.0
223	7377.5	0.0	0.0	0.0	0.0	0.0
224	6548.3	0.0	0.0	0.0	0.0	0.0
225	5512.9	0.0	0.0	0.0	0.0	0.0
226	4668.7	0.0	0.0	0.0	0.0	0.0
227	3824.5	0.0	0.0	0.0	0.0	0.0
228	2912.8	0.0	0.0	0.0	0.0	0.0
229	1049.0	0.0	0.0	0.0	0.0	0.0
230	2.9	0.0	0.0	0.0	0.0	0.0

TOTAL WEIGHT OF SLIDING MASS = 6175721.50(lbs)

EFFECTIVE WEIGHT OF SLIDING MASS = 6175721.50(lbs)

TOTAL AREA OF SLIDING MASS = ********(ft2)

TABLE 2A - SOIL STRENGTH & SOIL OPTIONS DATA ON THE 230 SLICES

Slice No.	Soil Type	Cohesion (psf)	Phi(Deg)	Options
1	2	40.00	16.00	
2	2	40.00	16.00	
3	2	40.00	16.00	
4	2	40.00	16.00	
5	2	40.00	16.00	
6	2	40.00	16.00	
7	2	40.00	16.00	
8	2	40.00	16.00	
9	2	40.00	16.00	
10	2	40.00	16.00	
11	2	40.00	16.00	
12	2	40.00	16.00	
13	2	40.00	16.00	
14	2	40.00	16.00	
15	2	40.00	16.00	
16	2	40.00	16.00	
17	2	40.00	16.00	
18	2	40.00	16.00	
19	2	40.00	16.00	
20	2	40.00	16.00	
21	2	40.00	16.00	
22	2	40.00	16.00	
23	2	40.00	16.00	
24	2	40.00	16.00	
25	2	40.00	16.00	
26	2	40.00	16.00	
27	2	40.00	16.00	
28	2	40.00	16.00	
29	2	40.00	16.00	
30	2	40.00	16.00	
31	2	40.00	16.00	
32	2	40.00	16.00	
33	2	40.00	16.00	
34	2	40.00	16.00	
35	2	40.00	16.00	
36	2	40.00	16.00	
37	2	40.00	16.00	
38	2	40.00	16.00	
39	2	40.00	16.00	
40	2	40.00	16.00	
41	2	40.00	16.00	
42	2	40.00	16.00	
43	2	40.00	16.00	
44	2	40.00	16.00	
45	2	40.00	16.00	
46	2	40.00	16.00	
47	2	40.00	16.00	
48	2	40.00	16.00	
49	2	40.00	16.00	
50	2	40.00	16.00	
51	2	40.00	16.00	
52	2	40.00	16.00	
53	2	40.00	16.00	
54	2	40.00	16.00	
55	2	40.00	16.00	
56	2	40.00	16.00	
57	2	40.00	16.00	
58	2	40.00	16.00	
59	2	40.00	16.00	
60	2	40.00	16.00	
61	2	40.00	16.00	
62	2	40.00	16.00	
63	2	40.00	16.00	
64	2	40.00	16.00	
65	2	40.00	16.00	

66	2	40.00	16.00
67	2	40.00	16.00
68	2	40.00	16.00
69	2	40.00	16.00
70	2	40.00	16.00
71	2	40.00	16.00
72	2	40.00	16.00
73	2	40.00	16.00
74	2	40.00	16.00
75	2	40.00	16.00
76	2	40.00	16.00
77	2	40.00	16.00
78	2	40.00	16.00
79	2	40.00	16.00
80	2	40.00	16.00
81	2	40.00	16.00
82	2	40.00	16.00
83	2	40.00	16.00
84	2	40.00	16.00
85	2	40.00	16.00
86	2	40.00	16.00
87	2	40.00	16.00
88	2	40.00	16.00
89	2	40.00	16.00
90	2	40.00	16.00
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229	1	250.00	25.00
230	1	250.00	25.00

SOIL OPTIONS: A = ANISOTROPIC, C = CURVED STRENGTH ENVELOPE (TANGENT PHI & C),
F = FIBER-REINFORCED SOIL (FRS), N = NONLINEAR UNDRAINED SHEAR STRENGTH,
R = RAPID DRAWDOWN OR RAPID LOADING (SEISMIC) SHEAR STRENGTH
NOTE: Phi and C in Table 4 are modified values based on specified
Soil Options (if any).

TABLE 3 - Effective and Base Shear Stress Data on the 230 Slices

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Effective Normal Stress (psf)	Available Shear Strength (psf)	Mobilized Shear Stress (psf)
1	-34.06	95.95	2.10	98.23	68.17	39.76
2	0.42	98.41	3.18	142.28	80.80	47.12
3	0.42	102.51	5.01	173.35	89.71	52.32
4	0.42	107.52	5.01	235.59	107.55	62.73
5	0.42	112.53	5.01	297.83	125.40	73.14
6	0.42	117.54	5.01	360.07	143.25	83.55
7	0.42	122.55	5.01	422.31	161.10	93.95
8	0.42	127.56	5.01	484.55	178.94	104.36
9	0.42	132.58	5.01	546.79	196.79	114.77
10	0.42	137.59	5.01	609.03	214.64	125.18
11	0.42	142.60	5.01	671.27	232.48	135.59
12	0.42	147.61	5.01	733.51	250.33	146.00
13	0.42	152.62	5.01	795.75	268.18	156.41
14	0.42	157.63	5.01	857.99	286.03	166.82
15	0.42	162.64	5.01	920.24	303.87	177.23
16	0.42	167.66	5.01	982.48	321.72	187.63
17	0.42	172.67	5.01	1044.72	339.57	198.04
18	0.42	177.68	5.01	1106.96	357.42	208.45
19	0.42	182.69	5.01	1169.20	375.26	218.86
20	0.42	187.70	5.01	1231.44	393.11	229.27
21	0.42	192.71	5.01	1293.68	410.96	239.68
22	0.42	197.73	5.01	1355.92	428.80	250.09
23	0.42	202.74	5.01	1418.16	446.65	260.50
24	0.42	207.75	5.01	1480.40	464.50	270.91
25	0.42	212.76	5.01	1542.64	482.35	281.31
26	0.42	217.77	5.01	1604.89	500.19	291.72
27	0.42	222.78	5.01	1667.13	518.04	302.13
28	0.42	227.80	5.01	1729.37	535.89	312.54
29	0.42	232.81	5.01	1791.61	553.74	322.95
30	0.42	237.82	5.01	1853.85	571.58	333.36
31	0.42	242.83	5.01	1916.09	589.43	343.77
32	0.42	247.84	5.01	1978.33	607.28	354.18
33	0.42	252.85	5.01	2040.57	625.12	364.59
34	0.42	257.87	5.01	2102.81	642.97	374.99
35	0.42	262.88	5.01	2165.05	660.82	385.40
36	0.42	267.89	5.01	2227.29	678.67	395.81
37	0.42	272.90	5.01	2289.54	696.51	406.22
38	0.42	277.91	5.01	2351.78	714.36	416.63
39	0.42	282.92	5.01	2414.02	732.21	427.04
40	0.42	287.93	5.01	2476.26	750.06	437.45
41	0.42	292.95	5.01	2538.50	767.90	447.86
42	0.42	297.96	5.01	2600.74	785.75	458.27

43	0.42	302.97	5.01	2662.98	803.60	468.67
44	0.42	307.98	5.01	2725.22	821.44	479.08
45	0.42	312.99	5.01	2787.46	839.29	489.49
46	0.42	318.00	5.01	2849.70	857.14	499.90
47	0.42	323.02	5.01	2911.94	874.99	510.31
48	0.42	328.03	5.01	2974.19	892.83	520.72
49	0.42	333.04	5.01	3036.43	910.68	531.13
50	0.42	338.05	5.01	3098.67	928.53	541.54
51	0.42	343.06	5.01	3160.91	946.38	551.95
52	0.42	348.07	5.01	3223.15	964.22	562.35
53	0.42	353.09	5.01	3285.39	982.07	572.76
54	0.42	358.10	5.01	3347.63	999.92	583.17
55	0.42	363.11	5.01	3409.87	1017.76	593.58
56	0.42	368.12	5.01	3472.11	1035.61	603.99
57	0.42	373.13	5.01	3534.35	1053.46	614.40
58	0.42	378.14	5.01	3596.59	1071.31	624.81
59	0.42	383.16	5.01	3658.84	1089.15	635.22
60	0.42	388.17	5.01	3721.08	1107.00	645.63
61	0.42	393.18	5.01	3783.32	1124.85	656.03
62	0.42	398.19	5.01	3845.56	1142.70	666.44
63	0.42	403.20	5.01	3907.80	1160.54	676.85
64	0.42	408.21	5.01	3970.04	1178.39	687.26
65	0.42	413.22	5.01	4032.28	1196.24	697.67
66	0.42	418.24	5.01	4094.52	1214.09	708.08
67	0.42	423.25	5.01	4156.76	1231.93	718.49
68	0.42	428.26	5.01	4219.00	1249.78	728.90
69	0.42	433.27	5.01	4281.24	1267.63	739.31
70	0.42	438.28	5.01	4343.49	1285.47	749.71
71	0.42	443.29	5.01	4405.73	1303.32	760.12
72	0.42	448.31	5.01	4467.97	1321.17	770.53
73	0.42	453.32	5.01	4530.21	1339.02	780.94
74	0.42	458.33	5.01	4592.45	1356.86	791.35
75	0.42	463.34	5.01	4654.69	1374.71	801.76
76	0.42	468.35	5.01	4716.93	1392.56	812.17
77	0.42	473.36	5.01	4779.17	1410.41	822.58
78	0.42	478.38	5.01	4841.41	1428.25	832.99
79	0.42	483.39	5.01	4903.65	1446.10	843.40
80	0.42	488.40	5.01	4965.89	1463.95	853.80
81	0.42	493.41	5.01	5028.13	1481.79	864.21
82	0.42	498.42	5.01	5090.38	1499.64	874.62
83	0.42	503.43	5.01	5152.62	1517.49	885.03
84	0.42	508.44	5.01	5214.86	1535.34	895.44
85	0.42	513.46	5.01	5277.10	1553.18	905.85
86	0.42	518.47	5.01	5339.34	1571.03	916.26
87	0.42	523.48	5.01	5401.58	1588.88	926.67
88	0.42	528.49	5.01	5463.82	1606.73	937.08
89	0.42	533.50	5.01	5526.06	1624.57	947.48
90	0.42	538.51	5.01	5588.30	1642.42	957.89
91	0.42	543.53	5.01	5650.54	1660.27	968.30
92	0.42	548.54	5.01	5712.78	1678.11	978.71
93	0.42	553.55	5.01	5775.03	1695.96	989.12
94	0.42	558.56	5.01	5837.27	1713.81	999.53
95	0.42	563.57	5.01	5899.51	1731.66	1009.94
96	0.42	568.58	5.01	5961.75	1749.50	1020.35
97	0.42	573.60	5.01	6023.99	1767.35	1030.76
98	0.42	578.61	5.01	6086.23	1785.20	1041.16
99	0.42	583.62	5.01	6148.47	1803.05	1051.57
100	0.42	588.63	5.01	6210.71	1820.89	1061.98
101	0.42	593.64	5.01	6272.95	1838.74	1072.39
102	0.42	598.65	5.01	6335.19	1856.59	1082.80
103	0.42	603.67	5.01	6397.43	1874.43	1093.21
104	0.42	608.68	5.01	6459.68	1892.28	1103.62
105	0.42	613.69	5.01	6521.92	1910.13	1114.03
106	0.42	618.70	5.01	6584.16	1927.98	1124.44
107	0.42	623.71	5.01	6646.40	1945.82	1134.84
108	0.42	628.72	5.01	6708.64	1963.67	1145.25
109	0.42	633.73	5.01	6770.88	1981.52	1155.66
110	0.42	638.75	5.01	6833.12	1999.37	1166.07
111	0.42	643.76	5.01	6895.36	2017.21	1176.48
112	0.42	648.77	5.01	6957.60	2035.06	1186.89
113	0.42	653.78	5.01	7019.84	2052.91	1197.30
114	0.42	658.79	5.01	7082.08	2070.75	1207.71
115	0.42	663.80	5.01	7144.33	2088.60	1218.12
116	0.42	668.82	5.01	7206.57	2106.45	1228.52

117	0.42	673.83	5.01	7268.81	2124.30	1238.93
118	0.42	678.84	5.01	7331.05	2142.14	1249.34
119	0.42	683.85	5.01	7393.29	2159.99	1259.75
120	0.42	688.86	5.01	7455.53	2177.84	1270.16
121	0.42	693.87	5.01	7517.77	2195.69	1280.57
122	0.42	698.89	5.01	7580.01	2213.53	1290.98
123	0.42	703.90	5.01	7642.25	2231.38	1301.39
124	0.42	708.91	5.01	7704.49	2249.23	1311.80
125	0.42	713.92	5.01	7766.73	2267.08	1322.20
126	0.42	718.93	5.01	7828.98	2284.92	1332.61
127	0.42	723.94	5.01	7891.22	2302.77	1343.02
128	0.42	728.95	5.01	7953.46	2320.62	1353.43
129	0.42	733.97	5.01	8015.70	2338.46	1363.84
130	0.42	738.98	5.01	8077.94	2356.31	1374.25
131	0.42	743.99	5.01	8140.18	2374.16	1384.66
132	0.42	749.00	5.01	8202.42	2392.01	1395.07
133	0.42	754.01	5.01	8264.66	2409.85	1405.48
134	0.42	759.02	5.01	8326.90	2427.70	1415.88
135	0.42	764.04	5.01	8389.14	2445.55	1426.29
136	0.42	769.05	5.01	8451.38	2463.40	1436.70
137	0.42	774.06	5.01	8513.63	2481.24	1447.11
138	0.42	779.07	5.01	8575.87	2499.09	1457.52
139	0.42	784.08	5.01	8638.11	2516.94	1467.93
140	0.42	789.09	5.01	8700.35	2534.78	1478.34
141	0.42	794.11	5.01	8762.59	2552.63	1488.75
142	0.42	799.12	5.01	8824.83	2570.48	1499.16
143	0.42	804.13	5.01	8887.07	2588.33	1509.57
144	0.42	809.14	5.01	8949.31	2606.17	1519.97
145	0.42	814.15	5.01	9011.55	2624.02	1530.38
146	0.42	819.16	5.01	9073.79	2641.87	1540.79
147	0.42	824.18	5.01	9136.03	2659.72	1551.20
148	0.42	829.19	5.01	9198.27	2677.56	1561.61
149	0.42	834.20	5.01	9260.52	2695.41	1572.02
150	0.42	839.21	5.01	9322.76	2713.26	1582.43
151	0.42	844.22	5.01	9385.00	2731.10	1592.84
152	0.42	849.23	5.01	9447.24	2748.95	1603.25
153	0.42	854.24	5.01	9509.48	2766.80	1613.65
154	0.42	859.26	5.01	9571.72	2784.65	1624.06
155	0.42	864.27	5.01	9633.96	2802.49	1634.47
156	0.42	869.28	5.01	9696.20	2820.34	1644.88
157	0.42	874.29	5.01	9758.44	2838.19	1655.29
158	0.42	879.30	5.01	9820.68	2856.04	1665.70
159	0.42	884.31	5.01	9882.92	2873.88	1676.11
160	0.42	889.33	5.01	9945.17	2891.73	1686.52
161	0.42	894.34	5.01	10007.41	2909.58	1696.93
162	0.42	899.35	5.01	10069.65	2927.42	1707.33
163	0.42	904.36	5.01	10131.89	2945.27	1717.74
164	0.42	909.37	5.01	10194.13	2963.12	1728.15
165	0.42	914.38	5.01	10256.37	2980.97	1738.56
166	0.42	919.40	5.01	10318.61	2998.81	1748.97
167	0.42	924.41	5.01	10380.85	3016.66	1759.38
168	0.42	929.42	5.01	10443.09	3034.51	1769.79
169	0.42	934.43	5.01	10505.33	3052.36	1780.20
170	0.42	939.44	5.01	10567.57	3070.20	1790.61
171	0.42	944.45	5.01	10629.82	3088.05	1801.01
172	0.42	949.47	5.01	10692.06	3105.90	1811.42
173	0.42	954.48	5.01	10754.30	3123.75	1821.83
174	0.42	959.49	5.01	10816.54	3141.59	1832.24
175	0.42	964.50	5.01	10878.78	3159.44	1842.65
176	0.42	969.51	5.01	10941.02	3177.29	1853.06
177	0.42	974.52	5.01	11003.26	3195.13	1863.47
178	0.42	979.53	5.01	11065.50	3212.98	1873.88
179	65.44	982.25	1.00	8057.10	2350.34	1370.77
180	65.44	984.43	9.50	6579.01	3317.84	1935.03
181	65.44	988.38	9.50	6339.98	3206.38	1870.03
182	45.73	992.68	6.67	7821.57	3897.26	2272.96
183	45.73	997.33	6.67	7681.62	3832.00	2234.90
184	45.73	1001.99	6.67	7541.67	3766.74	2196.84
185	60.74	1006.76	10.00	6232.38	3156.21	1840.76
186	60.74	1011.64	10.00	5980.95	3038.96	1772.38
187	48.76	1016.28	6.67	6636.50	3344.65	1950.67
188	48.76	1020.68	6.67	6488.22	3275.51	1910.34
189	48.76	1025.07	6.67	6339.95	3206.36	1870.02
190	47.58	1029.52	6.67	6259.18	3168.70	1848.05

191	47.58	1034.02	6.67	6114.00	3101.00	1808.57
192	47.58	1038.51	6.67	5968.82	3033.30	1769.09
193	49.66	1042.92	6.67	5710.93	2913.05	1698.95
194	49.66	1047.24	6.67	5560.42	2842.87	1658.02
195	49.66	1051.55	6.67	5409.91	2772.68	1617.08
196	45.34	1056.05	6.67	5472.60	2801.91	1634.13
197	45.34	1060.74	6.67	5333.81	2737.20	1596.39
198	45.34	1065.43	6.67	5195.02	2672.48	1558.64
199	49.59	1069.93	6.67	4860.63	2516.55	1467.70
200	49.59	1074.25	6.67	4710.29	2446.44	1426.82
201	49.59	1078.57	6.67	4559.95	2376.34	1385.93
202	50.57	1082.85	6.67	4365.80	2285.80	1333.13
203	50.57	1087.09	6.67	4213.14	2214.62	1291.61
204	50.57	1091.32	6.67	4060.49	2143.44	1250.10
205	45.71	1095.77	6.67	4097.90	2160.88	1260.27
206	45.71	1100.42	6.67	3958.01	2095.65	1222.23
207	45.71	1105.08	6.67	3818.12	2030.42	1184.18
208	45.00	1109.76	6.67	3702.20	1976.36	1152.66
209	45.00	1114.48	6.67	3564.43	1912.12	1115.19
210	45.00	1119.19	6.67	3426.65	1847.88	1077.72
211	50.02	1123.69	6.67	3128.11	1708.66	996.53
212	50.02	1127.97	6.67	2976.74	1638.08	955.36
213	50.02	1132.26	6.67	2825.37	1567.49	914.19
214	71.06	1136.02	10.00	1771.20	1075.92	627.50
215	71.06	1139.27	10.00	1530.61	963.74	562.07
216	48.75	1143.09	6.67	2052.96	1207.31	704.13
217	48.75	1147.48	6.67	1904.71	1138.18	663.81
218	48.75	1151.88	6.67	1756.47	1069.06	623.50
219	45.38	1156.42	6.67	1672.78	1030.03	600.73
220	45.38	1161.10	6.67	1533.85	965.25	562.95
221	45.38	1165.78	6.67	1394.92	900.46	525.17
222	45.31	1170.47	6.67	1257.16	836.22	487.70
223	45.31	1175.16	6.67	1118.46	771.54	449.98
224	45.31	1179.85	6.67	979.75	706.87	412.26
225	47.12	1184.46	6.67	818.36	631.61	368.37
226	47.12	1189.00	6.67	674.44	564.50	329.23
227	47.12	1193.53	6.67	530.53	497.39	290.09
228	59.16	1198.36	10.00	222.49	353.75	206.31
229	59.16	1203.49	10.00	140.58	65.55	38.23
230	64.32	1206.18	0.58	7.30	3.40	1.98

Table 4 - Base Force Data on the 230 Slices

Slice No. *	Alpha (deg)	X-Coord. Slice Cntr (ft)	Base Leng. (ft)	Effective Normal Force (lbs)	Available Shear Force (lbs)	Mobilized Shear Force (lbs)
1	-34.06	95.95	2.10	206.43	143.25	83.55
2	0.42	98.41	3.18	453.08	257.29	150.06
3	0.42	102.51	5.01	868.76	449.58	262.21
4	0.42	107.52	5.01	1180.69	539.03	314.37
5	0.42	112.53	5.01	1492.63	628.47	366.54
6	0.42	117.54	5.01	1804.56	717.92	418.70
7	0.42	122.55	5.01	2116.50	807.36	470.87
8	0.42	127.56	5.01	2428.43	896.81	523.04
9	0.42	132.58	5.01	2740.36	986.26	575.20
10	0.42	137.59	5.01	3052.30	1075.70	627.37
11	0.42	142.60	5.01	3364.23	1165.15	679.54
12	0.42	147.61	5.01	3676.17	1254.59	731.70
13	0.42	152.62	5.01	3988.10	1344.04	783.87
14	0.42	157.63	5.01	4300.04	1433.48	836.04
15	0.42	162.64	5.01	4611.97	1522.93	888.20
16	0.42	167.66	5.01	4923.91	1612.38	940.37
17	0.42	172.67	5.01	5235.84	1701.82	992.54
18	0.42	177.68	5.01	5547.77	1791.27	1044.70
19	0.42	182.69	5.01	5859.71	1880.71	1096.87
20	0.42	187.70	5.01	6171.64	1970.16	1149.04
21	0.42	192.71	5.01	6483.58	2059.60	1201.20
22	0.42	197.73	5.01	6795.51	2149.05	1253.37
23	0.42	202.74	5.01	7107.45	2238.50	1305.54
24	0.42	207.75	5.01	7419.38	2327.94	1357.70
25	0.42	212.76	5.01	7731.31	2417.39	1409.87

26	0.42	217.77	5.01	8043.25	2506.83	1462.04
27	0.42	222.78	5.01	8355.18	2596.28	1514.20
28	0.42	227.80	5.01	8667.12	2685.73	1566.37
29	0.42	232.81	5.01	8979.05	2775.17	1618.54
30	0.42	237.82	5.01	9290.99	2864.62	1670.70
31	0.42	242.83	5.01	9602.92	2954.06	1722.87
32	0.42	247.84	5.01	9914.86	3043.51	1775.04
33	0.42	252.85	5.01	10226.79	3132.95	1827.20
34	0.42	257.87	5.01	10538.72	3222.40	1879.37
35	0.42	262.88	5.01	10850.66	3311.85	1931.54
36	0.42	267.89	5.01	11162.59	3401.29	1983.70
37	0.42	272.90	5.01	11474.53	3490.74	2035.87
38	0.42	277.91	5.01	11786.46	3580.18	2088.04
39	0.42	282.92	5.01	12098.40	3669.63	2140.20
40	0.42	287.93	5.01	12410.33	3759.07	2192.37
41	0.42	292.95	5.01	12722.27	3848.52	2244.54
42	0.42	297.96	5.01	13034.20	3937.97	2296.70
43	0.42	302.97	5.01	13346.13	4027.41	2348.87
44	0.42	307.98	5.01	13658.07	4116.86	2401.04
45	0.42	312.99	5.01	13970.00	4206.30	2453.20
46	0.42	318.00	5.01	14281.94	4295.75	2505.37
47	0.42	323.02	5.01	14593.87	4385.19	2557.54
48	0.42	328.03	5.01	14905.81	4474.64	2609.70
49	0.42	333.04	5.01	15217.74	4564.09	2661.87
50	0.42	338.05	5.01	15529.67	4653.53	2714.04
51	0.42	343.06	5.01	15841.61	4742.98	2766.20
52	0.42	348.07	5.01	16153.54	4832.42	2818.37
53	0.42	353.09	5.01	16465.48	4921.87	2870.53
54	0.42	358.10	5.01	16777.41	5011.31	2922.70
55	0.42	363.11	5.01	17089.35	5100.76	2974.87
56	0.42	368.12	5.01	17401.28	5190.21	3027.03
57	0.42	373.13	5.01	17713.22	5279.65	3079.20
58	0.42	378.14	5.01	18025.15	5369.10	3131.37
59	0.42	383.16	5.01	18337.08	5458.54	3183.53
60	0.42	388.17	5.01	18649.02	5547.99	3235.70
61	0.42	393.18	5.01	18960.95	5637.43	3287.87
62	0.42	398.19	5.01	19272.89	5726.88	3340.03
63	0.42	403.20	5.01	19584.82	5816.33	3392.20
64	0.42	408.21	5.01	19896.76	5905.77	3444.37
65	0.42	413.22	5.01	20208.69	5995.22	3496.53
66	0.42	418.24	5.01	20520.63	6084.66	3548.70
67	0.42	423.25	5.01	20832.56	6174.11	3600.87
68	0.42	428.26	5.01	21144.49	6263.55	3653.03
69	0.42	433.27	5.01	21456.43	6353.00	3705.20
70	0.42	438.28	5.01	21768.36	6442.45	3757.37
71	0.42	443.29	5.01	22080.30	6531.89	3809.53
72	0.42	448.31	5.01	22392.23	6621.34	3861.70
73	0.42	453.32	5.01	22704.17	6710.78	3913.87
74	0.42	458.33	5.01	23016.10	6800.23	3966.03
75	0.42	463.34	5.01	23328.03	6889.68	4018.20
76	0.42	468.35	5.01	23639.97	6979.12	4070.37
77	0.42	473.36	5.01	23951.90	7068.57	4122.53
78	0.42	478.38	5.01	24263.84	7158.01	4174.70
79	0.42	483.39	5.01	24575.77	7247.46	4226.87
80	0.42	488.40	5.01	24887.71	7336.90	4279.03
81	0.42	493.41	5.01	25199.64	7426.35	4331.20
82	0.42	498.42	5.01	25511.58	7515.80	4383.37
83	0.42	503.43	5.01	25823.51	7605.24	4435.53
84	0.42	508.44	5.01	26135.44	7694.69	4487.70
85	0.42	513.46	5.01	26447.38	7784.13	4539.87
86	0.42	518.47	5.01	26759.31	7873.58	4592.03
87	0.42	523.48	5.01	27071.25	7963.02	4644.20
88	0.42	528.49	5.01	27383.18	8052.47	4696.37
89	0.42	533.50	5.01	27695.12	8141.92	4748.53
90	0.42	538.51	5.01	28007.05	8231.36	4800.70
91	0.42	543.53	5.01	28318.99	8320.81	4852.87
92	0.42	548.54	5.01	28630.92	8410.25	4905.03
93	0.42	553.55	5.01	28942.85	8499.70	4957.20
94	0.42	558.56	5.01	29254.79	8589.14	5009.37
95	0.42	563.57	5.01	29566.72	8678.59	5061.53
96	0.42	568.58	5.01	29878.66	8768.04	5113.70
97	0.42	573.60	5.01	30190.59	8857.48	5165.86
98	0.42	578.61	5.01	30502.53	8946.93	5218.03
99	0.42	583.62	5.01	30814.46	9036.37	5270.20

100	0.42	588.63	5.01	31126.39	9125.82	5322.36
101	0.42	593.64	5.01	31438.33	9215.26	5374.53
102	0.42	598.65	5.01	31750.26	9304.71	5426.70
103	0.42	603.67	5.01	32062.20	9394.16	5478.86
104	0.42	608.68	5.01	32374.13	9483.60	5531.03
105	0.42	613.69	5.01	32686.07	9573.05	5583.20
106	0.42	618.70	5.01	32998.00	9662.49	5635.36
107	0.42	623.71	5.01	33309.94	9751.94	5687.53
108	0.42	628.72	5.01	33621.87	9841.38	5739.70
109	0.42	633.73	5.01	33933.80	9930.83	5791.86
110	0.42	638.75	5.01	34245.74	10020.28	5844.03
111	0.42	643.76	5.01	34557.67	10109.72	5896.20
112	0.42	648.77	5.01	34869.61	10199.17	5948.36
113	0.42	653.78	5.01	35181.54	10288.61	6000.53
114	0.42	658.79	5.01	35493.48	10378.06	6052.70
115	0.42	663.80	5.01	35805.41	10467.51	6104.86
116	0.42	668.82	5.01	36117.34	10556.95	6157.03
117	0.42	673.83	5.01	36429.28	10646.40	6209.20
118	0.42	678.84	5.01	36741.21	10735.84	6261.36
119	0.42	683.85	5.01	37053.15	10825.29	6313.53
120	0.42	688.86	5.01	37365.08	10914.73	6365.70
121	0.42	693.87	5.01	37677.02	11004.18	6417.86
122	0.42	698.89	5.01	37988.95	11093.63	6470.03
123	0.42	703.90	5.01	38300.89	11183.07	6522.20
124	0.42	708.91	5.01	38612.82	11272.52	6574.36
125	0.42	713.92	5.01	38924.75	11361.96	6626.53
126	0.42	718.93	5.01	39236.69	11451.41	6678.70
127	0.42	723.94	5.01	39548.62	11540.85	6730.86
128	0.42	728.95	5.01	39860.56	11630.30	6783.03
129	0.42	733.97	5.01	40172.49	11719.75	6835.20
130	0.42	738.98	5.01	40484.43	11809.19	6887.36
131	0.42	743.99	5.01	40796.36	11898.64	6939.53
132	0.42	749.00	5.01	41108.30	11988.08	6991.70
133	0.42	754.01	5.01	41420.23	12077.53	7043.86
134	0.42	759.02	5.01	41732.16	12166.97	7096.03
135	0.42	764.04	5.01	42044.10	12256.42	7148.20
136	0.42	769.05	5.01	42356.03	12345.87	7200.36
137	0.42	774.06	5.01	42667.97	12435.31	7252.53
138	0.42	779.07	5.01	42979.90	12524.76	7304.70
139	0.42	784.08	5.01	43291.84	12614.20	7356.86
140	0.42	789.09	5.01	43603.77	12703.65	7409.03
141	0.42	794.11	5.01	43915.70	12793.09	7461.20
142	0.42	799.12	5.01	44227.64	12882.54	7513.36
143	0.42	804.13	5.01	44539.57	12971.99	7565.53
144	0.42	809.14	5.01	44851.51	13061.43	7617.69
145	0.42	814.15	5.01	45163.44	13150.88	7669.86
146	0.42	819.16	5.01	45475.38	13240.32	7722.03
147	0.42	824.18	5.01	45787.31	13329.77	7774.19
148	0.42	829.19	5.01	46099.25	13419.21	7826.36
149	0.42	834.20	5.01	46411.18	13508.66	7878.53
150	0.42	839.21	5.01	46723.11	13598.11	7930.69
151	0.42	844.22	5.01	47035.05	13687.55	7982.86
152	0.42	849.23	5.01	47346.98	13777.00	8035.03
153	0.42	854.24	5.01	47658.92	13866.44	8087.19
154	0.42	859.26	5.01	47970.85	13955.89	8139.36
155	0.42	864.27	5.01	48282.79	14045.33	8191.53
156	0.42	869.28	5.01	48594.72	14134.78	8243.69
157	0.42	874.29	5.01	48906.66	14224.23	8295.86
158	0.42	879.30	5.01	49218.59	14313.67	8348.03
159	0.42	884.31	5.01	49530.52	14403.12	8400.19
160	0.42	889.33	5.01	49842.46	14492.56	8452.36
161	0.42	894.34	5.01	50154.39	14582.01	8504.53
162	0.42	899.35	5.01	50466.33	14671.46	8556.69
163	0.42	904.36	5.01	50778.26	14760.90	8608.86
164	0.42	909.37	5.01	51090.20	14850.35	8661.03
165	0.42	914.38	5.01	51402.13	14939.79	8713.19
166	0.42	919.40	5.01	51714.06	15029.24	8765.36
167	0.42	924.41	5.01	52026.00	15118.68	8817.53
168	0.42	929.42	5.01	52337.93	15208.13	8869.69
169	0.42	934.43	5.01	52649.87	15297.58	8921.86
170	0.42	939.44	5.01	52961.80	15387.02	8974.03
171	0.42	944.45	5.01	53273.74	15476.47	9026.19
172	0.42	949.47	5.01	53585.67	15565.91	9078.36
173	0.42	954.48	5.01	53897.61	15655.36	9130.53

174	0.42	959.49	5.01	54209.54	15744.80	9182.69
175	0.42	964.50	5.01	54521.47	15834.25	9234.86
176	0.42	969.51	5.01	54833.41	15923.70	9287.03
177	0.42	974.52	5.01	55145.34	16013.14	9339.19
178	0.42	979.53	5.01	55457.28	16102.59	9391.36
179	65.44	982.25	1.00	8076.37	2355.96	1374.04
180	65.44	984.43	9.50	62492.70	31515.53	18380.50
181	65.44	988.38	9.50	60222.22	30456.78	17763.02
182	45.73	992.68	6.67	52143.83	25981.73	15153.08
183	45.73	997.33	6.67	51210.80	25546.66	14899.33
184	45.73	1001.99	6.67	50277.78	25111.58	14645.59
185	60.74	1006.76	10.00	62323.78	31562.06	18407.64
186	60.74	1011.64	10.00	59809.47	30389.61	17723.85
187	48.76	1016.28	6.67	44243.31	22297.66	13004.45
188	48.76	1020.68	6.67	43254.81	21836.71	12735.62
189	48.76	1025.07	6.67	42266.30	21375.77	12466.79
190	47.58	1029.52	6.67	41727.84	21124.68	12320.35
191	47.58	1034.02	6.67	40759.98	20673.36	12057.13
192	47.58	1038.51	6.67	39792.11	20222.03	11793.90
193	49.66	1042.92	6.67	38072.85	19420.33	11326.33
194	49.66	1047.24	6.67	37069.45	18952.44	11053.45
195	49.66	1051.55	6.67	36066.06	18484.55	10780.57
196	45.34	1056.05	6.67	36484.00	18679.43	10894.23
197	45.34	1060.74	6.67	35558.74	18247.98	10642.60
198	45.34	1065.43	6.67	34633.49	17816.53	10390.96
199	49.59	1069.93	6.67	32404.18	16776.98	9784.68
200	49.59	1074.25	6.67	31401.92	16309.62	9512.11
201	49.59	1078.57	6.67	30399.67	15842.26	9239.53
202	50.57	1082.85	6.67	29105.31	15238.70	8887.52
203	50.57	1087.09	6.67	28087.61	14764.14	8610.75
204	50.57	1091.32	6.67	27069.92	14289.58	8333.97
205	45.71	1095.77	6.67	27319.30	14405.87	8401.80
206	45.71	1100.42	6.67	26386.72	13970.99	8148.17
207	45.71	1105.08	6.67	25454.13	13536.12	7894.54
208	45.00	1109.76	6.67	24681.33	13175.76	7684.37
209	45.00	1114.48	6.67	23762.85	12747.47	7434.58
210	45.00	1119.19	6.67	22844.37	12319.17	7184.79
211	50.02	1123.69	6.67	20854.08	11391.08	6643.51
212	50.02	1127.97	6.67	19844.93	10920.51	6369.06
213	50.02	1132.26	6.67	18835.78	10449.94	6094.62
214	71.06	1136.02	10.00	17711.95	10759.22	6275.00
215	71.06	1139.27	10.00	15306.12	9637.36	5620.71
216	48.75	1143.09	6.67	13686.39	8048.73	4694.19
217	48.75	1147.48	6.67	12698.10	7587.89	4425.41
218	48.75	1151.88	6.67	11709.81	7127.04	4156.64
219	45.38	1156.42	6.67	11151.87	6866.87	4004.90
220	45.38	1161.10	6.67	10225.68	6434.98	3753.01
221	45.38	1165.78	6.67	9299.48	6003.09	3501.12
222	45.31	1170.47	6.67	8381.07	5574.82	3251.35
223	45.31	1175.16	6.67	7456.37	5143.63	2999.87
224	45.31	1179.85	6.67	6531.68	4712.44	2748.39
225	47.12	1184.46	6.67	5455.74	4210.72	2455.78
226	47.12	1189.00	6.67	4496.29	3763.32	2194.85
227	47.12	1193.53	6.67	3536.84	3315.92	1933.91
228	59.16	1198.36	10.00	2224.93	3537.50	2063.14
229	59.16	1203.49	10.00	1405.75	655.51	382.31
230	64.32	1206.18	0.58	4.22	1.97	1.15

Sum of the Resisting Forces = 1920837.44 (lbs)

Average Available Shear Strength = 1539.22(psf)

Sum of the Driving Forces = 1120271.81 (lbs)

Average Mobilized Shear Stress = 897.71(psf)

Total length of the failure surface = 1247.93(ft)

Factor of Safety Balance Check: FS = 1.71462

**** END OF GEOSTASE OUTPUT ****

NTMWD 121 RDF

APPENDIX 16-C

ALTERNATE LINER (OPTION 3) DESIGN DEMONSTRATION

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Biggs & Mathews Environmental, Inc.
Firm Registration No. F-256

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APPENDIX 16-C-G
MULTIMED Aquifer-Specific Data

APPENDIX 16-C-H
Leachate Data

APPENDIX 16-C-I
Calculations of the Dilution Attenuation Factor

APPENDIX 16-C-J
MULTIMED Model Output

1 INTRODUCTION

1.1 Purpose

This Alternate Liner Design Demonstration (ALDD) has been prepared to demonstrate that the proposed alternate liner design meets the performance criteria specified in 30 TAC §330.335. This is achieved by demonstrating that the predicted concentrations of selected leachate chemical constituents do not exceed maximum contaminant levels (as listed in Table 1, 30 TAC §330.331) in groundwater at the point of compliance (POC). This ALDD was conducted consistent with the procedures presented in the *Texas Water Commission Alternate Liner Design Handbook, A Performance Standard As Authorized By 30 Texas Administrative Code (TAC) §330.202 (Version 1, August 1993)*, and *Performance-Based Liners for MSW Landfills (RG-331),* as modified by current TCEQ practice. The Hydrologic Evaluation of Landfill Performance (HELP) and Multimedia Exposure Assessment (MULTIMED) computer models were used to provide information to support this demonstration.

1.2 Proposed Alternate Liner (Option 3)

The alternate liner system consists of a geosynthetic clay liner (GCL) overlain by a 60-mil HDPE geomembrane. The leachate collection layer consists of a geocomposite drainage blanket covered by 24-inches of soil. Details of the liner system are provided in Attachment 16-A. Figure 16-C-A.1 shows the location of the existing and proposed lined areas.

1.3 Ground (Subsurface) Water Characterization Report

Based on information provided in Attachment 5 – Ground (Subsurface) Water Characterization Report, which was updated and approved by TCEQ in August 2010, the current permitted groundwater monitoring system monitors groundwater that is potentially hydraulically isolated, disconnected pockets of subsurface water trapped in scattered fractures that penetrate to some depth in the weather and unweathered Austin Chalk.

For modeling purposes, an aquifer depth of 5 feet below ground surface, within the Austin Chalk was used.

2 ALTERNATE LINER DEMONSTRATION METHODS

2.1 HELP Model

The HELP Model Version 3.07 was used to estimate the amount of rainfall recharge through the existing in-situ soil layer to the groundwater table. In addition, the HELP Model was used to predict the amount of runoff, evapotranspiration, drainage, leachate collection, and percolation through the liner. The HELP Model is a water-balance model developed by the U.S. Army Corps of Engineers Waterways Experiment Station for the Environmental Protection Agency (EPA).

2.2 MULTIMED Model

The MULTIMED Model Version 1.01 was used to assess contaminant fate and transport between the landfill base and the POC. MULTIMED was developed by the Athens Environmental Research Laboratory for the EPA. MULTIMED estimates the capacity of the hydrogeologic system modeled to dilute and attenuate contaminant concentrations. The model can be used to simulate the fate and transport processes in both the unsaturated and the saturated subsurface environments.

2.3 Percolation Through Liner Calculations

Leakage through the geomembrane was calculated using the methods presented in the HELP model engineering documentation utilizing the maximum leachate head of 0.39 inches for the critical condition for various phases of landfill development included in Appendix 16-C-B – Leachate Generation Model. Percolation through the alternate liner system was assumed to equal the leakage through the geomembrane component of the liner system.

3 MODEL INPUT PARAMETERS

Appendices 16-C-B through 16-C-J present detailed information about the HELP and MULTIMED models and liner leakage calculations. Conservative assumptions were made in determining the recharge rate, percolation rate, and the dilution attenuation factor (DAF). The results of the leachate generation model utilizing the HELP Model are included in Appendix 16-C-B. The HELP model input parameters for determining the recharge rate through the existing in situ soil layer and percolation through the liner calculations are detailed in Appendix 16-C-C.

The MULTIMED model input parameters are detailed in Appendices 16-C-D through 16-C-H. Listed below is a brief description of the model input data included in each appendix:

- In Table 16-C-1, Appendix 16-C-D the MULTIMED chemical-specific data used in the ALDD has been provided.
- In Table 16-C-2, Appendix 16-C-E the MULTIMED source specific data used in the ALDD has been provided.
- The MULTIMED unsaturated zone information is provided in Appendix 16-C-F.
- In Table 16-C-3, Appendix 16-C-G the MULTIMED aquifer-specific data used in calculating the DAF for the perched groundwater zone has been provided.
- The leachate input data for the MULTIMED model is provided in Appendix 16-C-H.
- Calculations for the dilution attenuation factor for the perched groundwater zone have been provided in Appendix 16-C-I.

By assuming the leachate does not undergo adsorption, biodegradation, and decay, a single MULTIMED simulation accounts for all 24 constituents identified by the EPA as requiring landfill design protection criteria because the constituent concentration at the POC is independent of chemical-specific properties. The model result is expressed in terms of the DAF, which is defined as the ratio of the input concentration to the concentration at the POC. MULTIMED can be used to find the DAF by using an input concentration of 1.0 mg/L. The DAF is the reciprocal of the resulting concentration at the POC. The POC for this demonstration is shown on the Site Plan (Figure 16-C-A.1).

The required minimum DAFs for the 24 EPA constituents are given in Table 2, page 24 of the *Texas Water Commission Alternate Liner Design Handbook*. The largest DAF listed in Table 2 is 260 for trichloroethylene based on MCLs. Therefore, if MULTIMED

modeling results in a DAF of 260 or greater for a generic chemical that is modeled with no absorption, no biodegradation, and no decay, it can be concluded that the proposed alternate liner is acceptable. The actual DAF for a specific chemical would be higher than the result calculated by MULTIMED under these circumstances, since physical processes of absorption, biodegradation, and decay would reduce chemical concentrations at the POC to less than those predicted by MULTIMED.

4 RESULTS AND CONCLUSIONS

The HELP and MULTIMED models were used in conjunction with other calculations detailed in the appendices to evaluate the performance of the alternate liner system design by estimating constituent concentrations at the POC. The constituent concentrations at the base of the landfill liner and at the POC were used to calculate the DAF. The alternate liner must provide a DAF of 260 or greater for the perched groundwater zone located beneath the landfill disposal area. The DAF of 260 was selected from the Texas Water Commission's Alternate Liner Design Handbook, a performance standard for Trichloroethylene (TCE). The use of TCE is conservative and provides the largest acceptable DAF of the constituents listed in Table 1 in 30 TAC §330.331.

The results of the alternate liner design demonstration are provided below:

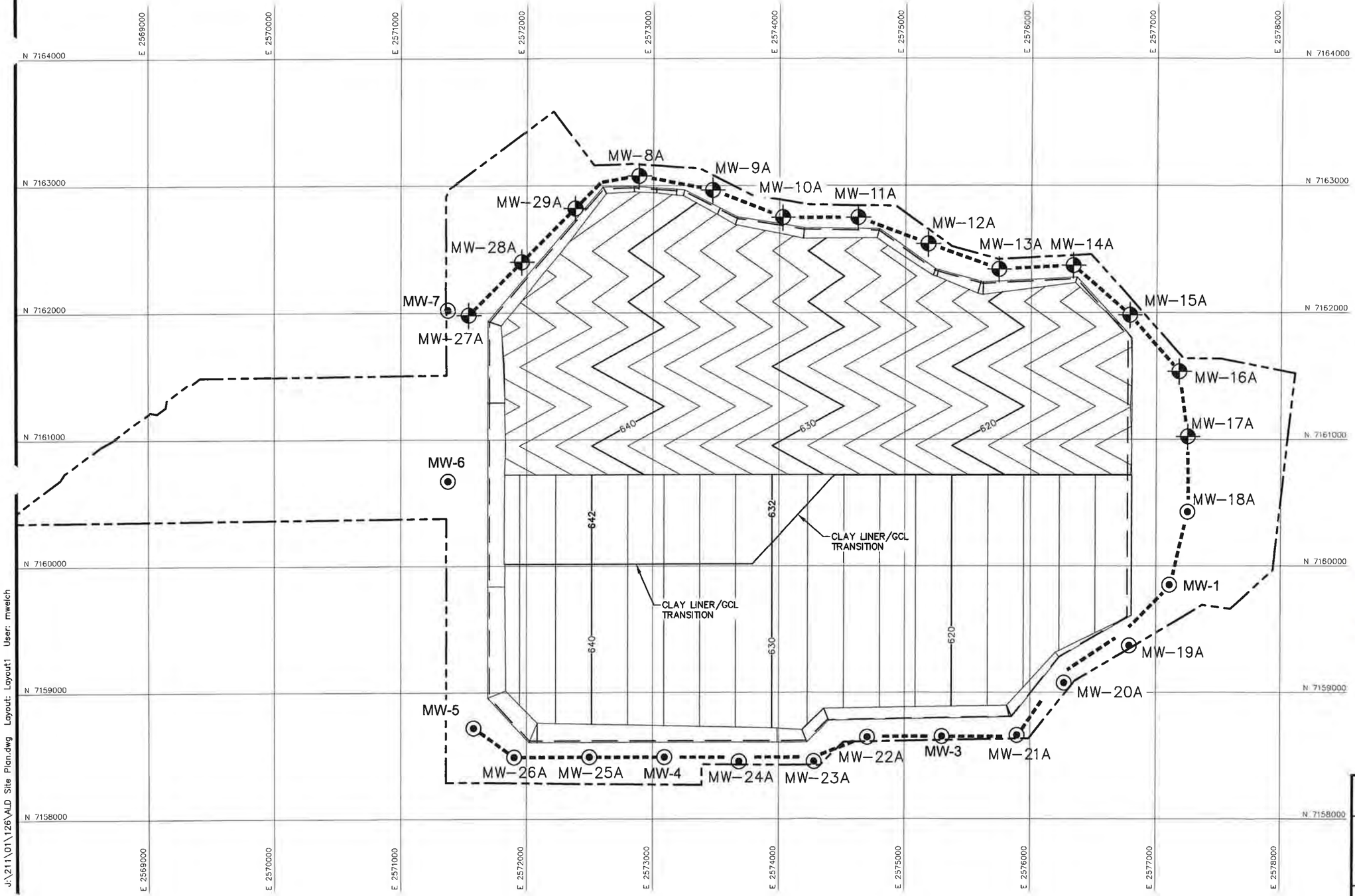
- POC distance = 200 ft
- Manufacturer's GCL Permeability = 5×10^{-9} cm/sec
- DAF = 4.85×10^{8} >> 260

For modeling purposes, it was assumed that there is an aquifer 5 feet below the liner system within the intact Austin Chalk, which extends from the bottom of the landfill to a depth of about 975 feet below natural ground. The low permeability of the Austin Chalk results in an exceedingly large DAF, which is much greater than 260.

121 RDF

APPENDIX 16-C-A

FIGURE 16-C-A.1 SITE PLAN



0 400 800
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- 630 SUBGRADE CONTOUR
- N 7160000 STATE PLANE GRID
- EXISTING MONITORING WELL
- FUTURE MONITORING WELL
- POINT OF COMPLIANCE

STATE OF TEXAS
DAVID L. CLARK
81905
PROFESSIONAL ENGINEER
6-19-19

J:\211\01\126\ALD Site Plan.dwg Layout: Layout1 User: mwelch

ISSUED FOR PERMITTING PURPOSES ONLY

REVISIONS						
REV	DATE	DESCRIPTION	DWN BY	DES BY	CHK BY	APP BY

ALTERNATE LINER DESIGN SITE PLAN

NORTH TEXAS MUNICIPAL WATER DISTRICT
121 RDF
LIMITED SCOPE PERMIT AMENDMENT

BIGGS & MATHEWS ENVIRONMENTAL
CONSULTING ENGINEERS
MANSFIELD • WICHITA FALLS
817-563-1144

TBPE FIRM NO. F-256 | TBPG FIRM NO. 50222

DSN. FAW	DATE : 06/19	DRAWING	
DWN. SRC	SCALE : GRAPHIC	16-C-A.1	
CHK. FAW	DWG : ALD Site Plan.dwg		

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APPENDIX 16-C-B

LEACHATE GENERATION MODEL

LEACHATE GENERATION MODEL

HELP MODEL

The Hydrologic Evaluation of Landfill Performance (HELP) Model, Version 3.07, was used to predict the amount of runoff, evapotranspiration, drainage, leachate collection, and percolation through the liner. The HELP Model is a water balance model that uses climate, soil, and landfill design data to perform a solution technique that accounts for the effects of surface storage, runoff, recirculation, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

The following stages of landfill development were modeled:

Case 1 – Active face with 10 feet of exposed waste; 3 years
Case 2 – Daily cover over 100 feet of waste; 5 years
Case 3 – Intermediate cover over 200 feet of waste; 10 years
Case 4 – Final cover over 350 feet of waste; 30 years

INPUT PARAMETERS

The HELP model input parameters for each case are summarized on page 16-C-B-4. The selection of each parameter is briefly described below.

Evapotranspiration Data

Default evapotranspiration data for Dallas, Texas were used in the model. The default evaporative zone depth and maximum leaf area index for bare ground was selected for Case 1. The default evaporative zone depth and maximum leaf area index for fair cover was selected for Cases 2 and 3. The default evaporative zone depth and maximum leaf area index for good cover was selected for Case 4.

Climate Data

The climate data used for the HELP model was synthetically generated using climate coefficients for Dallas, Texas.

Runoff Potential

To maximize percolation through the waste, the runoff potential was assumed as zero for the active face and as 50 percent for the areas with daily cover. Runoff will be allowed from intermediate cover, but the surface may be only rough graded; therefore, the runoff potential was designated as 70 percent for these cases. The final cover will be designed and constructed to promote runoff; therefore, the runoff potential was designated as 90 percent for this case.

Runoff Curve Number

Default curve numbers were chosen based on the soil data, ground cover, surface slope, and slope length of the selected case.

Erosion Layer

The erosion layer consists of a 18-inch-thick layer of soils that are capable of sustaining vegetation. Geotechnical information provided in Attachment 4 indicates that CH and CL soils will be available for use as erosion layer; therefore, default values for soil texture 11 were used in the model.

Infiltration Layer

The infiltration layer consists of an 42-inch-thick layer of available onsite soils. Geotechnical information provided in Attachment 4 indicates that CH and CL soils will be available for use for the infiltration layer. Default values for soil texture 12 were used to model the infiltration layer.

Daily and Intermediate Cover

The daily cover consists of a 6-inch-thick layer of available onsite soils, and the intermediate cover consists of a total 12-inch-thick layer of available onsite soils. Geotechnical information provided in Attachment 4 indicates that CH and CL soils will be available for use as daily and intermediate cover. Default values for soil texture 11 were used to model the daily and protective cover.

Waste Layers

Waste layers of 10, 100, 200, and 350 feet were used to represent the stages of landfill development. Default characteristics for soil texture 18 were selected to represent municipal waste.

Protective Cover

The protective cover consists of a 24-inch-thick layer of available onsite soils. Geotechnical information provided in Attachment 4 indicates that CH and CL soils will be available for use as protective cover. User-defined soils (designated as soil texture 61), were used to model the protective cover.

Leachate Collection Layer

The leachate collection layer will consist of a drainage geocomposite. User-defined values (designated soil texture 63) were used to model the leachate collection layer.

Flexible Membrane Liner

The flexible membrane liner consists of a 60-mil HDPE geomembrane. Default values for soil texture 35 were used to model the flexible membrane liner. The liner will be installed and tested in accordance with the requirements of Attachment 10 – Appendix 10B therefore, the liner was modeled for good installation quality, one defect per acre, and a pinhole density of one-half hole per acre.

Geosynthetic Clay Liner

Default values for the geosynthetic clay liner from the HELP model were used to model the geosynthetic liner. The HELP model default value for the geosynthetic clay liner hydraulic conductivity is 3×10^{-9} cm/sec or less. However, the geosynthetic clay liner will have a hydraulic conductivity of 5×10^{-9} cm/sec or less in accordance with Attachment 10 – Appendix 10B. This hydraulic conductivity of 3×10^{-9} cm/sec or less represents a conservative modeling assumption because it allows less percolation through the geosynthetic clay liner. The geosynthetic clay liner will be installed and tested in accordance with the requirements of Attachment 10 – Appendix 10B.

HELP MODEL OUTPUT

Output files for the HELP model are provided on pages 16-C-B-5 through 16-C-B-33. The output for each case is summarized on page 16-C-B-4.

NTMWD 121 RDF
Alternate Liner (Option 3) Design
HELP SUMMARY

Case No.	***1***	***2***	***3***	***4***
Description	Active Face 10' waste	Daily Cover 100' waste	Intermediate Cover 200' waste	Final Cover 350' waste
Years	3	5	10	30
Ground Cover	BARE	FAIR	FAIR	GOOD
Runoff Curve No.	80.3	88.0	88.1	95.2
Model Area (acre)	1	1	1	1
Runoff Area (%)	0	50	70	90
Maximum Leaf Area Index	0	2	2	3
Evaporative Zone Depth (in)	10	22	22	22
Erosion Layer				
Layer No.				1
Type				vertical percolation
Texture No.				11
Thickness (in)				18
Infiltration Layer				
Layer No.				2
Type				vertical percolation
Texture No.				12
Thickness (in)				42
Interim/Daily Cover				
Layer No.		1	1	3
Type		vertical percolation	vertical percolation	vertical percolation
Texture No.		11	11	11
Thickness (in)		6	12	12
Solid Waste				
Layer No.	1	2	2	4
Type	vertical percolation	vertical percolation	vertical percolation	vertical percolation
Texture No.	18	18	18	18
Thickness (in)	120	1200	2400	4200
Protective Cover				
Layer No.	2	3	3	5
Type	barrier soil	barrier soil	barrier soil	barrier soil
Texture No.	61	61	61	61
Thickness (in)	24	24	24	24
LCS				
Layer No.	3	4	4	6
Type	lateral drainage	lateral drainage	lateral drainage	lateral drainage
Texture No.	63	63	63	63
Thickness (in)	0.25	0.23	0.20	0.17
Slope (%)	1.46	1.46	1.46	1.46
Flow Distance (ft)	356	356	356	356
Hydraulic Conductivity (cm/sec)	7.98	3.04	1.90	0.73
Geomembrane				
Layer No.	4	5	5	7
Type	geomembrane	geomembrane	geomembrane	geomembrane
Texture No.	35	35	35	35
Thickness (in)	0.06	0.06	0.06	0.06
Installation Quality	Good - 3	Good - 3	Good - 3	Good - 3
Defects per acre	1	1	1	1
Pinholes per acre	0.5	0.5	0.5	0.5
Geosynthetic Clay Liner				
Layer No.	5	6	6	8
Type	barrier soil	barrier soil	barrier soil	barrier soil
Texture No.	17	17	17	17
Thickness (in)	0.24	0.24	0.24	0.24
Average Lateral Drainage (cf/yr)	9,391	3,492	5,579	1,007
Peak Lateral Drainage (cf/day)	593	396	321	88
Max Head within lateral drainage (in)	0.17	0.12	0.39	0.28

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** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
**
**
****
****

PRECIPITATION DATA FILE: E:\NTMWD\PRECIP.D4
TEMPERATURE DATA FILE: E:\NTMWD\TEMP.D7
SOLAR RADIATION DATA FILE: E:\NTMWD\RAD.D13
EVAPOTRANSPIRATION DATA: E:\NTMWD\EVAP.D11
SOIL AND DESIGN DATA FILE: E:\NTMWD\CASE1.D10
OUTPUT DATA FILE: E:\NTMWD\CASE1OUT.OUT

TIME: 16:36 DATE: 12/ 3/2018

****

TITLE: ACTIVE 10' WASTE

****

NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	120.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2829	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4640	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.25	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1397	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	7.980000020000	CM/SEC
SLOPE	=	1.46	PERCENT
DRAINAGE LENGTH	=	356.0	FEET

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.1999999960000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.3000000030000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	80.30	
FRACTION OF AREA ALLOWING RUNOFF	=	0.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	1.826	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	6.710	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.770	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	45.297	INCHES
TOTAL INITIAL WATER	=	45.297	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE	=	32.85 DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.65	1.93	2.42	3.63	4.27	2.59
2.00	1.76	3.31	2.47	1.76	1.67

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 3

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.62	1.35	3.90	1.96	2.32	2.35
	1.14	3.66	2.68	0.97	1.11	1.56
STD. DEVIATIONS	0.17	0.97	2.73	1.50	0.62	1.54
	1.08	0.83	0.65	0.63	0.60	1.10
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						

TOTALS	1.340	0.908	2.711	1.773	2.259	1.526
	1.923	3.001	2.609	1.240	0.842	1.096
STD. DEVIATIONS	0.231	0.437	1.635	1.160	0.887	0.742
	1.477	0.348	0.417	0.658	0.540	0.762

PERCOLATION/LEAKAGE THROUGH LAYER 2

TOTALS	0.0045	0.0001	0.7455	0.4120	0.0116	0.1150
	0.3981	0.1023	0.5967	0.0034	0.0007	0.1940
STD. DEVIATIONS	0.0050	0.0001	0.7423	0.3695	0.0186	0.1992
	0.6893	0.1456	0.8213	0.0039	0.0011	0.3346

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0078	0.0001	0.7288	0.4271	0.0132	0.1151
	0.3981	0.0985	0.6004	0.0033	0.0007	0.1941
STD. DEVIATIONS	0.0106	0.0001	0.7176	0.3899	0.0213	0.1993
	0.6893	0.1483	0.8277	0.0039	0.0011	0.3347

PERCOLATION/LEAKAGE THROUGH LAYER 5

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2

AVERAGES	0.0001	0.0000	0.0077	0.0046	0.0002	0.0012
	0.0042	0.0011	0.0067	0.0001	0.0000	0.0019
STD. DEVIATIONS	0.0001	0.0000	0.0076	0.0041	0.0004	0.0020
	0.0073	0.0016	0.0088	0.0001	0.0000	0.0033

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0001	0.0000	0.0127	0.0077	0.0002	0.0021
	0.0069	0.0017	0.0108	0.0001	0.0000	0.0034
STD. DEVIATIONS	0.0002	0.0000	0.0125	0.0070	0.0004	0.0036
	0.0120	0.0026	0.0149	0.0001	0.0000	0.0058

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 3

	INCHES	CU. FEET	PERCENT
PRECIPITATION	23.61 (6.895)	85704.3	100.00
RUNOFF	0.000 (0.0000)	0.00	0.000
EVAPOTRANSPIRATION	21.228 (5.6808)	77055.96	89.909
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.58385 (1.48421)	9379.370	10.94387
AVERAGE HEAD ON TOP OF LAYER 2	0.002 (0.001)		

LATERAL DRAINAGE COLLECTED FROM LAYER 3	2.58715 (1.47855)	9391.368	10.95787
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.00000 (0.00000)	0.003	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.004 (0.002)		
CHANGE IN WATER STORAGE	-0.205 (0.4642)	-743.01	-0.867

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 3

	(INCHES)	(CU. FT.)
PRECIPITATION	2.49	9038.700
RUNOFF	0.000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.168510	611.69208
AVERAGE HEAD ON TOP OF LAYER 2	0.056	
DRAINAGE COLLECTED FROM LAYER 3	0.16331	592.80865
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.000000	0.00006
AVERAGE HEAD ON TOP OF LAYER 4	0.088	
MAXIMUM HEAD ON TOP OF LAYER 4	0.174	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	4.7 FEET	
SNOW WATER	0.28	1017.5434

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3931
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0770

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 3

LAYER	(INCHES)	(VOL/VOL)
1	33.3417	0.2778
2	11.1360	0.4640
3	0.0250	0.1000

4	0.0000	0.0000
5	0.1800	0.7500
SNOW WATER	0.000	

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**                                                                  **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE        **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)        **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY          **
**                     USAE WATERWAYS EXPERIMENT STATION            **
**                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY    **
**                                                                  **
**                                                                  **
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PRECIPITATION DATA FILE:     E:\NTMWD\PRECIP2.D4
TEMPERATURE DATA FILE:       E:\NTMWD\TEMP2.D7
SOLAR RADIATION DATA FILE:   E:\NTMWD\RAD2.D13
EVAPOTRANSPIRATION DATA:     E:\NTMWD\EVAP2.D11
SOIL AND DESIGN DATA FILE:   E:\NTMWD\CASE2.D10
OUTPUT DATA FILE:            E:\NTMWD\CASE2OUT.OUT


TIME:  16:14     DATE:  12/ 4/2018


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     TITLE:  DAILY COVER 100'WASTE

**********************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  11
          THICKNESS                    =      6.00   INCHES
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2368 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                    MATERIAL TEXTURE NUMBER  18
          THICKNESS                    =   1200.00   INCHES
          POROSITY                     =      0.6710 VOL/VOL
          FIELD CAPACITY               =      0.2920 VOL/VOL
          WILTING POINT                =      0.0770 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2900 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
```

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4640	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.23	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	7.98000002000	CM/SEC
SLOPE	=	1.46	PERCENT
DRAINAGE LENGTH	=	356.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	88.00

FRACTION OF AREA ALLOWING RUNOFF	=	50.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	3.647	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	13.520	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	2.354	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	360.714	INCHES
TOTAL INITIAL WATER	=	360.714	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE	=	32.85	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.65	1.93	2.42	3.63	4.27	2.59
2.00	1.76	3.31	2.47	1.76	1.67

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	1.19	1.68	2.94	3.70	3.29	2.31
	1.14	2.79	3.01	1.23	1.10	1.43
STD. DEVIATIONS	0.88	1.01	2.33	3.31	1.42	1.27
	0.81	1.34	1.28	1.20	0.49	0.85

RUNOFF

TOTALS	0.010	0.000	0.089	0.271	0.101	0.063
	0.014	0.034	0.123	0.007	0.003	0.007
STD. DEVIATIONS	0.023	0.000	0.119	0.537	0.108	0.090
	0.031	0.059	0.132	0.013	0.004	0.011

EVAPOTRANSPIRATION

TOTALS	1.140	1.357	2.129	2.670	4.453	2.357
	1.790	2.489	2.550	1.328	0.988	0.870
STD. DEVIATIONS	0.172	0.264	0.507	1.318	1.627	1.267
	1.653	1.354	0.432	0.722	0.250	0.384

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0000	0.0005	0.1297	0.4367	0.3830	0.0036
	0.0077	0.0001	0.0002	0.0001	0.0002	0.0001
STD. DEVIATIONS	0.0000	0.0011	0.1747	0.4378	0.8269	0.0079
	0.0171	0.0002	0.0004	0.0002	0.0003	0.0002

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0000	0.0005	0.1207	0.4456	0.3827	0.0040
	0.0077	0.0001	0.0002	0.0001	0.0002	0.0001
STD. DEVIATIONS	0.0000	0.0011	0.1594	0.4404	0.8261	0.0089
	0.0171	0.0002	0.0004	0.0002	0.0003	0.0002

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0000	0.0000	0.0014	0.0048	0.0041	0.0000
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0017	0.0048	0.0085	0.0001
	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0000	0.0000	0.0021	0.0080	0.0067	0.0001
	0.0001	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0028	0.0079	0.0144	0.0002
	0.0003	0.0000	0.0000	0.0000	0.0000	0.0000

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	INCHES	CU. FEET	PERCENT
PRECIPITATION	25.81 (6.303)	93683.0	100.00
RUNOFF	0.721 (0.6883)	2617.34	2.794
EVAPOTRANSPIRATION	24.122 (4.6614)	87561.44	93.466
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.96192 (1.25520)	3491.754	3.72720
AVERAGE HEAD ON TOP OF LAYER 3	0.001 (0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 4	0.96192 (1.25520)	3491.752	3.72720
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000 (0.00000)	0.002	0.00000
AVERAGE HEAD ON TOP OF LAYER 5	0.001 (0.002)		
CHANGE IN WATER STORAGE	0.003 (0.9787)	12.52	0.013

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	3.80	13794.000
RUNOFF	0.862	3127.6128
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.125025	453.84250
AVERAGE HEAD ON TOP OF LAYER 3	0.033	
DRAINAGE COLLECTED FROM LAYER 4	0.10912	396.11896
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00004
AVERAGE HEAD ON TOP OF LAYER 5	0.059	
MAXIMUM HEAD ON TOP OF LAYER 5	0.116	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	4.0 FEET	
SNOW WATER	0.40	1453.1432

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3685
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1070

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.5264	0.2544
2	347.8660	0.2899
3	11.1360	0.4640
4	0.0230	0.1000
5	0.0000	0.0000
6	0.1800	0.7500
SNOW WATER	0.000	

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**                                                                              **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                   **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                    **
**                   DEVELOPED BY ENVIRONMENTAL LABORATORY                      **
**                     USAE WATERWAYS EXPERIMENT STATION                        **
**                FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                              **
**                                                                              **
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PRECIPITATION DATA FILE:     E:\NTMWD\PRECIP3.D4
TEMPERATURE DATA FILE:       E:\NTMWD\TEMP3.D7
SOLAR RADIATION DATA FILE:   E:\NTMWD\RAD3.D13
EVAPOTRANSPIRATION DATA:     E:\NTMWD\EVAP3.D11
SOIL AND DESIGN DATA FILE:   E:\NTMWD\CASE3.D10
OUTPUT DATA FILE:            E:\NTMWD\CASE3OUT.OUT


TIME:  16:16     DATE:  12/ 4/2018


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     TITLE:  INT COVER 200' WASTE

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     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  11
        THICKNESS                    =     12.00   INCHES
        POROSITY                     =      0.4640 VOL/VOL
        FIELD CAPACITY               =      0.3100 VOL/VOL
        WILTING POINT                =      0.1870 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2634 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
      NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  3.00
               FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.


                                LAYER  2
                                --------

               TYPE 1 - VERTICAL PERCOLATION LAYER
                   MATERIAL TEXTURE NUMBER  18
        THICKNESS                    =   2400.00   INCHES
        POROSITY                     =      0.6710 VOL/VOL
        FIELD CAPACITY               =      0.2920 VOL/VOL
        WILTING POINT                =      0.0770 VOL/VOL
        INITIAL SOIL WATER CONTENT   =      0.2914 VOL/VOL
        EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC
```

LAYER 3

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4640	VOL/VOL
FIELD CAPACITY	=	0.3100	VOL/VOL
WILTING POINT	=	0.1870	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4640	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04	CM/SEC

LAYER 4

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.20	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	1.89999998000	CM/SEC
SLOPE	=	1.46	PERCENT
DRAINAGE LENGTH	=	356.0	FEET

LAYER 5

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 6

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER = 88.10

FRACTION OF AREA ALLOWING RUNOFF	=	70.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	4.625	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	12.278	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	3.014	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	713.841	INCHES
TOTAL INITIAL WATER	=	713.841	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE	=	32.85	DEGREES
MAXIMUM LEAF AREA INDEX	=	2.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.65	1.93	2.42	3.63	4.27	2.59
2.00	1.76	3.31	2.47	1.76	1.67

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 10

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						

TOTALS	1.11	2.03	2.49	3.73	3.76	2.39
	2.07	2.35	3.31	2.37	1.75	1.82
STD. DEVIATIONS	0.72	0.95	1.79	2.78	2.09	1.39
	1.89	1.40	1.53	2.11	1.51	1.31

RUNOFF

TOTALS	0.009	0.029	0.107	0.339	0.269	0.089
	0.249	0.058	0.199	0.148	0.079	0.019
STD. DEVIATIONS	0.028	0.038	0.154	0.546	0.425	0.101
	0.504	0.071	0.242	0.319	0.169	0.028

EVAPOTRANSPIRATION

TOTALS	1.220	1.532	2.121	2.948	4.407	2.812
	2.041	2.097	2.611	1.625	1.117	1.202
STD. DEVIATIONS	0.492	0.381	0.713	0.982	1.453	1.318
	1.653	1.436	1.074	0.788	0.475	0.593

PERCOLATION/LEAKAGE THROUGH LAYER 3

TOTALS	0.0743	0.0135	0.2057	0.3205	0.3160	0.0128
	0.0140	0.0000	0.0002	0.1107	0.2012	0.2743
STD. DEVIATIONS	0.1484	0.0226	0.2928	0.4549	0.6439	0.0384
	0.0323	0.0000	0.0003	0.3405	0.3260	0.4091

LATERAL DRAINAGE COLLECTED FROM LAYER 4

TOTALS	0.0944	0.0160	0.1833	0.3197	0.3309	0.0212
	0.0140	0.0000	0.0002	0.0918	0.1988	0.2669
STD. DEVIATIONS	0.1898	0.0282	0.2708	0.4538	0.6441	0.0441
	0.0323	0.0000	0.0003	0.2841	0.3035	0.3835

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3

AVERAGES	0.0007	0.0002	0.0021	0.0035	0.0034	0.0001
	0.0001	0.0000	0.0000	0.0011	0.0021	0.0027
STD. DEVIATIONS	0.0014	0.0003	0.0029	0.0049	0.0069	0.0003
	0.0003	0.0000	0.0000	0.0035	0.0034	0.0039

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0069	0.0013	0.0134	0.0241	0.0242	0.0016
	0.0010	0.0000	0.0000	0.0067	0.0150	0.0195
STD. DEVIATIONS	0.0139	0.0023	0.0198	0.0343	0.0470	0.0033
	0.0024	0.0000	0.0000	0.0207	0.0229	0.0280

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 10

	INCHES		CU. FEET	PERCENT
PRECIPITATION	29.19	(6.651)	105959.7	100.00
RUNOFF	1.594	(1.0631)	5787.01	5.462
EVAPOTRANSPIRATION	25.732	(4.1636)	93405.41	88.152
PERCOLATION/LEAKAGE THROUGH LAYER 3	1.54305	(1.50314)	5601.254	5.28621
AVERAGE HEAD ON TOP OF LAYER 3	0.001	(0.001)		
LATERAL DRAINAGE COLLECTED FROM LAYER 4	1.53705	(1.48880)	5579.478	5.26566
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.00000	(0.00000)	0.006	0.00001
AVERAGE HEAD ON TOP OF LAYER 5	0.009	(0.009)		
CHANGE IN WATER STORAGE	0.327	(1.4117)	1187.79	1.121

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 10

	(INCHES)	(CU. FT.)
PRECIPITATION	4.45	16153.499
RUNOFF	1.365	4956.0176
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.120300	436.68802
AVERAGE HEAD ON TOP OF LAYER 3	0.032	
DRAINAGE COLLECTED FROM LAYER 4	0.08833	320.64343
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.000000	0.00013
AVERAGE HEAD ON TOP OF LAYER 5	0.200	
MAXIMUM HEAD ON TOP OF LAYER 5	0.390	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	9.2 FEET	
SNOW WATER	1.00	3631.1433

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3630
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1370

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 10

LAYER	(INCHES)	(VOL/VOL)
1	3.9397	0.3283
2	701.7777	0.2924
3	11.1360	0.4640
4	0.0800	0.3999
5	0.0000	0.0000
6	0.1800	0.7500
SNOW WATER	0.000	

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**                                                                           **
**                                                                           **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE                **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                 **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                    **
**                    USAE WATERWAYS EXPERIMENT STATION                      **
**             FOR USEPA RISK REDUCTION ENGINEERING LABORATORY               **
**                                                                           **
**                                                                           **
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PRECIPITATION DATA FILE:    E:\NTMWD\PRECIP4.D4
TEMPERATURE DATA FILE:      E:\NTMWD\TEMP4.D7
SOLAR RADIATION DATA FILE:  E:\NTMWD\RAD4.D13
EVAPOTRANSPIRATION DATA:    E:\NTMWD\EVAP4.D11
SOIL AND DESIGN DATA FILE:  E:\NTMWD\CASE4.D10
OUTPUT DATA FILE:           E:\NTMWD\CASE4OUT.OUT


TIME:  15:56     DATE:   4/29/2019


*******************************************************************************

     TITLE:  FINAL COVER 350' WASTE

*******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                LAYER  1
                                --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER  11
          THICKNESS                    =     18.00   INCHES
          POROSITY                     =      0.4640 VOL/VOL
          FIELD CAPACITY               =      0.3100 VOL/VOL
          WILTING POINT                =      0.1870 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2593 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.639999998000E-04 CM/SEC
        NOTE:  SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY  4.20
                 FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 12

THICKNESS	=	42.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3420 VOL/VOL
WILTING POINT	=	0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3293 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.419999997000E-04 CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 12

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3420 VOL/VOL
WILTING POINT	=	0.2100 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3420 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.419999997000E-04 CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	4200.00 INCHES
POROSITY	=	0.6710 VOL/VOL
FIELD CAPACITY	=	0.2920 VOL/VOL
WILTING POINT	=	0.0770 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02 CM/SEC

LAYER 5

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 61

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4640 VOL/VOL
FIELD CAPACITY	=	0.3100 VOL/VOL
WILTING POINT	=	0.1870 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4640 VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.999990007000E-04 CM/SEC

LAYER 6

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	0.17	INCHES
POROSITY	=	0.8500	VOL/VOL
FIELD CAPACITY	=	0.1000	VOL/VOL
WILTING POINT	=	0.0050	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.730000019000	CM/SEC
SLOPE	=	1.46	PERCENT
DRAINAGE LENGTH	=	356.0	FEET

LAYER 7

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 35

THICKNESS	=	0.06	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.199999996000E-12	CM/SEC
FML PINHOLE DENSITY	=	0.50	HOLES/ACRE
FML INSTALLATION DEFECTS	=	1.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 8

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 17

THICKNESS	=	0.24	INCHES
POROSITY	=	0.7500	VOL/VOL
FIELD CAPACITY	=	0.7470	VOL/VOL
WILTING POINT	=	0.4000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.7500	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.300000003000E-08	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	95.20	
FRACTION OF AREA ALLOWING RUNOFF	=	90.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	5.501	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.236	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	4.206	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	1260.334	INCHES
TOTAL INITIAL WATER	=	1260.334	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE	=	32.85 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00
START OF GROWING SEASON (JULIAN DATE)	=	63
END OF GROWING SEASON (JULIAN DATE)	=	329
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.65	1.93	2.42	3.63	4.27	2.59
2.00	1.76	3.31	2.47	1.76	1.67

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING

COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.29	1.79	2.22	3.48	3.85	2.64
	2.76	1.67	3.70	2.52	1.61	1.76
STD. DEVIATIONS	0.88	1.03	1.32	2.14	1.79	1.71
	2.20	1.24	2.03	2.07	1.21	1.26
RUNOFF						
TOTALS	0.131	0.261	0.408	0.994	1.051	0.653
	0.827	0.288	1.075	0.717	0.263	0.272
STD. DEVIATIONS	0.188	0.283	0.484	1.006	0.887	0.636
	1.069	0.338	0.867	0.973	0.401	0.339
EVAPOTRANSPIRATION						
TOTALS	1.196	1.402	1.941	3.172	3.180	2.135
	1.986	1.383	2.241	1.485	0.905	1.066
STD. DEVIATIONS	0.460	0.484	0.735	0.995	1.114	1.217
	1.168	1.003	1.089	0.849	0.404	0.456
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	0.0204	0.0439	0.0765	0.0417	0.0489	0.0311
	0.0003	0.0001	0.0002	0.0002	0.0037	0.0107
STD. DEVIATIONS	0.0428	0.0778	0.1332	0.1286	0.1226	0.1084
	0.0010	0.0003	0.0004	0.0004	0.0137	0.0349
LATERAL DRAINAGE COLLECTED FROM LAYER 6						
TOTALS	0.0183	0.0396	0.0759	0.0451	0.0466	0.0375
	0.0016	0.0001	0.0002	0.0001	0.0034	0.0091
STD. DEVIATIONS	0.0400	0.0715	0.1270	0.1313	0.1081	0.1242
	0.0064	0.0003	0.0004	0.0003	0.0126	0.0316
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	0.0002	0.0005	0.0008	0.0005	0.0005	0.0003
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
STD. DEVIATIONS	0.0004	0.0009	0.0014	0.0014	0.0013	0.0012
	0.0000	0.0000	0.0000	0.0000	0.0001	0.0004

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.0035	0.0082	0.0144	0.0089	0.0089	0.0074
	0.0003	0.0000	0.0000	0.0000	0.0007	0.0017
STD. DEVIATIONS	0.0076	0.0149	0.0241	0.0258	0.0206	0.0244
	0.0012	0.0000	0.0001	0.0001	0.0025	0.0060

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.29 (5.380)	106304.6	100.00
RUNOFF	6.941 (2.4138)	25194.46	23.700
EVAPOTRANSPIRATION	22.091 (3.1134)	80191.54	75.436
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.27754 (0.34680)	1007.477	0.94773
AVERAGE HEAD ON TOP OF LAYER 5	0.000 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	0.27754 (0.34902)	1007.470	0.94772
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.00000 (0.00000)	0.007	0.00001
AVERAGE HEAD ON TOP OF LAYER 7	0.005 (0.006)		
CHANGE IN WATER STORAGE	-0.024 (1.3062)	-88.93	-0.084

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.98	18077.400
RUNOFF	3.358	12189.9404
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.034208	124.17662
AVERAGE HEAD ON TOP OF LAYER 5	0.009	
DRAINAGE COLLECTED FROM LAYER 6	0.02432	88.29591
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000000	0.00010
AVERAGE HEAD ON TOP OF LAYER 7	0.143	
MAXIMUM HEAD ON TOP OF LAYER 7	0.281	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	7.0 FEET	
SNOW WATER	1.00	3631.1433

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3570

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1912

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	3.9329	0.2185

2	13.8290	0.3293
3	4.1040	0.3420
4	1226.4000	0.2920
5	11.1360	0.4640
6	0.0170	0.1000
7	0.0000	0.0000
8	0.1800	0.7500
SNOW WATER	0.000	

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121 RDF

APPENDIX 16-C-C

HELP MODEL RAINFALL RECHARGE AND PERCOLATION THROUGH LINER CALCULATIONS

HELP MODEL RAINFALL RECHARGE CALCULATION

HELP MODEL

The Hydrologic Evaluation of Landfill Performance (HELP) Model Version 3.07 was used to estimate the amount of rainfall recharge through the existing in-situ soil layer to the groundwater table. The HELP Model is a water balance model that uses climate, soil, and precipitation data to calculate a solution that accounts for the effects of surface storage, runoff, infiltration, percolation, soil moisture storage, evapotranspiration, and lateral drainage.

MODEL SETUP

The site was modeled as a 1-acre unit area for the existing in-situ soil layer. The evaporative zone depth and leaf area index were suggested by the HELP model for Dallas, Texas. The runoff potential was 90 percent since runoff outside the limits of the landfill will be allowed. The Soil Conservation Service (SCS) runoff curve number was determined based on soil data and expected ground cover for the existing in-situ soil layer from the United States Department of Agriculture, Soil Conservation Service, *Soil Survey of Gray County, Texas*, 1966.

CLIMATE DATA

Synthetic precipitation data were generated using the HELP model coefficients for Dallas, Texas. The synthetic data was augmented to include actual peak daily precipitation data. Temperature and solar radiation data were synthetically generated by the HELP model using program defaults for Dallas, Texas.

SOIL PROFILE

Soil texture 15 was selected from the HELP Model default soil characteristics to represent the subgrade soils that are present at the site. Default values for soil texture 15 were selected for porosity, field capacity, wilting point, and saturated hydraulic conductivity. The moisture content of the subgrade soil was initialized by the HELP Model program. The thickness of the subgrade was assumed to be 95 feet, which represents the approximate thickness of the unsaturated zone.

HELP OUTPUT

The HELP input data and output files are presented on the following pages.

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** HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE **
** HELP MODEL VERSION 3.07 (1 NOVEMBER 1997) **
** DEVELOPED BY ENVIRONMENTAL LABORATORY **
** USAE WATERWAYS EXPERIMENT STATION **
** FOR USEPA RISK REDUCTION ENGINEERING LABORATORY **
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**
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PRECIPITATION DATA FILE: E:\NTMWD\PRECIP4.D4
TEMPERATURE DATA FILE: E:\NTMWD\TEMP4.D7
SOLAR RADIATION DATA FILE: E:\NTMWD\RAD4.D13
EVAPOTRANSPIRATION DATA: E:\NTMWD\EVAP4.D11
SOIL AND DESIGN DATA FILE: E:\NTMWD\NATURAL.D10
OUTPUT DATA FILE: E:\NTMWD\NATOUT.OUT

TIME: 11:14 DATE: 12/ 5/2018

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TITLE: NATURAL CONDITION

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.

LAYER 1

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 15

THICKNESS	=	60.00	INCHES
POROSITY	=	0.4750	VOL/VOL
FIELD CAPACITY	=	0.3780	VOL/VOL
WILTING POINT	=	0.2650	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3624	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.170000003000E-04	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 4.20
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	81.00	
FRACTION OF AREA ALLOWING RUNOFF	=	90.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	7.386	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	10.450	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	5.830	INCHES

INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	21.742	INCHES
TOTAL INITIAL WATER	=	21.742	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
DALLAS TEXAS

STATION LATITUDE	=	32.85	DEGREES
MAXIMUM LEAF AREA INDEX	=	3.00	
START OF GROWING SEASON (JULIAN DATE)	=	63	
END OF GROWING SEASON (JULIAN DATE)	=	329	
EVAPORATIVE ZONE DEPTH	=	22.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	10.80	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	66.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	63.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	66.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
1.65	1.93	2.42	3.63	4.27	2.59
2.00	1.76	3.31	2.47	1.76	1.67

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
44.00	48.50	56.10	65.90	73.70	82.00
86.30	85.50	78.60	67.90	55.60	47.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR DALLAS TEXAS
AND STATION LATITUDE = 32.85 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	1.29	1.79	2.22	3.48	3.85	2.64
	2.76	1.67	3.70	2.52	1.61	1.76
STD. DEVIATIONS	0.88	1.03	1.32	2.14	1.79	1.71
	2.20	1.24	2.03	2.07	1.21	1.26

RUNOFF						
TOTALS	0.001	0.008	0.020	0.135	0.111	0.049
	0.106	0.008	0.101	0.079	0.016	0.007
STD. DEVIATIONS	0.002	0.021	0.058	0.296	0.291	0.107
	0.246	0.023	0.159	0.173	0.056	0.023
EVAPOTRANSPIRATION						
TOTALS	1.365	1.528	2.089	3.361	3.876	2.836
	2.590	1.663	2.810	1.810	1.087	1.309
STD. DEVIATIONS	0.551	0.598	0.888	1.116	1.423	1.632
	1.694	1.277	1.438	1.005	0.516	0.514
PERCOLATION/LEAKAGE THROUGH LAYER 1						
TOTALS	0.2532	0.1871	0.1666	0.2014	0.3457	0.2251
	0.1276	0.0840	0.0414	0.1916	0.2377	0.2931
STD. DEVIATIONS	0.3858	0.2377	0.2286	0.3308	0.5028	0.2384
	0.1712	0.1675	0.1073	0.4548	0.3098	0.3894

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	29.29 (5.380)	106304.6	100.00
RUNOFF	0.640 (0.5255)	2323.33	2.186
EVAPOTRANSPIRATION	26.325 (4.0510)	95559.31	89.892
PERCOLATION/LEAKAGE THROUGH LAYER 1	2.35447 (1.36185)	8546.727	8.03985
CHANGE IN WATER STORAGE	-0.034 (1.5970)	-124.81	-0.117

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.98	18077.400
RUNOFF	1.381	5014.2349
PERCOLATION/LEAKAGE THROUGH LAYER 1	0.422089	1532.18311
SNOW WATER	1.00	3631.1433

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4369
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.2650

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	20.7101	0.3452
SNOW WATER	0.000	

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PERCOLATION THROUGH LINER CALCULATION

The leakage through the geomembrane was calculated using the methods presented in the HELP model engineering documentation. The results of the leachate generation model in Appendix 16-C-B demonstrate that the maximum head on the geomembrane liner for the critical condition is approximately 0.39 inches, which is used to calculate leakage through the geomembrane. Percolation through the alternate liner system was conservatively assumed to equal the leakage through the geomembrane component of the liner system. These calculations are provided on pages 16-C-C-8 through 16-C-C-10 in this appendix following the HELP output.

NTMWD 121 RDF
Percolation Through Liner Calculation

Required: Determine the infiltration rate for leachate through the geomembrane of the alternate liner system.

References:
1) *Hydrologic Evaluation of Landfill Performance (HELP),* Engineering Documentation.
2) *Hydrologic Evaluation of Landfill Performance (HELP),* User's Guide for Version 3.

Assumptions:
1) The controlling soil layer for leachate infiltration through the geomembrane is the geosynthetic clay liner (GCL). This demonstration provides the maximum allowable hydraulic conductivity for a GCL based on a DAF = 260.
2) Good liner contact with low permeability controlling soil.

Solution:

Radius of Leakage

Pinholes $R = 0.174h^{0.45}K^{-0.13}$ Ref 1, Equation 163

where: R = radius of wetted area around pinhole (in)
h = hydraulic head on liner = 0.39 in
K = hydraulic conductivity of controlling soil layer = 3.00E-09 cm/sec
1.02E-04 in/day

R= 0.38 in

Defects $R = 0.222h^{0.45}K^{-0.13}$ Ref 1, Equation 164

where: R = radius of wetted area around defect (in)
h = hydraulic head on liner = 0.39 in
K = hydraulic conductivity of controlling soil layer = 3.00E-09 cm/sec
1.02E-04 in/day

R= 0.48 in

Average Hydraulic Gradient

$i = 1 + [h / (2T\ln (R / r))]$ Ref 1, Equation 152

where: i = average hydraulic gradient (in)
h = hydraulic head on liner = 0.39 in
T = thickness of controlling layer = 0.24 in
R = radius of wetted area (in)
r = radius of flaw (in)

Pinholes
R = 0.38 in
r = 0.5 mm
= 0.02 in
i = 1.28 in/in

Defects
R = 0.48 in
$area$ = 1.0 cm^2
r = 0.22 in
i = 2.05 in/in

Leakage Rate

$q = 0.877[(Kin\ \pi R^2) / 6{,}276{,}640]$ Ref 1, Equation 151

where: q = leakage rate (in/day)
i = average hydraulic gradient
n = density of flaws (no./ac)
T = thickness of controlling layer = 0.24 in
R = radius of wetted area (in)
K = hydraulic conductivity of controlling soil layer = 1.02E-04 in/day

NTMWD 121 RDF
Percolation Through Liner Calculation

Pinholes	n =	0.5	holes/ac	see page 6N-1-C-10
	i =	1.28		
	R =	0.38	in	
	q_p =	4.042E-12	in/day	
Defects	n =	1	holes/ac	see page 6N-1-C-10
	i =	2.05		
	R =	0.48	in	
	q_d =	2.12E-11	in/day	

Vapor Diffusion

$q = K_m [(h + T) / T]$ Ref 1, Equation 141

where: q = leakage rate (in/day)

T = thickness of geomembrane =	0.06	in
h = hydraulic head on liner =	0.39	in
K_m = hydraulic conductivity of geomembrane =	2.0E-13	cm/sec
	6.80E-09	in/day

q = 5.10E-08 in/day

Infiltration / Percolation Rate

$Q = q + q_p + q_d$ = 5.10E-08 in/day

4.73E-07 m/yr

SOURCE: REFERENCE 2

Pinhole Density: the number of defects (diameter of hole equal to or smaller than the geomembrane thickness; hole estimated as 1 mm in diameter) in a given area generally resulting from manufacturing flaws such as polymerization deficiencies.

Installation Defect Density: the number of defects (diameter of hole larger than the geomembrane thickness; hole estimated as 1 cm^2 in area) per acre resulting primarily from seaming faults and punctures during installation.

Geotextile Transmissivity: the product of the in-plane saturated hydraulic conductivity and thickness of the geotextile.

The density of pinholes and installation defects is a subject of speculation. Ideally, geomembranes would not have any defects. If any were known to exist during construction, the defects would be repaired. However, geomembranes are known to leak and therefore reasonably conservative estimates of the defect densities should be specified to determine the maximum probable leakage quantities.

The density of defects has been measured at a number of landfills and other facilities and reported in the literature. These findings provide guidance for estimating the defect densities. Typical geomembranes may have about 0.5 to 1 pinholes per acre (1 to 2 pinholes per hectare) from manufacturing defects. The density of installation defects is a function of the quality of installation, testing, materials, surface preparation, equipment, and QA/QC program. Representative installation defect densities as a function of the quality of installation are given below for landfills being built today with the state-of-the-art in materials, equipment and QA/QC. In the last column the frequency of achieving a particular installation quality is given. The estimates are based on limited data but are characteristic of the recommendations provided in the literature.

Installation Quality	Defect Density (number per acre)	Frequency (percent)
Excellent	Up to 1	10
Good	1 to 4	40
Fair	4 to 10	40
Poor	10 to 20*	10

* Higher defect densities have been reported for older landfills with poor installation operations and materials; however, these high densities are not characteristic of modern practice.

The user must also enter the placement quality of the geomembrane liner if pinholes or installation defects are reported. There are six different possible entries for the geomembrane liner placement quality. The program selects which equation will be used to compute the geomembrane based on the placement quality specified and the saturated hydraulic conductivity of the lower permeability soil (drainage limiting soil) adjacent to

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APPENDIX 16-C-D

MULTIMED CHEMICAL-SPECIFIC DATA

MULTIMED CHEMICAL-SPECIFIC DATA

Table 16-C-D-1

Variable Name	Units	Value	Comments
Solid phase decay coefficient	1/yr	0	Decay not used.
Dissolved phase decay coefficient	1/yr	0	Decay not used.
Chemical decay coefficient	1/yr	0	Decay not used.
Acid catalyst hydrolysis constant	l/m-yr	0	Hydrolysis not used.
Neutral hydrolysis rate constant	1/yr	0	Hydrolysis not used.
Base catalyst hydrolysis constant	l/m-yr	0	Hydrolysis not used.
Reference temperature	degrees C	20	Not used in model since decay not used.
Normalized distribution coefficient	ml/g	0	0 because simulation is steady state, with no chemical decay.
Distribution coefficient	ml/g		Derived by MULTIMED from normalized distribution coefficient.
Biodegradation coefficient	1/yr	0	Biodegradation not allowed by TCEQ.

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APPENDIX 16-C-E

MULTIMED SOURCE-SPECIFIC DATA

MULTIMED SOURCE-SPECIFIC DATA

Table 16-C-E-1

Variable Name	Units	Value	Comments
Infiltration rate	m/yr	0.473 e $^{-}$6	Refer to Appendix 16-C-C, Pg. 16-C-C-9
Area of Alternate Liner disposal unit	m^2	0.102 e $^{-}$7	252 ac.* Refer to Drawing 16-C-A.1
Spread of contaminant source	m		Derived from MultiMed
Recharge rate	m/yr	0.598 e^{-}1	From HELP Model
Initial concentration at landfill	mg/l	1.0	Set at 1 to find DAF
Length scale of facility	m		Derived from MultiMed
Width scale of facility	m		Derived from MultiMed

*Represents the remaining landfill disposal footprint for Cells 7-12.

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APPENDIX 16-C-F

MULTIMED UNSATURATED ZONE DATA

MULTIMED UNSATURATED ZONE DATA

The unsaturated zone was not modeled as part of this alternate liner design demonstration. The attenuating effects of the unsaturated zone were conservatively disregarded.

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APPENDIX 16-C-G

MULTIMED AQUIFER-SPECIFIC DATA

MULTIMED AQUIFER-SPECIFIC DATA

Table 6N-1-3

Variable Name	Unit	Value	Comments
Particle diameter	cm	0.15 e^{-2}	From Reference 1, Table 6-10, p.105, value from Medium Clay
Aquifer porosity	unitless	0.42	From Reference 1, Table 6-3, p.94, value from Clay
Bulk density	g/cc	1.49	From Reference 1, Table 6-11, p.106, value from Clay
Aquifer thickness	m	1.52	From site specific data (See Attachment 4)
Mixing zone depth	m		Derived from MultiMed
Hydraulic conductivity	m/yr	0.26	From site geotechnical tests (See note below)
Hydraulic gradient	unitless	0.7	Representative site gradient (See Attachment 4)
Groundwater seepage velocity	m/yr		Derived from MultiMed
Retardation coefficient	unitless		Derived from MultiMed
Longitudinal dispersivity	m		Derived from MultiMed
Transversal dispersivity	m		Derived from MultiMed
Vertical dispersivity	m		Derived from MultiMed
Organic carbon content	%	0.1 e^{-5}	Conservative Assumption
Receptor well distance	m	61	200 ft. (See Drawing 16-C-A.1)
Z-distance from water table	m	0	Assume water table at bottom of liner

References

1. Sharp-Hansen, S., C. Travers, P. Hummel, and T. Allison, 1990. *A Subtitle D Landfill Application Manual For The Multimedia Exposure Model (MULTIMED)*, U.S. Environmental Protection Agency, 470 p.

Note

The hydraulic conductivity is obtained from site geotechnical test information provided in Attachment 4, Section 7.3. The hydraulic conductivity of 8.25 x 10^{-8} cm/sec was converted to 0.260 meters/year (m/yr) for use as MULTIMED input. This valve represents the most conservative hydraulic conductivity of the perched groundwater zone.

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APPENDIX 16-C-H

LEACHATE DATA

LEACHATE DATA

An initial concentration (C_o) equal to 1.0 mg/L was used for MULTIMED modeling, as detailed in the *Texas Water Commission Alternate Liner Design Handbook, Input Leachate Requirements* (page 23).

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APPENDIX 16-C-I

CALCULATIONS OF THE DILUTION ATTENUATION FACTOR

CALCULATIONS OF THE DILUTION ATTENUATION FACTOR

Result from MULTIMED model:

chemical concentration at the point of compliance = 2.06×10^{-9} mg/L
(see Appendix 16-C-J)

to find the resulting DAF, take the reciprocal:
Alternate Liner DAF = $1/(2.06 \times 10^{-9}$ mg/L)

DAF = 4.85×10^{8}

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APPENDIX 16-C-J

MULTIMED MODEL OUTPUT

MULTIMED MODEL OUTPUT

MULTIMED model output follows.

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U. S. ENVIRONMENTAL PROTECTION AGENCY

EXPOSURE ASSESSMENT

MULTIMEDIA MODEL

MULTIMED (Version 1.01, June 1991)

1

Run options

121RDF ALTERNATE LINER DEMONSTRATION

Liner: FML\GCL Project: 211.01.126 Date: 12/6/18
Chemical simulated is default chemical

Option Chosen	Saturated zone model
Run was	DETERMIN
Infiltration input by user	
Run was steady-state	
Reject runs if Y coordinate outside plume	
Reject runs if Z coordinate outside plume	
Gaussian source used in saturated zone model	

1
1

CHEMICAL SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Solid phase decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Dissolved phase decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Overall chemical decay coefficient	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	0.100E+11
Acid catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Neutral hydrolysis rate constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Base catalyzed hydrolysis rate	1/M-yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Reference temperature	C	CONSTANT	20.0	-999.	0.000E+00	100.
Normalized distribution coefficient	ml/g	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Distribution coefficient	--	DERIVED	-999.	-999.	0.000E+00	0.100E+11
Biodegradation coefficient (sat. zone)	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Air diffusion coefficient	cm2/s	CONSTANT	0.000E+00	-999.	0.000E+00	10.0
Reference temperature for air diffusion	C	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Molecular weight	g/M	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Mole fraction of solute	--	CONSTANT	0.000E+00	-999.	0.100E-08	1.00
Vapor pressure of solute	mm Hg	CONSTANT	0.000E+00	-999.	0.000E+00	100.
Henry's law constant	atm-m^3/M	CONSTANT	0.000E+00	-999.	0.100E-09	1.00
Overall 1st order decay sat. zone	1/yr	DERIVED	0.000E+00	0.000E+00	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00
Not currently used		CONSTANT	-999.	-999.	0.000E+00	1.00

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SOURCE SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Infiltration rate	m/yr	CONSTANT	0.473E-06	-999.	0.100E-09	0.100E+11
Area of waste disposal unit	m^2	CONSTANT	0.102E+07	-999.	0.100E-01	-999.
Duration of pulse	yr	CONSTANT	-999.	-999.	0.100E-08	-999.
Spread of contaminant source	m	DERIVED	-999.	-999.	0.100E-08	0.100E+11
Recharge rate	m/yr	CONSTANT	0.598E-01	-999.	0.000E+00	0.100E+11
Source decay constant	1/yr	CONSTANT	0.000E+00	-999.	0.000E+00	-999.
Initial concentration at landfill	mg/l	CONSTANT	1.00	-999.	0.000E+00	-999.
Length scale of facility	m	CONSTANT	0.101E+04	-999.	0.100E-08	0.100E+11
Width scale of facility	m	CONSTANT	0.101E+04	-999.	0.100E-08	0.100E+11
Near field dilution		DERIVED	1.00	0.000E+00	0.000E+00	1.00

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AQUIFER SPECIFIC VARIABLES

VARIABLE NAME	UNITS	DISTRIBUTION	PARAMETERS MEAN	PARAMETERS STD DEV	LIMITS MIN	LIMITS MAX
Particle diameter	cm	CONSTANT	0.150E-02	-999.	0.100E-08	100.
Aquifer porosity	--	CONSTANT	0.420	-999.	0.100E-08	0.990
Bulk density	g/cc	CONSTANT	1.49	-999.	0.100E-01	5.00
Aquifer thickness	m	CONSTANT	3.05	-999.	0.100E-08	0.100E+06
Source thickness (mixing zone depth)	m	DERIVED	0.100E+05	-999.	0.100E-08	0.100E+06
Conductivity (hydraulic)	m/yr	CONSTANT	0.260	-999.	0.100E-06	0.100E+09
Gradient (hydraulic)		CONSTANT	0.700E-02	-999.	0.100E-07	-999.
Groundwater seepage velocity	m/yr	DERIVED	-999.	-999.	0.100E-09	0.100E+09
Retardation coefficient	--	DERIVED	1.00	-999.	1.00	0.100E+09
Longitudinal dispersivity	m	FUNCTION OF X	3.35	-999.	0.100E-02	0.100E+05
Transverse dispersivity	m	FUNCTION OF X	1.11	-999.	0.100E-02	0.100E+05
Vertical dispersivity	m	FUNCTION OF X	0.188	-999.	0.100E-02	0.100E+05
Temperature of aquifer	C	CONSTANT	20.0	-999.	0.000E+00	100.
pH	--	CONSTANT	7.50	-999.	0.300	14.0
Organic carbon content (fraction)		CONSTANT	0.100E-05	-999.	0.100E-05	1.00
Well distance from site	m	CONSTANT	61.0	-999.	1.00	-999.
Angle off center	degree	CONSTANT	0.000E+00	-999.	0.000E+00	360.
Well vertical distance	m	CONSTANT	0.000E+00	-999.	0.000E+00	1.00

CONCENTRATION AFTER SATURATED ZONE MODEL 0.2060E-10