WASTE MANAGEMENT OF TEXAS
A WASTE MANAGEMENT COMPANY
9708 Giles Lane
Austin Texas 78781

July 12, 2018

Texas Commission on Environmental Quality
MSW Permits Section, Waste Permit Division
P.O. Box 13087, MC-124
Austin, Texas 78711-3087

Attn: Chance Goodin
Manager, MSW Permits Section

Re: Addendum to Permit Modification Request
Changes to Final Cover Design to Include a Water Balance Alternative Final Cover
Waste Management of Texas, Inc.
Austin Community Recycling and Disposal Facility
Travis County, Texas
TCEQ Permit No. MSW 249D

Dear Mr. Goodin:

Waste Management of Texas, Inc. (WMTX) is submitting the attached addendum pertaining to the Permit Modification (PM) request, prepared by Golder Associates Inc. (Golder), for changes to final cover design to include a water balance alternative final cover at the Austin Community Recycling and Disposal Facility. In accordance with the requirements of 30 Texas Administrative Code (TAC) Section 305.44(b):

I 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.

Enclosed with this letter are the original and one copy. An additional copy has been forwarded to Mr. David Mann, Waste Program Manager of the TCEQ Region 11 office in Austin, Texas.

If you have any questions concerning this letter, please contact Tim Champagne, PE of WMTX at (512) 731-9768 or me at (512) 272-6245.

ON BEHALF OF WASTE MANAGEMENT OF TEXAS, INC.

Steve Jacobs
Texas Area Director of Landfill Operations
9708 Giles Lane
Austin TX 78754

cc: David Mann – TCEQ Region 11

GOLDER

TRANSMITTAL

July 12, 2018

Project No. 1782540

Chance Goodin, Manager, MSW Permits Section
Texas Commission on Environmental Quality
PO Box 13087, MC-124
Austin, Texas 78711-3087

FROM William E. Gordon, PE WEG
EMAIL William_Gordon@golder.com

ADDENDUM TO PERMIT MODIFICATION REQUEST, WATER BALANCE ALTERNATIVE FINAL COVER AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY, TRAVIS COUNTY, TEXAS TCEQ PERMIT NO. MSW-249D, TRACKING NO. 22075131; RN100215938/CN600127856

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☐ **Air Freight**		☐ **Other**	
☐ **Email**			

Quantity	Item	Description
3	1 Original and 2 copies	Addendum to Permit Modification Request Water Balance Alternative Final Cover.

On behalf of Waste Management of Texas, Inc. (WMTX), Golder Associates Inc. (Golder) is submitting this addendum to the above-referenced Permit Modification (PM) request to the existing Texas Commission on Environmental Quality (TCEQ) Permit Number Municipal Solid Waste (MSW) 249D, at the Austin Community Recycling and Disposal Facility, located in Travis County, Texas. The TCEQ requested clarifications on several items within the PM request in an email dated June 1, 2018.

The clarifications presented herein are summarized below:

1) Ensure to include the revisions on the public website.

WMTX will post all revisions to the initial PM to the following publically accessible web site as requested.

http://www.wm.com/wm/permits-texas/permits.jsp

2) Include missing revised page 15 in Attachment III.

Revision: The missing revised page 15 is attached.

3) Revise the test frequency to include at least one test per soil type in Attachment 7, Appendix A, Table 1 and page 23.

Revision: Attachment 7, Appendix A, Table 1 (renamed as Table 7A.8 to be consistent with the document) is attached and has been revised to include preconstruction testing for each soil type. Page 22 (previously page 23) has been revised to clarify that each soil type is to be tested.

4) Include a statement indicating that preconstruction testing must be performed for each construction event in Attachment 7, Appendix A, pages 23 and 26.

Revision: Attachment 7, Appendix A, has been revised to indicate that preconstruction testing will be performed for each construction event. The relevant changes are shown on pages 22 and 25 (previously pages 23 and 26). Additional clarifications have been made to address comment 8 below and to clarify that the required permeability of the storage layer can vary.

5) Provide slope stability analyses for minimum and maximum cover thicknesses, including the erosion layer (ensure 12 inches in all cases), all the interfaces and fully saturated condition for all layers or explain how one set of analysis would suffice in Attachment 3, Appendix C.5A.

Revision: Additional slope stability analyses have been performed as requested. As part of these slope stability analyses, we have reduced the shear strength and interface shear strength parameters to more conservative values. The following is a summary of the results indicating the slopes have the appropriate factor of safety for all analyses.

Failure Type		Total WB Cover Thickness (ft)	Factor of Safety
Circular	Thru Cover	2.7(1)	3.4
		5.0(2)	3.4
	Thru Waste	2.7	2.4
		5.0	2.4
Block	at base of Erosion Layer	2.7	2.6
		5.0	
	at base of Storage Layer	2.7	2.9
		5.0	1.6

Notes:

1. **12-inch thick erosion layer over 20-inch thick storage layer.**
2. **12-inch thick erosion layer over 48-inch thick storage layer.**

As indicated in the table, using the revised conservative shear strength values, the factors of safety are quite high with one exception: block failure along the base of the storage area.

6) Revise to indicate that the constructed cover system will be tested to verify the target values for all properties were achieved during construction or that slope stability will be reanalyzed using as-built values if they differ from those proposed in Attachment 3, Appendix C.5A.

Revision: Based on the revised stability analysis, the critical condition (i.e. the lowest factor of safety) is failure at the base of the storage layer. For this condition, the minimum shear strength to achieve a factor of safety of 1.5 is 235 lb/ft^2. Soil strength greater than 235 lb/ft^2 will result in a higher

factor of safety so further analyses are not needed.

The Final Cover Quality Control Plan (Appendix A to Attachment 7) has been revised to include shear strength conformance testing to confirm a minimum shear strength of 235 lb/ft^2 is achieved within the layer.

7) Add drawings to show details of tie-ins between water balance cover and other types in Attachment 7 Add drawings to show details of tie-ins between water balance cover and other cover types in Attachment 7.

Revision: Figure ATT7-2A is attached and has been added to include details of the tie-ins. This includes the 3 ft. thick existing (2008) clay cover for the slope of Subtitle D Cells WD-6 and the east end of WD-7 and the tie-in to future Subtitle D cells where a composite cover may be constructed. Tie-ins to pre-Subtitle D cells will be performed in a similar manner as the tie-in to WD-6.

8) Specify the test methods and frequencies for the tube samples that will be taken from each lift of test pad in Attachment 7, Appendix A, Section 5.1, page 26.

Revision: This requested revisions, and others mentioned above, to page 25 (previously page 26) have been made and is attached.

CLOSING

The changes listed above are included in "red-line" format in Enclosure 1.

To aid with the review, the complete "red-line" versions of the February 21, 2018 and October 26, 2017 submittals are also provided. To aid in updating permit application document, the final versions of the relevant sections have been attached in their entirety for replacement within the existing application.

If you have any questions, please do not hesitate to call either Mr. William E. (Chip) Gordon, PE or Jeff Fassett, PE of Golder at (281) 821-6868.

List of Enclosures

Enclosure 1	Red-line version of current revisions
Enclosure 2	Red-line version of revisions in February 21, 2018 Response to Comments
Enclosure 3	Red-line version of revisions in October 26, 2017 PM Request
Enclosure 4	Complete unmarked versions of revised documents

p:_2017 project folders\1782540 acl wb permit mod\response to 2nd nod june 2018\pre-final\tceq transmittal letter_rev1_7-12-18.docx

ENCLOSURES

ENCLOSURE 1

RED-LINE VERSION OF CURRENT REVISIONS

WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

SITE DEVELOPMENT PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

500 Century Plaza Drive
Suite 190
Houston, Texas 77073
(281) 821-6868

Permit Issued: May 10, 2010
Revised April 2011
Revised June 2011
Revised October 2017
Revised February 2018
Revised July 2018

Part III, Attachment 3

WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 3
WASTE MANAGEMENT UNIT DESIGN REPORT

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

Golder Associates

500 Century Plaza Drive
Suite 190
Houston, Texas 77073
(281) 821-6868

August 2006
Revision 1 – May 2007
Revision 2 – August 2007
Revision 3 – December 2007
Revision 4 – February 2008
Revision 5 – March 2008
Revision 6 – May 2008
Revised October 2017
Revised February 2018
Revised July 2018

The analyses (included in Appendix C.5) indicate that, provided the geocomposite drainage layer is adequate to convey drainage without building up pore water pressures in the geocomposite, the factor of safety against sliding will be approximately 1.6.

Additional analyses (included in Appendix D) were performed to determine the geocomposite drainage layer transmissivity required to adequately convey surface water infiltration over the maximum final cover slope length. If the minimum measured transmissivity value reported in Appendix D is not met, the maximum flow length must be reduced (i.e., the geocomposite drainage layer must be "daylighted") in direct proportion to the ratio of the actual measured transmissivity and the required measured transmissivity. A detail depicting "daylighting" is included on Figure ATT7-2 in Attachment 7, the Closure Plan.

The site has the option of installing a water balance alternate final cover system over existing and proposed Subtitle D disposal cells in the expansion area of the West Hill. A stability analysis of the water balance final cover was ~~also~~ therefore performed using the limit equilibrium analysis. The section analyzed consists of a 710-foot long, 25-percent slope, consistent with the section analyzed for the composite final cover system. Material parameters were selected based on review of literature and site data, which are also consistent with other slope stability analyses in Appendix C. The analysis (included in Appendix C.5A) indicate that the factor of safety against sliding will ~~be approximately 4.1~~be greater than 1.5.

APPENDIX C.5A

FINAL COVER STABILITY – WATER BALANCE ALTERNATIVE FINAL COVER

FINAL COVER STABILITY - WATER BALANCE ALTERNATIVE FINAL COVER

Made By: JBF
Checked by: MX
Reviewed by:

1.0 OBJECTIVE

To investigate the stability of the water balance alternative final cover system.

2.0 GIVEN

Final cover slopes are as follows:
Future final cover area: 4H:1V (S = 25%) with a maximum length of slope conservatively assumed to be 710 ft.

Based on the "EPA Guide to Technical Resources for the Design of Land Disposal Facilities", the recommend factor of safety for the final cover slope is selected to be 1.3 at minimum.

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

INTENDED FOR PERMITTING PURPOSES ONLY

3.0 ASSUMPTIONS

The water balance final cover profile is as follows:

1-ft erosion layer
Storage layer (thickness varies from 20 inches to 4 feet)
Subgrade

Soil source for the water balance final cover materials will be on-site clay soil materials.
Based on a review of available data, the following parameters were assigned to the materials.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ (degree)	c (psf)	Moist	Saturated	
Erosion Layer	0	100	105	120	Conservative Estimate
Interface Between Erosion Layer & Storage Layer	0	75	105	120	Conservative Estimate
Storage Layer	0	500	119	132	Part III, Attachment 3, Text Section 4.2.3, Tables 3.3 and 3.4
Interface Between Storage Layer & Subgrade	0	250	110	132	
Waste	Bi-Linear Function		65	--	Bray, et al., "Shear Strength of Municipal Solid Waste", 2009.

Notes:

1. As shown in Part III, Attachment 3, Text Section 4.2.3, Tables 3.3 and 3.4, the mininum shear strengh of onsite clay materials is 2,100 psf. For conservative purposes, the shear strength of the final cover soil is assumed to be a significantly lower value of 500 psf and the interface is assumed to be even lower at 250 psf. The upper interface is conservatively assumed to have a shear strength of 75 psf.
2. The final cover system, including both the top erosion layer and the storage layer, will be constructed of on-site clay materials . The storage layer will be compacted as described in the final cover quality control plan to reach the required permeability, and the erosion layer will be lightly compacted and vegetation will be established on the final cover.

4.0 METHODS

Two slope stability analyses were performed for the final cover system:

- Circular failure for the final cover system
- Block (i.e. sliding) failure of the final cover system along the final cover/subgrade interface

Circular Failure Mode:

A slope stability software (SLIDE v7.034) was used to perform the analysis. The thickness of the Storage Layer was varied from 20 in to 4 ft. A 12-inch thick erosion layer was conservatively modeled assuming a 75-psf shear strength (i.e. equivalent to the interface strength) throughout. The minimum factor of safety is shown below and output of stability analysis is attached.

Results of the analysis indicate that, under a circular failure mode, the thickness of the Storage Layer does not affect the factor of safety. The results are as follows.

Failure surface in the final cover only	**FS =**	**3.4**
Failure surface into the waste	**FS =**	**2.4**

Block Failure Mode:

A limit equilibrium analysis was performed to determine the minimum factor of safety against a sliding block failure. The equation below was derived based on the force equilibrium of the final cover soil layers. Please refer to Chapter 12.3 of "Principles of Geotechnical Engineering" by Braja M. Das.

$$FS = \frac{c + (\gamma b \cos\beta - \gamma_w d \cos\beta)\tan\phi}{\gamma b \sin\beta}$$

(i) Block failure between Erosion Layer and Storage Layer (i.e. upper soil interface). Assume Erosion Layer is saturated.

ϕ =	0	interface friction angle
c =	75	interface cohesion (psf)
β =	14.0	slope angle (degrees)
γ =	120	saturated unit weight of soil (pcf)
b =	1.0	erosion layer thickness (ft)
d =	1	water depth in cover (conservatively assume the entire final cover is saturated) (ft)
γ_w =	62.4	unit weight of water (pcf)
FS =	**2.6**	**> 1.5**

(ii) Block failure between Storage Layer and subgrade for variable Storage Layer thicknesses. Assume Erosion Layer and Storage Layer are saturated.

ϕ =	0	interface friction angle
c =	250	interface cohesion (psf)
β =	14.0	slope angle (degrees)
γ =	132	saturated unit weight of soil (pcf)
b =	**Varies**	soil thickness (ft) (Storage Layer thickness + Erosion Layer)

d =	**Varies**	water depth in cover (conservatively assume the entire layer is saturated) (ft)
γ_w =	62.4	unit weight of water (pcf)

Total WB Cover Thickness, b (ft)	Water depth, d (ft)	FS	> 1.5	
2.7	**2.7**	**2.9**	✓	Lower Interface - Min. Thickness
5.0	**5.0**	**1.6**	✓	Lower Interface - Max. Thickness

5.0 RESULTS

The future 4H:1V water balance alternative final cover slope will have a minimum factor of safety greater than 1.5.

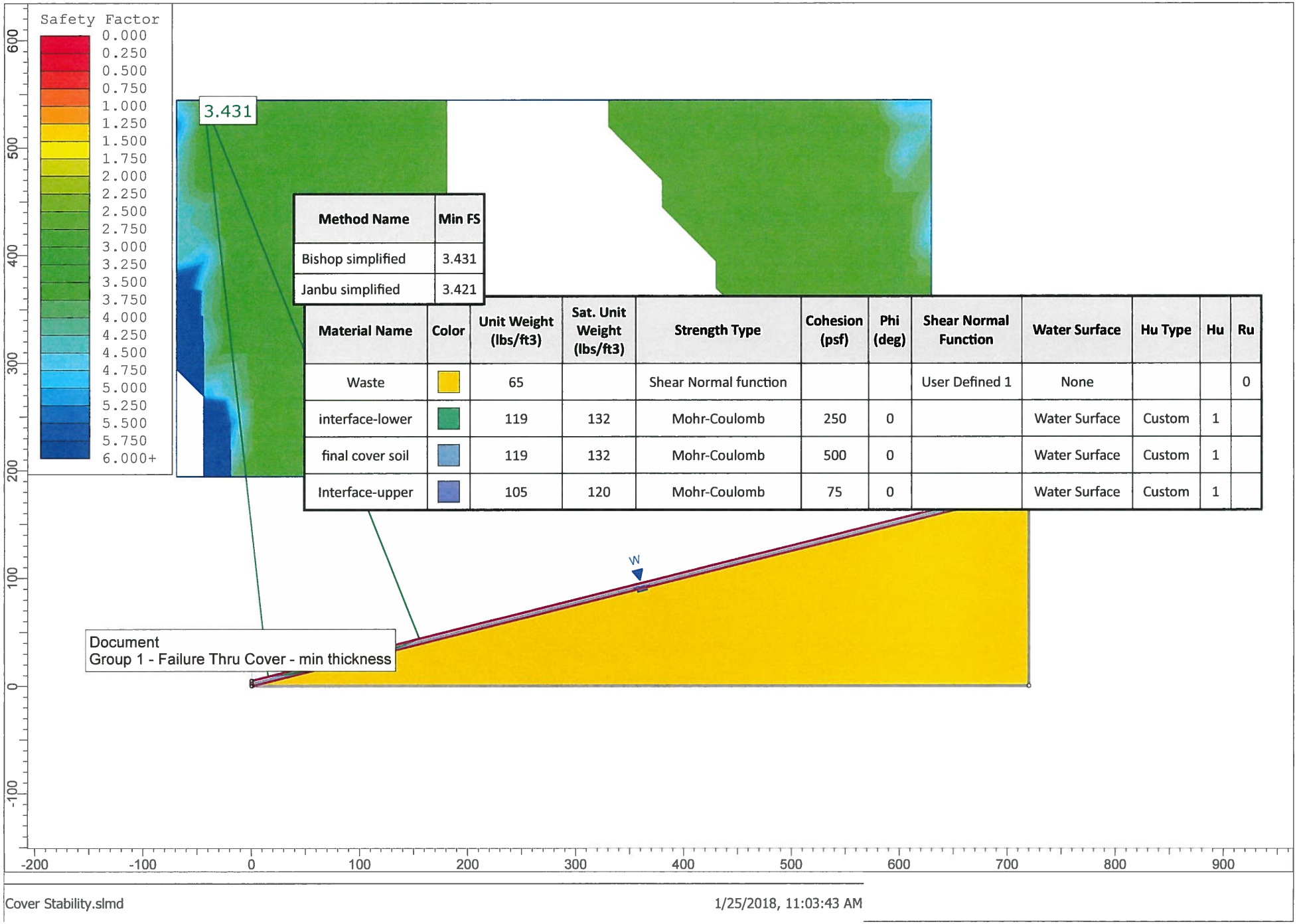
Failure Type		Total WB Cover Thickness (ft)	Factor of Safety
Circular	Thru Cover	2.7	3.4
		5.0	3.4
	Thru Waste	2.7	2.4
		5.0	2.4
Block	at base of Erosion Layer	2.7	2.6
		5.0	
	at base of Storage Layer	2.7	2.9
		5.0	1.6

Based on the worst case conditions (i.e. the condition with the lowest factor of safety), the minimum FS is 1.6 for a failure along the 4-foot thick storage layer/subgrade interface.

To achieve a FS ≥ 1.5, the shear strength of the must be greater than 235 psf under at a normal load of 350 psf.

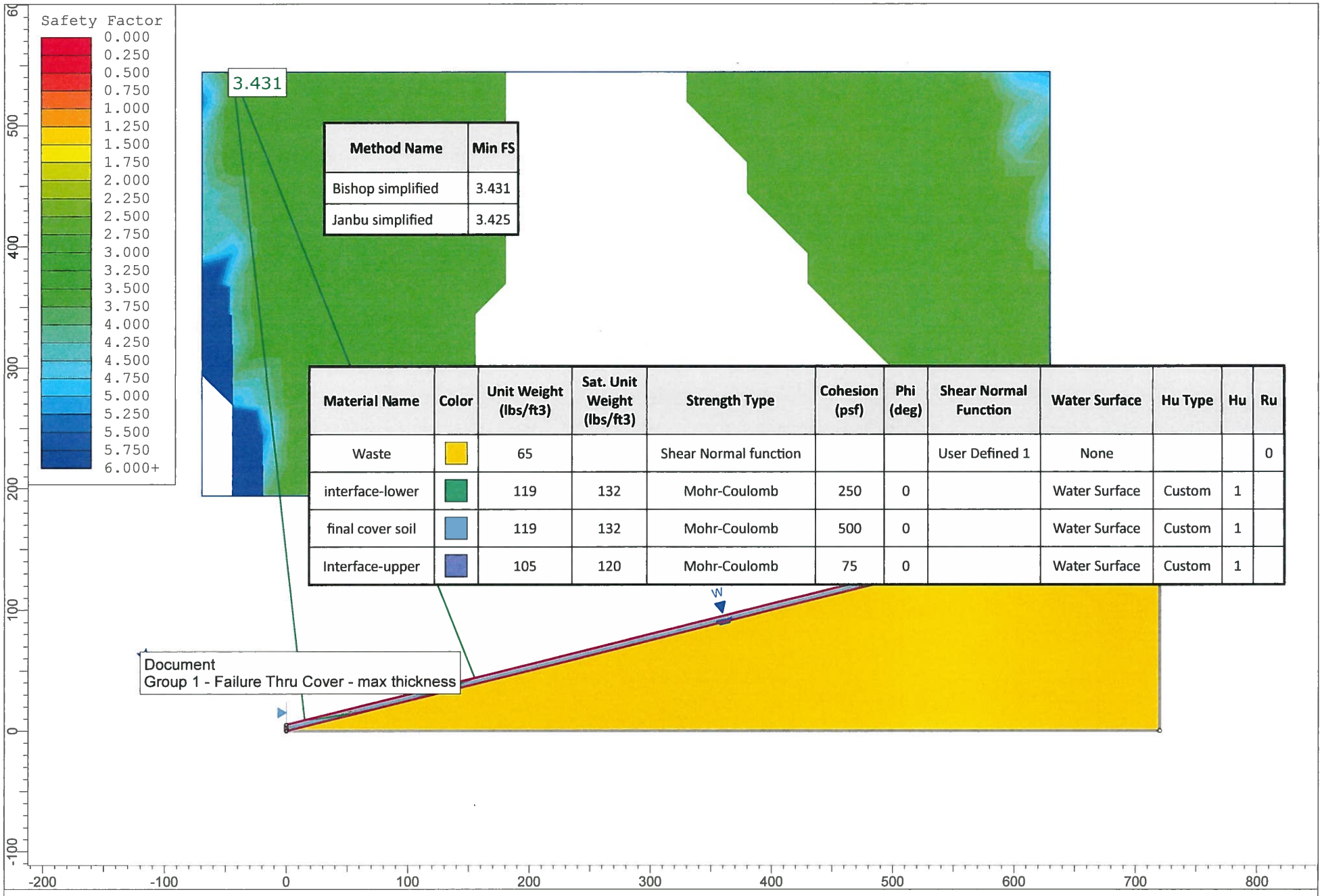
6.0 CONCLUSION

Circular and block failure modes were evaluated for the proposed Water Balance Cover. Using conservative values for soil shear strength and interface shear strength, the analysis demonstrates that the proposed water balance alternative final cover will be stable.



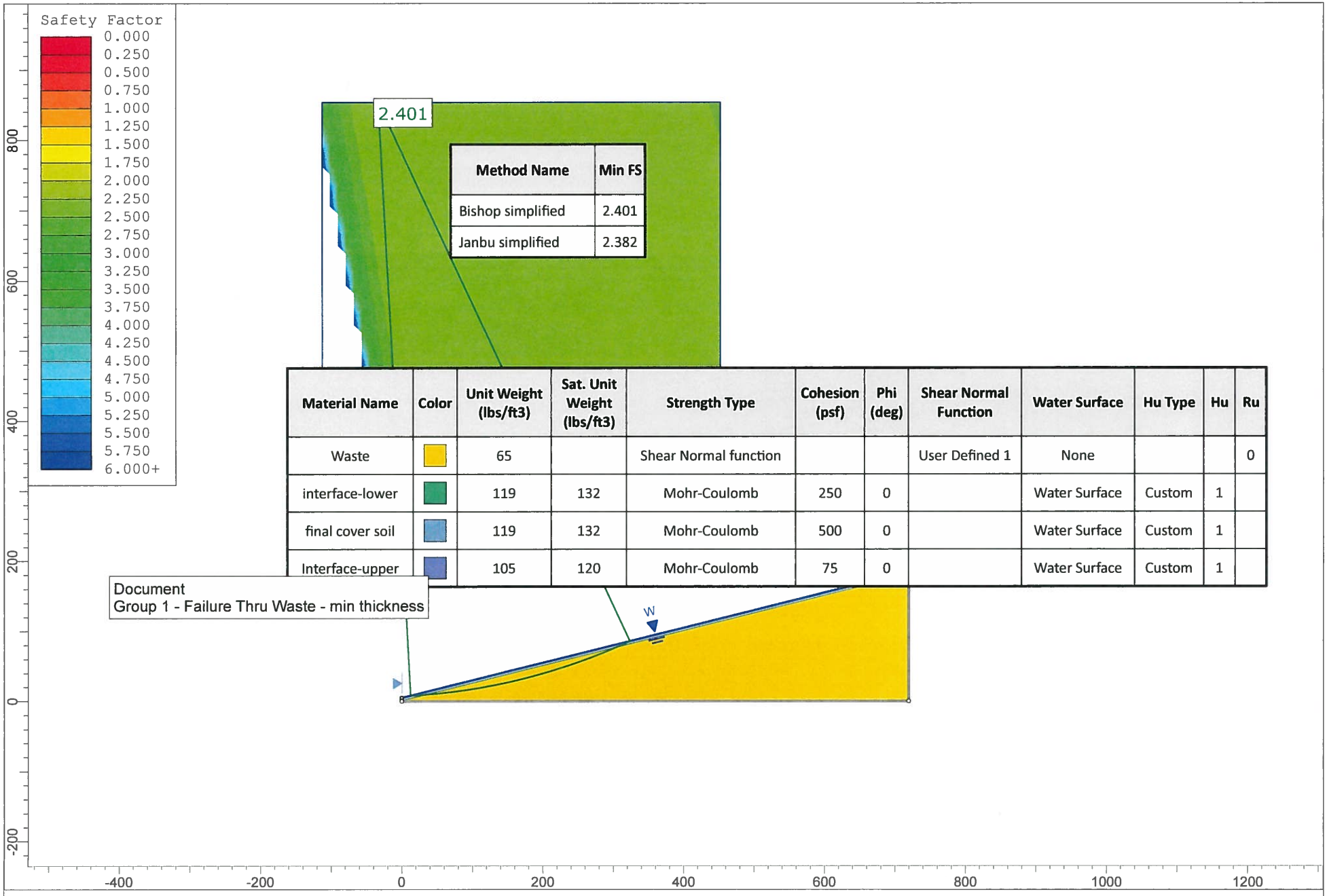
Method Name	Min FS
Bishop simplified	3.431
Janbu simplified	3.421

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu	Ru
Waste		65		Shear Normal function			User Defined 1	None			0
interface-lower		119	132	Mohr-Coulomb	250	0		Water Surface	Custom	1	
final cover soil		119	132	Mohr-Coulomb	500	0		Water Surface	Custom	1	
Interface-upper		105	120	Mohr-Coulomb	75	0		Water Surface	Custom	1	



Method Name	Min FS
Bishop simplified	3.431
Janbu simplified	3.425

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type	Hu	Ru
Waste		65		Shear Normal function			User Defined 1	None			0
interface-lower		119	132	Mohr-Coulomb	250	0		Water Surface	Custom	1	
final cover soil		119	132	Mohr-Coulomb	500	0		Water Surface	Custom	1	
Interface-upper		105	120	Mohr-Coulomb	75	0		Water Surface	Custom	1	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Method Name
Min FS
Bishop simplified
2.401
Janbu simplified
2.382
Material Name
Color
Unit Weight (lbs/ft3)
Sat. Unit Weight (lbs/ft3)
Strength Type
Cohesion (psf)
Phi (deg)
Shear Normal Function
Water Surface
Hu Type
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Waste
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Shear Normal function
User Defined 1
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Mohr-Coulomb
250
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Water Surface
Custom
1
final cover soil
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Mohr-Coulomb
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Interface-upper
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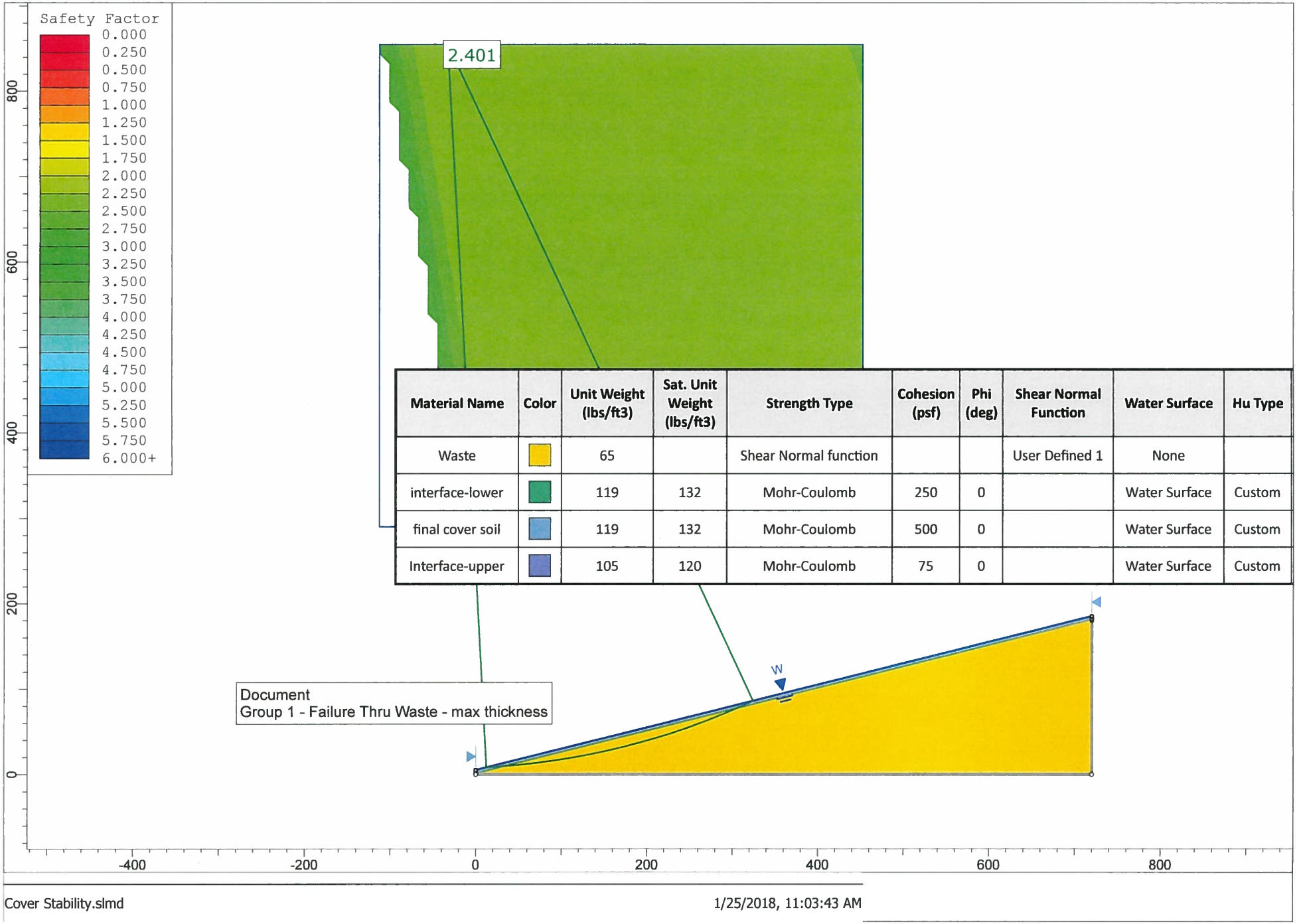


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Hu Type
Waste		65		Shear Normal function			User Defined 1	None	
interface-lower		119	132	Mohr-Coulomb	250	0		Water Surface	Custom
final cover soil		119	132	Mohr-Coulomb	500	0		Water Surface	Custom
Interface-upper		105	120	Mohr-Coulomb	75	0		Water Surface	Custom

Cover Stability.slmd

1/25/2018, 11:03:43 AM

Part III, Attachment 7

WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7
CLOSURE PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

Golder Associates

500 Century Plaza Drive, Suite 190
Houston, Texas 77073
(281) 821-6868
Firm Registration Number F-2578

August 2005
Revision 1 – December 2005
Revision 2 – October 2006
Revision 3 – February 2008
Revision 4 – March 2008
Revised August 2016
Revised October 2017
Revised February 2018
Revised July 2018

Figure ATT7-9 Fill Cross Section E-E'
Figure ATT7-10 Fill Cross Section F-F'
Figure ATT7-11 Fill-Cross Section G-G'
Figure ATT7-12 Maximum Closure Area

APPENDICES

Appendix A Final Cover Quality Control Plan
Appendix B Approved Landscaping Design
Appendix C TCEQ Regulatory Guidance Document RG-494

2.0 FINAL COVER

2.1 Final Cover Design

The final landfill contours and final cover details are provided on Figures ATT7-1A through ATT7-1C, ATT7-2, and ATT7-3. Landfill cross-sections are included as Figures ATT7-4 through ATT7-11. The final cap has side slopes ranging from 3 horizonal to 1 vertical (3H:1V) to 4H:1V to a maximum elevation of approximately 740 feet mean sea level (ft-msl). The upper portions of the final cover are sloped at a minimum 3-percent grade down to the crest of the 3H:1V or 4H:1V slopes to minimize erosion. The side slopes of the entire proposed expansion area will be 4H:1V with a short 3H:1V slope tying into the existing final cover crest. Add-on berms intercept runoff from the top surface and along the sideslopes of the cover and direct it to downchutes. These downchutes convey rainfall runoff down the sideslopes to the perimeter channels and detention ponds. Details of the surface water management features are included in Part III, Attachment 2.

The thickness and design of the final cover varies based on the design of the bottom liner. For existing disposal cells with no synthetic bottom liner (pre-Subtitle D cells), the final cover system is comprised of 18 inches of compacted earthen material with a coefficient of permeability (hydraulic conductivity) between 6.8×10^{-6} cm/sec and 8.1×10^{-6} cm/sec and 6 inches of soil capable of supporting native vegetation. For existing Subtitle D disposal cells with a synthetic bottom liner, the final cover system is comprised of 36 inches of compacted earthen material with a hydraulic conductivity of 1.0×10^{-7} cm/sec or less and 6 inches of soil capable of supporting native vegetation. The proposed final cover over existing pre-Subtitle D cells in the West Hill that have not yet been covered will be comprised of 18 inches of compacted earthen material with a coefficient of permeability (hydraulic conductivity) of 6.8×10^{-6} cm/sec or less and 6 inches of soil capable of supporting native vegetation. The final cover over existing and proposed Subtitle-D disposal cells in the expansion area of the West Hill will (as shown on Figure ATT7-1B) consist of ~~a water balance final cover or~~ a composite system comprised of, from the bottom up; an infiltration layer of 18 inches of compacted earthen material with a hydraulic conductivity of 1×10^{-5} cm/sec or less; a 40-mil textured linear low density polyethylene (LLDPE) geomembrane that has a permeability less than or equal to the permeability of the bottom liner system; a geocomposite (geonet/geotextile) drainage layer; and an erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation. The LLDPE geomembrane and geocomposite may be replaced with an alternate material that incorporates both the geomembrane and drainage layer (e.g., Super Gripnet® by Agru America) provided material equivalency in terms of barrier and flow characteristics is demonstrated.

Alternatively, the site has the option to install a water balance alternative final cover over existing and proposed Subtitle D disposal cells in the expansion area of the West Hill. The water balance final cover will be comprised of a storage layer of 20 inches thick (minimum) overlain by an erosion layer of 6 inches (minimum), in accordance with TCEQ Regulatory Guidance RG-494, Guidance for Requesting a Water Balance (WB) Alternative Final Cover for a Municipal Landfill, Revised March 2017 (Part III, Attachment 7, Appendix C). When using high plasticity clay (liquid limit >50) as the storage layer, the erosion layer will be increased to 1-foot thick in accordance with Section 3 of RG-494. Hydraulic conductivity testing results of the storage layer soils may require a thicker storage layer in accordance with RG-494, as discussed in Appendix A, Section 5.2. The storage layer thickness is determined from Table 3 in Section 10 of the RG-494 as follows:

Site Name (Geoclimatic Region)	$K_{As\text{-}Built}$ (cm/sec)	$K_{In\text{-}Service}$ (cm/sec)	Minimum Storage Layer Thickness for Bare Ground (ft)
Austin Community Recycling and Disposal Facility (Region 4 - Austin)	1.00E-08	1.00E-06	1 ft 8 in
	5.00E-08	5.00E-06	2 ft 7 in
	1.00E-07	1.00E-05	3 ft 11 in

The areas defining where a particular final cover system has been or will be used are shown on Figures ATT7-1A, ATT7-1B, and ATT7-1C. Details for the proposed and existing final cover designs are depicted on Figures ATT7-2 and ATT7-3.

2.2 Final Cover Installation Procedure

The installation procedures for the cover system are described in the "Final Cover Quality Control Plan", included as Appendix A to this document.

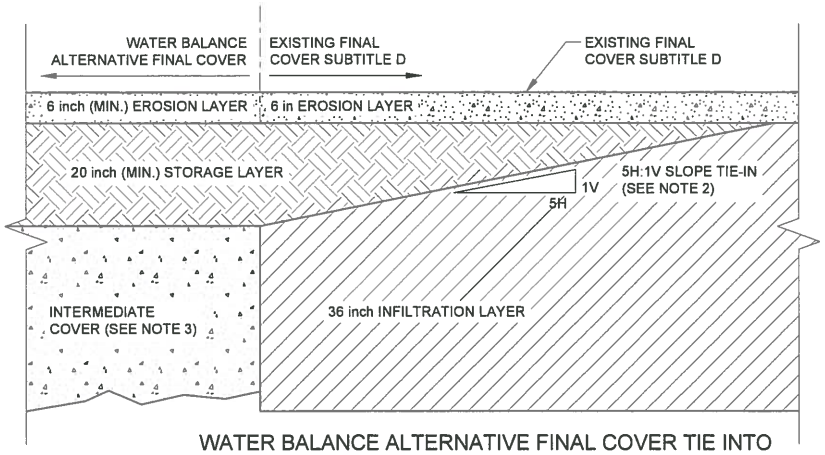
In order to maintain an adequate factor of safety against sliding, the geocomposite drainage layer in the ~~geo~~composite final cover system must be sized adequately to convey infiltration without allowing the build-up of pore water pressures. Analyses (included in Appendix D.2 of Part III, Attachment 3, the Waste Management Unit Design Report) were performed to determine the geocomposite drainage layer transmissivity required to adequately convey surface water infiltration over the maximum final cover slope length. If the minimum measured transmissivity value reported in Appendix D.2 is not met, the maximum flow length must be reduced (i.e., the geocomposite drainage layer must be "daylighted") in direct proportion to the ratio of the actual measured transmissivity and the required measured transmissivity.

2.3 Quality Control and Testing Frequency

Specific quality assurance and quality control closure activities for final cover placement are presented in the "Final Cover Quality Control Plan", included as Appendix A to this document.

2.4 Vegetation

To minimize erosion, the final cover surface will be seeded or sodded following application of the final cover. Bermuda or a native grass mix is recommended for permanent vegetative cover. Naturally occurring grasses and wildflowers may also be used. A temporary cover of rye grass, winter wheat or other cool-weather vegetation may also be used. These vegetative species generate root depths that are less than the soil depths on top of the infiltration layer, or less than six inches. During the early stages of vegetative growth, mulching, slope soil regrading and mowing will be performed as required to promote

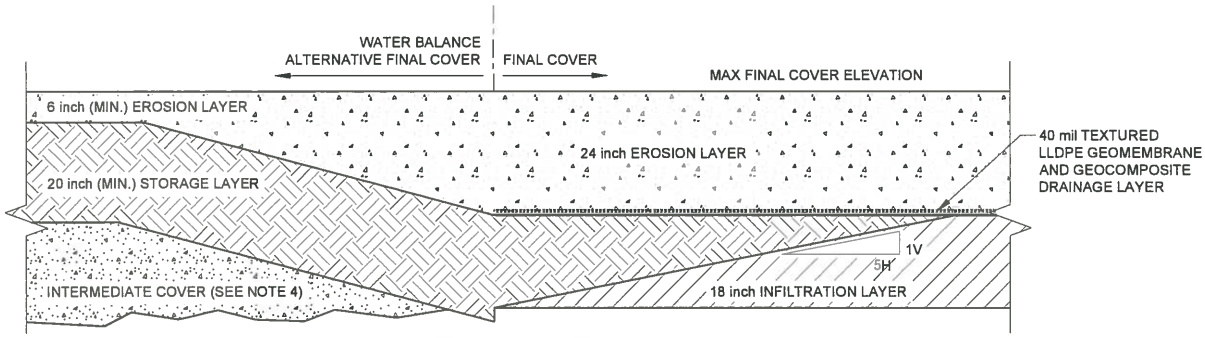


WATER BALANCE ALTERNATIVE FINAL COVER TIE INTO EXISTING FINAL COVER OVER SUBTITLE D (SLOPE OF WD-6 AND EAST END OF WD-7)

SCALE 1" = 3' — 1 / ATT7-2A

NOTE(S)

1. TOP OF EROSION LAYER NOT TO EXCEED MAXIMUM FINAL COVER DESIGN ELEVATIONS.
2. THE TIE-IN BETWEEN THE STORAGE LAYER AND THE EXISTING 3 ft THICK INFILTRATION LATER WILL BE SLOPED AT 5H:1V. TIE-IN THICKNESS WILL VARY BASED ON REQUIRED THICKNESS OF THE STORAGE AND EROSION LAYER.
3. INTERMEDIATE COVER THICKNESS WILL VARY WITH THE THICKNESS OF THE STORAGE/EROSION LAYER TO MAINTAIN THE TOP OF WASTE SURFACE AT OR BELOW PERMITTED WASTE GRADES.
4. TIE-IN TO EXISTING PRE SUBTITLE D FINAL COVERS WITH 18 inch CLAY WILL BE PERFORMED IN A SIMILAR MANNER.



WATER BALANCE ALTERNATIVE FINAL COVER TIE INTO POTENTIAL FUTURE SUBTITLE D FINAL COVER

SCALE 1" = 3' — 2 / ATT7-2A

NOTE(S)

1. TOP OF EROSION LAYER NOT TO EXCEED MAXIMUM FINAL COVER DESIGN ELEVATIONS.
2. THE TIE-IN BETWEEN THE STORAGE LAYER AND THE EXISTING 18 inch THICK INFILTRATION LATER WILL BE SLOPED AT 5H:1V.
3. EXISTING 40 mil TEXTURED LLDPE AND GEOCOMPOSITE DRAINAGE LAYER TO BE PULLED BACK TO ALLOW FOR THE CLAY SOIL TIE-IN AND THEN REPLACED.
4. INTERMEDIATE COVER THICKNESS WILL VERY WITH THE THICKNESS OF THE STORAGE AND EROSION LAYER TO MAINTAIN THE TOP OF WASTE SURFACE AT OR BELOW PERMITTED WASTE GRADES.

0 1.5 3
1" = 3' FEET

CLIENT
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS

CONSULTANT
GOLDER

YYYY-MM-DD	2018-07-09
PREPARED	RS
DESIGN	CEI
REVIEW	CEI
APPROVED	WEG

PROJECT
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
MUNICIPAL SOLID WASTE EXPANSION
APPLICATION PERMIT MSW-249D

TITLE
WATER BALANCE ALTERNATIVE FINAL COVER TIE-IN DETAILS

PROJECT No 093-94428 | Rev. 0 | FIGURE ATT7-2A

Path: \\houtondata_2009 Project Folders\093-94428 WM ACL & Temple Digital Drawings\ACL Expansion Application\ATT7\ | File Name: 093944284001.dwg
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A
1 in
0

Part III, Attachment 7, Appendix A

AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7, APPENDIX A
FINAL COVER QUALITY CONTROL PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

500 Century Plaza Drive
Suite 190
Houston, Texas 77073
(281) 821-6868

August 2005
Revision 1 – December 2005
Revision 2 – March 2006
Revision 3 – October 2006
Revised July 2018

In accordance with 30 TAC §330.457(a)(1) and 30 TAC §330.457(d), the ACRDF may choose to install an alternate final cover over portions of the Subtitle-D cells in the western and southwestern part of the expansion area and over the vertical expansion area of the West Hill. The alternate final cover would consist of a Water Balance (WB) Cover as described in the document "Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas" prepared by Miland V. Khier, Ph.D., P.E., dated August 4, 2016. The water balance cover consists of a layer of silty and clayey soils to store water and sustain vegetation until the water is removed by evapotranspiration. The thickness of this cover may vary in accordance with the TCEQ Guidance Document RG-494 dated March 2017 (Part III, Attachment 7, Appendix C) depending upon the soil properties used and the hydraulic conductivity of the constructed cover. TCEQ Guidance Document RG-494 provides for four options for the design and construction of water balance covers. The ACRDF will utilize Option 1 – Statewide Design Table for constructing water balance covers at the facility.

The owner/operator is responsible for fully implementing this FCQCP. The site manager (SM) or designated alternate will be responsible for contracting with a qualified independent quality assurance/quality control (QA/QC) professional prior to initiation of final cover construction. Each phase of the soil and geosynthetic evaluation shall be conducted by or under the supervision of the QA/QC Professional. The QA/QC Professional shall be an independent, licensed, professional engineer (P.E.) experienced in geotechnical engineering and soils testing.

A qualified engineering technician performing daily QA/QC observation and testing will be under the direct supervision of the QA/QC Professional. The engineering technician shall be NICET-certified at level 1 or higher, an engineering technician with a minimum of 2 years of directly related experience, a graduate engineer or geologist, or an engineering technician with other applicable certificates (e.g., Certified Engineering Technologist, CET) approved by the TCEQ.

Full-time quality assurance shall be provided by the QA/QC Professional or his/her qualified representative(s) as described in this plan. QA/QC documentation will be provided to the executive director, in accordance with Section 5.0 of this plan.

5.0 Water Balance Alternative Cover System

The purpose of these guidelines is to establish an approach for placement and compaction during construction of the WB final cover at the Austin Community Landfill that will meet the required standards presented in "TCEQ Guidance Document RG-494 dated March 2017.

5.1 Preconstruction Testing and Test Pad Construction

The goal of ~~the~~ preconstruction testing is to characterize the borrow soils and to define the "acceptance window" for each type of soil. The acceptance window is the range of unit weight/water content combinations that have been shown to produce a target permeability (~~k <~~ 1 x 10^{-7} cm/sec or less) in the 6-inch diameter remolded permeability samples, without falling above the line-of-optimums. Preconstruction testing will be performed for each construction event in accordance with Table 7A.8.

Table ~~17~~7A.8: Preconstruction Testing

Test	Method	Frequency	Comment
Percent Fines	ASTM D1140	1 per 20,000 cy and each soil type	
Specific Gravity	ASTM D854		
Atterberg Limits	ASTM D4318		
Water Content	ASTM D2216		Use 60°C oven.
Standard Proctor Test	ASTM D698		To define line-of-optimums. Use Method A.
Modified Proctor Test	ASTM ~~D1157~~D1557		Revise line-of-optimums as necessary.
6-inch Diameter Remolded Hydraulic Conductivity(1)	ASTM D5084		To define the lower limit of the acceptable zone – at least 2 tests per sample
Shear Strength(2)	ASTM D5321 or ASTM D4767		Remold sample at maximum acceptable water content and minimum acceptable density. Test under normal stress or confining stress of 350 psf.

Notes: (1) Increase cell pressure as necessary to control swell during saturation. Once saturation (B-value) reaches 95%, reduce effective confining pressure to 4 psi.

(2) Minimum Shear Strength must be 235 lb/ft^2 or greater. If the soil strength is determined to be less than 235 lb/ft^2 an alternate borrow source meeting this minimum requirement shall be utilized for construction.

Based on this preconstruction testing, acceptance windows for construction will be developed. An example of an acceptance window is provided below. New acceptance windows will be developed for each construction event and soil type encountered; however, data from previous construction may be used to supplement this testing if it is demonstrated to appropriately represent the soil encountered in the current construction.

4. The QA/QC monitor will obtain bag samples from each in-place moisture-density test on the completed lift for water content testing in the lab.
5. The QA/QC monitor will obtain ~~a~~ at least one 3-inch diameter Shelby tube sample from the completed 50-ft x 50-ft lift.

The tube samples from each lift should be tested for the following:

- Water content (ASTM D2216)
- Dry unit weight (ASTM D854)
- Atterberg limits (ASTM D4318)
- Hydraulic conductivity (ASTM D5084)

Once it has been determined that the construction practices and soil testing will provide a compacted clay cover with a permeability meeting or less than the target permeability ~~k ≤ 1 x 10^{-7} cm/s~~, construction of the WB cover may begin.

5.2 WB Cover Construction and Testing

Construction of the WB final cover must proceed in the same manner as the test pad construction or as determined in previous construction at the facility. The soil shall be spread in loose lift thickness of 10-inches of less. Compaction will be in accordance with the procedures identified either through previous construction or in test pad construction that produced ~~a k~~ the target permeability ~~≤ 1 x 10^{-7} cm/s~~.

The total thickness of the WB final cover may vary based upon the permeability of the constructed cover. The final cover thickness will be determined as follows:

- First, initial preconstruction testing data of the borrow source soil will be used to determine the target permeability and the thickness of the WB cover, based on TCEQ Guidance Document RG-494 (March 2017), Table 3 (Part III, Attachment 7, Appendix C). Additional preconstruction samples will be obtained as the borrow source is excavated during construction of the WB final cover.
- Second, during cover construction, soil samples of the as-built final cover will be taken and tested for hydraulic conductivity as described in Section 5.3. Hydraulic conductivity results of the as-built final cover samples will be used to verify that the geometric mean of the samples is no greater than the target hydraulic conductivity used to set the final cover thickness in accordance with TCEQ Guidance Document RG-494 (March 2017), Table 3. For areas exceeding the target hydraulic conductivity, additional compaction and re-testing will be performed to ensure that the geometric mean meets the target hydraulic conductivity.
- Last, the final cover thickness may be adjusted, as needed, based on the results of the preconstruction soil samples taken throughout the construction process and in accordance with TCEQ Guidance Document RG-494 (March 2017), Table 3. In no case will the thickness be decreased from the thickness determined in the preconstruction testing.
- Should the preconstruction testing indicate the borrow source properties have changed and an increase to the final cover thickness is required, the subgrade shall be adjusted based on the thickness of the WB cover. For all WB cover constructions, the permitted top of final cover grades will be maintained per the TCEQ permitted final grading plan to ensure proper drainage and transition between existing and new final cover areas. The final top of waste grades will be at or below the permitted final elevation once the cover is installed. In no case will the

TCEQ Guidance Document RG-494 (March 2017), Table 3 provides the following guidance for WB cover thickness in the Austin area:

K (as-built), cm/sec	Minimum Storage Layer Thickness
1×10^{-8}	1 ft 8 in
5×10^{-8}	2 ft 7 in
1×10^{-7}	3 ft 11 in

5.3 Construction Testing

The goal of the construction testing is to demonstrate that the soil is being compacted within the acceptance window and that the in-place soil has a k that is at or less than the target value determined during preconstruction testing ~~(if less ≤ 1×10^{-7} cm/s)~~. Both water content and unit weight will be determined in the field using the nuclear density gauge and in the lab using 3-inch diameter Shelby tubes. Minimum testing frequencies are presented below:

Construction Testing

Test	Method	Minimum Frequency
Field Moisture/Density Test(1)	ASTM D6938	1 per 8,000 ft^2, per 6-inch lift
Water Content	ASTM D2216	As needed to calibrate nuclear gauge. Use 60°C oven.
Percent Fines	ASTM D1140	1 per 100,000 ft^2, per 6-inch lift
Atterberg Limits	ASTM D4318	
Hydraulic Conductivity(1)	ASTM D5084	1 per 2.5 acres of cover per lift evenly distributed through all lifts

Notes: (1) Increase cell pressure as necessary to control swell during saturation. Once saturation (B-value) reaches 95%, reduce effective confining pressure to 4 psi.

Key items:

- 90% of both the field and lab values must plot within the acceptance window.
- The geometric mean of the k values must be ≤ the target permeability determined during preconstruction testing. The geometric mean is determined as the nth root of the product of n numbers.

$$\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}.$$

For example: for 3 k-values the geometric mean is $(X_1 \bullet X_2 \bullet X_3)^{0.333}$.

5.4 ~~Protective Cover Soil~~Erosion Layer

A ~~layer of protective~~ 6-inch thick soil erosion layer capable of supporting vegetation will be placed over the storage layer. If high plasticity clay (liquid limit >50) is used for the storage layer, the erosion layer soil shall be a minimum of 1 foot thick, with the top 6 inches capable of supporting vegetation (topsoil)~~cover soil shall be placed over the WB cover. The protective cover soil will be a minimum of 1 foot thick, with the top 6 inches capable of supporting vegetation (topsoil).~~ The ~~soil cover~~erosion layer material shall consist of soils that are classified as SCS Hydrologic Soil Groups (HSG) A, B, or C. These soils have infiltration rates ranging approximately 0.05 inches/hour (3.5×10^{-5} cm/sec) to greater than 0.30 inches/hour (2.1×10^{-4} cm/sec), according to the Soil Conservation Service publication TR-55 (June 1986). Compaction of the soil cover material can affect the HSG, making a soil in a particular soil group less pervious and thus make it behave as another soil group. Because low ground pressure equipment will be used, compaction of the soil will be minimal.

5.5 Thickness Verification

Both the WB cover thickness and the ~~protective cover~~erosion layer soil thickness shall be verified by instrument survey method only. The verification points, for record purposes, shall be on a grid such that there exists a minimum of one verification point per 10,000 square feet. A minimum of two reference points is required for verification. The selected grid shall be the same for both beginning and finished elevations of the cover, so that minimum thickness can be calculated and verified. All elevation calculations necessary for thickness determination will be included as part of the supporting documentation to the FCSER.

5.6 Vegetation Establishment

The WB covers constructed at the ACRDF are to be constructed in accordance with Option 1, Statewide Design Tables as described in TCEQ Regulatory Guidance Document RG-494. Guidance Document RG-494 is based on "Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas, (Khire, 2016). Section 6.5 of this document notes that transpiration was not simulated in the development of the design tables, though "plants are expected to be maintained to minimize erosion and to maintain aesthetics". The establishment of vegetation on the WB cover will therefore provide additional transpiration of soil moisture above the assumptions used in the design tables resulting in a conservative estimate of percolation through the cover.

Accordingly, the top 6-inches of the ~~protective cover~~erosion layer soil shall be capable of supporting native plant growth. The soil may be evaluated for agronomic properties and to determine if soil amendments will be needed. The soil must be seeded or sodded after completion of the WB cover (weather permitting). Temporary or permanent erosion control materials (i.e. mulches, containment meshes, geomatting systems, etc) may be used to minimize erosion and aid establishment of vegetation.

Part III, Attachment 7, Appendix C

TCEQ REGULATORY GUIDANCE
Waste Permits Division
RG-494 • Revised March 2017

Guidance for Requesting a Water Balance (WB) Alternative Final Cover for a Municipal Solid Waste Landfill

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1. Introduction

This guidance document is for owners and operators of municipal solid waste (MSW) landfills who are considering a water balance (WB) alternative final cover system (cover).

2. Applicability

This guidance is applicable to a landfill that has a synthetic membrane–compacted clay composite liner requirement as part of its permit and/or proposed permit application.

Pursuant to Title 30, Texas Administrative Code (30 TAC) Section 330.457(d), an alternative final cover design may be approved if it meets both of the following performance standards:

- Achieves an equivalent reduction in infiltration as the clay-rich soil cover layer specified in 30 TAC Section 330.457(a)(1) or (2).
- Provides equivalent protection from wind and water erosion as the erosion layer specified in 30 TAC Section 330.457(a)(3).

3. WB Cover Overview

In general, a WB cover limits percolation through the cover by use of silty and clayey soils to store water and sustain vegetation until the water is removed by evapotranspiration. A WB cover requires soil that can provide adequate water-holding capacity, supply moisture and nutrients to plants, and maintain long term slope stability and erosion resistance. As calculated by the Universal Soil Loss Equation, erosion of a WB cover should be less than or equal to 3 tons per acre per year. Total thickness of a WB cover, including the erosion layer, should not be less than two feet, which is the minimum required soil thickness of the synthetic membrane–compacted clay composite cover system. It is recommended that WB covers using high plasticity clay as the storage layer be overlain with a minimum one-foot thick erosion layer to reduce the potential for desiccation cracking in the storage layer. This recommendation is consistent with TCEQ final cover rules for Type IV landfills and pre-Subtitle D landfills. Healthy vegetation is essential to minimize erosion. The design of a WB cover should take into consideration site-specific soil, meteorological, and vegetation information.

4. Design and Permitting Options for WB Covers

This guidance discusses four options for the design and permitting of WB covers. Each option is considered to have equal merit in terms of the equivalency demonstration required in 30 TAC Section 330.457(d).

4.1. Option 1 – Statewide Design Table

Option 1 involves using procedures discussed in *Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas* (Khire 2016). This report documents the delineation and mapping of geoclimatic regions, region-specific analyses of candidate WB cover soils, performance modeling, and regional WB cover designs. The assumptions and model inputs discussed in the report are specific to that project. Selected charts depicting project results and the final cover design table are included in Section 10 (Attachment B: Statewide Design Table) of this publication.

Under Option 1, the applicant first determines the geoclimatic region in which the landfill facility is located. The geoclimatic regions are depicted in Figure 1 in Section 10. The storage layer thickness can then be determined from Table 3 in Section 10, which relates hydraulic conductivity to storage layer thickness.

The application should include information listed in Table 2 in Section 9 (Attachment A: Water Balance cover Guidance Summary Table) under the heading "General Requirements."

4.2. Option 2 – Cover Performance Verification

Option 2 involves site-specific field-scale testing using cover performance verification test plots to confirm the WB cover's design and performance.

Lysimeter test plots are effective in measuring the amount of percolation through cover soils. These test plots are the preferred method of evaluating WB cover performance when coupled with *in situ* soil instrumentation and laboratory testing of soils. Design aspects and construction considerations of lysimeter test plots have been documented by Benson et al. (1999) and Albright et al. (2010), and these publications may serve as references for lysimeter design and construction. Instrumentation used to monitor test plots should be capable of continuous data collection, and test plots should be configured to represent the area of the landfill cover with the greatest water-storage demand.

The application should include a WB cover design that has been modeled to allow less than or equal to 4 mm percolation in a year through the cover using site-specific soil, vegetation, and weather data. After approval, the applicant would construct the test plot concurrently with the installation of the initial section of the landfill's final cover.

The verification procedure should demonstrate the WB cover's performance under the precipitation conditions used in the modeling. The application should

contain a plan for artificial moisture loading if natural weather patterns do not produce the necessary precipitation as follows:

- If modeling involved the 20-year weather data procedure, then years 1 and 2 should simulate the average annual precipitation, and year 3 should simulate the 95th percentile precipitation conditions.
- If the modeling involved the 30-year weather data procedure, then years 1, 2, and 3 should simulate the three consecutive years that resulted in the peak percolation.

The test plot should be installed, maintained, and monitored to allow for collection of data to determine whether the actual performance (e.g. moisture patterns and percolation through the cover) is adequate. The test plot should be designed to assess compliance with the less than or equal to 4 mm percolation limit. The permit application should detail the soil monitoring equipment, methods used, and how the methods will confirm the function of the WB cover. Careful consideration should be given to selection of monitoring equipment and methods to reduce the uncertainty in modeled estimates, which might be larger than required cover performance. The monitoring equipment and methods should include at least the following data:

- Continuous moisture content
- Basal percolation
- Soil temperature
- Weather data

Soil moisture and basal percolation should be collected using automatic data-acquisition systems to provide essentially continuous records.

The test plot should be constructed concurrently with the construction of the initial section of landfill WB cover during closure or partial closure. The initial section of landfill cover containing the test plot should be limited to less than or equal to 10 acres. At least one lysimeter should be installed within the test plot, and each lysimeter should have dimensions of at least 30 feet by 30 feet. At least three clusters of soil probes should be installed with the lysimeter, with one of the clusters upslope, one within, and one downslope of the lysimeter. Each probe cluster should consist of at least three probes with duplicate sensors located in the upper, middle, and lower portions of the cover soil with vertical spacing no greater than 1 foot. The probes should be capable of continuous measurement of soil moisture. Alternative monitoring equipment and methods will be considered.

The test plot should be operated, maintained, and monitored for a minimum of three years after vegetation is established. In all cases, data gathering from the test plot should begin no later than six months after construction.

During the cover evaluation period, the applicant should prepare and submit an annual report documenting the results of all the monitoring and discussing the performance of the cover system. The report should include:

- Soil data
- Vegetation data
- Weather data
- Soil moisture retention curves
- Basal percolation
- Observed erosion and any cover repairs
- Observations and recommendations of the project engineer

Data collected from a test plot may be suitable for use at other facilities with similar weather and soil data. Applicants intending to use such data at multiple sites should discuss this possibility with the MSW Permits Section prior to implementation in order to ensure agreement on the applicability of the data.

The measured percolation listed in Table 1 serves as a guide when evaluating test plot results annually.

Table 1: Measured Percolation

Measured Percolation	Evaluation
≤ 8 mm	Satisfactory: remainder of the landfill can be installed pursuant to the WB cover construction quality control plan (CQCP)[a].
> 8 mm and ≤12 mm	• Requires a permit modification with revised modeling and cover design for the remainder of the landfill. • Upon approval, the cover can be installed pursuant to the approved WB cover CQCP.
> 12 mm	• Requires a permit modification with revised modeling, WB cover design, and test plot design. Upon approval, an initial phase of cover may be constructed that includes a test plot for cover-performance verification. • WB cover beyond the maximum of 10 acres should not be constructed until satisfactory performance has been successfully demonstrated.

a. See Section 6 of this publication for details about the CQCP.

4.3. Option 3 – Model Calibration

Option 3 involves constructing and monitoring one or more test plots to obtain site-specific field-collected data; the data are used to calibrate the model employed in the WB cover design process.

Prior to designing and constructing a test plot, the TCEQ strongly recommends that facilities proposing model calibration coordinate with the MSW Permits Section to ensure that the calibration study sufficiently addresses the recommendations in this guidance. Test plot design parameters for discussion include:

- Test plot size and location.
- Monitoring instrumentation and parameters.
- Data-gathering procedures.

If a test plot will be located on property covered by an MSW permit, then prior authorization from the TCEQ would be required. If a test plot will be located on property not covered by an MSW permit, a detailed work plan should be submitted for agency review to ensure agreement on the data acquisition requirements and methods.

The application for a field-scale WB test plot should address the information discussed in this section and the items noted in the General Requirements and Model Requirements Sections under Option 3 in Table 2 of Attachment A, Section 9 of this publication to include the following:

- Detailed design plans and construction specifications of the test plot.
- Construction quality assurance procedures.
- Operating and monitoring procedures.

Test plots should be operated for at least three years after vegetation has been established to design parameters in order to minimize the impact of the initial moisture of the cover soils and to incorporate a variety of weather conditions at the site. The length of time between test plot construction and initiation of data collection may be shortened if the modeled cover design does not rely on vegetation. Using data collected from the test plot, the model is run to predict the performance of the proposed WB cover, and a revised WB cover is designed.

In order to calibrate the water balance model, input parameters should be adjusted within an appropriate range until the model-predicted soil water contents and soil water storages closely match the field data for the duration of the monitoring period. For a model to be considered calibrated, the model must demonstrate that:

- Model-predicted soil water contents and soil water storages do not show a consistent bias (over-prediction or under-prediction of the parameter throughout the modeling period).
- Maximum and minimum soil water storages predicted by the model are within 5 percent of the field values.

To assess the model calibration results, the sensitivity of the input parameters on the predicted soil water storages, water contents, surface runoff,

evapotranspiration, and cumulative percolation should be reported in the form of time series plots.

Provided the data collected from the test plot can be successfully used to calibrate the model and design the WB cover, a permit modification application should be submitted requesting authorization for the WB cover. The application should address the requirements of 30 TAC Section 305.70 and include the information in Attachment A, Section 9 of this publication.

Calibration test plot data may be suitable for use at other facilities with similar climatological and soil conditions. Applicants intending to use data from a calibration test plot at multiple sites should discuss this possibility with the MSW Permits Section in advance to ensure agreement on the applicability of the data at other sites.

Initial calibration efforts will likely yield valuable information about proper monitoring methods, monitoring instrument types and numbers, size of test plots, and length of monitoring period. The use of this information in the development of subsequent focused model calibration projects is encouraged.

Test plots for model calibration should be installed, maintained, and monitored to ensure the collection of accurate data to ensure that the WB cover model can be properly calibrated. Test plots should be configured to represent the area of the landfill cover with the greatest water-storage demand and monitored with instrumentation capable of continuous data collection.

The following information should be generated from test plot monitoring to define the adequacy of site-specific parameters used in the model to predict the performance of the WB cover:

- Continuous moisture content with depth.
- Soil temperature.
- Percolation.

Site-specific parameters to be collected include, but are not limited to:

- Root depth and density.
- Leaf-area index.
- Plant water intake.
- Initial moisture content.
- *In situ* soil geotechnical and hydraulic properties (density, porosity, saturated and unsaturated hydraulic conductivity, and water retention curves).
- Moisture content.
- Moisture retention profiles.
- Adequate number of moisture sensor nests.
- Adequate vertical spacing of moisture sensor nests (not greater than 1 foot) within each nest.
- Duplicate moisture sensors at each depth within each nest.
- Parameters or criteria for runoff.

In addition to site-specific field data, the following meteorological parameters should be collected on-site contemporaneously with test-plot monitoring:

- Precipitation.
- Pan evaporation (obtain from local weather-reporting stations).
- Air temperature.
- Solar radiation (obtain from local weather-reporting station).
- Wind speed.
- Relative humidity.
- Cloud cover.
- Dew point (calculated).

Sources of soil cover material should be evaluated with a test plot. A field-scale lysimeter may be included in the calibration test plot for a better understanding of potential percolation from the WB cover.

4.4. Option 4 – Landfills in Arid Areas

Option 4 is available only for landfills having less than or equal to 25 inches of average annual precipitation as defined by 30 TAC Subsection 330.5(b)(1)(D). Option 4 involves site-specific modeling, but does not require construction and monitoring of a test plot. For meteorological data, the nearest weather station to the landfill with at least the most recent 30 years of precipitation data should be used to determine the average annual precipitation for the period.

A landfill with less than or equal to 25 inches average annual precipitation would be expected to use site-specific parameters including soil properties, vegetation, and climate and weather data in the design and modeling of the WB cover. However, the design of the WB cover for such sites may be based solely on successful numerical modeling, provided the model is an accepted and proven numerical unsaturated flow model.

The application should contain the information specified in Option 2 with the exception of design drawings and operational specifications for a test plot.

5. Modeling Guidelines for Options 2, 3, and 4

The selected computer model for options 2, 3, or 4 should integrate soil, meteorological, and vegetation data, and the effects on hydrology and soil-water balance, to predict the performance of the proposed WB cover. The computer model should:

- Simulate unsaturated flow.
- Include a surface boundary simulating soil-atmosphere interactions (precipitation, infiltration, evaporation, and runoff).
- Include adequate models for saturated and unsaturated hydraulic behavior.
- Model root water uptake (also known as transpiration).
- Integrate climate data.

Various computer programs for alternative cover modeling are described in Interstate Technology and Regulatory Council (ITRC) (2003). The UNSAT-H (Version 3.0) model has been the primary computer model used in WB cover equivalency demonstrations. If using a computer program other than UNSAT_H, the basis for its selection should be explained. The selected model default values should only be used if they are representative of site-specific conditions.

The model should be run to simulate the performance of the proposed WB cover as designed. The results of each year's model simulation should be summarized in a table that lists the values for the following parameters:

- Precipitation (P).
- Potential evapotranspiration (PET).
- P/PET ratio.
- Model-estimated "actual" evaporation and transpiration.
- Runoff as a percent of total precipitation.
- Storage.
- Percolation through the WB cover.
- Total mass balance error for the year.

The lower flux boundary should be the bottom surface of the WB cover. The mass balance error should be added proportionately to the percolation, surface runoff, and evapotranspiration. The results should also be presented graphically, showing the model-estimated storage requirement plotted by year, and the calculated available storage capacity for the WB cover.

The effective water storage capacity of the cover soil should not be less than the modeled capacity. The annual percentage runoff generated by the model is expected to be less than 10 percent of total water applied (precipitation and irrigation). Higher modeled runoff amounts may be acceptable if hourly rainfall data have been shown to support rainfall application rates and the hydraulic properties of the surface soil layer are representative of *in situ* soils. If irrigation is proposed to establish and sustain plant growth or to simulate precipitation, the water impingement due to the irrigation should be accounted for in the model. If the site receives snow or ice, the model input needs to be adjusted to account for moisture from snow and ice melt.

For sites where model calibration is indicated, site-specific soil parameters and field-study generated data should be used. A detailed discussion of the calibration process, input values, and output results should be provided. Model calibration should include considerations for hysteresis. Care should be taken to model only representative conditions, any model input data that are not based on field monitoring results and parameters should be identified, and the rationale for their use discussed.

5.1. Recognized Modeling Scenarios

MSW Permits Section has recognized two modeling scenarios, the 20-year approach and the 30-year approach.

5.1.1. 20-Year Weather Data Approach

Step 1. Select a weather reporting station nearest to the landfill that has at least 50 years of continuous monthly precipitation data. From the precipitation data, calculate the mean (average precipitation year) and 95th percentile (wet precipitation year) annual precipitation values.

Step 2. Select a weather reporting station nearest to the landfill that has at least 20 years of high quality continuous data for precipitation, maximum and minimum air temperature, average relative humidity (or dew point), average wind speed, and total solar radiation. This may or may not be the same weather station selected in Step 1. The most recent 20-year period for which complete weather data is available should be used.

Step 3. Select an average precipitation year and wet precipitation year from the data set chosen in Step 2 that either equal or are slightly higher than the average and wet precipitation years calculated from the 50-year precipitation data set.

Step 4. Run the model using the selected average precipitation year and the 95th percentile year from the data set chosen in Step 2. The modeling should simulate 20 consecutive average precipitation years, followed by one 95th percentile year.

5.1.2. 30-Year Weather Data Approach

This approach requires the most recent 30 years of high-quality continuous data for precipitation, maximum and minimum air temperature, average relative humidity (or dew point), average wind speed, and total solar radiation. Not all weather stations have a complete set of data; therefore, this approach may not be practicable. Assuming the data is available, each of the consecutive 30 years of weather data is input to the model.

5.2. Soil Considerations

The WB cover soils should be modeled using input data representative of the properties and characteristics of the soil that will be used in the WB cover throughout the soil profile. The soil should be compatible with, and support the growth of, the plants proposed for use in the WB cover, which includes achieving the required root depth, root density, and plant surface coverage so the percolation and erosion are adequately controlled. Sampling and laboratory testing should characterize the engineering, hydraulic, and agronomic properties of the soils to be used in the WB cover. The laboratory testing should be performed on undisturbed *in situ* soil and reconstructed, recompacted soil samples. At a minimum, results of the following tests should be reported for candidate soils and used to determine if the soils need to be amended before use in the WB cover:

- Unified Soil Classification System (USCS) classification.
- Bulk density.
- Maximum dry density obtained according to standard proctor tests.
- Compaction percentage.

- Soil water retention curve.
- Saturated hydraulic conductivity at proposed soil placement conditions.
- Nutrients (nitrogen, phosphorus, potassium, micronutrients).
- Other characteristics (e.g., organic matter, sodium adsorption ratio).

Generally, the upper six to twelve inches of the soil profile should be conducive to plant growth. If soil amendments are necessary, then the soil-amendment process should be fully described and addressed in the WB cover CQCP[b]. The amended soil should be retested to ensure target soil conditions have been met. Include a map that shows the soil-borrow sources and the test-sample locations.

The soil water characteristic curves should be defined using experimental data obtained for a wide range of suction values. The following information should be provided:

- Trend of the moisture retention curve, as defined using established models (e.g. the van Genuchten model), including the actual data points obtained in the laboratory testing program.
- Hydraulic conductivity function, predicted using the moisture retention curve and the measured saturated hydraulic conductivity.

5.3. Vegetation Considerations

If the WB cover is designed with reliance on vegetation for moisture transpiration, documentation should be provided that the proposed plants can achieve the modeled root depths, root densities, and percent coverage. The vegetation selection(s) should include a site-specific analysis and recommendation by a vegetation expert (such as an agricultural extension service agent, range scientist, or botanist) with supporting documentation from peer-reviewed published sources that are readily available. Each plant type should be discussed with data on its suitability for the landfill location and the proposed soil types. The vegetation analysis should take into account that the soil may not have all the properties of a natural or *in situ* soil, and the WB cover CQCP should include a program of amending the soil (with compost, fertilizer, etc.) as necessary to support plant growth.

If the WB cover is designed without reliance on vegetation for moisture transpiration, then the plants proposed for erosion control and the target percent coverage should be specified to meet the less than or equal to 3 tons per acre-year standard. The publications of the United States Department of Agriculture's (USDA) on local and county soil and vegetation types may provide such information.

b. See Section 6 of this publication for details about the CQCP.

6. Construction Quality Control Plan (CQCP) Considerations for All WB Covers

Construction quality control specifications should allow verification that the WB cover is constructed consistent with the conditions, parameters, and assumptions used in the modeling and design effort. The parameters, conditions, and assumptions used to demonstrate equivalency of the WB cover should be translated into the following and recorded in the CQCP:

- Material specifications.
- Construction quality control testing specifications and procedures.

If construction of the WB cover includes a test plot, the CQCP should contain detailed construction quality control procedures for the test plot as well as the rest of the WB cover to be installed. Specifications documented in the CQCP should include:

- Soil density and hydraulic conductivity.
- Construction methods to achieve the design density and hydraulic conductivity.
- Moisture content.
- All proposed soil types (USCS tests).
- Vegetation and how it will be established, evaluated, and maintained.
- Provisions for initial irrigation, fertilization, and seeding as needed to establish and maintain robust vegetation with desired root density and depth.
- Tests and testing frequency for verifying design conditions.

6.1. CQCP Tests and Testing Frequencies

- Borrow-source testing should be performed for USCS classification at a frequency of at least one test per 20,000 cubic yards.
- Hydraulic conductivity testing of borrow source soil should be performed using large diameter (greater than or equal to 6 inches) samples at a minimum frequency of every 20,000 cubic yards.
- Constructed soil cover should be tested for field density and moisture content at a frequency of at least two tests per acre per lift.
- Moisture contents of constructed soil cover should be in the dry of optimum region.
- Undisturbed constructed soil cover samples should be collected in 3-inch or greater diameter thin-wall tubes at a frequency of at least one test per 2.5 acres per lift and tested in the laboratory for moisture content, dry unit weight, and saturated hydraulic conductivity.

6.2. CQCP Soils and Vegetation

The CQCP should specify how soils will be evaluated for agronomic properties, how soils will be amended, and if vegetation will be fertilized or irrigated and, if

so, under what circumstances. Methods and procedures should be specified for assessing the vegetation and for determining whether it has been established in accordance with the design specifications. The CQCP should include test procedures and frequencies for assessing the viability of the vegetation and quantifying the percent vegetation, including root depth and density if vegetation was used in the WB cover design model. Vegetation measurement methods for the plant types proposed should be accepted or approved by the USDA, Texas Department of Agriculture, or similar government entities.

WB cover construction methods must ensure that the as-built soil density is adequate for sufficient vegetation growth, for maintaining design values for unsaturated hydraulic conductivity, and for minimizing the development of cracks, macro features, and differential settlement.

6.3. CQCP and Out-Of-Specification Situations

The CQCP should include specifications for equipment weight and traffic on the cover, and procedures for identifying and correcting out-of-specification situations or damage. The CQCP should outline a procedure that describes the required actions and documentation when out-of-specification situations occur.

6.4. Final Cover System Evaluation Report (FCSER) and Engineer Certification

The CQCP should state that a FCSER with engineer certification will be submitted for each section of WB cover that is constructed. The FCSER should provide the following information:

- Completed report forms required by the TCEQ.
- Summary of construction activities.
- Drawings showing sample and test locations.
- Field and laboratory test results.
- Instructions to limit equipment weight and traffic on the cover, and procedures for identifying and correcting out-of-specification compaction and other situations or damage.
- As-built drawings (including cover elevation and thickness of the soil layers).
- Vegetation details for erosion control purposes; the plants proposed for erosion control and the target percent coverage.
- Description of any construction problems and how they were resolved.
- Statement of compliance with the MSW rules and the WB cover CQCP.
- Signature and seal of a licensed professional engineer.

7. Vegetation Establishment Report for All WB Covers

The application should specify that a vegetation establishment report will be submitted semi-annually until the vegetation is established to design conditions.

The report should describe the type and quantity of vegetation established and the overall percentage of coverage. Vegetation root structure (depth and density) should be evaluated and documented if vegetation inputs were used in the WB cover design model.

If the vegetation or root structure do not meet specifications, then corrective action may be necessary to improve vegetation.

8. Closure Plan and Post-Closure Care Plan Considerations for All WB Covers

The facility's closure plan should describe each type of final cover system, including the proposed WB alternative final cover system, and the parts of the landfill that may be covered with each type (for example, Subtitle D areas, pre-Subtitle D areas, side slopes, and top dome surfaces). The closure plan should include the WB cover CQCP.

The post-closure care plan for the facility should document the post-closure inspection, maintenance, and reporting requirements associated with the alternative final cover design. Post-closure care cost estimates should include the cost of long-term maintenance of vegetation, which may include reseeding, fertilizing, irrigating, and restoring cover that has been eroded or damaged.

9. Attachment A: Water Balance Cover Guidance Summary Table

For easy reference, Table 2 summarizes the four options and informational requirements for the design and permitting of WB covers discussed above.

Table 2: Water Balance Cover Guidance Summary

Description	Option 1	Option 2	Option 3	Option 4
Applicability				
Existing or proposed landfills that have a synthetic geomembrane-compacted clay composite liner	X	X	X	X
May be submitted as part of a new permit or permit amendment application or as a permit modification application under 30 TAC Subsection 305.70(k)(10).	X	X	X (two permit modifications required)	X
Can be utilized by landfills:	Statewide	Statewide	Statewide	Only in areas with <25" average annual precipitation (most recent 30 years data)
Criteria				
Modeled percolation ≤4 mm/yr	X	X	X	X
Measured Percolation ≤8 mm/yr		Satisfactory		
Measured Percolation >8 mm/yr & ≤12 mm/yr		Revised design & modeling via new permit modification		

Description	Option 1	Option 2	Option 3	Option 4
Measured Percolation >12 mm in any year		• New design & modeling via new permit modification • New test plot evaluation of revised cover design		
Minimum of 18″ of storage layer thickness	X	X	X	X
Minimum of 6″ of erosion layer or 12" of erosion layer with high plasticity clay storage layer	X	X	X	X
General Requirements				
Site specific modeling		X	X	X
Performance verification test plot		X • ≤10 acres of final cover • Minimum of one lysimeter • Minimum of three clusters of soil probes • Minimum 30′ x 30′ test plot • Annual reports		
Model calibration test plot			X 1st Permit Modification: • Detailed design plans • CQCP for test plot and operating procedures	

Description	Option 1	Option 2	Option 3	Option 4
Test Plot Duration		Minimum 3 years after vegetation establishment	Minimum 3 years after vegetation establishment	
Detailed drawings of the test plot		X	X	
Site specific weather data		X	X	X
Site specific soil data	X	X	X	X
Site specific vegetation data		Optional, if available	Optional, if available	Optional, if available
Borrow source characterization - Borrow and test location map, soil tests (listed in Section 6.1 with frequency of no less than every 20,000 cy	X	X	X	X
Narrative, test results and calculations explaining the estimated target as-built saturated hydraulic conductivity	X			
Minimum thickness of the storage layer as determined from Table 3 in Attachment B	X			
Description & detailed drawings of the final cover design that include design details for the proposed WB cover, along with details of the standard cover system and any other alternative final cover approved for the facility, and details of tie-ins between all of the cover systems, as applicable	X	X	X	X
WB cover CQCP – See Section 6 of this publication for details	X	X	X	X

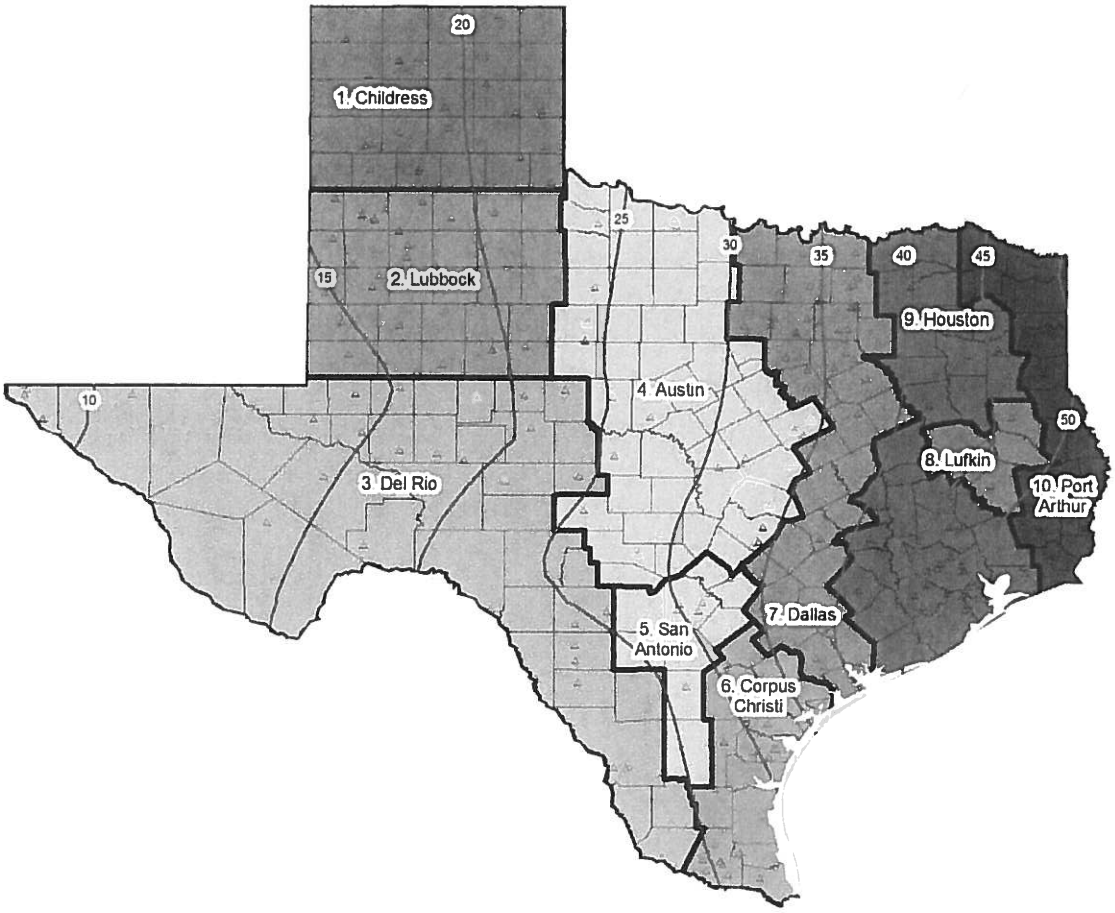
Description	Option 1	Option 2	Option 3	Option 4
Soil loss ≤3 tons/acre/year calculations	X	X	X	X
Slope stability evaluations	X	X	X	X
Closure and Post-Closure Care Plan	X	X	X	X
Financial Assurance	For the most expensive final cover option in the facility permit	For the most expensive final cover option in the facility permit	For the most expensive final cover option in the facility permit	For the most expensive final cover option in the facility permit
Calculations & narrative demonstrating that the design meets the two criteria in 30 TAC Section M330.457(d)	X	X	X	X
Semi-Annual Vegetation Establishment Reports	X (until vegetation reaches design coverage	X (until vegetation reaches design coverage)	X (until vegetation reaches design coverage)	X (until vegetation reaches design coverage)
Model Requirements				
If a computer model, besides UNSAT-H is used, basis for selecting the model		X	X	X
User's guide for models besides UNSAT-H		X	X	X
Version of the program		X	X	X
Detailed description of the specific options selected		X	X	X
All model assumptions		X	X	X
Input data, range of values for each input, and justification with respect to site-specific conditions		X	X	X

Description	Option 1	Option 2	Option 3	Option 4
Model input and output files		X	X	X
Sensitivity analyses of any variables for which a site-specific value cannot be determined		X	X	X
Summary table of the model results for each year listing: Precipitation, PET, P/PET ratio, model-estimated "actual" evaporation and transpiration, runoff as percent of total precipitation, storage, percolation, total mass balance error for each year		X	X	X
Narrative explaining the results, scenarios modeled, the sensitivity analyses performed, the worst case scenarios and how it was determined		X	X	X

10. Attachment B: Statewide Design Table

The following map, charts, and table are extracted from "Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas" authored by Dr. Milind V. Khire. The entire report may be viewed at <txswana.org/images/downloads/Water_Balance/txswana_water_balance_covers_khire_uncc_final_report.pdf>.

Figure 1: Map Showing Geoclimatic Regions (Figure 7 in the Khire report)



Legend

——— Average Year Annual Precipitation (in)

Figure 2: Peak annual percolation predicted by UNSAT-H vs. thickness of storage layer for in-service storage layer hydraulic conductivity of 10^{-6} cm/s (Figure 18 in the Khire report).

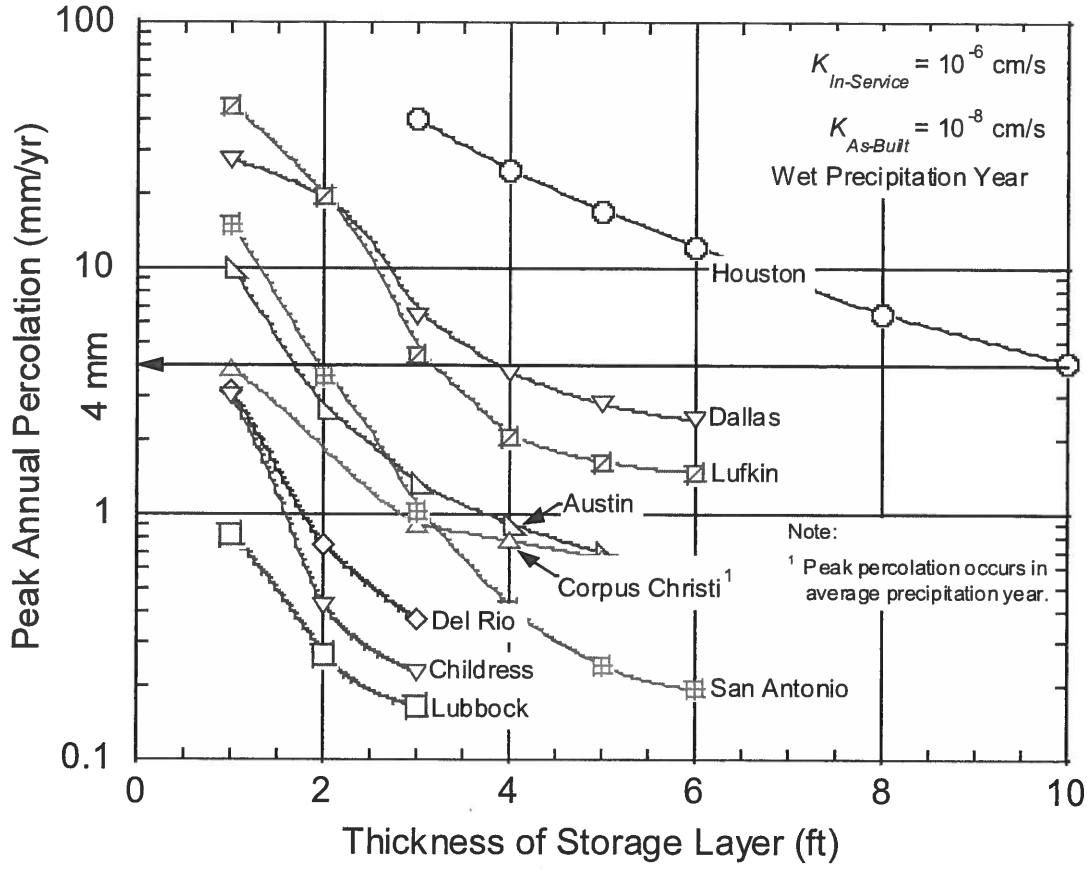


Figure 3: Peak annual percolation predicted by UNSAT-H vs. thickness of storage layer for in-service storage layer hydraulic conductivity of 5×10^{6} cm/s (Figure 19 in the Khire report).

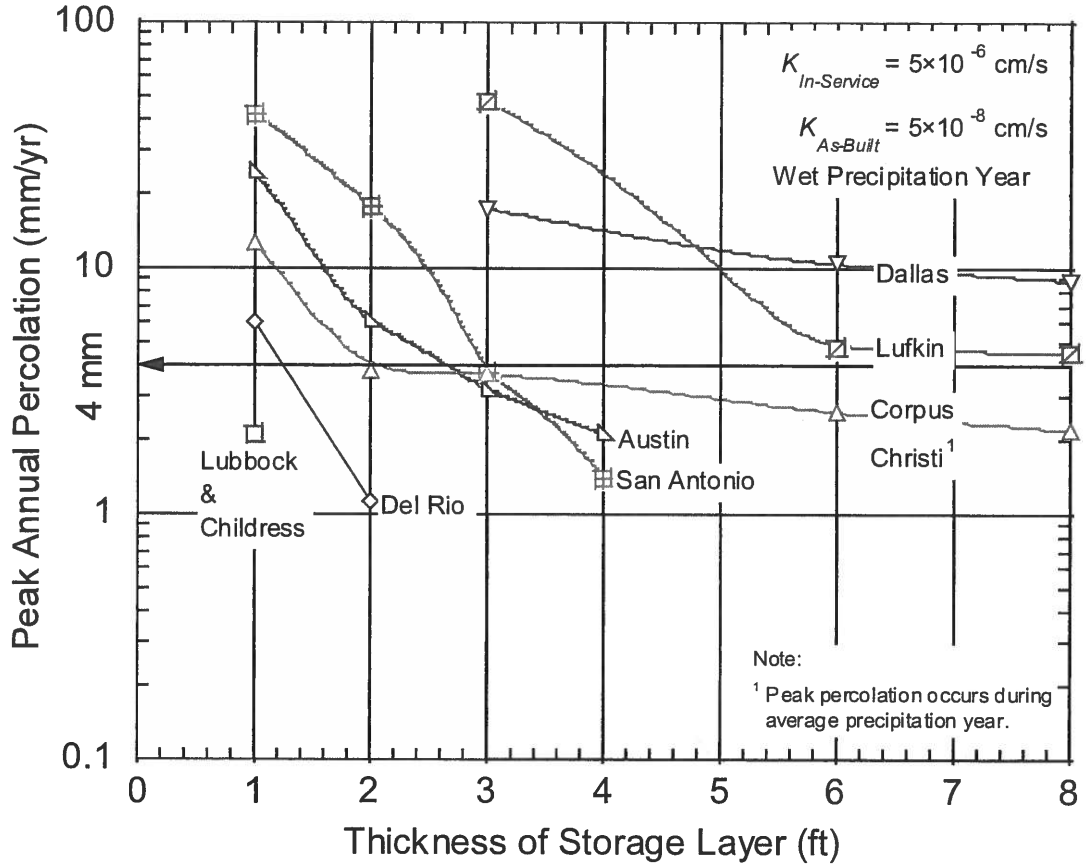


Figure 4: Peak annual percolation predicted by UNSAT-H vs. thickness of storage layer for in-service storage layer hydraulic conductivity of 10^{-5} cm/s (Figure 20 in the Khire report).

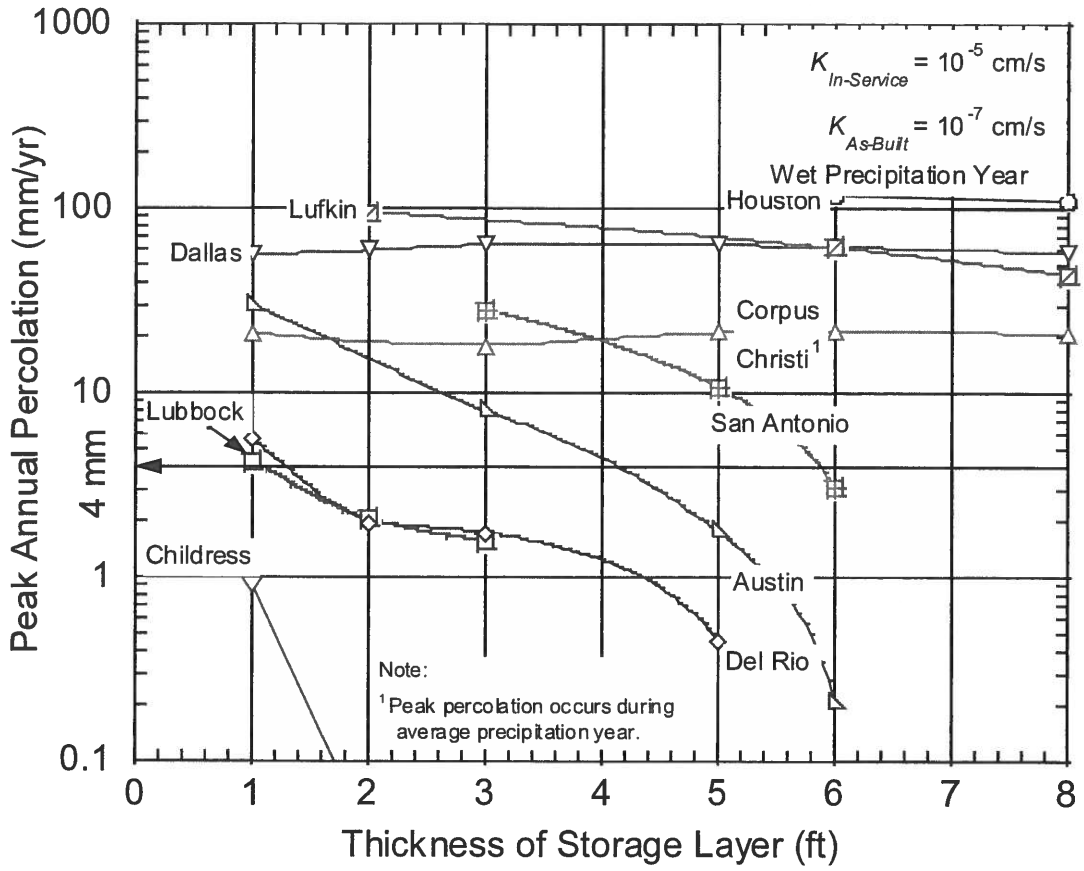


Table 3: Summary of minimum storage-layer thicknesses required to meet TCEQ criterion of 4 mm peak percolation (Table 8 in the Khire report).

Geoclimatic Region	$K_{As\text{-}Built}$ (cm/sec)	$K_{In\text{-}Service}$ (cm/sec)	Minimum Storage Layer Thickness for Bare Ground (ft)[c]
1-Childress	1.00E-08	1.00E-06	1 ft 0 in
	5.00E-08	5.00E-06	1 ft 0 in
	1.00E-07	1.00E-05	1 ft 0 in
	4.50E-07	4.50E-05	1 ft 7 in
	5.40E-05	2.70E-04	5 ft 8 in
2-Lubbock	1.00E-08	1.00E-06	1 ft 0 in
	5.00E-08	5.00E-06	1 ft 0 in
	1.00E-07	1.00E-05	1 ft 0 in
	4.50E-07	4.50E-05	10 ft+[d]
3-Del Rio	1.00E-08	1.00E-06	1 ft 0 in
	5.00E-08	5.00E-06	1 ft 3 in
	1.00E-07	1.00E-05	1 ft 7 in
	4.50E-07	4.50E-05	1 ft 10 in
	5.40E-05	2.70E-04	6 ft 2 in
4-Austin	1.00E-08	1.00E-06	1 ft 8 in
	5.00E-08	5.00E-06	2 ft 7 in
	1.00E-07	1.00E-05	3 ft 11 in
5-San Antonio	1.00E-08	1.00E-06	1 ft 11 in
	5.00E-08	5.00E-06	2 ft 11 in
	1.00E-07	1.00E-05	5 ft 10 in
6-Corpus Christi	1.00E-08	1.00E-06	1 ft 7 in
	5.00E-08	5.00E-06	2 ft 6 in
7-Dallas	1.00E-08	1.00E-06	3 ft 10 in
	5.00E-08	5.00E-06	8 ft+[d]
8-Lufkin	1.00E-08	1.00E-06	3 ft 1 in
	5.00E-08	5.00E-06	6 ft 0 in
9-Houston	1.00E-08	1.00E-06	10 ft 0 in
	5.00E-08	5.00E-06	10 ft+[d]

c. Thickness of vegetative layer needs to be 6 inches or greater.

d. Unable to meet criteria for up to the specified thickness.

11. References

Albright, W.H., et al. 2004. Field water balance of landfill final covers. *Journal of Environmental Quality* 33: 2317–32. In Desert Research Institute (DRI) Alternative Cover Assessment Program (ACAP) Refereed Articles. Available at <www.dri.edu/images/stories/research/programs/acap/acap-publications/1.pdf>.

Albright, William H., Craig H. Benson, W. Joseph Waugh. 2010. *Water Balance Covers for Waste Containment: Principles and Practice.* Reston, VA: ASCE Press.

Benson, Craig H., et al. 1999. *Test Section Installation Instructions.* Alternative Cover Assessment Program, Environmental Geotechnics Report No. 99-3. University of Wisconsin–Madison. In DRI ACAP Project Reports. Available at <www.dri.edu/images/stories/research/programs/acap/acap-publications/dri-acap-test-section-installation-details.pdf>.

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ITRC, Alternative Landfill Technologies Team. 2003, *Technical and Regulatory Guidance for Design, Installation, and Monitoring of Alternative Final Landfill Covers.* Washington D.C.: Interstate Technology and Regulatory Council. Available at <www.itrcweb.org/GuidanceDocuments/ALT-2.pdf>.

Khire, M.V., 2016, *Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas.* University of North Carolina at Charlotte. Available at <txswana.org/images/downloads/Water_Balance/txswana_water_balance_covers_khire_uncc_final_report.pdf>.

ENCLOSURE 2

RED-LINE VERSION OF REVISIONS IN FEBRUARY 21, 2018 RESPONSE TO COMMENTS

WASTE MANAGEMENT OF TEXAS
A WASTE MANAGEMENT COMPANY
9708 Giles Lane
Austin, Texas 78781

February 21, 2018

Texas Commission on Environmental Quality
MSW Permits Section, Waste Permit Division
P.O. Box 13087, MC-124
Austin, Texas 78711-3087

Attn: Chance Goodin
Manager, MSW Permits Section

Re: Response to TCEQ Comments
Permit Modification Request – Changes to Final Cover Design to Include a Water Balance Alternative Final Cover
Waste Management of Texas, Inc.
Austin Community Recycling and Disposal Facility
Travis County, Texas
TCEQ Permit No. MSW 249D

Dear Mr. Goodin:

Waste Management of Texas, Inc. (WMTX) is submitting the attached response to comments pertaining to the Permit Modification (PM) request, prepared by Golder Associates Inc. (Golder), for changes to final cover design to include a water balance alternative final cover at the Austin Community Recycling and Disposal Facility. In accordance with the requirements of 30 Texas Administrative Code (TAC) Section 305.44(b):

I 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.

Enclosed with this letter are the original and one copy. An additional copy has been forwarded to Mr. David Mann, Waste Program Manager of the TCEQ Region 11 office in Austin, Texas.

If you have any questions concerning this letter, please contact Tim Champagne, PE of WMTX at (512) 731-9768 or me at (512) 272-6245.

ON BEHALF OF WASTE MANAGEMENT OF TEXAS, INC.

Steve Jacobs
Texas Area Director of Landfill Operations
9708 Giles Lane
Austin TX 78754

cc: David Mann – TCEQ Region 11

Golder Associates

February 21, 2018

Our Ref.: 1782540

Texas Commission on Environmental Quality
MSW Section, Waste Permits Division
P.O. Box 13087, MC-124
Austin, Texas 78711-3087

Attn: Arten Avakian, Project Manager
Municipal Solid Waste Permits Section

RE: RESPONSE TO TCEQ COMMENTS
PERMIT MODIFICATION REQUEST
WATER BALANCE ALTERNATIVE FINAL COVER
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D
TRACKING NO. 22075131; RN100215938/CN600127856

Dear Mr. Avakian:

On behalf of Waste Management of Texas, Inc. (WMTX), Golder Associates Inc. (Golder) is submitting this response to comments for the above-referenced Permit Modification (PM) request to the existing Texas Commission on Environmental Quality (TCEQ) Permit Number Municipal Solid Waste (MSW) 249D, at the Austin Community Recycling and Disposal Facility, located in Travis County, Texas. The TCEQ provided these comments on the PM request in a notice of deficiency (NOD) letter dated December 19, 2017.

The responses presented herein are cross-referenced to the TCEQ comments using the comment numbers and quoting the original comments.

1. Comment: Clarify what the proposed alternative final cover layer thicknesses and properties are to be. The final cover stability analysis in proposed new Appendix C.5A indicates the infiltration layer will be four feet thick, and the erosion layer one foot thick, whereas the proposed revisions to the closure plan state the cover will consist of an 18-inch (minimum) infiltration layer and six-inch thick (minimum) erosion layer. The final cover quality control plan, in proposed new Section 5.0 (Alternative Water Balance Cover System) suggests that you still need to investigate the properties of the construction materials before you can specify the final design.

   Response: The final cover stability analysis located in Appendix C.5C was performed to demonstrate cover stability for a worst case scenario.

   RG-494, Option 1 provides flexibility in thickness of the water balance cover storage layer and erosion layer to accommodate variability in site specific soil properties. This is determined based on the hydraulic conductivity of water balance cover soils in accordance with the TCEQ guidance document RG-494 at the time of construction. The procedures for determining final cover thickness has been added to Part III, Attachment 7, Appendix A, Section 5.2. The minimum thickness was incorrectly stated as 18-inches in the initial submittal and has been corrected to 20-inches in this submittal. While the minimum thickness of the storage layer is 20-inches, it may increase to up to 3-feet 11-inches depending upon the hydraulic conductivity of the soil used in the construction. In no case will it be less than 20-inches thick.

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Golder Associates: Operations in Africa, Asia, Australasia, Europe, North America and South America

The following two conditions will be ensured for all WBAFC design regardless of the specific thickness of the cover:

(1) The final grades, i.e. the top of the final cover, will be maintained per the TCEQ permitted final grading plan to ensure proper drainage and transition between existing and new final cover areas.

(2) Final waste grades will be maintained as necessary to be at or below the TCEQ permitted final elevation once the cover is installed.

To achieve the above two requirements, the subgrade of the Water Balance Alternative Final Cover (WBAFC) will be adjusted based on the WBAFC thickness.

The erosion layer thickness, in accordance with the guidance document RG-494, will be 6-inch thick at minimum. When high plasticity clay (liquid limit >50) is used as the storage layer, the erosion layer will be increased to 1 foot thick.

The following changes have been made in response to the question:

a) Section 2.1 of Attachment 7, Closure Plan has been revised to indicate the minimum thickness of the storage layer is 20-inches, and to more clearly state the ultimate thickness is dependent upon the hydraulic conductivity of the storage layer soils used in the construction.

b) Attachment 7, Appendix A, Final Cover Quality Control Plan, Sections 1.2 and 5.2 have been revised to more clearly state that the storage layer thickness is to be determined based on the hydraulic conductivity of the storage layer soils used in the construction.

2. Comment: Provide layer and interface stability analyses for each proposed final cover material, hydraulic conductivity and thickness configuration. If the demonstration uses material property values documented in other parts of the permit, identify precisely where those data are in the application.

   Response: Part III, Attachment 3, Appendix C.5A has been revised to address material properties, to discuss the final cover profile, and to add a new circular failure mode analysis.

3. Comment: Provide complete references for the document by Dr. Miland V. Khier, cited in the final cover quality control plan and for the sources of equations used in the stability analysis.

   Response: The reference to the document prepared by Dr. Miland V. Khire cited in Attachment 7, Appendix A, Final Cover Quality Control Plan, Sections 1.2 and 5.0 have been revised to reference the TCEQ document RG-494.

   The equation used in the stability analysis was derived based on the force equilibrium of the final cover soil layer. Please refer to Chapter 12.3 of "Principles of Geotechnical Engineering" by Braja M. Das. This reference has been added to Part III, Attachment 3, Appendix C.5A, Section 3.0 (under Block Failure Mode).

4. Comment: Provide a marked copy of the table of contents for Attachment 7 to show the changes to pagination.

Response: A marked copy of the table of contents for Attachment 7 has been added. There is no change to the pagination.

5. Comment: Provide marked copies of Figures ATT7-1A and ATT7-1B to show the proposed changes.

   Response: Marked copies of these figures have been added as requested.

6. Comment: Provide clean copies and marked copy of the table of contents for Attachment 7, Appendix A to show added section, and changes to section numbers and pagination.

   Response: Clean and marked copies of the table of contents for Attachment 7, Appendix A have been added as requested.

Three additional change were made. Part III, Attachment 7, Appendix A Section 5.3 was revised to show the proposed construction testing frequencies consistent with RG-494. Figure ATT7-1B was revised to more clearly show the West Hill expansion area. Figure ATT7-2 was revised to more clearly show the thickness of the erosion layer may vary.

The following documents are included in this submittal:

- Part III, cover page
- Part III, Attachment 3
  - Cover page
  - Table of contents
  - Appendix C.5A Final Cover Stability – Water Balance Alternative Final Cover
- Part III, Attachment 7
  - Cover page
  - Table of contents
  - Section 2.1
  - Figures ATT7-1A and ATT7-1B
  - Figure ATT7-2
- Part III, Attachment 7, Appendix A
  - Cover page
  - Table of Contents
  - Pages 2, 22, and 26 through 29.
- TCEQ-20650 Form
  - Page one and the signature page

CLOSING

If you have any questions, please do not hesitate to call either Mr. William E. (Chip) Gordon P.E. or Ms. May Xin, P.E. of Golder at (281) 821-6868.

Sincerely,

GOLDER ASSOCIATES INC.

May Xin, PE
Senior Engineer

William Gordon, PE
Senior Engineer

Jeff Fassett, PE
Associate

GOLDER ASSOCIATES INC.
Professional Engineering Firm
Registration Number F-2578

Enclosures:
Enclosure 1 – Marked Copies
Enclosure 2 – Clean Copies
Enclosure 3 - TCEQ-20650 Form Page 1 and Signature Page

cc: Mr. Jayson Lang, WMTX
Mr. Tim Champagne, WMTX

ENCLOSURES

ENCLOSURE 1

MARKED COPIES

WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

SITE DEVELOPMENT PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

Golder Associates

500 Century Plaza Drive
Suite 190
Houston, Texas 77073
(281) 821-6868

Permit Issued: May 10, 2010
Revised April 2011
Revised June 2011
Revised October 2017
Revised February 2018

WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 3
WASTE MANAGEMENT UNIT DESIGN REPORT

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

500 Century Plaza Drive
Suite 190
Houston, Texas 77073
(281) 821-6868

August 2006
Revision 1 – May 2007
Revision 2 – August 2007
Revision 3 – December 2007
Revision 4 – February 2008
Revision 5 – March 2008
Revision 6 – May 2008
Revised October 2017
Revised February 2018

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 3
WASTE MANAGEMENT UNIT DESIGN REPORT

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- Appendix G.6 Leachate Evaporation Pond Layout

The interior waste slope stability analysis is presented in Appendix C.3.

4.3.2.4 Stability of Final Filled Configuration

The final filled configuration was considered across cells WD-11, WD-12, and WD-13, up to a maximum cover elevation of 740 feet. The configuration was analyzed using appropriate shear strength parameters and worst-case geometry. The results, based on analyses performed using SLIDE and included in Appendix C.4, indicate that the final waste slopes will be stable with a minimum factor of safety of 1.58.

4.3.2.5 Stability of Final Cover System

A stability analysis of the final cover liner system was performed using methods outlined by Soong and Koerner (1996) to estimate the potential for sliding to occur following closure of the landfill cells. A worst-case section, consisting of a 710-foot long, 25-percent slope was analyzed. Based on a review of the literature and unpublished data on similar materials under similar loading conditions, the critical interface shear strength within the final cover liner system was estimated to be 21°.

The analyses (included in Appendix C.5) indicate that, provided the geocomposite drainage layer is adequate to convey drainage without building up pore water pressures in the geocomposite, the factor of safety against sliding will be approximately 1.6.

Additional analyses (included in Appendix D) were performed to determine the geocomposite drainage layer transmissivity required to adequately convey surface water infiltration over the maximum final cover slope length. If the minimum measured transmissivity value reported in Appendix D is not met, the maximum flow length must be reduced (i.e., the geocomposite drainage layer must be "daylighted") in direct proportion to the ratio of the actual measured transmissivity and the required measured transmissivity. A detail depicting "daylighting" is included on Figure ATT7-2 in Attachment 7, the Closure Plan.

A stability analysis of the water balance final cover was also performed using the limit equilibrium analysis. The section analyzed consists of a 710-foot long, 25-percent slope, consistent with the section analyzed for the composite final cover system. Material parameters were selected based on review of literature and site data, which are also consistent with other slope stability analyses in Appendix C. The analysis (included in Appendix C.5A) indicate that the factor of safety against sliding will be approximately 2.64.1.

APPENDIX C.5A

FINAL COVER STABILITY – WATER BALANCE ALTERNATIVE FINAL COVER

FINAL COVER STABILITY - WATER BALANCE ALTERNATIVE FINAL COVER

Made By: MX
Checked by: JBF
Reviewed by:

1.0 OBJECTIVE

To investigate the veneer slope stability of the water balance alternative final cover system.

2.0 GIVEN

Final cover slopes are as follows:

Future final cover area: 4H:1V (S = 25%) with a maximum length of slope conservatively assumed to be 710 ft.

Based on the "EPA Guide to Technical Resources for the Design of Land Disposal Facilities", the recommend factor of safety for the final cover slope is selected to be 1.5 at minimum.

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3.0 ASSUMPTIONS

A worst-case, i.e. a thickest final cover profile is used for the slope stability analysis for conservative purposes:

1-ft erosion layer with the top 6 inches vegetative cover
4-ft storage layer ($K_{as\text{-}built} \leq$ 1.00*10-7 cm/sec - worst case, i.e. thickest final cover)
Subgrade

Soil source for the water balance final cover will be on-site clay soil materials.

Based on a review of available data, the following parameters were assigned to the materials.

Material	Strength Parameters		Unit Weight (pcf)		Reference
	ϕ (degree)	c (psf)	Moist	Saturated	
Final Cover Soil	0	1000	119	132	Part III, Attachment 3, Text Section 4.2.3, Tables 3.3 and 3.4
Interface Between Final Cover Soil & Subgrade	0	750	N/A	N/A	

Notes:

1. The shear strength of the final cover soil is estimated based on the on-site soil shear strength (Strata IA and IB). As shown in Part III, Attachment 3, Text Section 4.2.3, Tables 3.3 and 3.4, the mininum shear strengh of onsite clay materials is 2,100 psf. For conservative purposes, the shear strength of the final cover soil is assumed to be 1,000 psf and the interface is assumed to be even lower at 750 psf.
2. The final cover system, including both the top erosion layer and the storage layer, will be constructed of on-site clay materials . The storage layer will be compacted as described in the final cover quality control plan to reach the required permeability, and the erosion layer will be resonably compacted and vegetation will be established on the final cover. For slope stability analysis purposes, it is not necessary to analyze the top soil stability separately, rather, the entire final cover system is considered as one unit.

3.0 METHODS

Two slope stability analyses were performed for the final cover system:

- Circular failure for the final cover system
- Block (i.e. sliding) failure of the final cover system along the final cover/subgrade interface

Circular Failure Mode:

A slope stability software (SLIDE v7.029) was used to perform the analysis. The minimum factor of safety is shown below and output of stability analysis is attached.

Allow failure surface in the final cover only	**FS_{min} = 9.5**
Allow failure surface into the waste	**FS_{min} = 2.6**

Block Failure Mode:

A limit equilibrium analysis was performed to determine the minimum factor of safety against a sliding block failure along the interface. The equation below was derived based on the force equilibrium of the final cover soil layer. Please refer to Chapter 12.3 of "Principles of Geotechnical Engineering" by Braja M. Das.

$$FS = \frac{c + (\gamma b \cos\beta - \gamma_w d \cos\beta)\tan\phi}{\gamma b \sin\beta}$$

Potential Sliding of the Water Balance Final Cover

ϕ =	0	interface friction angle
c =	750	interface cohesion (psf)
β =	14.0	slope angle (degrees)
γ =	132	saturated unit weight of soil (pcf)
b =	5.0	soil thickness (ft)
d =	5	water depth in cover (conservatively assume the entire final cover is saturated) (ft)
γ_w =	62.4	unit weight of water (pcf)
FS =	**4.7**	**> 1.5**

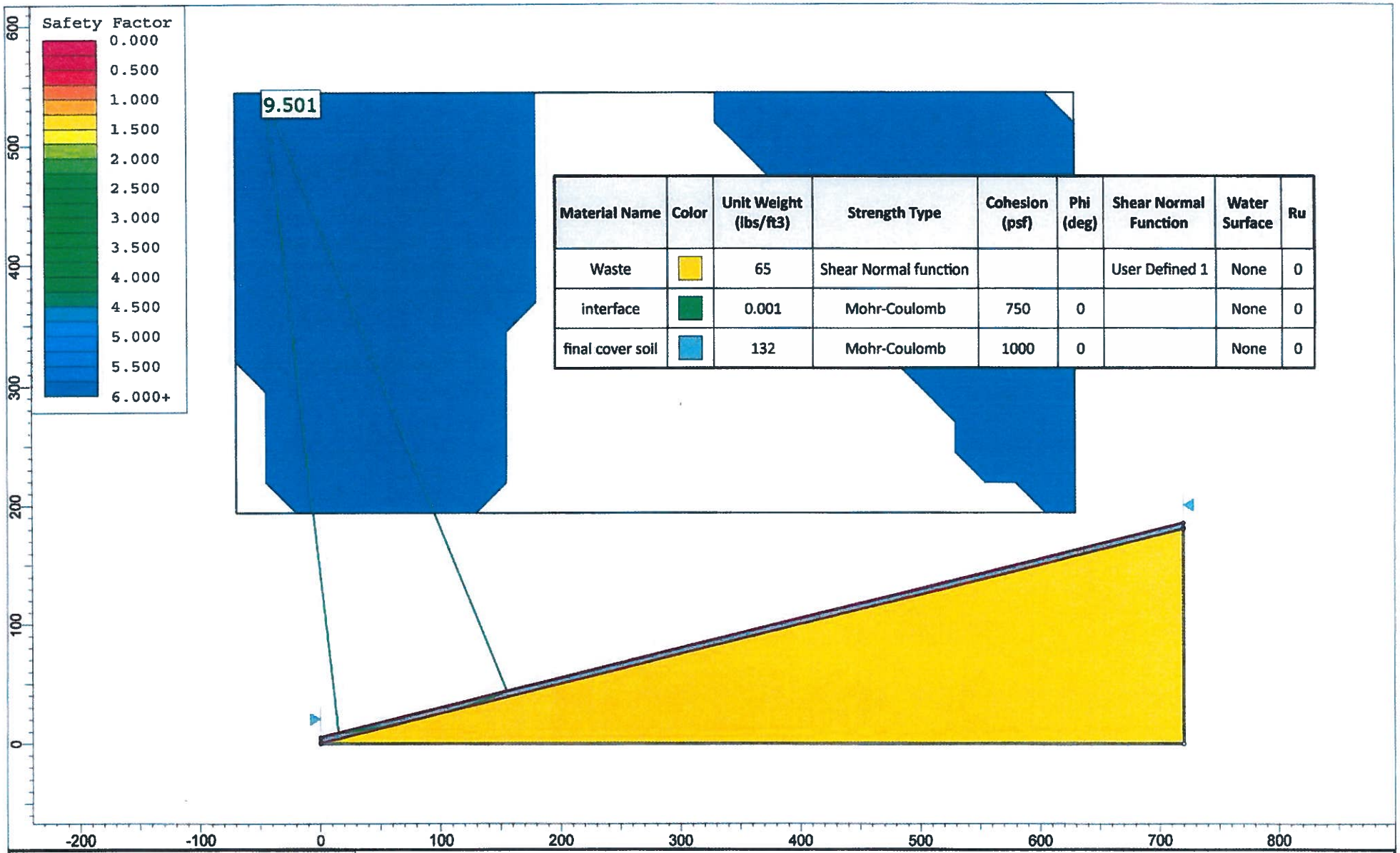
Factor of safety against sliding of the water balance final cover = **4.7** **> 1.5**

5.0 RESULTS

The future 4H:1V water balance alternative final cover slope will have a minimum factor of safety greater than 1.5.

6.0 CONCLUSION

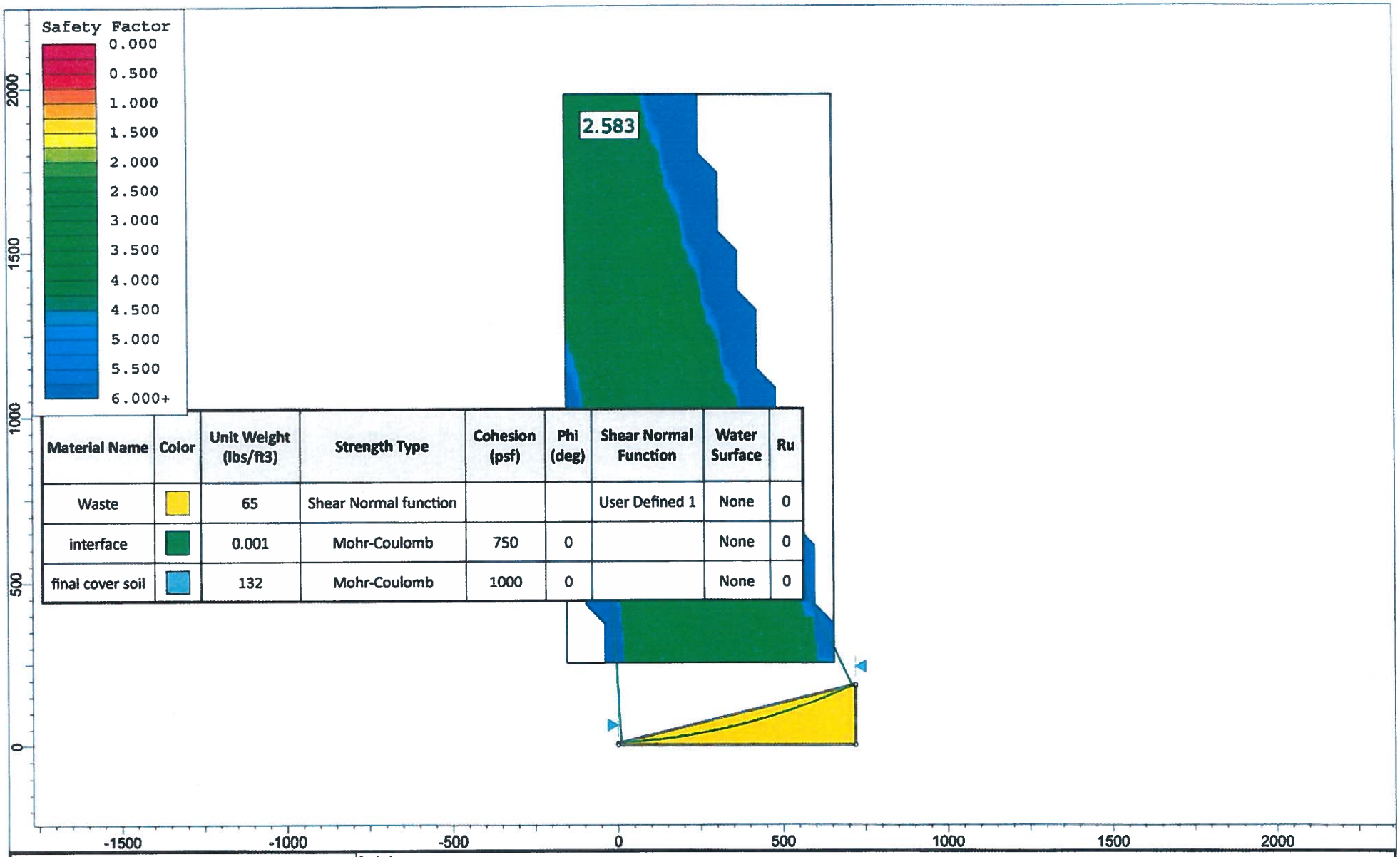
The analysis demonstated that the proposed water balance alternative final cover will be stable.



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Waste		65	Shear Normal function			User Defined 1	None	0
interface		0.001	Mohr-Coulomb	750	0		None	0
final cover soil		132	Mohr-Coulomb	1000	0		None	0

Rocscience	Project: SLIDE - An Interactive Slope Stability Program		
	Analysis Description:		
	Drawn By:	Scale: 1:1324	Company:
	Date: 1/25/2018, 11:03:43 AM		File Name: slide3 720 ft long.slim

SLIDEINTERPRET 7.029



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Shear Normal Function	Water Surface	Ru
Waste		65	Shear Normal function			User Defined 1	None	0
interface		0.001	Mohr-Coulomb	750	0		None	0
final cover soil		132	Mohr-Coulomb	1000	0		None	0

rocscience

SLIDEINTERPRET 7.029

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:4806	Company
Date	1/25/2018, 11:03:43 AM		File Name slide3 720 ft long.slim

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	slide3 720 ft long.slim
Slide Modeler Version:	7.029
Project Title:	SLIDE - An Interactive Slope Stability Program
Date Created:	1/25/2018, 11:03:43 AM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Right to Left
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	Bishop simplified Janbu simplified
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Grid Search
Radius Increment:	10
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Material Properties

Property	Waste	Interface	final cover soil
Color			
Strength Type	Shear Normal function	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	65	0.001	132
Cohesion [psf]		750	1000
Friction Angle [deg]		0	0
Water Surface	None	None	None
Ru Value	0	0	0

Shear Normal Functions

Name: User Defined 1

Normal (psf)	Shear (psf)
0	400
800	400
6000	3900

Global Minimums

Method: bishop simplified

FS	9.501230
Center:	-44.515, 544.451
Radius:	538.991
Left Slip Surface Endpoint:	15.039, 8.760
Right Slip Surface Endpoint:	155.028, 43.757
Resisting Moment:	6.92928e+007 lb-ft
Driving Moment:	7.29304e+006 lb-ft
Total Slice Area:	466.864 ft2
Surface Horizontal Width:	139.989 ft
Surface Average Height:	3.335 ft

Method: janbu simplified

FS	9.481210
Center:	-44.515, 544.451
Radius:	538.991
Left Slip Surface Endpoint:	15.039, 8.760
Right Slip Surface Endpoint:	155.028, 43.757
Resisting Horizontal Force:	124310 lb
Driving Horizontal Force:	13111.2 lb
Total Slice Area:	466.864 ft2
Surface Horizontal Width:	139.989 ft
Surface Average Height:	3.335 ft

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 3000
Number of Invalid Surfaces: 1785

Error Codes:

Error Code -102 reported for 2 surfaces
Error Code -106 reported for 20 surfaces
Error Code -108 reported for 36 surfaces
Error Code -1000 reported for 1727 surfaces

Method: janbu simplified

Number of Valid Surfaces: 2945
Number of Invalid Surfaces: 1840

Error Codes:

Error Code -102 reported for 2 surfaces
Error Code -106 reported for 20 surfaces
Error Code -108 reported for 91 surfaces
Error Code -1000 reported for 1727 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

Slice Data

Global Minimum Query (bishop simplified) - Safety Factor: 9.50123

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	2.82691	71.8132	6.49482	final cover soil	1000	0	105.25	1000	13.4214	0	13.4214	25.4034	25.4034
2	2.82691	212.617	6.79736	final cover soil	1000	0	105.25	1000	62.6663	0	62.6663	75.2116	75.2116
3	2.82691	347.769	7.10009	final cover soil	1000	0	105.25	1000	109.911	0	109.911	123.021	123.021
4	2.82691	477.26	7.40302	final cover soil	1000	0	105.25	1000	155.152	0	155.152	168.827	168.827
5	2.82691	601.077	7.70616	final cover soil	1000	0	105.25	1000	198.385	0	198.385	212.627	212.627
6	2.82691	719.209	8.00952	final cover soil	1000	0	105.25	1000	239.606	0	239.606	254.415	254.415
7	2.82691	831.643	8.3131	final cover soil	1000	0	105.25	1000	278.809	0	278.809	294.188	294.188
8	2.82691	938.366	8.61691	final cover soil	1000	0	105.25	1000	315.991	0	315.991	331.941	331.941
9	2.82691	1039.37	8.92098	final cover soil	1000	0	105.25	1000	351.149	0	351.149	367.67	367.67
10	2.82691	1134.63	9.22529	final cover soil	1000	0	105.25	1000	384.273	0	384.273	401.368	401.368
11	2.82691	1224.13	9.52987	final cover soil	1000	0	105.25	1000	415.361	0	415.361	433.03	433.03
12	2.82691	1307.87	9.83472	final cover soil	1000	0	105.25	1000	444.405	0	444.405	462.651	462.651
13	2.82691	1385.83	10.1398	final cover soil	1000	0	105.25	1000	471.404	0	471.404	490.227	490.227
14	2.82691	1457.98	10.4453	final cover soil	1000	0	105.25	1000	496.35	0	496.35	515.753	515.753
15	2.72688	1439.79	10.7456	interface	750	0	78.9371	750	513.019	0	513.019	528	528
16	2.72688	1439.79	11.0408	interface	750	0	78.9371	750	512.597	0	512.597	527.999	527.999
17	2.72688	1439.79	11.3363	interface	750	0	78.9371	750	512.175	0	512.175	528	528
18	2.72688	1439.79	11.6321	interface	750	0	78.9371	750	511.75	0	511.75	527.999	527.999
19	2.72688	1439.79	11.9282	interface	750	0	78.9371	750	511.324	0	511.324	527.999	527.999
20	2.72688	1439.79	12.2246	interface	750	0	78.9371	750	510.898	0	510.898	528	528
21	2.72688	1439.79	12.5214	interface	750	0	78.9371	750	510.468	0	510.468	527.999	527.999
22	2.72688	1439.79	12.8185	interface	750	0	78.9371	750	510.042	0	510.042	528.002	528.002
23	2.72688	1439.79	13.1159	interface	750	0	78.9371	750	509.607	0	509.607	528	528
24	2.72688	1439.79	13.4138	interface	750	0	78.9371	750	509.176	0	509.176	528.001	528.001
25	2.72688	1439.79	13.7119	interface	750	0	78.9371	750	508.74	0	508.74	528	528
26	2.72688	1439.79	14.0105	interface	750	0	78.9371	750	508.303	0	508.303	528	528
27	2.72688	1439.79	14.3095	interface	750	0	78.9371	750	507.866	0	507.866	528	528
28	2.72688	1439.79	14.6088	interface	750	0	78.9371	750	507.427	0	507.427	528.001	528.001
29	2.72688	1439.79	14.9086	interface	750	0	78.9371	750	506.986	0	506.986	528.003	528.003
30	2.72688	1439.79	15.2088	interface	750	0	78.9371	750	506.541	0	506.541	528.001	528.001
31	2.72688	1439.79	15.5094	interface	750	0	78.9371	750	506.095	0	506.095	528	528
32	2.72688	1439.79	15.8104	interface	750	0	78.9371	750	505.65	0	505.65	528.002	528.002
33	2.72688	1439.79	16.1119	interface	750	0	78.9371	750	505.199	0	505.199	528.001	528.001
34	2.72688	1439.79	16.4139	interface	750	0	78.9371	750	504.747	0	504.747	528	528
35	2.72688	1439.79	16.7163	interface	750	0	78.9371	750	504.292	0	504.292	527.999	527.999
36	2.72688	1439.79	17.0192	interface	750	0	78.9371	750	503.838	0	503.838	528.001	528.001
37	2.72688	1439.79	17.3226	interface	750	0	78.9371	750	503.379	0	503.379	527.999	527.999
38	2.89957	1493.29	17.6361	final cover soil	1000	0	105.25	1000	481.544	0	481.544	515.004	515.004
39	2.89957	1414.46	17.9599	final cover soil	1000	0	105.25	1000	453.7	0	453.7	487.816	487.816
40	2.89957	1328.7	18.2842	final cover soil	1000	0	105.25	1000	423.464	0	423.464	458.239	458.239
41	2.89957	1235.96	18.6091	final cover soil	1000	0	105.25	1000	390.819	0	390.819	426.258	426.258
42	2.89957	1136.21	18.9347	final cover soil	1000	0	105.25	1000	355.747	0	355.747	391.853	391.853
43	2.89957	1029.4	19.2608	final cover soil	1000	0	105.25	1000	318.241	0	318.241	355.019	355.019
44	2.89957	915.497	19.5877	final cover soil	1000	0	105.25	1000	278.284	0	278.284	315.736	315.736
45	2.89957	794.454	19.9152	final cover soil	1000	0	105.25	1000	235.86	0	235.86	273.991	273.991
46	2.89957	666.228	20.2434	final cover soil	1000	0	105.25	1000	190.953	0	190.953	229.768	229.768
47	2.89957	530.773	20.5722	final cover soil	1000	0	105.25	1000	143.55	0	143.55	183.052	183.052
48	2.89957	388.042	20.9018	final cover soil	1000	0	105.25	1000	93.633	0	93.633	133.828	133.828
49	2.89957	237.988	21.2321	final cover soil	1000	0	105.25	1000	41.1856	0	41.1856	82.0772	82.0772
50	2.89957	80.5622	21.5632	final cover soil	1000	0	105.25	1000	-13.8088	0	-13.8088	27.7842	27.7842

Global Minimum Query (janbu simplified) - Safety Factor: 9.48121

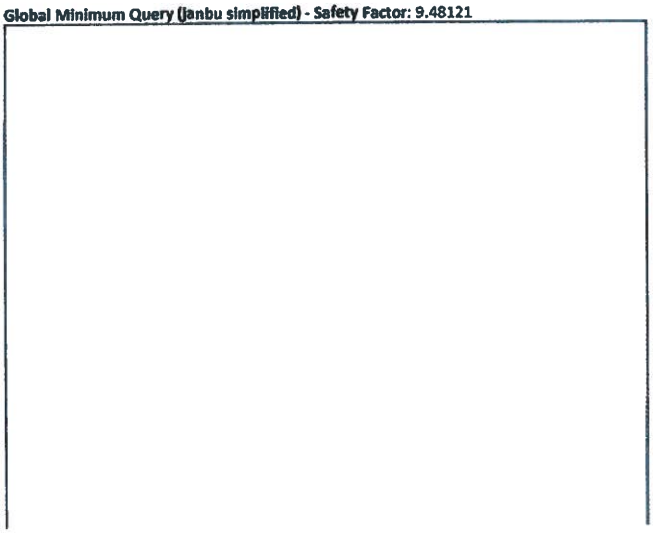
Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	2.82691	71.8132	6.49482	final cover soil	1000	0	105.472	1000	13.3955	0	13.3955	25.4029	25.4029
2	2.82691	212.617	6.79736	final cover soil	1000	0	105.472	1000	62.6393	0	62.6393	75.2111	75.2111
3	2.82691	347.769	7.10009	final cover soil	1000	0	105.472	1000	109.883	0	109.883	123.021	123.021
4	2.82691	477.26	7.40302	final cover soil	1000	0	105.472	1000	155.123	0	155.123	168.827	168.827
5	2.82691	601.077	7.70616	final cover soil	1000	0	105.472	1000	198.354	0	198.354	212.626	212.626
6	2.82691	719.209	8.00952	final cover soil	1000	0	105.472	1000	239.574	0	239.574	254.415	254.415
7	2.82691	831.643	8.3131	final cover soil	1000	0	105.472	1000	278.776	0	278.776	294.187	294.187
8	2.82691	938.366	8.61691	final cover soil	1000	0	105.472	1000	315.957	0	315.957	331.94	331.94
9	2.82691	1039.37	8.92098	final cover soil	1000	0	105.472	1000	351.11	0	351.11	367.666	367.666
10	2.82691	1134.63	9.22529	final cover soil	1000	0	105.472	1000	384.235	0	384.235	401.365	401.365
11	2.82691	1224.13	9.52987	final cover soil	1000	0	105.472	1000	415.323	0	415.323	433.029	433.029
12	2.82691	1307.87	9.83472	final cover soil	1000	0	105.472	1000	444.367	0	444.367	462.651	462.651
13	2.82691	1385.83	10.1398	final cover soil	1000	0	105.472	1000	471.362	0	471.362	490.225	490.225
14	2.82691	1457.98	10.4453	final cover soil	1000	0	105.472	1000	496.308	0	496.308	515.752	515.752
15	2.72688	1439.79	10.7456	interface	750	0	79.1038	750	512.987	0	512.987	527.999	527.999
16	2.72688	1439.79	11.0408	interface	750	0	79.1038	750	512.565	0	512.565	527.999	527.999
17	2.72688	1439.79	11.3363	interface	750	0	79.1038	750	512.139	0	512.139	527.998	527.998
18	2.72688	1439.79	11.6321	interface	750	0	79.1038	750	511.717	0	511.717	528.001	528.001
19	2.72688	1439.79	11.9282	interface	750	0	79.1038	750	511.288	0	511.288	527.999	527.999
20	2.72688	1439.79	12.2246	interface	750	0	79.1038	750	510.862	0	510.862	528.001	528.001
21	2.72688	1439.79	12.5214	interface	750	0	79.1038	750	510.433	0	510.433	528	528
22	2.72688	1439.79	12.8185	interface	750	0	79.1038	750	510.002	0	510.002	528.001	528.001
23	2.72688	1439.79	13.1159	interface	750	0	79.1038	750	509.568	0	509.568	527.999	527.999
24	2.72688	1439.79	13.4138	interface	750	0	79.1038	750	509.137	0	509.137	528.002	528.002
25	2.72688	1439.79	13.7119	interface	750	0	79.1038	750	508.701	0	508.701	528.002	528.002
26	2.72688	1439.79	14.0105	interface	750	0	79.1038	750	508.261	0	508.261	527.999	527.999
27	2.72688	1439.79	14.3095	interface	750	0	79.1038	750	507.823	0	507.823	528	528
28	2.72688	1439.79	14.6088	interface	750	0	79.1038	750	507.381	0	507.381	527.999	527.999
29	2.72688	1439.79	14.9086	interface	750	0	79.1038	750	506.94	0	506.94	528.001	528.001
30	2.72688	1439.79	15.2088	interface	750	0	79.1038	750	506.495	0	506.495	528	528
31	2.72688	1439.79	15.5094	interface	750	0	79.1038	750	506.049	0	506.049	528	528
32	2.72688	1439.79	15.8104	interface	750	0	79.1038	750	505.6	0	505.6	528	528
33	2.72688	1439.79	16.1119	interface	750	0	79.1038	750	505.15	0	505.15	528	528
34	2.72688	1439.79	16.4139	interface	750	0	79.1038	750	504.697	0	504.697	528	528
35	2.72688	1439.79	16.7163	interface	750	0	79.1038	750	504.243	0	504.243	528	528
36	2.72688	1439.79	17.0192	interface	750	0	79.1038	750	503.786	0	503.786	527.999	527.999
37	2.72688	1439.79	17.3226	interface	750	0	79.1038	750	503.326	0	503.326	527.999	527.999
38	2.89957	1493.29	17.6361	final cover soil	1000	0	105.472	1000	481.471	0	481.471	515.002	515.002
39	2.89957	1414.46	17.9599	final cover soil	1000	0	105.472	1000	453.628	0	453.628	487.816	487.816
40	2.89957	1328.7	18.2842	final cover soil	1000	0	105.472	1000	423.388	0	423.388	458.238	458.238
41	2.89957	1235.96	18.6091	final cover soil	1000	0	105.472	1000	390.74	0	390.74	426.254	426.254
42	2.89957	1136.21	18.9347	final cover soil	1000	0	105.472	1000	355.668	0	355.668	391.851	391.851
43	2.89957	1029.4	19.2608	final cover soil	1000	0	105.472	1000	318.162	0	318.162	355.017	355.017
44	2.89957	915.497	19.5877	final cover soil	1000	0	105.472	1000	278.203	0	278.203	315.734	315.734
45	2.89957	794.454	19.9152	final cover soil	1000	0	105.472	1000	235.777	0	235.777	273.989	273.989
46	2.89957	666.228	20.2434	final cover soil	1000	0	105.472	1000	190.87	0	190.87	229.766	229.766
47	2.89957	530.773	20.5722	final cover soil	1000	0	105.472	1000	143.465	0	143.465	183.051	183.051
48	2.89957	388.042	20.9018	final cover soil	1000	0	105.472	1000	93.546	0	93.546	133.826	133.826
49	2.89957	237.988	21.2321	final cover soil	1000	0	105.472	1000	41.0972	0	41.0972	82.0751	82.0751
50	2.89957	80.5622	21.5632	final cover soil	1000	0	105.472	1000	-13.8986	0	-13.8986	27.7823	27.7823

Interslice Data

Global Minimum Query (bishop simplified) - Safety Factor: 9.50123

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	15.039	8.75974	0	0	0
2	17.8659	9.08157	293.211	0	0
3	20.6928	9.41852	569.626	0	0
4	23.5197	9.77064	828.456	0	0
5	26.3466	10.1379	1069	0	0
6	29.1735	10.5205	1290.64	0	0
7	32.0004	10.9182	1492.86	0	0
8	34.8273	11.3313	1675.23	0	0
9	37.6542	11.7597	1837.4	0	0
10	40.4811	12.2034	1979.11	0	0
11	43.308	12.6626	2100.2	0	0
12	46.135	13.1371	2200.61	0	0
13	48.9619	13.6272	2280.36	0	0
14	51.7888	14.1328	2339.56	0	0
15	54.6157	14.6539	2378.42	0	0
16	57.3426	15.1714	2328.19	0	0
17	60.0694	15.7035	2270.7	0	0
18	62.7963	16.2502	2205.96	0	0
19	65.5232	16.8115	2133.95	0	0
20	68.2501	17.3875	2054.65	0	0
21	70.977	17.9783	1968.07	0	0
22	73.7038	18.5839	1874.18	0	0
23	76.4307	19.2044	1772.97	0	0
24	79.1576	19.8398	1664.44	0	0
25	81.8845	20.4901	1548.56	0	0
26	84.6114	21.1554	1425.32	0	0
27	87.3382	21.8359	1294.72	0	0
28	90.0651	22.5314	1156.72	0	0
29	92.792	23.2422	1011.32	0	0
30	95.5189	23.9682	858.501	0	0
31	98.2457	24.7095	698.241	0	0
32	100.973	25.4662	530.525	0	0
33	103.7	26.2384	355.333	0	0
34	106.426	27.026	172.646	0	0
35	109.153	27.8293	-17.5565	0	0
36	111.88	28.6483	-215.295	0	0
37	114.607	29.483	-420.592	0	0
38	117.334	30.3335	-633.469	0	0
39	120.233	31.2553	-772.182	0	0
40	123.133	32.1952	-893.43	0	0
41	126.033	33.1532	-993.952	0	0
42	128.932	34.1295	-1070.34	0	0
43	131.832	35.1242	-1119.02	0	0
44	134.731	36.1374	-1136.29	0	0
45	137.631	37.1692	-1118.24	0	0
46	140.53	38.2197	-1060.83	0	0
47	143.43	39.289	-959.842	0	0
48	146.33	40.3773	-810.885	0	0
49	149.229	41.4847	-609.391	0	0
50	152.129	42.6112	-350.61	0	0
51	155.028	43.7571	0	0	0

Global Minimum Query (Janbu simplified) - Safety Factor: 9.48121



Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	15.039	8.75974	0	0	0
2	17.8659	9.08157	293.862	0	0
3	20.6928	9.41852	570.928	0	0
4	23.5197	9.77064	830.409	0	0
5	26.3466	10.1379	1071.6	0	0
6	29.1735	10.5205	1293.9	0	0
7	32.0004	10.9182	1496.78	0	0
8	34.8273	11.3313	1679.8	0	0
9	37.6542	11.7597	1842.62	0	0
10	40.4811	12.2034	1984.99	0	0
11	43.308	12.6626	2106.75	0	0
12	46.135	13.1371	2207.82	0	0
13	48.9619	13.6272	2288.23	0	0
14	51.7888	14.1328	2348.09	0	0
15	54.6157	14.6539	2387.61	0	0
16	57.3426	15.1714	2337.86	0	0
17	60.0694	15.7035	2280.86	0	0
18	62.7963	16.2502	2216.6	0	0
19	65.5232	16.8115	2145.07	0	0
20	68.2501	17.3875	2066.26	0	0
21	70.977	17.9783	1980.16	0	0
22	73.7038	18.5839	1886.76	0	0
23	76.4307	19.2044	1786.04	0	0
24	79.1576	19.8398	1678	0	0
25	81.8845	20.4901	1562.61	0	0
26	84.6114	21.1554	1439.87	0	0
27	87.3382	21.8359	1309.75	0	0
28	90.0651	22.5314	1172.25	0	0
29	92.792	23.2422	1027.35	0	0
30	95.5189	23.9682	875.024	0	0
31	98.2457	24.7095	715.263	0	0
32	100.973	25.4662	548.047	0	0
33	103.7	26.2384	373.357	0	0
34	106.426	27.026	191.173	0	0
35	109.153	27.8293	1.47578	0	0
36	111.88	28.6483	-195.757	0	0
37	114.607	29.483	-400.545	0	0
38	117.334	30.3335	-612.912	0	0
39	120.233	31.2553	-750.901	0	0
40	123.133	32.1952	-871.421	0	0
41	126.033	33.1532	-971.213	0	0
42	128.932	34.1295	-1046.87	0	0
43	131.832	35.1242	-1094.82	0	0
44	134.731	36.1374	-1111.34	0	0
45	137.631	37.1692	-1092.55	0	0
46	140.53	38.2197	-1034.39	0	0
47	143.43	39.289	-932.66	0	0
48	146.33	40.3773	-782.952	0	0
49	149.229	41.4847	-580.703	0	0
50	152.129	42.6112	-321.164	0	0
51	155.028	43.7571	0	0	0

List Of Coordinates

Focus Search Window

X	Y
720	180
720	185
0	5
0	0

External Boundary

X	Y
720	0
720	180
720	181
720	185
0	5
0	1
0	0

Material Boundary

X	Y
0	1
720	181

Material Boundary

X	Y
0	0
720	180

Slide Analysis Information

SLIDE - An Interactive Slope Stability Program

Project Summary

File Name:	slide3 720 ft long.slim
Slide Modeler Version:	7.029
Project Title:	SLIDE - An Interactive Slope Stability Program
Date Created:	1/25/2018, 11:03:43 AM

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Failure Direction:	Right to Left
Data Output:	Standard
Maximum Material Properties:	20
Maximum Support Properties:	20

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	Bishop simplified Janbu simplified
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Grid Search
Radius Increment:	10
Composite Surfaces:	Disabled
Reverse Curvature:	Invalid Surfaces
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Material Properties

Property	Waste	Interface	final cover soil
Color			
Strength Type	Shear Normal function	Mohr-Coulomb	Mohr-Coulomb
Unit Weight [lbs/ft3]	65	0.001	132
Cohesion [psf]		750	1000
Friction Angle [deg]		0	0
Water Surface	None	None	None
Ru Value	0	0	0

Shear Normal Functions

Name: User Defined 1

Normal (psf)	Shear (psf)
0	400
800	400
6000	3900

Global Minimums

Method: bishop simplified

FS	2.582720
Center:	-96.277, 1917.534
Radius:	1913.147
Left Slip Surface Endpoint:	9.184, 7.296
Right Slip Surface Endpoint:	709.605, 182.401
Resisting Moment:	1.44089e+009 lb-ft
Driving Moment:	5.57895e+008 lb-ft
Total Slice Area:	16563.8 ft2
Surface Horizontal Width:	700.421 ft
Surface Average Height:	23.6483 ft

Method: janbu simplified

FS	2.563790
Center:	-96.277, 1917.534
Radius:	1913.147
Left Slip Surface Endpoint:	9.184, 7.296
Right Slip Surface Endpoint:	709.605, 182.401
Resisting Horizontal Force:	727391 lb
Driving Horizontal Force:	283717 lb
Total Slice Area:	16563.8 ft2
Surface Horizontal Width:	700.421 ft
Surface Average Height:	23.6483 ft

Valid / Invalid Surfaces

Method: bishop simplified

Number of Valid Surfaces: 3472
Number of Invalid Surfaces: 1478

Error Codes:

Error Code -102 reported for 10 surfaces
Error Code -103 reported for 139 surfaces
Error Code -106 reported for 15 surfaces
Error Code -108 reported for 82 surfaces
Error Code -1000 reported for 1232 surfaces

Method: janbu simplified

Number of Valid Surfaces: 3403
Number of Invalid Surfaces: 1547

Error Codes:

Error Code -102 reported for 10 surfaces
Error Code -103 reported for 139 surfaces
Error Code -106 reported for 15 surfaces
Error Code -108 reported for 151 surfaces
Error Code -1000 reported for 1232 surfaces

Error Codes

The following errors were encountered during the computation:

-102 = Two surface / slope intersections, but resulting arc is actually outside soil region.
-103 = Two surface / slope intersections, but one or more surface / nonslope external polygon intersections lie between them. This usually occurs when the slip surface extends past the bottom of the soil region, but may also occur on a benched slope model with two sets of Slope Limits.
-106 = Average slice width is less than 0.0001 * (maximum horizontal extent of soil region). This limitation is imposed to avoid numerical errors which may result from too many slices, or too small a slip region.
-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).
-1000 = No valid slip surfaces are generated at a grid center. Unable to draw a surface.

Slice Data

Global Minimum Query (bishop simplified) - Safety Factor: 2.58272

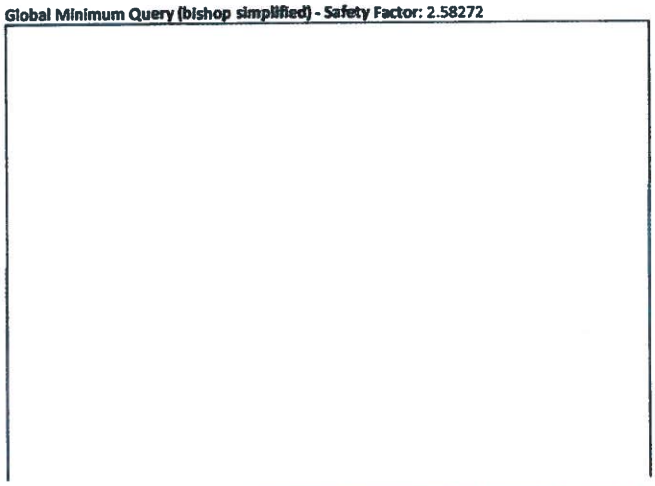
Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	21.1373	5580.25	3.47709	final cover soil	1000	0	387.189	1000	240.483	0	240.483	264.009	264.009
2	5.48733	2897.31	3.87654	interface	750	0	290.392	750	508.33	0	508.33	528.008	528.008
3	14.1201	8602.84	4.1709	Waste	400	0	154.875	400	597.971	0	597.971	609.266	609.266
4	14.1201	10849.4	4.59502	Waste	400	0	154.875	400	755.921	0	755.921	768.368	768.368
5	14.1201	12999.4	5.01939	Waste	-138.462	33.9436	182.145	470.429	904.641	0	904.641	920.639	920.639
6	14.1201	15052.6	5.44404	Waste	-138.462	33.9436	218.776	565.037	1045.2	0	1045.2	1066.05	1066.05
7	14.1201	17008.9	5.86899	Waste	-138.462	33.9436	253.524	654.782	1178.53	0	1178.53	1204.59	1204.59
8	14.1201	18868	6.29426	Waste	-138.462	33.9436	286.397	739.682	1304.67	0	1304.67	1336.26	1336.26
9	14.1201	20629.7	6.71988	Waste	-138.462	33.9436	317.398	819.75	1423.63	0	1423.63	1461.03	1461.03
10	14.1201	22293.7	7.14588	Waste	-138.462	33.9436	346.533	894.998	1535.43	0	1535.43	1578.88	1578.88
11	14.1201	23859.8	7.57227	Waste	-138.462	33.9436	373.811	965.448	1640.1	0	1640.1	1689.79	1689.79
12	14.1201	25327.7	7.99908	Waste	-138.462	33.9436	399.233	1031.11	1737.65	0	1737.65	1793.75	1793.75
13	14.1201	26697.2	8.42634	Waste	-138.462	33.9436	422.809	1092	1828.11	0	1828.11	1890.74	1890.74
14	14.1201	27967.8	8.85408	Waste	-138.462	33.9436	444.538	1148.12	1911.49	0	1911.49	1980.73	1980.73
15	14.1201	29139.2	9.28231	Waste	-138.462	33.9436	464.424	1199.48	1987.79	0	1987.79	2063.69	2063.69
16	14.1201	30211.2	9.71106	Waste	-138.462	33.9436	482.471	1246.09	2057.05	0	2057.05	2139.61	2139.61
17	14.1201	31183.2	10.1404	Waste	-138.462	33.9436	498.687	1287.97	2119.26	0	2119.26	2208.46	2208.46
18	14.1201	32055	10.5702	Waste	-138.462	33.9436	513.071	1325.12	2174.46	0	2174.46	2270.2	2270.2
19	14.1201	32826.1	11.0007	Waste	-138.462	33.9436	525.623	1357.54	2222.63	0	2222.63	2324.81	2324.81
20	14.1201	33496	11.4318	Waste	-138.462	33.9436	536.352	1385.25	2263.81	0	2263.81	2372.27	2372.27
21	14.1201	34064.4	11.8636	Waste	-138.462	33.9436	545.258	1408.25	2297.98	0	2297.98	2412.52	2412.52
22	14.1201	34530.8	12.2961	Waste	-138.462	33.9436	552.343	1426.55	2325.16	0	2325.16	2445.55	2445.55
23	14.1201	34894.5	12.7292	Waste	-138.462	33.9436	557.605	1440.14	2345.35	0	2345.35	2471.31	2471.31
24	14.1201	35155.2	13.1632	Waste	-138.462	33.9436	561.051	1449.04	2358.56	0	2358.56	2489.78	2489.78
25	14.1201	35312.3	13.5978	Waste	-138.462	33.9436	562.673	1453.23	2364.8	0	2364.8	2500.9	2500.9
26	14.1201	35365.3	14.0333	Waste	-138.462	33.9436	562.484	1452.74	2364.07	0	2364.07	2504.66	2504.66
27	14.1201	35313.5	14.4696	Waste	-138.462	33.9436	560.474	1447.55	2356.35	0	2356.35	2500.98	2500.98
28	14.1201	35156.3	14.9068	Waste	-138.462	33.9436	556.649	1437.67	2341.67	0	2341.67	2489.86	2489.86
29	14.1201	34893.1	15.3448	Waste	-138.462	33.9436	551.004	1423.09	2320.02	0	2320.02	2471.22	2471.22
30	14.1201	34523.2	15.7838	Waste	-138.462	33.9436	543.542	1403.82	2291.38	0	2291.38	2445.02	2445.02
31	14.1201	34046	16.2237	Waste	-138.462	33.9436	534.262	1379.85	2255.78	0	2255.78	2411.23	2411.23
32	14.1201	33460.8	16.6647	Waste	-138.462	33.9436	523.161	1351.18	2213.18	0	2213.18	2369.78	2369.78
33	14.1201	32766.8	17.1066	Waste	-138.462	33.9436	510.24	1317.81	2163.6	0	2163.6	2320.63	2320.63
34	14.1201	31963.2	17.5496	Waste	-138.462	33.9436	495.496	1279.73	2107.02	0	2107.02	2263.72	2263.72
35	14.1201	31049.2	17.9937	Waste	-138.462	33.9436	478.925	1236.93	2043.44	0	2043.44	2199	2199
36	14.1201	30024.1	18.4388	Waste	-138.462	33.9436	460.529	1189.42	1972.85	0	1972.85	2126.39	2126.39
37	14.1201	28886.9	18.8852	Waste	-138.462	33.9436	440.302	1137.18	1895.23	0	1895.23	2045.85	2045.85
38	14.1201	27636.8	19.3327	Waste	-138.462	33.9436	418.24	1080.2	1810.59	0	1810.59	1957.32	1957.32
39	14.1201	26272.8	19.7815	Waste	-138.462	33.9436	394.347	1018.49	1718.89	0	1718.89	1860.72	1860.72
40	14.1201	24794.1	20.2315	Waste	-138.462	33.9436	368.611	952.018	1620.14	0	1620.14	1755.99	1755.99
41	14.1201	23199.5	20.6829	Waste	-138.462	33.9436	341.031	880.788	1514.31	0	1514.31	1643.06	1643.06
42	14.1201	21488.2	21.1356	Waste	-138.462	33.9436	311.604	804.787	1401.4	0	1401.4	1521.86	1521.86
43	14.1201	19658.9	21.5897	Waste	-138.462	33.9436	280.325	724.002	1281.38	0	1281.38	1392.31	1392.31
44	14.1201	17710.7	22.0452	Waste	-138.462	33.9436	247.19	638.423	1154.23	0	1154.23	1254.33	1254.33
45	14.1201	15642.4	22.5021	Waste	-138.462	33.9436	212.193	548.035	1019.94	0	1019.94	1107.84	1107.84
46	14.1201	13452.7	22.9606	Waste	-138.462	33.9436	175.328	452.824	878.484	0	878.484	952.764	952.764
47	14.1201	11140.5	23.4207	Waste	400	0	154.875	400	721.918	0	721.918	789.005	789.005
48	14.1201	8704.54	23.8823	Waste	400	0	154.875	400	547.915	0	547.915	616.489	616.489
49	5.01674	2648.84	24.1959	interface	750	0	290.392	750	397.567	0	397.567	528.049	528.049
50	19.255	5083.31	24.5954	final cover soil	1000	0	387.189	1000	86.8334	0	86.8334	264.065	264.065

Global Minimum Query (janbu simplified) - Safety Factor: 2.56379

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [degrees]	Base Material	Base Cohesion [psf]	Base Friction Angle [degrees]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	21.1373	5580.25	3.47709	final cover soil	1000	0	390.048	1000	240.311	0	240.311	264.01	264.01
2	5.48733	2897.31	3.87654	interface	750	0	292.536	750	508.187	0	508.187	528.009	528.009
3	14.1201	8602.84	4.1709	Waste	400	0	156.019	400	597.889	0	597.889	609.266	609.266
4	14.1201	10849.4	4.59502	Waste	400	0	156.019	400	755.829	0	755.829	768.368	768.368
5	14.1201	12999.4	5.01939	Waste	-138.462	33.9436	183.46	470.352	904.521	0	904.521	920.634	920.634
6	14.1201	15052.6	5.44404	Waste	-138.462	33.9436	220.352	564.937	1045.05	0	1045.05	1066.05	1066.05
7	14.1201	17008.9	5.86899	Waste	-138.462	33.9436	255.347	654.657	1178.35	0	1178.35	1204.6	1204.6
8	14.1201	18868	6.29426	Waste	-138.462	33.9436	288.452	739.53	1304.44	0	1304.44	1336.26	1336.26
9	14.1201	20629.7	6.71988	Waste	-138.462	33.9436	319.672	819.571	1423.37	0	1423.37	1461.03	1461.03
10	14.1201	22293.7	7.14588	Waste	-138.462	33.9436	349.014	894.798	1535.12	0	1535.12	1578.88	1578.88
11	14.1201	23859.8	7.57227	Waste	-138.462	33.9436	376.481	965.218	1639.75	0	1639.75	1689.8	1689.8
12	14.1201	25327.7	7.99908	Waste	-138.462	33.9436	402.08	1030.85	1737.26	0	1737.26	1793.76	1793.76
13	14.1201	26697.2	8.42634	Waste	-138.462	33.9436	425.814	1091.7	1827.67	0	1827.67	1890.75	1890.75
14	14.1201	27967.8	8.85408	Waste	-138.462	33.9436	447.692	1147.79	1911	0	1911	1980.74	1980.74
15	14.1201	29139.2	9.28231	Waste	-138.462	33.9436	467.713	1199.12	1987.26	0	1987.26	2063.7	2063.7
16	14.1201	30211.2	9.71106	Waste	-138.462	33.9436	485.881	1245.7	2056.47	0	2056.47	2139.62	2139.62
17	14.1201	31183.2	10.1404	Waste	-138.462	33.9436	502.205	1287.55	2118.64	0	2118.64	2208.47	2208.47
18	14.1201	32055	10.5702	Waste	-138.462	33.9436	516.684	1324.67	2173.79	0	2173.79	2270.21	2270.21
19	14.1201	32826.1	11.0007	Waste	-138.462	33.9436	529.321	1357.07	2221.92	0	2221.92	2324.82	2324.82
20	14.1201	33496	11.4318	Waste	-138.462	33.9436	540.118	1384.75	2263.05	0	2263.05	2372.27	2372.27
21	14.1201	34064.4	11.8636	Waste	-138.462	33.9436	549.077	1407.72	2297.18	0	2297.18	2412.52	2412.52
22	14.1201	34530.8	12.2961	Waste	-138.462	33.9436	556.203	1425.99	2324.32	0	2324.32	2445.55	2445.55
23	14.1201	34894.5	12.7292	Waste	-138.462	33.9436	561.496	1439.56	2344.48	0	2344.48	2471.32	2471.32
24	14.1201	35155.2	13.1632	Waste	-138.462	33.9436	564.956	1448.43	2357.66	0	2357.66	2489.79	2489.79
25	14.1201	35312.3	13.5978	Waste	-138.462	33.9436	566.582	1452.6	2363.87	0	2363.87	2500.91	2500.91
26	14.1201	35365.3	14.0333	Waste	-138.462	33.9436	566.383	1452.09	2363.1	0	2363.1	2504.66	2504.66
27	14.1201	35313.5	14.4696	Waste	-138.462	33.9436	564.351	1446.88	2355.36	0	2355.36	2501	2501
28	14.1201	35156.3	14.9068	Waste	-138.462	33.9436	560.49	1436.98	2340.66	0	2340.66	2489.87	2489.87
29	14.1201	34893.1	15.3448	Waste	-138.462	33.9436	554.803	1422.4	2318.99	0	2318.99	2471.23	2471.23
30	14.1201	34523.2	15.7838	Waste	-138.462	33.9436	547.279	1403.11	2290.34	0	2290.34	2445.04	2445.04
31	14.1201	34046	16.2237	Waste	-138.462	33.9436	537.929	1379.14	2254.71	0	2254.71	2411.24	2411.24
32	14.1201	33460.8	16.6647	Waste	-138.462	33.9436	526.747	1350.47	2212.12	0	2212.12	2369.8	2369.8
33	14.1201	32766.8	17.1066	Waste	-138.462	33.9436	513.727	1317.09	2162.54	0	2162.54	2320.65	2320.65
34	14.1201	31963.2	17.5496	Waste	-138.462	33.9436	498.874	1279.01	2105.96	0	2105.96	2263.73	2263.73
35	14.1201	31049.2	17.9937	Waste	-138.462	33.9436	482.188	1236.23	2042.39	0	2042.39	2199	2199
36	14.1201	30024.1	18.4388	Waste	-138.462	33.9436	463.657	1188.72	1971.81	0	1971.81	2126.4	2126.4
37	14.1201	28886.9	18.8852	Waste	-138.462	33.9436	443.288	1136.5	1894.22	0	1894.22	2045.86	2045.86
38	14.1201	27636.8	19.3327	Waste	-138.462	33.9436	421.071	1079.54	1809.6	0	1809.6	1957.33	1957.33
39	14.1201	26272.8	19.7815	Waste	-138.462	33.9436	397.009	1017.85	1717.94	0	1717.94	1860.73	1860.73
40	14.1201	24794.1	20.2315	Waste	-138.462	33.9436	371.094	951.408	1619.23	0	1619.23	1756	1756
41	14.1201	23199.5	20.6829	Waste	-138.462	33.9436	343.323	880.208	1513.46	0	1513.46	1643.07	1643.07
42	14.1201	21488.2	21.1356	Waste	-138.462	33.9436	313.695	804.248	1400.6	0	1400.6	1521.87	1521.87
43	14.1201	19658.9	21.5897	Waste	-138.462	33.9436	282.203	723.508	1280.64	0	1280.64	1392.31	1392.31
44	14.1201	17710.7	22.0452	Waste	-138.462	33.9436	248.841	637.977	1153.57	0	1153.57	1254.33	1254.33
45	14.1201	15642.4	22.5021	Waste	-138.462	33.9436	213.607	547.644	1019.36	0	1019.36	1107.85	1107.85
46	14.1201	13452.7	22.9606	Waste	-138.462	33.9436	176.494	452.494	877.995	0	877.995	952.769	952.769
47	14.1201	11140.5	23.4207	Waste	400	0	156.019	400	721.431	0	721.431	789.013	789.013
48	14.1201	8704.54	23.8823	Waste	400	0	156.019	400	547.413	0	547.413	616.494	616.494
49	5.01674	2648.84	24.1959	interface	750	0	292.536	750	396.612	0	396.612	528.058	528.058
50	19.255	5083.31	24.5954	final cover soil	1000	0	390.048	1000	85.5371	0	85.5371	264.077	264.077

Interslice Data

Global Minimum Query (bishop simplified) - Safety Factor: 2.58272



Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	9.18358	7.29589	0	0	0
2	30.3209	8.58022	7872.28	0	0
3	35.8082	8.95206	9276.16	0	0
4	49.9283	9.98176	10846.5	0	0
5	64.0484	11.1166	12174.7	0	0
6	78.1685	12.3568	13623.8	0	0
7	92.2887	13.7025	15305.2	0	0
8	106.409	15.1539	17173.1	0	0
9	120.529	16.7114	19183.7	0	0
10	134.649	18.3751	21295.2	0	0
11	148.769	20.1453	23468.5	0	0
12	162.889	22.0224	25666.2	0	0
13	177.009	24.0066	27853.5	0	0
14	191.129	26.0983	29997.6	0	0
15	205.25	28.2978	32067.8	0	0
16	219.37	30.6056	34035.7	0	0
17	233.49	33.022	35875.1	0	0
18	247.61	35.5475	37562	0	0
19	261.73	38.1824	39074.4	0	0
20	275.85	40.9272	40392.8	0	0
21	289.97	43.7825	41499.6	0	0
22	304.09	46.7487	42379.6	0	0
23	318.21	49.8264	43019.8	0	0
24	332.33	53.0161	43409.5	0	0
25	346.451	56.3183	43540.1	0	0
26	360.571	59.7338	43405.3	0	0
27	374.691	63.263	43001.4	0	0
28	388.811	66.9068	42326.5	0	0
29	402.931	70.6656	41381.6	0	0
30	417.051	74.5403	40169.6	0	0
31	431.171	78.5316	38696.1	0	0
32	445.291	82.6402	36969	0	0
33	459.411	86.867	34998.9	0	0
34	473.532	91.2127	32798.5	0	0
35	487.652	95.6782	30383.6	0	0
36	501.772	100.264	27772	0	0
37	515.892	104.972	24984.6	0	0
38	530.012	109.802	22044.9	0	0
39	544.132	114.756	18979	0	0
40	558.252	119.835	15815.9	0	0
41	572.372	125.039	12587.6	0	0
42	586.492	130.369	9328.86	0	0
43	600.613	135.828	6077.51	0	0
44	614.733	141.416	2874.48	0	0
45	628.853	147.133	-236.149	0	0
46	642.973	152.983	-3207.04	0	0
47	657.093	158.965	-5987.53	0	0
48	671.213	165.081	-8217	0	0
49	685.333	171.333	-9456.49	0	0
50	690.35	173.587	-8896.39	0	0
51	709.605	182.401	0	0	0

Global Minimum Query (Janbu simplified) - Safety Factor: 2.56379

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [degrees]
1	9.18358	7.29589	0	0	0
2	30.3209	8.58022	7932.37	0	0
3	35.8082	8.95206	9347.96	0	0
4	49.9283	9.98176	10934.4	0	0
5	64.0484	11.1166	12278.7	0	0
6	78.1685	12.3568	13746.3	0	0
7	92.2887	13.7025	15450	0	0
8	106.409	15.1539	17343.7	0	0
9	120.529	16.7114	19383.3	0	0
10	134.649	18.3751	21527.1	0	0
11	148.769	20.1453	23735.6	0	0
12	162.889	22.0224	25971.3	0	0
13	177.009	24.0066	28199.1	0	0
14	191.129	26.0983	30386.1	0	0
15	205.25	28.2978	32501.5	0	0
16	219.37	30.6056	34516.7	0	0
17	233.49	33.022	36405.2	0	0
18	247.61	35.5475	38142.8	0	0
19	261.73	38.1824	39707.5	0	0
20	275.85	40.9272	41079.5	0	0
21	289.97	43.7825	42241.1	0	0
22	304.09	46.7487	43176.8	0	0
23	318.21	49.8264	43873.6	0	0
24	332.33	53.0161	44320.4	0	0
25	346.451	56.3183	44508.6	0	0
26	360.571	59.7338	44431.7	0	0
27	374.691	63.263	44085.7	0	0
28	388.811	66.9068	43468.6	0	0
29	402.931	70.6656	42581.2	0	0
30	417.051	74.5403	41426.3	0	0
31	431.171	78.5316	40009.3	0	0
32	445.291	82.6402	38337.8	0	0
33	459.411	86.867	36422.3	0	0
34	473.532	91.2127	34275.3	0	0
35	487.652	95.6782	31912.3	0	0
36	501.772	100.264	29351.2	0	0
37	515.892	104.972	26612.4	0	0
38	530.012	109.802	23719.3	0	0
39	544.132	114.756	20697.8	0	0
40	558.252	119.835	17576.8	0	0
41	572.372	125.039	14387.9	0	0
42	586.492	130.369	11165.8	0	0
43	600.613	135.828	7948.01	0	0
44	614.733	141.416	4775.32	0	0
45	628.853	147.133	1691.56	0	0
46	642.973	152.983	-1256.17	0	0
47	657.093	158.965	-4017.44	0	0
48	671.213	165.081	-6227.91	0	0
49	685.333	171.333	-7448.27	0	0
50	690.35	173.587	-6875.36	0	0
51	709.605	182.401	0	0	0

List Of Coordinates

External Boundary

X	Y
720	0
720	180
720	181
720	185
0	5
0	1
0	0

Material Boundary

X	Y
0	1
720	181

Material Boundary

X	Y
0	0
720	180

AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7
CLOSURE PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

500 Century Plaza Drive, Suite 190
Houston, Texas 77073
(281) 821-6868
Firm Registration Number F-2578

August 2005
Revision 1 – December 2005
Revision 2 – October 2006
Revision 3 – February 2008
Revision 4 – March 2008
Revised August 2016
Revised October 2017
Revised February 2018

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7
CLOSURE PLAN

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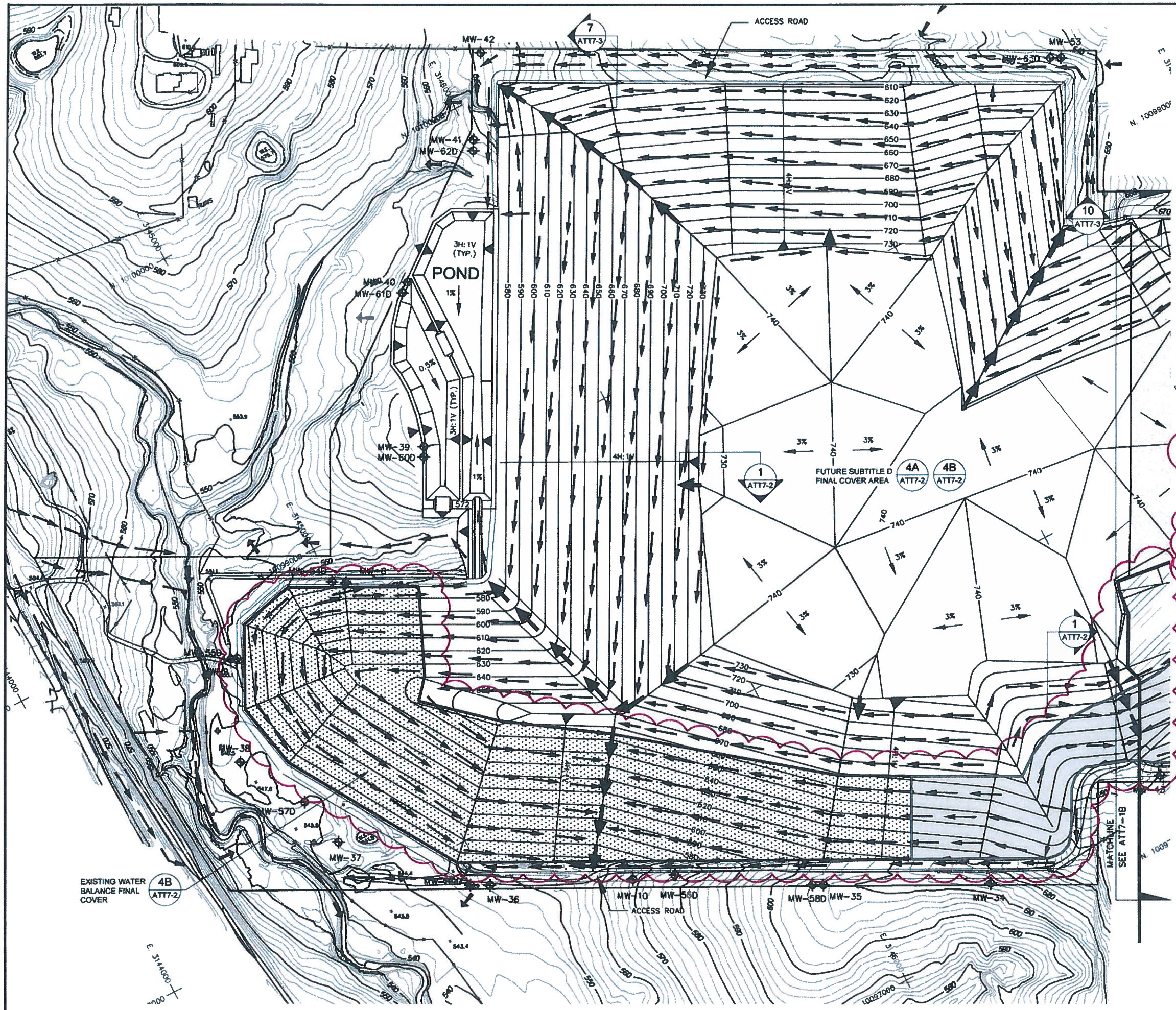
2.0 FINAL COVER

2.1 Final Cover Design

The final landfill contours and final cover details are provided on Figures ATT7-1A through ATT7-1C, ATT7-2, and ATT7-3. Landfill cross-sections are included as Figures ATT7-4 through ATT7-11. The final cap has side slopes ranging from 3 horizonal to 1 vertical (3H:1V) to 4H:1V to a maximum elevation of approximately 740 feet mean sea level (ft-msl). The upper portions of the final cover are sloped at a minimum 3-percent grade down to the crest of the 3H:1V or 4H:1V slopes to minimize erosion. The side slopes of the entire proposed expansion area will be 4H:1V with a short 3H:1V slope tying into the existing final cover crest. Add-on berms intercept runoff from the top surface and along the sideslopes of the cover and direct it to downchutes. These downchutes convey rainfall runoff down the sideslopes to the perimeter channels and detention ponds. Details of the surface water management features are included in Part III, Attachment 2.

The thickness and design of the final cover varies based on the design of the bottom liner. For existing disposal cells with no synthetic bottom liner (pre-Subtitle D cells), the final cover system is comprised of 18 inches of compacted earthen material with a coefficient of permeability (hydraulic conductivity) between 6.8×10^{-6} cm/sec and 8.1×10^{-6} cm/sec and 6 inches of soil capable of supporting native vegetation. For existing Subtitle D disposal cells with a synthetic bottom liner, the final cover system is comprised of 36 inches of compacted earthen material with a hydraulic conductivity of 1.0×10^{-7} cm/sec or less and 6 inches of soil capable of supporting native vegetation. The proposed final cover over existing pre-Subtitle D cells in the West Hill that have not yet been covered will be comprised of 18 inches of compacted earthen material with a coefficient of permeability (hydraulic conductivity) of 6.8×10^{-6} cm/sec or less and 6 inches of soil capable of supporting native vegetation. The final cover over existing and proposed Subtitle-D disposal cells in the expansion area of ~~and~~ the West Hill will (as shown on Figure ATT7-1B) consist of a water balance final cover or a composite system comprised of, from the bottom up; an infiltration layer of 18 inches of compacted earthen material with a hydraulic conductivity of 1×10^{-5} cm/sec or less; a 40-mil textured linear low density polyethylene (LLDPE) geomembrane that has a permeability less than or equal to the permeability of the bottom liner system; a geocomposite (geonet/geotextile) drainage layer; and an erosion layer consisting of 24 inches of protective soil cover, of which the uppermost 6 inches will be capable of supporting native vegetation. The LLDPE geomembrane and geocomposite may be replaced with an alternate material that incorporates both the geomembrane and drainage layer (e.g., Super Gripnet® by Agru America) provided material equivalency in terms of barrier and flow characteristics is demonstrated.

The water balance final cover will be comprised of a storage layer of ~~18~~ 20 inches thick (minimum) overlain by an erosion layer of 6 inches (minimum), in accordance with TCEQ Regulatory Guidance RG-494, Guidance for Requesting a Water Balance (WB) Alternative Final Cover for a Municipal Landfill, Revised March 2017. When using high plasticity clay (liquid limit >50) as the storage layer, the erosion layer will be increased to ~~one~~1-foot thick in accordance with Section 3 of RG-494. Hydraulic conductivity testing results of the storage layer soils may require a thicker storage layer in accordance with RG-494, as discussed in Appendix A, Section 5.2. The storage layer thickness ~~are~~ is determined from Table 3 in Section 10 of the RG-494 as follows:



LEGEND

- PERMIT BOUNDARY
- FENCE
- GRADE BREAKS
- 100-YEAR FLOODPLAIN
- MONITORING WELL
- GAS PROBE
- SURFACE WATER FLOW DIRECTION (CHANNELS/DITCHES/ADD-ON BERMS)
- SURFACE WATER DOWNCHUTE
- SURFACE WATER ENTRANCE OR DISCHARGE POINT
- STATE PLANE COORDINATE SYSTEM
- FINAL COVER ALREADY IN PLACE (AS OF AUGUST 2016)
- PIGGYBACK LINER AREA
- FUTURE PRE-SUBTITLE D FINAL COVER AREA
- 20-ACRE INTERMEDIATE COVER ALREADY IN PLACE (AS OF AUGUST 2017)

NOTES

1. TOP OF FINAL COVER GRADES ARE SHOWN ON THIS SHEET.
2. TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED FEBRUARY 26, 2006.
3. THE 100-YEAR FLOODPLAIN IS BASED ON THE CURRENTLY PROPOSED FEMA FLOODPLAIN AS WELL AS THE CURRENTLY PROPOSED CITY OF AUSTIN FLOODPLAIN. SEE PART I/II, APPENDIX B (FLOODPLAIN LOCATION RESTRICTION).
4. SEE PART III, ATTACHMENT 2 FOR DETAILS OF STORMWATER MANAGEMENT FEATURES.

150 0 150 300
scale feet

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REV	DATE	DESCRIPTION	BY	APP BY
9	02/18	WATER BALANCE FINAL COVER PM	TNB	JY
8	02/12	STORMWATER SYSTEM REVISIONS	RF	JY
7	04/08	APRIL 2008 REVISIONS	CEI	CGD
6	02/08	2008 REVISIONS	CEI	CGD
5	08/07	RESPONSE TO TECHNICAL MOD DATED JULY 2, 2007	CEI	LAL
4	05/07	RESPONSE TO TECHNICAL MOD DATED APRIL 3, 2007	CEI	LAL
3	10/06	CHAPTER 330 RULE REVISION UPDATE	CEI	LAL
2	03/06	RESPONSE TO SECOND TECHNICAL MOD	CEI	LAL

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WASTE MANAGEMENT

PROJECT: MUNICIPAL SOLID WASTE EXPANSION APPLICATION
PERMIT MSW-249D
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS

TITLE: FINAL CONTOUR MAP-WEST

DESIGN	CEI
DRAWN	RE/ME/MED
CHECKED	
APPROVED	
DATE	JUNE 2005
SCALE	AS SHOWN
JOB NO	033-4651
DWG NO	103945786010

FIGURE NUMBER

ATT7-1A

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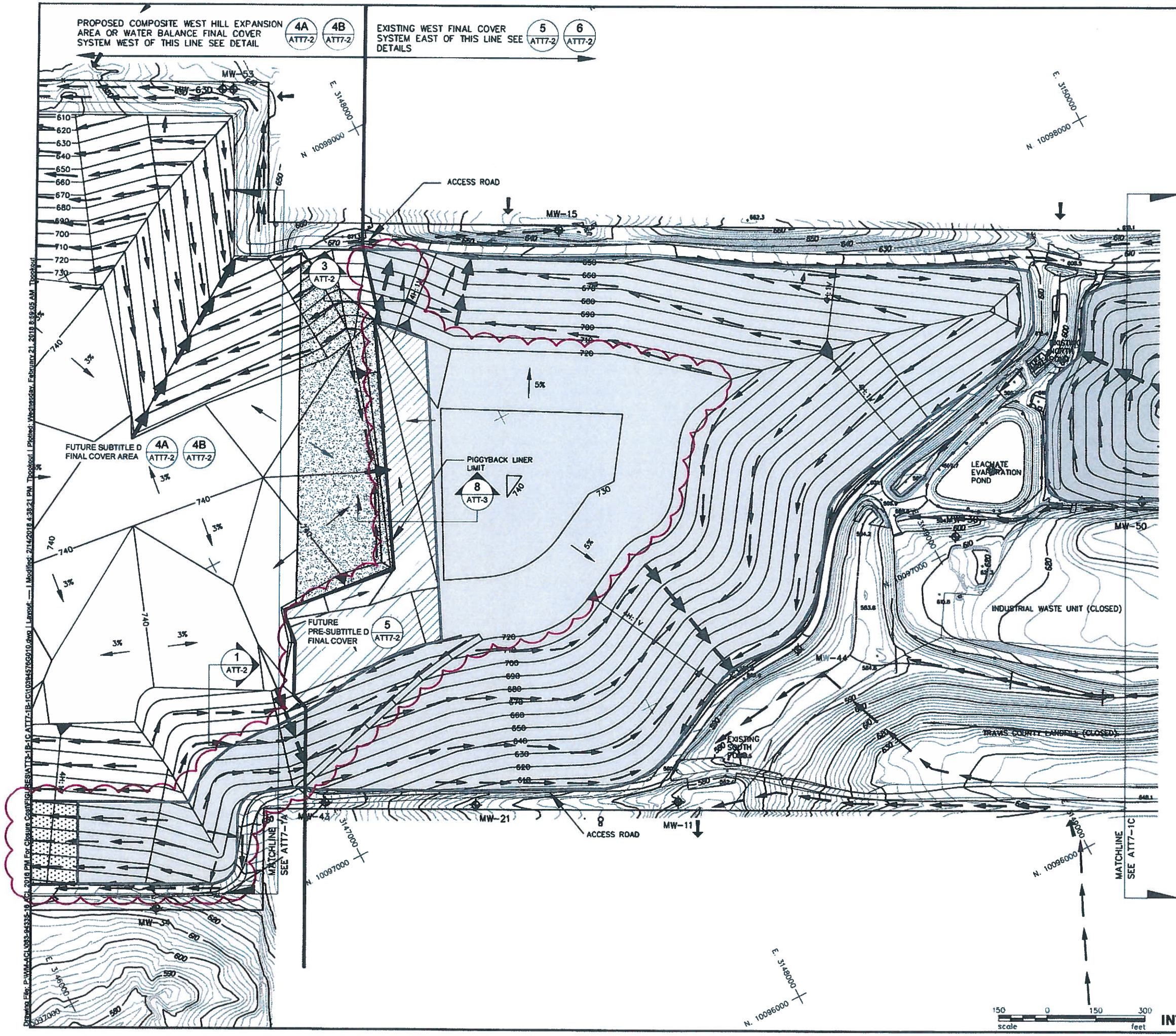

LEGEND

- PERMIT BOUNDARY
- FENCE
- GRADE BREAKS
- 100-YEAR FLOODPLAIN
- CLOSED UNIT BOUNDARY
- MONITORING WELL
- GAS PROBE
- SURFACE WATER FLOW DIRECTION (CHANNELS/DITCHES/ADD-ON BERMS)
- SURFACE WATER DOWNCHUTE
- SURFACE WATER ENTRANCE OR DISCHARGE POINT
- STATE PLANE COORDINATE SYSTEM
- FINAL COVER ALREADY IN PLACE (AS OF AUGUST 2016)
- PIGGYBACK LINER AREA
- FUTURE PRE-SUBTITLE D FINAL COVER AREA
- 20-ACRE INTERMEDIATE COVER ALREADY IN PLACE (AS OF AUGUST 2017)

NOTES

1. TOP OF FINAL COVER GRADES ARE SHOWN ON THIS SHEET.
2. TOPOGRAPHY COMPILED BY PHOTOGRAMMETRIC METHODS FROM AERIAL PHOTOGRAPHY DATED FEBRUARY 26, 2006.
3. THE 100-YEAR FLOODPLAIN IS BASED ON THE CURRENTLY PROPOSED FEMA FLOODPLAIN AS WELL AS THE CURRENTLY PROPOSED CITY OF AUSTIN FLOODPLAIN. SEE PART I/II, APPENDIX B (FLOODPLAIN LOCATION RESTRICTION).
4. SEE PART III, ATTACHMENT 2 FOR DETAILS OF STORMWATER MANAGEMENT FEATURES.
5. THE LIMITS OF THE INDUSTRIAL WASTE UNIT AND TRAVIS COUNTY LANDFILL ARE SHOWN AS APPROXIMATE.
6. GAS PROBE LAYOUT WAS REVISED BY TETRA TECH INC. JANUARY 2015.

REV	DATE	DESCRIPTION	DR BY	APP BY
11	02/18	WATER BALANCE FINAL COVER PM	TNB	MX
10	09/16	UPDATED THE EXISTING FINAL COVER AREA	TNB	MX
9	01/15	2015 GAS PROBE LAYOUT REVISIONS	ARM	JCM
8	02/12	STORMWATER SYSTEM REVISIONS	RF	JY
7	04/08	APRIL 2008 REVISIONS	CEI	CGD
6	02/08	2008 REVISIONS	CEI	CGD
5	08/07	RESPONSE TO TECHNICAL NOD DATED JULY 2, 2007	CEI	LAL
4	05/07	RESPONSE TO TECHNICAL NOD DATED APRIL 3, 2007	CEI	CGD
3	10/06	CHAPTER 330 RULE REVISION UPDATE	CEI	LAL

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WASTE MANAGEMENT

PROJECT: MUNICIPAL SOLID WASTE EXPANSION APPLICATION PERMIT MSW-249D
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS

TITLE: FINAL CONTOUR MAP-CENTRAL

DRAWN	CEI
REVIEWED	
CHECKED	
APPROVED	
DATE	JUNE 2005
SCALE	AS SHOWN
JOB NO	033-4651
DWG NO	10394576G010

FIGURE NUMBER

ATT7-1B

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TEXAS REGISTRATION F-2578

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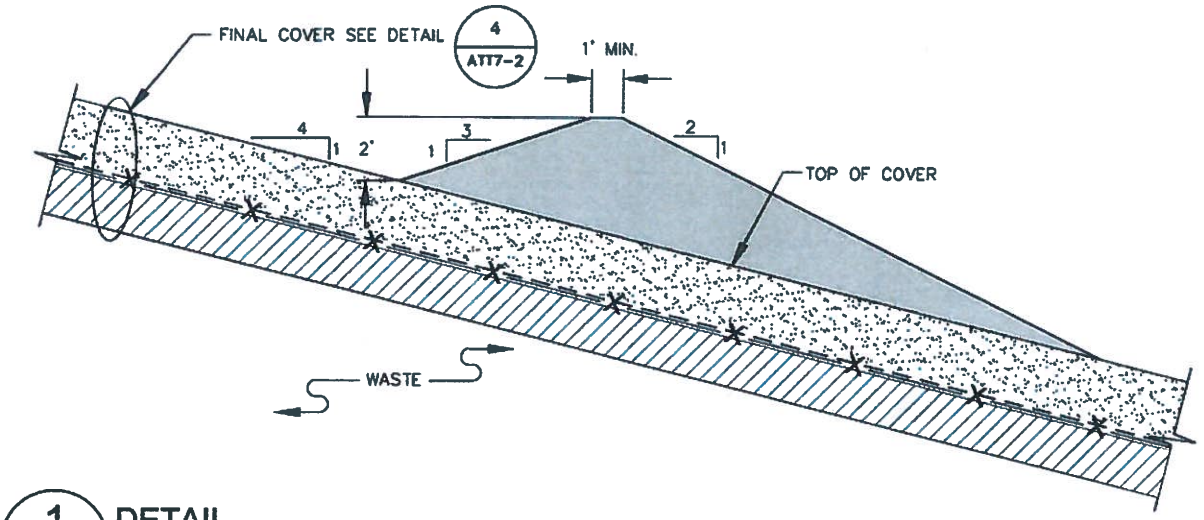

1 DETAIL
ATT7-1
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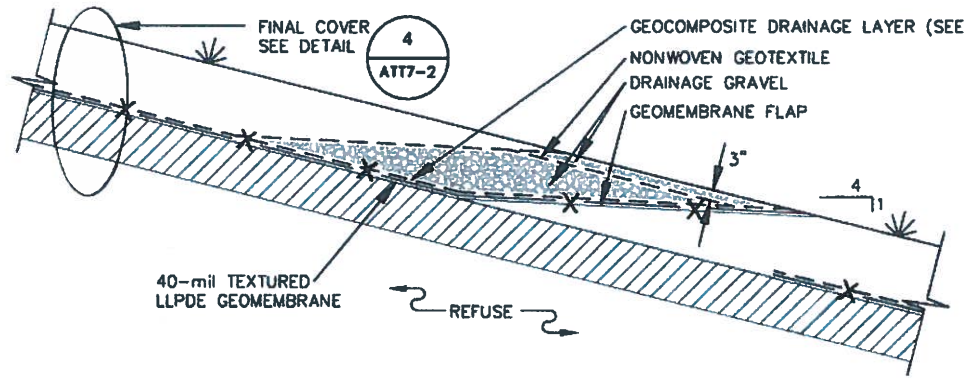

2 DETAIL
ATT7-2
GEOCOMPOSITE DAYLIGHT DRAINAGE

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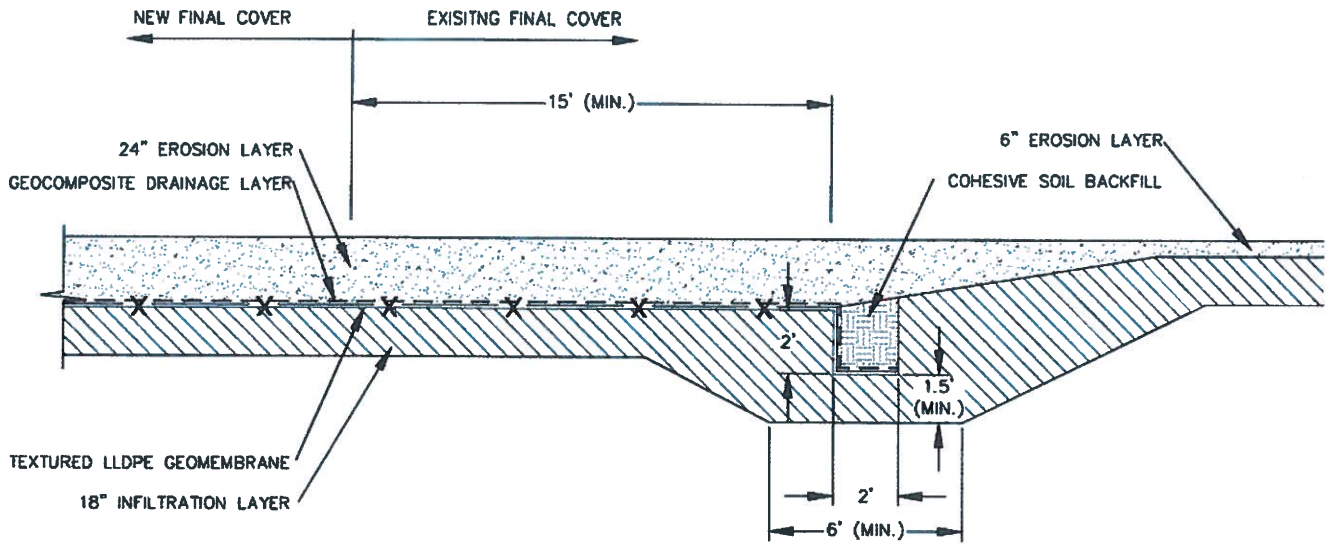

3 DETAIL
ATT7-1
TIE-IN BETWEEN SUBTITLE D AND PRE-SUBTITLE D FINAL COVER AT SIDESLOPES

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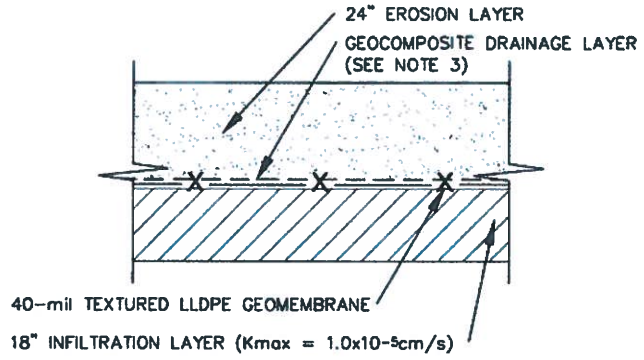

4A DETAIL
ATT7-1
FINAL COVER DETAIL

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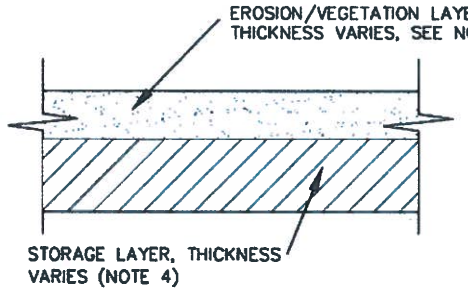

4B DETAIL
ATT7-1
WATER BALANCE ALTERNATIVE FINAL COVER

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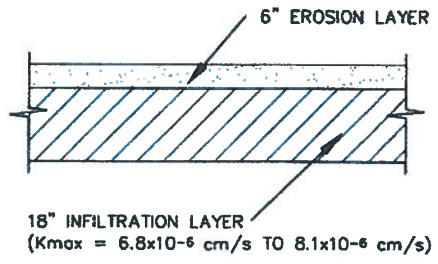

5 DETAIL
ATT7-1
EXISTING AND PROPOSED FINAL COVER PRE-SUBTITLE D

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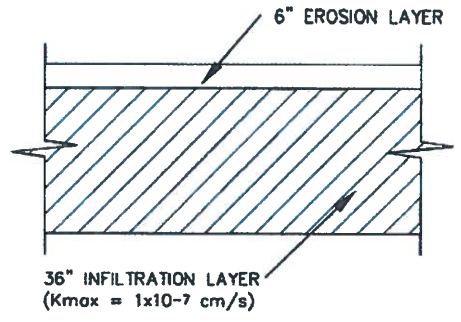
scale feet



6 DETAIL
ATT7-1
EXISTING FINAL COVER SUBTITLE D

2 0 2 4
scale feet

NOTES

1. GEOSYNTHETICS SHOWN EXAGGERATED FOR CLARITY.
2. SEE ATTACHMENT 2 FOR DETAILS OF STORMWATER MANAGEMENT FEATURES.
3. SEE ATTACHMENT 3, APPENDIX D FOR DESIGN OF THE GEOCOMPOSITE DRAINAGE LAYER.
4. THICKNESS AND PERMEABILITY OF THE WATER BALANCE COVER STORAGE LAYER AND EROSION LAYER MAY VARY. SEE SDP ATTACHMENT 7, APPENDIX A FOR GUIDANCE.

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REV.	DATE	DESCRIPTION	DR. BY	APP. BY
2	02/18	ADDED ALTERNATE DETAIL AND NOTE	TNB	REG
1	10/08	CHAPTER 330 RULE REVISION UPDATE	CB	LAL

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WASTE MANAGEMENT, INC.

PROJECT: MUNICIPAL SOLID WASTE EXPANSION APPLICATION
PERMIT MSW-249D
AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS

TITLE: FINAL COVER DETAILS I

DRAWN	ML
REVIEWED	
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APPROVED	
DATE	JUNE 2005
SCALE	AS SHOWN
JOB NO.	033-4651
DWG. NO.	033-4651-ATT7-2

FIGURE NUMBER

ATT7-2

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WASTE MANAGEMENT, INC.

AUSTIN COMMUNITY RECYCLING AND DISPOSAL FACILITY
AUSTIN, TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7, APPENDIX A
FINAL COVER QUALITY CONTROL PLAN

Prepared for:

Waste Management of Texas, Inc.

Prepared by:

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August 2005
Revision 1 – December 2005
Revision 2 – March 2006
Revision 3 – October 2006
Revised October 2017
Revised February 2018

AUSTIN COMMUNITY RECYCLING & DISPOSAL FACILITY
TRAVIS COUNTY, TEXAS
TCEQ PERMIT NO. MSW-249D

PERMIT AMENDMENT APPLICATION

PART III

ATTACHMENT 7, APPENDIX A
FINAL COVER QUALITY CONTROL PLAN

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Figure ATT7A-2 Fusion Weld Seam Break Classifications

In accordance with 30 TAC §330.457(a)(1) and 30 TAC §330.457(d), the ACRDF may choose to install an alternate final cover over portions of the Subtitle-D cells in the western and southwestern part of the expansion area and over the vertical expansion area of the West Hill. The alternate final cover would consist of a Water Balance (WB) Cover as described in the document "Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas" prepared by Miland V. Khier, Ph.D., P.E., dated August 4, 2016. The water balance cover consists of a layer of silty and clayey soils to store water and sustain vegetation until the water is removed by evapotranspiration. The thickness of this cover may vary in accordance with the TCEQ Guidance Document RG-494 dated March 2017 depending upon the soil properties used and the hydraulic conductivity of the constructed cover. TCEQ Guidance Document RG-494 ~~dated March 2017~~ provides for four options for the design and construction of water balance covers. The ACRDF will utilize Option 1 – Statewide Design Table for constructing water balance covers at the facility.

The owner/operator is responsible for fully implementing this FCQCP. The site manager (SM) or designated alternate will be responsible for contracting with a qualified independent quality assurance/quality control (QA/QC) professional prior to initiation of final cover construction. Each phase of the soil and geosynthetic evaluation shall be conducted by or under the supervision of the QA/QC Professional. The QA/QC Professional shall be an independent, licensed, professional engineer (P.E.) experienced in geotechnical engineering and soils testing.

A qualified engineering technician performing daily QA/QC observation and testing will be under the direct supervision of the QA/QC Professional. The engineering technician shall be NICET-certified at level 1 or higher, an engineering technician with a minimum of 2 years of directly related experience, a graduate engineer or geologist, or an engineering technician with other applicable certificates (e.g., Certified Engineering Technologist, CET) approved by the TCEQ.

Full-time quality assurance shall be provided by the QA/QC Professional or his/her qualified representative(s) as described in this plan. QA/QC documentation will be provided to the executive director, in accordance with Section 5.0 of this plan.

2.0 COHESIVE SOIL COVER EVALUATION

This section outlines generally acceptable construction practices and specifications and quality control testing requirements for cohesive soil cover used in the standard final cover. Construction practices for the ~~alternate~~ WB alternative final cover are presented in Section 5 of this FCQCP.

2.1 Preconstruction Material Evaluation

The first step in the construction of a cohesive soil cover is to pre-qualify the soil materials that are selected for final cover construction. Cohesive soil cover material may be obtained from in-situ soil strata which are typically stockpiled soils excavated as cells are constructed, or from a select borrow source. Representative samples from these sources shall be subject to the minimum preconstruction testing program shown in Table 7A.1.

Only the geocomposite should be placed in direct contact with the geomembrane. Light equipment such as low ground pressure dozers (less than 5 pounds per square inch contact pressure) shall be used to place the soil cover and a minimum of 12 inches of material shall be maintained between the dozer and the underlying geosynthetics. If possible, cover should be placed during the coolest weather available. Soil cover material shall be deployed in "fingers" along the geosynthetics to control the amount of slack and minimize wrinkles and prevent folds. Soil cover shall generally be placed in an up-slope direction on sideslopes.

The soil cover material shall consist of soils that are classified as SCS Hydrologic Soil Groups (HSG) A, B, or C. These soils have infiltration rates ranging approximately 0.05 inches/hour (3.5×10^{-5} cm/sec) to greater than 0.30 inches/hour (2.1×10^{-4} cm/sec), according to the Soil Conservation Service publication TR-55 (June 1986). Compaction of the soil cover material can affect the HSG, making a soil in a particular soil group less pervious and thus make it behave as another soil group. Because low ground pressure equipment will be used, compaction of the soil will be minimal.

Geosynthetic Cover System

The final thickness of the protective/erosion layer shall be a minimum of 24 inches directly above the geocomposite drainage layer. The required thickness of the layer shall be verified by survey techniques on an established grid system with not less than one verification point per 10,000 square feet of surface area. A minimum of two verification points is required.

The soil used as the soil cover layer will be capable of sustaining native plant growth and must be seeded or sodded immediately after completion of the final cover (weather permitting). Temporary or permanent erosion control materials (i.e. mulches, containment meshes, geomatting systems, etc.) may be used to minimize erosion and aid establishment of vegetation. An alternative erosion layer may also be constructed (subject of the approval of TCEQ) consisting of cobbles, riprap, or other hard armor systems for areas in which the establishment of vegetation cover has proven difficult.

Other quality assurance for the soil cover layer should consist of continuous observation by the QA/QC Professional or his representative during construction; inspection of any manufacturer's or supplier's material test data and certification; and performing any additional test believed necessary by the QA/QC Professional to verify that the layer has been constructed in accordance with the closure plan.

5.0 ~~Alternate~~ Water Balance Alternative Cover System

The purpose of these guidelines is to establish an approach for placement and compaction during construction of the WB final cover at the Austin Community Landfill that will meet the required standards presented in "~~Geoclimatic Design of Water Balance Covers for Municipal Solid Waste Landfills in Texas (Khire, 2016)~~TCEQ Guidance Document RG-494 dated March 2017.

5.1 Preconstruction Testing and Test Pad Construction

The goal of the preconstruction testing is to characterize the borrow soils and to define the "acceptance window" for each type of soil. The acceptance window is the range of unit weight/water content combinations that have been shown to produce a $k \leq 1 \times 10^{-7}$ cm/s in the 6-inch diameter remolded permeability samples, without falling above the line-of-optimums.

3. The QA/QC monitor will perform a minimum of 4 in-place moisture-density tests using a nuclear density gauge. If the water content/density falls within the acceptance window move to Step 4, otherwise compact the soil until passing results are obtained.
4. The QA/QC monitor will obtain bag samples from each in-place moisture-density test on the completed lift for water content testing in the lab.
5. The QA/QC monitor will obtain a 3 inch diameter Shelby tube sample from the completed lift.

The tube samples from each lift should be tested for the following:

- Water content
- Dry unit weight
- Atterberg limits
- Hydraulic conductivity

Once it has been determined that the construction practices and soil testing will provide a compacted clay cover with a $k \leq 1 \times 10^{-7}$ cm/s, construction of the WB cover may begin.

5.2 WB Cover Construction and Testing

Construction of the WB final cover must proceed in the same manner as the test pad construction or as determined in previous construction at the facility. The soil shall be spread in loose lift thickness of 10-inches of less. Compaction will be in accordance with the procedures identified either through previous construction or in test pad construction that produced a $k \leq 1 \times 10^{-7}$ cm/s.

The total thickness of the WB final cover may vary based upon the permeability of the constructed cover. The final cover thickness will be determined as follows:

- First, initial preconstruction testing data of the borrow source soil will be used to determine the target permeability and the thickness of the WB cover, based on TCEQ Guidance Document RG-494 (March 2017), Table 3.
- Second, during cover construction, soil samples of the as-built final cover will be taken and tested for hydraulic conductivity as described in Section 5.3. Hydraulic conductivity results of the as-built final cover samples will be used to verify that the geometric mean of the samples is no greater than the target hydraulic conductivity used to set the final cover thickness in accordance with TCEQ Guidance Document RG-494 (March 2017), Table 3. For areas exceeding the target hydraulic conductivity, additional compaction and re-testing will be performed to ensure that the geometric mean meets the target hydraulic conductivity.
- Last, the final cover thickness may be adjusted, as needed, based on the results of the preconstruction soil samples taken throughout the construction process and in accordance with TCEQ Guidance Document RG-494 (March 2017), Table 3. In no case will the thickness be decreased from the thickness determined in the preconstruction testing.
- Should the preconstruction testing indicate an increase to the final cover thickness is required, the subgrade shall be adjusted based on the thickness of the WB cover. For all WB cover constructions, the permitted top of final cover grades will be maintained per the TCEQ permitted final grading plan to ensure proper drainage and transition between existing and new final cover areas. The final top of waste grades will be at or below the permitted final elevation once the cover is installed. In no case will the increase in the thickness of the WB cover or the erosion layer raise the final surface of the cover above the permitted design elevations.

TCEQ Guidance Document RG-494 (March 2017), Table 3 provides the following guidance for WB cover thickness in the Austin area:

K (as-built), cm/sec	Minimum Storage Layer Thickness
1×10^{-8}	1 ft 8 in
5×10^{-8}	2 ft 7 in
1×10^{-7}	3 ft 11 in

5.3 Construction Testing

The goal of the construction testing is to demonstrate that the soil is being compacted within the acceptance window and that the in-place soil has a k that is at or less than ~~≤ 1 x 10^{-7} cm/s~~the target value determined during preconstruction testing (if less ≤ 1 x 10^{-7} cm/s). Both water content and unit weight will be determined in the field using the nuclear density gauge and in the lab using 3-inch diameter Shelby tubes. Minimum testing frequencies are presented below:

Construction Testing

Test	Method	Minimum Frequency
Field Moisture/Density Test(1)	ASTM D6938	1 per 8,000 ft^2, per 6-inch lift
Water Content	ASTM D2216	As needed to calibrate nuclear gauge. Use 60°C oven.
Percent Fines	ASTM D1140	1 per 100,000 ft^2, per 6-inch lift ~~(~ 1/2000 cy or 9 per lift)~~
Atterberg Limits	ASTM D4318	
Hydraulic Conductivity(1)	ASTM D5084	1 per 2.5 acres of cover per lift evenly distributed through all lifts ~~(~ 1/2,000 cy or 8 per lift)~~

Notes: (1) Increase cell pressure as necessary to control swell during saturation. Once saturation (B-value) reaches 95%, reduce effective confining pressure to 4 psi.

Key items:

- 90% of both the field and lab values must plot within the acceptance window.
- The geometric mean of the k values must be ≤ ~~1.0 x 10^{-7} cm/s~~the target permeability determined during preconstruction testing. The geometric mean is determined as the nth root of the product of n numbers.

$$\left(\prod_{i=1}^{n} x_i\right)^{\frac{1}{n}} = \sqrt[n]{x_1 x_2 \cdots x_n}.$$

For example: for 3 k-values the geometric mean is $(X_1 \cdot X_2 \cdot X_3)^{0.333}$.

5.4 Protective Cover Soil