Volume 4
Part III Landfill Permit Amendment
Site Development Plan
TCEQ MSW Permit No. 1522B

Volume 4 of 5

prepared for

City of Victoria, Texas
City of Victoria Landfill Lateral and Vertical Expansion
Victoria County, Texas

STATE OF TEXAS
SCOTT MARTIN
120819
LICENSED
PROFESSIONAL ENGINEER

Scott Martin
4/5/2022

prepared by

Burns & McDonnell Engineering Company, Inc.
8911 N Capital of Texas Hwy, Building 3, Suite 3100
Austin, Texas 78759
Texas Firm Registration No. F-845

City of Victoria, Texas
Part III Landfill Permit Amendment
Site Development Plan
TCEQ MSW Permit No. 1522B

Volume 4 of 5

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Notes

The professional engineering seal included on this page applies only for this Table of Contents and is for permitting purposes only.

The responsible engineer has signed, sealed, and dated applicable engineering documents within the application as required by the Texas Engineering Practice Act.

The responsible geoscientist has signed, sealed, and dated applicable documents within the application as required by the Texas Geoscientist Practice Act

Certification

I hereby certify, as a Professional Engineer in the state of Texas, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the City of Victoria, Texas or others without specific verification or adaptation by the Engineer.

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ATTACHMENT 7 – SLOPE STABILITY AND SETTLEMENT ANALYSIS

Introduction

This project involves the permitting and design of a new cell and partial piggyback of the existing cell at the Victoria, Texas municipal solid waste (MSW) landfill near Victoria, Texas. The new cell is located south of the existing cell. The new portion of landfill has a geosynethic liner system and side slopes that are 3H:1V. The piggyback over the existing landfill is over an eastern portion of the existing cell and increases the crest height approximately 40 feet from existing permitted geometry. The final side slope crest elevation will be 160 feet and the landfill crest elevation will be 180 feet.

This packet contains slope stability, settlement evaluations and cover stability for both the new cell and piggyback portion of the existing cell.

Subsurface Information

As part of work at the site, 8 borings were drilled. Six of these borings were within the footprint of the future cell and two borings were located to the north of the existing landfill cell. All borings were drilled to a depth of 50 feet below ground surface. Standard Penetration Test (SPT) and Shelby tube samples were obtained. Shelby tube samples were obtained at depths based on materials encountered and observations made by the on-site Burns & McDonnell (BMcD) Geotechnical Engineer. Laboratory testing was assigned by BMcD Geotech and included index testing, unconsolidated undrained triaxial testing, consolidation and direct shear strength testing.

Upper subsurface materials were made up mainly of high plasticity clays. Beneath the high plasticity clays were sandy high plasticity and low plasticity clays, with some intermittent layers of clayey sands or poorly graded sands. Different material types were controlled by the varying sand to fines ratio. Underlying these soils and down to termination depth were poorly graded sands with some locations being clayey sands. These material types were also controlled by variations in the sand to fines ratio.

The upper high plasticity clays are stiff to very stiff consistency based on SPT blow counts and pocket penetrometer readings. The sandy high plasticity and low plasticity clays are very stiff to hard consistency based on SPT blow counts and pocket penetrometer readings. Poorly graded sands and clayey sands are very dense based on SPT blow counts.

For the purposes of design and based on reviewing laboratory testing results, the following soil design groups will be used for the evaluations:

- Fat Clay
- Sandy Fat Clay
- Sandy Lean Clay
- Clayey Sand
- Poorly Graded Sand

Groundwater was encountered during drilling of borings between depths of 31 to 38 feet below ground surface. This corresponds to elevations between 22 and 30 feet. In reviewing previous groundwater monitoring data from groundwater wells installed in 2019, groundwater was measured between elevations 25 and 33 feet with an average of 30 feet.

A plan view with borings, boring fence diagram, SPT blow counts and laboratory testing results are included in Attachment A.

Soil Design Parameters

For determining soil design parameters, laboratory results and published correlations were reviewed. Laboratory results were given precedence over published correlations when both were available. Discussions for each design parameter and how they were determined are below.

Unit Weight

For cohesive soil groups, densities were based on measured values from the strength and consolidation testing performed. For sand materials, densities were based on blow counts and the correlation shown in Table 3-1 of the *United States Army Corps of Engineer (USACE) EM 1110-2-2504, Design of Sheet Pile Walls*.

Undrained Strength

Unconsolidated undrained triaxial tests (ASTM D2850) were performed on three Fat Clay samples and on four Sandy Fat Clay samples. Four of the samples tested were in the upper 10 feet of the borings and the other three tested were between 10 and 20 feet.

In plotting up these values, there was a distinction between the undrained cohesion for the samples in the upper 10 feet and then the samples between 10 and 20 feet below ground surface. It is likely that there is some effect from overconsolidation and desiccation of these upper materials from long-term drying cycles that are common in Texas, with previous experience encountering typical active zones greater than 10 feet in the vicinity of this project. Based on this, the design undrained cohesion values were applied to both the Fat Clay and Sandy Fat Clay soils, with the value from 0 to 10 feet being 3,000 psf and below 10 feet being 2,000 psf.

For the Sandy Lean Clay layer encountered below 20 feet below ground surface, no triaxial testing was performed. Therefore, SPT blow counts were used to estimate cohesion for this soil. The correlation values in Table 3-4 in *USACE EM 1110-2-2504* were reviewed. Based on the average blow count, an undrained cohesion of 4,000 psf was used for the Sandy Lean Clay.

Drained Strength

To determine drained shear strength, direct shear tests (ASTM D3080) performed on cohesive soils and correlated values from blow counts for cohesionless soils were considered. The results will be discussed separately below.

Direct shear testing was performed on Fat Clay, Sandy Fat Clay and Sandy Lean Clay samples. Based on observations made during drilling and reviewing the laboratory testing data, these different layers are representative of the variations in the ratio of fine and sand content. Additionally, during the initial review of each direct shear test, there was a significant variation in the results for similar soils that indicates the variability of the soil types between similar samples and even within samples.
Although variations were found to be present, grouping of the direct shear testing results was performed into three discrete soil layers mentioned above by plotting normal stresses and shear stresses from each

sample tested. Fat Clay and Sandy Fat Clay results were grouped together. Sandy Lean Clay results were the second group. For determining drained shear strength parameters of these soils, a trendline for each grouping was determined.

For the Fat Clay and Sandy Fat Clay grouping, a friction angle of 19 degrees and a cohesion of 466 psf were determined. This relationship has a coefficient of variation of 16% for all the data points, which indicates a moderate fit between the drained shear strength envelope and all the measured data.

For the Sandy Lean Clay grouping, a friction angle of 23.7 degrees and a cohesion of 683 psf were determined. This relationship has a coefficient of variation of 9% for all the data points, which indicates a good fit between the drained shear strength envelope and all the measured data.

For Clayey Sand and Poorly Graded Sands, blow counts were used to estimate the drained friction angles of the soils. The correlated values in Table 3-1 of *USACE EM 1110-2-2504* were reviewed. Based on a median SPT blow count of greater than 50 blow per foot, a drained friction angle of 38 degrees was determined for the Clayey Sands and Poorly Graded Sands.

Consolidation
Two consolidation tests (ASTM D2435) were performed, one on Fat Clay and the other on Sandy Fat Clay. Measured consolidation parameters ranged as noted below:

- Consolidation Index: 0.19 (Sandy Fat Clay) to 0.25 (Fat Clay)
- Reconsolidation index: 0.02 (Fat Clay) to 0.024 (Sandy Fat Clay)
- P'c: 2.3 tsf (Sandy Fat Clay) to 3.0 tsf (Fat Clay)

For Fat Clays, the results from the consolidation test on the Fat Clay soil will apply. For Sandy Fat Clays and Sandy Lean Clays, the results from the consolidation test on Sandy Fat Clay soils will apply.

Modulus
Modulus values for the Sandy Clay and Poorly Graded Sand soils are needed to estimate settlements. Modulus values were determined based on SPT blow counts and correlated values. Both soils have median SPT blow counts greater than 50 blows per foot, indicating very dense consistencies. Table 5-5 of the *EPRI Manual on Estimating Soil Properties for Foundation Design* was utilized to determine the drained modulus of sands. It recommends a Modulus to Atmospheric Pressure ratio between 500 and 1,000 for dense sands. Ratios of 750 and 1,000 will be used for Clayey Sands and Poorly Graded Sands, respectively. A lower value for Clayey Sands will be used because of the higher fines content in this material. These ratios corresponded to modulus values of 1,500 ksf and 2,000 ksf for Clayey Sands and Poorly Graded Sands, respectively.

MSW
Design parameters for MSW were determined based off published shear strength parameters and estimated densities based on previous information at the landfill. The paper by Diaz-Beltran, Iguaran-Fernandez, Larrahondo and Jaramillo entitled *Shear Strength of Municipal Solid Waste (MSW): Beyond the Raw Values of "Cohesion" and Friction Angles* provides a detailed review of available literature on

measurements of shear strength of MSW. There is a significant variation in the cohesion and friction angle values measured by different researchers, with no apparent correlation between the parameters (i.e. higher cohesion does not correlate with higher friction angles). Based on this paper, the most frequently measured shear strength parameters are 300 to 600 psf for cohesion and 30 degrees for friction angle. Based on this, a cohesion of 300 psf and a friction angle of 30 degrees were used for MSW shear strength parameters. Previous measurements of MSW at the site indicated a MSW unit weight of approximately 1,500 pounds per cubic yard. Based on this, a design unit weight of 60 pounds per cubic foot for MSW was used. **Design Parameters:**

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Material	Design N_{60} (blows/ft)	Unit Weight (pcf)	Undrained Cohesion (psf)	Friction Angle (deg)	Drained Cohesion (psf)
Fat Clay	15	115	3000 - 0 to 10 feet, 2000 - below 10 feet	19	450
Fat Clay with Sand	25	120		19	450
Sandy Lean Clay	35	125	4000	23.7	675
Clayey Sand	50	130		38	0
Poorly Graded Sand	50	130		38	0
MSW		60		30	300

Material	Cc	Cr	p'c (ksf)	eo	E (ksf)
Fat Clay	0.194	0.02	6	0.897	
Fat Clay with Sand	0.25	0.024	4.6	0.715	
Sandy Lean Clay					
Clayey Sand					1500
Poorly Graded Sand					2000

References, strength testing and consolidation results and the MSW shear strength reference are included in Attachment B.

Geosynthetic Design Parameters

Geosynthetic materials will be utilized as part of the base liner and will be considered as part of an alterative cover design. They also have been utilized for the base liner system in the existing cell. Interface shear strengths of geosynthetics for the base liner and cover can control slope stability and require special evaluation. Note that the existing permitted cover system is a soil only system and does not require an interface evaluation.

For the base liner of the existing cell, the system is made up of the following materials, from top to bottom:

- 24 inches of protective cover soil (assumed cohesive),
- Leachate Collection System
  - Granular drainage material with geotextile fabric on top
- 60-mil HDPE Smooth Geomembrane
- Clay subgrade

For the base liner of the new cell, the system will be made up of the following materials, from top to bottom:

- 24 inches of protective cover soil (assumed cohesive),
- Leachate Collection System
  - Geocomposite
- 60-mil HDPE Textured Geomembrane
- Needle punched GCL encased with an underlying textured 60-mil geomembrane (in leachate sumps only)
- Clay subgrade

For the cover system, two alternatives were considered that contain geosynthetics. The proposed cover system with noted alternatives is made up of the following materials, from top to bottom:

- 12 inches of cover soil,
- Drainage Layer
  - Geocomposite
- 40-mil LLDPE Textured Geomembrane
- 18 inches of Compacted Clay

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To estimate these different interface strengths, published values in the *GRI Report #30* were reviewed. For each interface, both peak and residual strengths will be noted. Base liner interfaces and strengths for the existing and new cells will be noted separately. The interface information for the existing cell base liner are noted below:

Table 1. Existing Cell Base Liner Interfaces and Strengths

	Peak		Residual	
Interface	Friction Angle (deg)	Cohesion (psf)	Friction Angle (deg)	Cohesion (psf)
Cover Material – Geotextile	30	100	21	0
Geotextile – Granular Drainage Material	33	0	33	0
Granular Material – Geomembrane (smooth)	21	0	17	0
Geomembrane (smooth) – Compacted Clay	11	280	11	0

The interface information for the new cell base liner are noted below:

Table 2. New Cell Base Liner Interfaces and Strengths

	Peak		Residual	
Interface	Friction Angle (deg)	Cohesion (psf)	Friction Angle (deg)	Cohesion (psf)
Cover Material – Geocomposite	30	100	21	0
Geocomposite – Geomembrane (textured)	25	160	17	0
Geomembrane (textured) – GCL	23	160	13	0
GCL Internal (needle punched)	16	760	6	120
Geomembrane (textured) – Compacted Clay	18	200	16	0

For the cover system, the geomembrane is assumed to be textured given the side slopes and lengths of slopes. Estimated interface information for the cover system are listed below:

Table 3. New and Existing Cells Cover Interfaces and Strengths

	Peak		Residual	
Interface	Friction Angle (deg)	Cohesion (psf)	Friction Angle (deg)	Cohesion (psf)
Cover Material – Geocomposite	30	100	21	0
Geocomposite – Geomembrane (textured)	26	160	17	190
Granular Material – Geomembrane (textured)	34	0	31	0
Geomembrane (textured) – Compacted Clay	21	220	13	140

For determining the controlling strength for the base liner, the interface shear strength for every interface was calculated for a range of effective stresses. This was done because different interfaces control for different effective stress ranges. Based on this evaluation, the following design strength envelope was determined for the existing cell base liner:

Table 4. Existing Cell Base Liner Design Strength Envelope

Peak		Residual	
Effective Stress (psf)	Interface Shear Strength (psf)	Effective Stress (psf)	Interface Shear Strength (psf)
0	0	0	0
1500	572	10000	1944
10000	2224		

The following design strength envelope was determined for the new cell base liner:

Table 5. New Cell Base Liner Design Strength Envelope

Peak		Residual	
Effective Stress (psf)	Interface Shear Strength (psf)	Effective Stress (psf)	Interface Shear Strength (psf)
0	100	0	0
500	363	1000	225
10000	3449	10000	1171

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For the cover system, all interface strength values will be evaluated using the parameters listed in Table 3. Excerpt from the *GRI Report #30* and base liner strength determinations are included are included in Attachment C.

Sections

Sections were drawn across the area of the new cell. Section B was drawn across the new cell only and Section D was drawn across the new call and piggyback area of the existing landfill cell. Section information is included in Attachment D.

For the new cell, the base liner has a slope of 0.5% for the center portion of the cell and 1.0% on the sump side of the cell on the south side of the cell. Based on this, the south slope of the new cell is the controlling slope. Final landfill side slopes were specified as 3H:1V with a crest elevation of 160 feet. Above this point, the top slope decreases to 5% with a maximum top of landfill elevation of 180 feet.

For the piggyback area, the base liner has a slope of 0.5% for the center portion of the cell and 1.0% on the sump side on the north side of the existing cell. The existing permitted slope is 4H:1V. This slope will be extended up in the piggyback area to match the new permitted geometry. The top of landfill elevations are the same as those noted for the new cell.

Different subsurface conditions represented by the different borings were then evaluated. Subsurface conditions with the maximum Fat Clay, Sandy Fat Clay and Sandy Lean Clay soils were determined to be controlling as they represent the lowest strength materials, especially for drained shear strengths. Given the excavation that will occur to reach design base liner elevations, much of these materials will be removed beneath the landfill. It was determined that using borings B-4 and B-5 to determine the subsurface conditions along Section B would provide the controlling subsurface conditions.

For the piggyback area on top of the existing landfill, Section D was drawn given the relatively limited width of the piggyback. For subsurface conditions, B-2 was considered for the north portion of the existing cell given the proximity of this boring to the piggyback. For the southern portion of subsurface conditions, B-5 and B-7 were compared with B-5 being determined to have controlling conditions.

Slope Stability

Slope stability calculations were performed for Sections B and D using UTexas4. Calculations were performed for the following conditions:

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- End of Construction (EOC) – Undrained strength (cohesion) for cohesive soils, full MSW height
- Long-term Steady State 1 (LTSS-1) – Effective Shear Strength envelope for all soils, full MSW height
- Long-term Steady State 2 (LTSS-2) – Noncircular Surface Through Liner, Effective Shear Strength envelope for all soils, Peak and residual liner strengths, full MSW height

For the EOC case, the cohesion values determined based on the undrained unconsolidated triaxial testing were used for modeling the Fat Clay, Sandy Fat Clay and Sandy Lean Clay. These tests were performed on materials that were only consolidated under the existing soil conditions at the time of the investigations. During placement of the MSW, the materials will be loaded in an undrained manner as layers of MSW are placed. After placement of each layer, dissipation of excess pore pressures will occur, increasing the effective stress increases in these soils, thus increasing the undrained shear strengths of these material. Based on this, using the in-situ undrained cohesion under full MSW landfill loading, essentially assuming the MSW is placed instantaneously, is a conservative design assumption.

For the LTSS–2 case, the stability factor of safety was controlled by the interface shear strength of the base liner. As noted, the existing and new cell base liners vary, with each having a separate interface strength envelope. The existing cell base liner interface strength envelope was used for Section E and the new cell base liner interface strength envelope was used for Section B.

Base liner evaluations will consider both peak shear strength and residual shear strength. Residual shear strengths can be caused by settlement induced liner movement or strain compatibility of the MSW shear strength (peak strength developed at high strains) and the liner system (peak strength developed at low strains).

The 2014 USGS Deaggregation online program was utilized for determining the design seismic event peak ground acceleration. For a Site Class B/C, which represents acceleration on bedrock, the bedrock acceleration is 0.028g. Given this low acceleration, evaluating seismic stability was not considered necessary and was not performed.

For the EOC and LTSS-1 cases, a "floating grid" search method was used for calculating the stability factor of safety. This method involves setting a gridded location of circular centers and then choosing a point along the surface to run all the circular surfaces through. UTexas4 will then cycle through all the circles based on the different circular centers. Multiple points along the surface were evaluated to determine the lowest factor of safety.

For the LTSS-2 case, noncircular surfaces are evaluated. Since this case is to evaluate surfaces along the liner interface, the surface must stay within the base liner system. This requires a noncircular surface.

Multiple different points along the slope surface and base liner were evaluated to determine the controlling factor of safety. Results of the slope stability analyses are listed below:

Table 6. Slope Stability Factors of Safety

Section	Case	Factor of Safety
Section B	EOC	2.60
	LTSS – 1	2.57
	LTSS – 2 – Peak Textured	2.28
	LTSS – 2 – Residual Textured	1.41
Section D	EOC	3.22
	LTSS – 1	3.22
	LTSS – 2 – Peak Smooth	2.18
	LTSS – 2 – Residual Smooth	1.87

No direct guidance for slope stability factors of safety is included in Texas DEQ regulations for MSW landfill. Therefore, generally accepted minimum factors of safety for slope stability were relied upon and are listed below:

- EOC – 1.3
- LTSS-1 and LTSS-2 peak liner strength – 1.5
- LTSS-2 residual liner strength – 1.0

Factors of safety for EOC and LTSS cases are based off generally accepted values for slope stability evaluations of MSW landfills. For LTSS-2 with residual liner strength, the paper by Stark and Poeppel entitled *Landfill Liner Interface Strengths from Torsional-Ring-Shear Tests* was reviewed. Direction in this paper is to consider a case with fully residual strengths for the liner with a target factor of safety of 1.0.

Inputs and outputs from the UTexas4 program, the 2014 USGS deaggregation for the site and the Stark and Poeppel paper are included in Attachment E.

Settlement

Total and differential settlements were evaluated to confirm that the settlements do not affect design liner grades such that leachate flow towards the sumps is disrupted.

Settlement is controlled by the specific settlement characteristics of the soils as well as the thickness of the soil deposits. Based on site conditions in this area of Texas, the soil deposits are known to be very deep (hundreds to thousands of feet). While these deep soils are very stiff, they will still experience

some strain caused by the loading from the landfill. Given the size of the landfill, the depth of stress from the MSW will be very deep also, on the order of several thousand feet.
For the upper 100 feet, site conditions and settlement parameters are considered to be well known. Consolidation testing for the Fat Clay, Sandy Fat Clay and Sandy Lean Clay were performed to determine consolidation characteristics. Modulus values were estimated for the Clayey Sand and Poorly Graded Sand based on measured blow counts and correlated values.

As noted, the soils are several thousand feet deep at this site. Characteristics of these deeper soils are not specifically known but given a general understanding of the deposits at the site and indications of the soils near the base of the current investigation, these soils are expected to be very dense/hard deposits. For modeling the settlement response of these deeper soils, a modulus of 4,000 ksf was used for all of these materials. This value was chosen based on the upper end modulus values recommended in Table D-3 of the *USACE EM 1110-1-1904 Settlement Analysis*.

For evaluating the soils beneath 100 feet, the depth of soils that are assumed to settle was reviewed based on available geologic information. Published geology maps indicated that the approximate upper 1,000 feet at the site is made up of the Lissie and Willis formations. These formations are noted as being made up of unconsolidated alluvial formations and are expected to settle under the landfill loading. Below the Willis formation is the Fleming and Oakville formations. These formations are described as calcareous sedimentary rock. Given this designation, these formations are not considered compressible.

Assuming that the Lissie and Willis formations extend 1,000 feet, the total expected settlement is 28 inches beneath the center of the landfill (cover elevation of 180 feet), 20 inches under the slope crest (cover elevation of 160 feet) and 6 inches at the perimeter of the landfill.

Results from the Settle3D analysis and geology references are included in Attachment F.

Cover Stability
Cover stability was also evaluated for cover options that will include geosynthetics. Both dry and saturated conditions were evaluated for peak interface shear strengths for the four different interfaces. For saturated conditions, the maximum allowable water height is the full 2 feet thickness of the soil/granular material cover. A slope of 3H:1V was evaluated based on current grading plans. Note that the existing landfill cell is to sloped at 4H:1V.

Ditches will be constructed as part of the surface water management along the landfill cover slope. To account for this additional driving force from the small earthen embankments, multiple calculations considering different ways to apply the loading were performed.

The soil cover-geocomposite, geocomposite-geomembrane and granular material-geomembrane interfaces are above the geomembrane that will collect water and thus are influenced by pore pressures. The geomembrane-compacted clay interface is below the geomembrane and so no pore pressure will be assumed in these calculations.

Interface strengths used in modeling are based on the *GRI Report #30*. Interface shear strengths for interfaces with either cohesive soils or textured geomembrane include adhesion. Adhesion has a significant effect on the stability of the cover system as the thin soil veneer has a relatively low driving force associated with it.

For peak strengths, factors of safety were above 1.5 for all cases. The only limiting condition was the granular material – geomembrane where the maximum amount of water on the interface can be 0.9 feet. During final construction, confirmation of the assumed interface shear strengths will be required to confirm the final materials are stable. Calculations for the cover stability based on published interface shear strengths are included in Attachment G.

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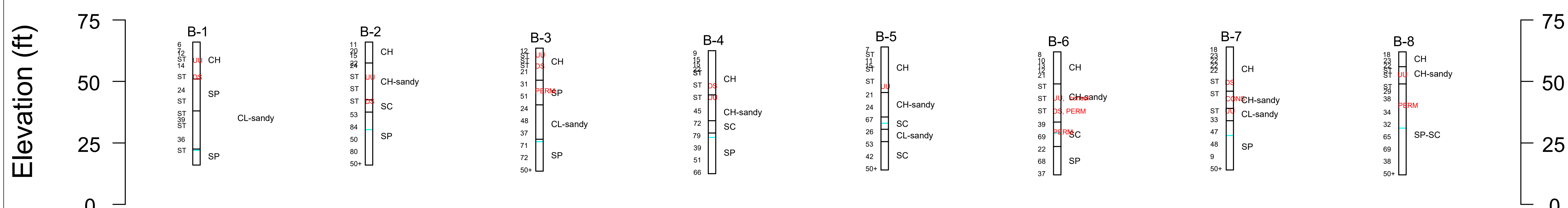
Attachment A – Subsurface Information


Latitude: 28.686063
Longitude: -96.902041
Smith Rd Number 2
FM 1686
1686
Chocolate Bayou
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
MW-10/P-1
MW-11/P-2
MW-23
MW-24
MW-12/P-3
OW-25
OW-26
MW-13/P-4
MW-C1
MW-A2
MW-A5
MW-14/P-5
MW-20/P-11
MW-15/P-6
MW-15A
MW-19/P-10
MW-22
MW-18/P-9
MW-21
MW-17/P-8
OW-27
OW-28
MW-16/P-7
EB-01
EB-02
EB-03
EB-04
EB-05
EB-06
EB-07
EB-08
EB-09
EB-10
EB-11
EB-12
EB-13
EB-14
EB-15
EB-16
EB-17
EB-18
EB-19
EB-20
EB-21
EB-23
EB-24
Google Earth
© 2020 Google
3000 ft


Elevation (ft)
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
CH
SP
CL-sandy
CH-sandy
SC
SP-SC
PERM

Boring	Sample Depth	Material	Blow Count (bpf)	qp (tsf)	MC	<#200	LL	PL	PI	Dry Unit Weight (p	UU (psf)	Cc	Cr	P'c (ksf)	eo
B-1	0-1.5	CH	6												
	2-3.5	CH	7		27		85	18	67						
	4-5.5	CH	12												
	6-8.0	CH		3	33		89	22	67	87	1200				
	8.5-10	CH	14												
	13-15	CH		4.5	20		50	17	33	101					
	18.5-20	SP	24												
	23-25	SP													
	28-30	SP			2	3									
	30-31.5	CL w Sand	39												
	33-35	CL w Sand		4.5	14	64									
	38.5-40	CL w Sand	36												
	43-45	SP		4.5	22	7									
B-2	0-1.5	CH	11												
	2-3.5	CH	20												
	4-5.5	CH	15												
	6-7.5	CH	22		20		62	17	45						
	8.5-10	CH w Sand	24												
	13-15	CH w Sand		4.5	18	69	52	14	38	102	1420				
	18-20	CH w Sand		4.5											
	23-25	CL w Sand		4.5	8	47				115.1					
	28.5-30	SC-SP	53												
	33.5-35	SC-SP	84		15	23									
	38.5-40	SC-SP	50												
	43.5-45	SC-SP	80		15	30									
	48.5-50	SC-SP	100												
B-3	0-1.5	CH	12												
	2-4.0	CH		4	26		73	17	56	95	3530				
	4-6.0	CH		4.5	21		63	15	48	94					
	6-8.0	CH		4.5											
	8.5-10	CH	21												
	13.5-15	SP-SM	31												
	18.5-20	SP-SM	51		2	12									
	23.5-25	CL w Sand	24		18	99	43	14	29						
	28.5-30	CL w Sand	48												
	33.5-35	CL w Sand	37												
	38.5-40	SP-SM	71												
	43.5-45	SP-SM	72		15	10									
	48.5-50	SP-SM	100												
B-4	0-1.5	CH	9												
	2-3.5	CH	15		22		79	16	63						
	4-5.5	CH	15												
	6-7.5	CH	22												
	8-10.0	CH		4.5											
	13-15	CH		4.5	28	93	69	20	49	92.5					
	18-20	CH w Sand		4.5	19	72				102.9	1830				
	23.5-25	CH w Sand	45												
	28.5-30	SC	72		14	57									
	33.5-35	SP-SM	79												
	38.5-40	SP-SM	39		21	10									
	43.5-45	SP-SM	51												
	48.5-50	SP-SM	66		16	58									
B-5	0-1.5	CH	7												
	2-4.0	CH		4.5											
	4-5.5	CH	11												
	6-7.5	CH	15												
	8-10.0	CH		3	21		58	16	42	99.9	4340				
	13-15	CH		3											
	18.5-20	CH w Sand	21												
	23.5-25	CH w Sand	24		17	86	50	15	35						
	28.5-30	SC	67		6	30									
	33.5-35	CH	26		26	100	79	19	60						
	38.5-40	SC	53												
	43.5-45	SC	42		17	86									
	48.5-50	SC	100												
B-6	0-1.5	CH	8												
	2-3.5	CH	10												
	4-5.5	CH	13		23		80	18	62						
	6-7.5	CH	12												
	8.5-10	CH	21												
	13-15	CH w Sand		3.5											
	18-20	CH w Sand		4	18		52	15	37	89.3	2490	0.25	0.024	4.6	0.715
	23-25	CL w Sand		4.5	15		37	13	24	110					
	28.5-30	SC	39												
	33.5-35	SC	69		11	77									
	38.5-40	SP-SM	22												
	43.5-45	SP-SM	68		14	16									
	48.5-50	SP-SM	37												
B-7	0-1.5	CH	18												
	2-3.5	CH	23												
	4-5.5	CH	22		21		78	18	60						
	6-7.5	CH	22												
	8.5-10	CH	22												
	13-15	CH		4.5											
	18-20	CH w Sand		2.5	24	86	70	21	49	89		0.194	0.02	6	0.897
	23-25	CH w Sand		3.5	20	68	55	19	36	108					
	28.5-30	SP-SM	33												
	33.5-35	SP-SM	47		16	9									
	38.5-40	SC	48		12	50	35	13	22						
	43.5-45	SP-SM	9		19	17									
	48.5-50	SP-SM	100												
B-8	0-1.5	CH	8												
	2-3.5	CH	17												
	4-5.5	CH	19		15		66	16	50						
	6-8.0	CH w Sand		4.5	18	78	55	15	40	105.1	5870				
	8-10.0	CH w Sand		4.5											
	13-15	SC		2	8	39									
	15-16.5	SC	29												
	18.5-20	SC	38												
	23.5-25	SC	34												
	28.5-30	SC	32												
	33.5-35	SC	65		13	47									
	38.5-40	SC	69												
	43.5-45	SC	38		18	27									
	48.5-50	SC	100												

Blow Counts

	CH	CH-Sand	CL/CL-Sand
Min	6	21	24
Max	23	45	48
Average	15	28	37
Median	15	24	37

	SC/SC-SP	SP/SP-SM
Min	29	9
Max	100	100
Average	60	53
Median	53	51

Liquid Limit

	CH	CH-Sand	CL/CL-Sand
Min	50	50	37
Max	89	79	43
Average	71	59	40
Median	71	55	40

Plastic Limit

	CH	CH-Sand	CL/CL-Sand
Min	15	14	13
Max	22	21	14
Average	18	17	14
Median	17	15	14

Plasticity Index

	CH	CH-Sand	CL/CL-Sand
Min	33	35	24
Max	67	60	29
Average	54	42	27
Median	53	38	27

<#200

	CH-Sand	SC/SC-SP	SP/SP-SM
Min	68	23	3
Max	100	86	58
Average	80	47	16
Median	78	47	10

Moisture Content

	CH	CH-Sand	CL/CL-Sand
Min	15	17	14
Max	33	26	18
Average	23	20	16
Median	22	19	15

	SC/SC-SP	SP/SP-SM
Min	6	2
Max	18	22
Average	12	14
Median	13	16

Attachment B – Design Parameters Determination

Table 3-1
Granular Soil Properties (after Teng 1962)

Compactness	Relative Density (%)	SPT N (blows per ft)	Angle of Internal Friction (deg)	Unit Weight Moist (pcf)	Unit Weight Submerged (pcf)
Very Loose	0-15	0-4	<28	<100	<60
Loose	16-35	5-10	28-30	95-125	55-65
Medium	36-65	11-30	31-36	110-130	60-70
Dense	66-85	31-50	37-41	110-140	65-85
Very Dense	86-100	>51	>41	>130	>75

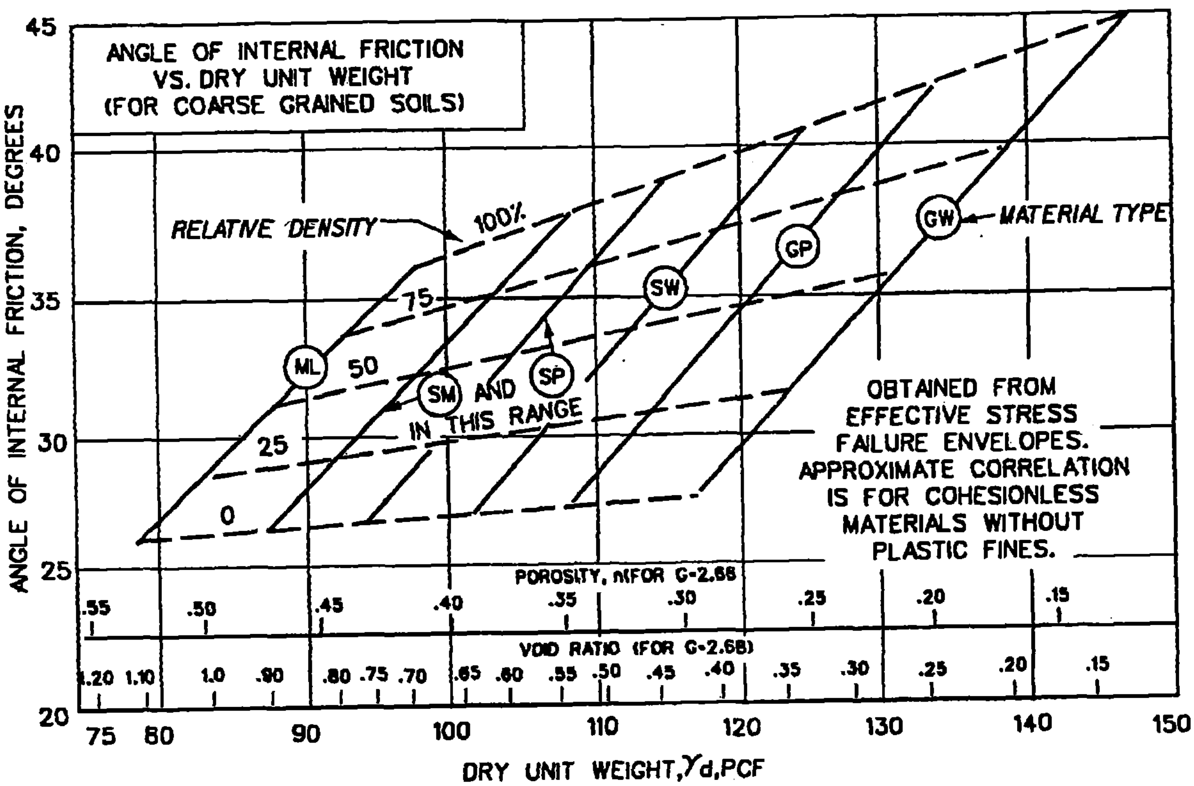


Figure 3-1. Cohesionless Soil Properties (after U.S. Department of the Navy 1971)

Table 3-2
Ratio of ϕ/δ (After Allen, Duncan, and Snacio 1988)

Soil Type	Steel	Wood	Concrete
Sand	$\delta/\phi = 0.54$	$\delta/\phi = 0.76$	$\delta/\phi = 0.76$
Silt & Clay	$\delta/\phi = 0.54$	$\delta/\phi = 0.55$	$\delta/\phi = 0.50$

Table 3-3
Values of δ for Various Interfaces
(after U.S. Department of the Navy 1982)

Soil Type	δ (deg)
(a) Steel sheet piles	
Clean gravel, gravel sand mixtures, well-graded rockfill with spalls	22
Clean sand, silty sand-gravel mixture, single-size hard rockfill	17
Silty sand, gravel or sand mixed with silt or clay	14
Fine sandy silt, nonplastic silt	11
(b) Concrete sheet piles	
Clean gravel, gravel sand mixtures, well-graded rockfill with spalls	22-26
Clean sand, silty sand-gravel mixture, single-size hard rockfill	17-22
Silty sand, gravel or sand mixed with silt or clay	17
Fine sandy silt, nonplastic silt	14

Table 3-4
Correlation of Undrained Shear Strength of Clay (q_u=2c)

Consistency	qu (psf)	SPT (blows/ft)	Saturated Unit Weight (psf)
Very Soft	0-500	0-2	<100-110
Soft	500-1,000	3-4	100-120
Medium	1,000-2,000	5-8	110-125
Stiff	2,000-4,000	9-16	115-130
Very Stiff	4,000-8,000	16-32	120-140
Hard	>8,000	>32	>130

(5) Since an undrained condition may be expected to occur under "fast" loading in the field, it represents a "short-term" condition; in time, drainage will occur, and the drained strength will govern (the "long-term" condition). To model these conditions in the laboratory, three types of tests are generally used; unconsolidated undrained (Q or UU), consolidated undrained (R or CU), and consolidated drained (S or CD). Undrained shear strength in the laboratory is determined from either Q or R tests and drained shear strength is established from S tests or from consolidated undrained tests with pore pressure measurements ($\bar{R}$).

(6) The undrained shear strength, S_u, of a normally consolidated clay is usually expressed by only a cohesion intercept; and it is labeled c_u to indicate that ϕ was taken as zero. c_u decreases dramatically with water content; therefore, in design it is common to consider the fully saturated condition even if a clay is partly saturated in the field. Typical undrained shear strength values are presented in Table 3-4. S_u increases with depth (or effective stress) and this is commonly expressed with the ratio "S_u/p" (p denotes the effective vertical stress). This ratio correlates roughly with plasticity index and overconsolidation ratio (Figures 3-2, 3-3, respectively). The undrained shear strength of many overconsolidated soils is further complicated due to the presence of fissures; this leads to a lower field strength than tests on small laboratory samples indicate.

(7) The drained shear strength of normally consolidated clays is similar to that of loose sands ($c' = O$), except that ϕ is generally lower. An empirical correlation of the effective angle of internal friction, ϕ', with plasticity index for normally consolidated clays is shown in Figure 3-4. The drained shear strength of over-consolidated clays is similar to that of dense sands (again with lower ϕ'), where there is a peak strength (c' nonzero) and a "residual" shear strength ($c' = O$).

(8) The general approach in solving problems involving clay is that, unless the choice is obvious, both undrained and drained conditions are analyzed separately. The more critical condition governs the design. Total stresses are used in an analysis with undrained shear strength (since pore pressures are "included" in the undrained shear strength) and effective stresses in a drained case; thus such analyses are usually called total and effective stress analyses, respectively.

(9) At low stress levels, such as near the top of a wall, the undrained strength is greater than the drained

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Table 5-4

EXPONENT M FOR SHEAR MODULUS

Plasticity Index, PI	Exponent, M
0	0
20	0.18
40	0.30
60	0.41
80	0.48
≥ 100	0.50

Source: Hardin and Drnevich (15), p. 672.

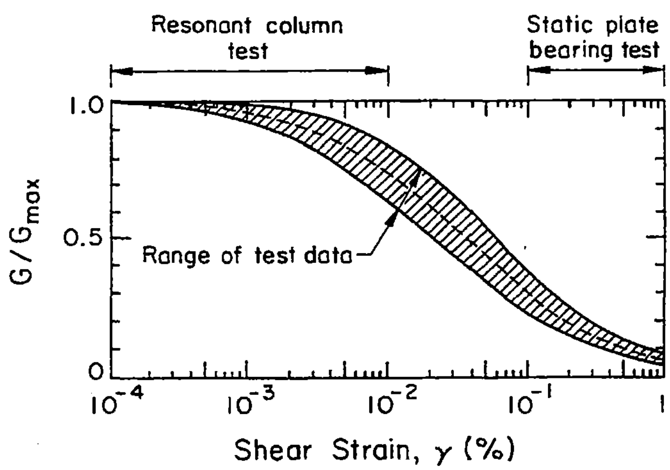

Figure 5-11. Shear Modulus versus Shear Strain for Sands

Source: Seed and Idriss (16).

with limits of the data being $60\ N^{0.71} < G_{max}/p_a < 300\ N^{0.8}$. The static shear modulus then would be some 5 to 10 percent of the computed G_{max} value.

MODULUS FOR COHESIONLESS SOILS

Cohesionless soils such as sands do not exhibit significant time-dependency to loading caused by excess pore water stress dissipation, and therefore the modulus under undrained loading conditions exists only briefly. Almost always, the modulus

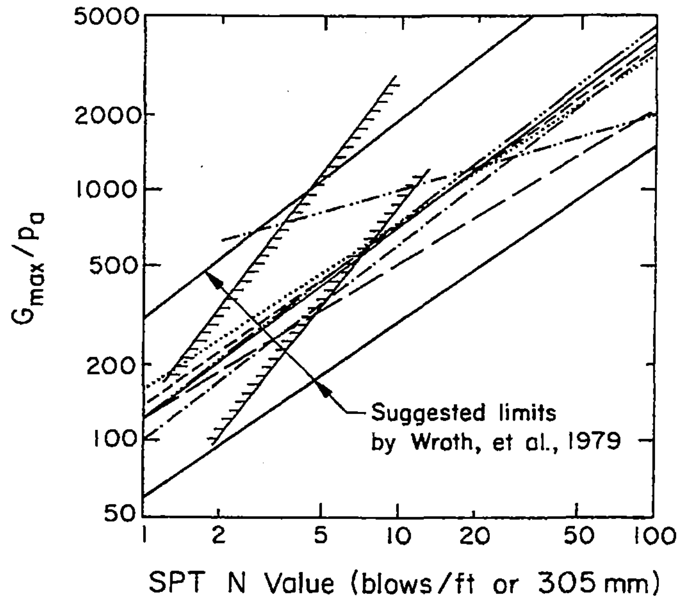

Figure 5-12. Dynamic Shear Modulus versus N for Cohesive Soils

Source: Wroth, et al. (9), p. 96.

is considered for drained conditions. However, for finer-grained silts, some significant time-dependency may develop which will have to be considered on a case-by-case basis.

For drained loading, the modulus can be described by the drained elastic modulus (E_d), the shear modulus (G), or the drained constrained modulus (M_d). E and G commonly are evaluated in triaxial compression, while M is evaluated in one-dimensional compression. All of these are interrelated through Poisson's ratio, as noted previously in Equations 5-3 and 5-6. Unless otherwise stated, the moduli will be secant values given by E_{ds} and M_{ds}.

Typical Values

A number of authors have given typical ranges for the modulus of cohesionless soils. Table 5-5 is representative of these ranges for sands in general and for driven piles in particular. These values generally would be representative of secant moduli within common design stress levels.

Alternatively, Duncan and Chang (18) suggested a hyperbolic model to estimate the drained tangent modulus, starting from an initial isotropic stress, as follows:

Table 5-5

TYPICAL RANGES OF DRAINED MODULUS FOR SAND

Consistency	Normalized Elastic Modulus, E_d/p_a Typical	Driven Piles[a]
loose	100 to 200	275 to 550
medium	200 to 500	550 to 700
dense	500 to 1000	700 to 1100

a - Source: Poulos (17), p. 207.

$$E_t = \kappa p_a (\bar{\sigma}_3/p_a)^n [1 - R_f (1 - \sin \bar{\phi}_{tc})(\bar{\sigma}_1 - \bar{\sigma}_3)/(2 \bar{\sigma}_3 \sin \bar{\phi}_{tc})]^2 \qquad (5\text{-}21)$$

in which $\bar{\sigma}_1$ and $\bar{\sigma}_3$ = effective major and minor principal stresses, respectively, $\bar{\phi}_{tc}$ = effective stress friction angle in triaxial compression, and κ, n, and R_f = modulus parameters given in Table 5-6. For convenience in computer code implementation, Trautmann and Kulhawy (1) approximated κ as follows:

$$\kappa \approx 300 + 900 \phi_{rel} \qquad (5\text{-}22)$$

with ϕ_{rel} defined in Equation 5-8.

Correlations with Strength

The shear modulus commonly is correlated to the effective soil strength through the rigidity index (I_r), as defined below for drained loading:

$$I_r = G/(\bar{\sigma} \tan \bar{\phi}_{tc}) \qquad (5\text{-}23)$$

Selected values for I_r are given in Table 5-7. Of particular interest to note is that I_r increases with increasing relative density and decreases with increasing normal stress. It also is lower with more compressible soil minerals.

When using the rigidity index (I_r) for drained loading, volume changes normally have to be considered. Therefore, I_r must be corrected for the volumetric strains (ϵ_v) to yield a reduced rigidity index (I_{rr}), as given below by Vesić (20):

Table 5-6

TYPICAL DRAINED HYPERBOLIC MODULUS PARAMETERS

Unified Soil Classification	κ	n	R_f
GW	300 to 1200	1/3	0.7
GP	500 to 1800	1/3	0.8
SW	300 to 1200	1/2	0.7
SP	300 to 1200	1/2	0.8
ML	300 to 1200	2/3	0.8

Source: Kulhawy, et al. (6), p. 10-19.

Table 5-7

VALUES OF RIGIDITY INDEX FOR SELECTED COHESIONLESS SOILS

Soil	Relative Density D_r (%)	Normalized Mean Normal Stress, $\bar{\sigma}_o/p_a$	Rigidity Index, I_r
Chattahoochee sand	80	0.1	200
	80	1	118
	80	10	52
	80	100	12
	20	0.1	140
	20	1	85
Ottawa sand	82	0.05	265
	21	0.05	89
Piedmont silt	-	0.70	10 to 30

Source: Vesić (20), p. 68.

$$I_{rr} = I_r/(1 + I_r\ \epsilon_v) \qquad (5\text{-}24)$$

Vesić (20) noted that ϵ_v would be zero for dense soils and range from 0 to 0.05 for loose soils in the stress range from 1 to 10 atmospheres. For convenience in computer code implementation, Trautmann and Kulhawy (1) approximated ϵ_v as follows:

$$\epsilon_v \approx 0.005(\bar{\sigma}_v/p_a)(1 - \phi_{rel}) \qquad (5\text{-}25)$$

in which $\bar{\sigma}_v$ = vertical effective stress (up to 10 atmospheres), and ϕ_{rel} is defined in Equation 5-8.

Correlations with SPT N Value

Young's Modulus. Early correlations in the literature related E_{ds} of sands directly to the standard penetration test (SPT) N value. Several of these correlations are shown in Figure 5-13. Others within the same ranges are given by Mitchell and Gardner (23). Later correlations attempted to relate the constrained modulus (M) and N as a function of overburden stress (e.g., 24).

However, all attempts to date which correlate a modulus with N show considerable scatter. This lack of correlation is to be expected because the SPT N value varies with many factors, as described in Section 2, and these factors have yet to be incorporated in these correlations. Therefore, as a first order estimator, the following may be used:

$$E/p_a \approx 5\ N_{60} \qquad \text{(sands with fines)} \qquad (5\text{-}26a)$$

$$\approx 10\ N_{60} \qquad \text{(clean NC sands)} \qquad (5\text{-}26b)$$

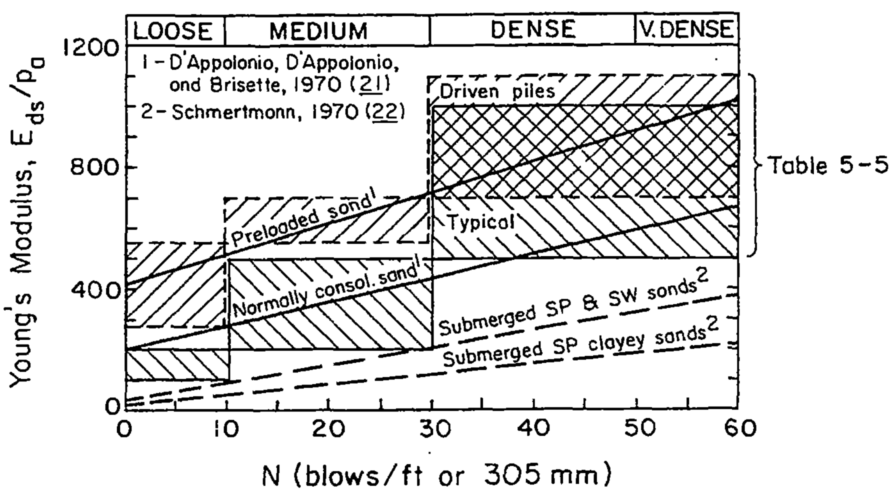

Figure 5-13. Comparative Plot of Drained Modulus Correlations for Sand

Source: Callanan and Kulhawy (13), p. 3-16.

$\approx 15\ N_{60}$ (clean OC sands) (5-26c)

in which N_{60} is the N value corrected for field procedures to an average energy ratio of 60 percent. Equation 2-11 gives the appropriate correction factors.

Pressuremeter Modulus. The pressuremeter test (PMT) provides a direct measurement of the horizontal modulus of cohesionless soils. This modulus (E_{PMT}) often is presumed to be roughly equivalent to Young's modulus (E). Correlations between the N value and E_{PMT} have been developed, as shown in Figure 5-14. The scatter shown is typical of other N correlations because of the reasons noted above.

Dilatometer Modulus. The dilatometer test (DMT) also provides a direct modulus measurement for cohesionless soils. The dilatometer modulus (E_D) is related to Young's modulus as follows:

$$E_D = E/(1 - \nu^2) \quad (5\text{-}27)$$

No general correlations of E_D with N have been presented at this time. However, the DMT and other in-situ tests can be used effectively to develop convenient

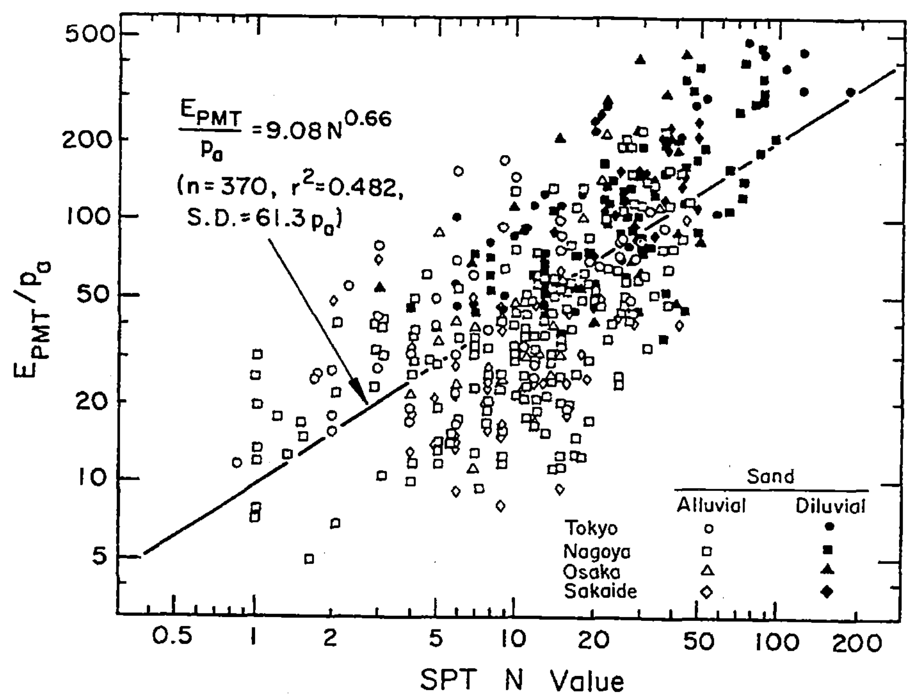

Figure 5-14. PMT Modulus of Sand versus N Value

Source: Ohya, et al. (11), p. 129.

EPRI

Topics:
Soils
Testing
Foundations
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Transmission lines
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EPRI EL-6800
Project 1493-6
Final Report
August 1990

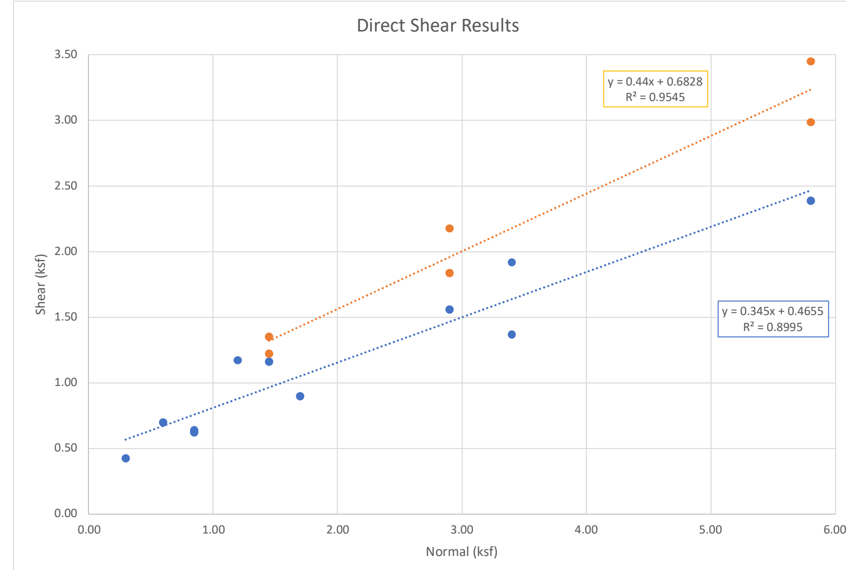
Manual on Estimating Soil Properties for Foundation Design

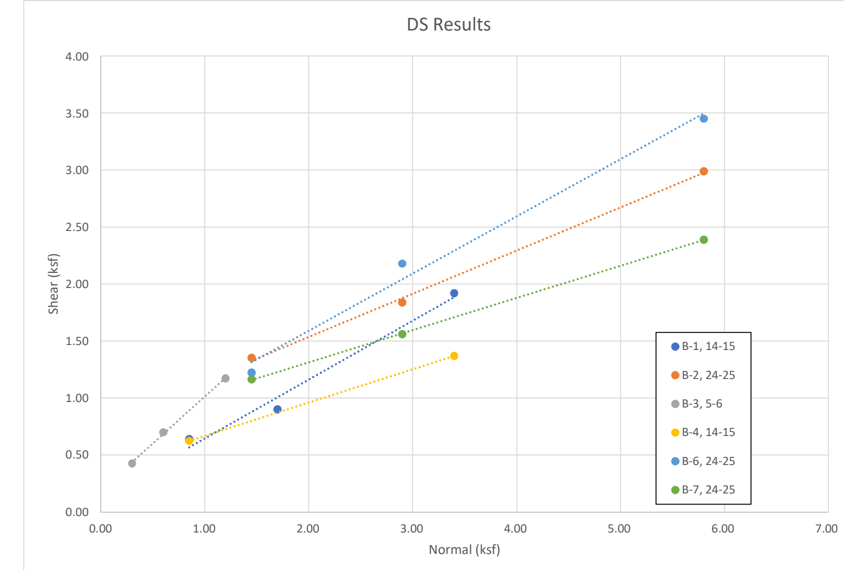
Prepared by
Cornell University
Ithaca, New York

	Material	Dry Density (pcf)	Moisture Content (%)	Atterbergs			Normal	Shear	Shear - Calculated	Difference	Difference^2
B-1, 14-15	CH	99.7	22.4	50	17	33	0.85	0.64	0.8	-0.12	0.01
		100.7	22.6				1.70	0.90	1.1	-0.15	0.02
		102.6	20.8				3.40	1.92	1.6	0.28	0.08
B-2, 24-25	Sand Lean Clay	115.1	15.3				1.45	1.35	1.3	0.03	0.00
		116.8	13.8				2.90	1.84	2.0	-0.12	0.01
		114.2	16.2				5.80	2.99	3.2	-0.25	0.06
B-3, 5-6	CH	93.5	29.1	63	15	48	0.30	0.43	0.6	-0.14	0.02
		93	29.6				0.60	0.70	0.7	0.03	0.00
		96.3	27.9				1.20	1.17	0.9	0.29	0.09
B-4, 14-15	CH	92.5	30	69	20	49	0.85	0.63	0.8	-0.13	0.02
		92.5	30.5								
		92.3	30.2				3.40	1.37	1.6	-0.27	0.07
B-6, 24-25	Sand Lean Clay	110.1	15.5	37	13	24	1.45	1.22	1.3	-0.10	0.01
		109.7	15.3				2.90	2.18	2.0	0.22	0.05
		109.6	15.5				5.80	3.45	3.2	0.22	0.05
B-7, 24-25	CH with Sand	106.5	20.9	55	19	36	1.45	1.16	1.0	0.20	0.04
		107.8	20.3				2.90	1.56	1.5	0.09	0.01
		110.5	18.9				5.80	2.39	2.5	-0.08	0.01

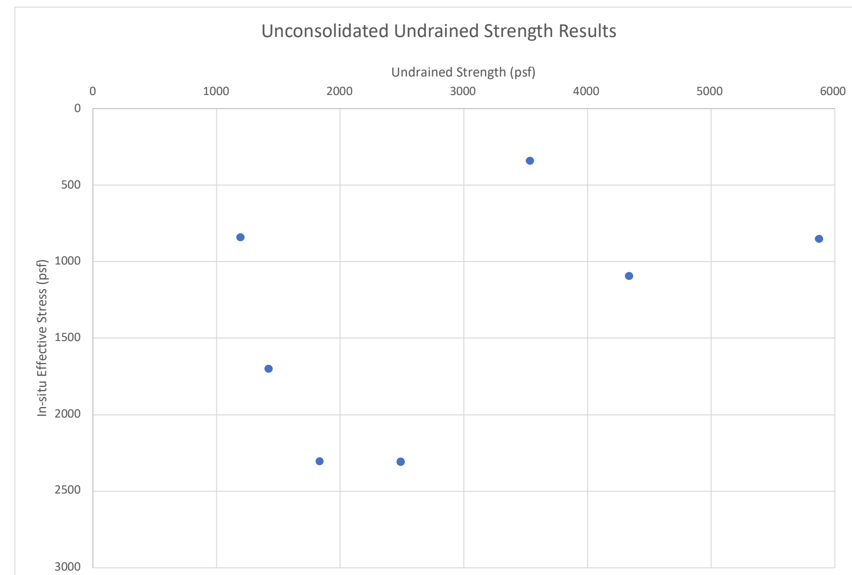
	CH	CL/SC
Phi (radians)	**0.345**	**0.440**
Cohesion	**0.466**	**0.683**
phi (deg)	**19.0**	**23.7**
c (psf)	**466**	**683**

	CH	CL/SC
Sum	0.37	0.18
St Dev	0.19	0.19
Average	1.2	2.2
COV	16%	9%





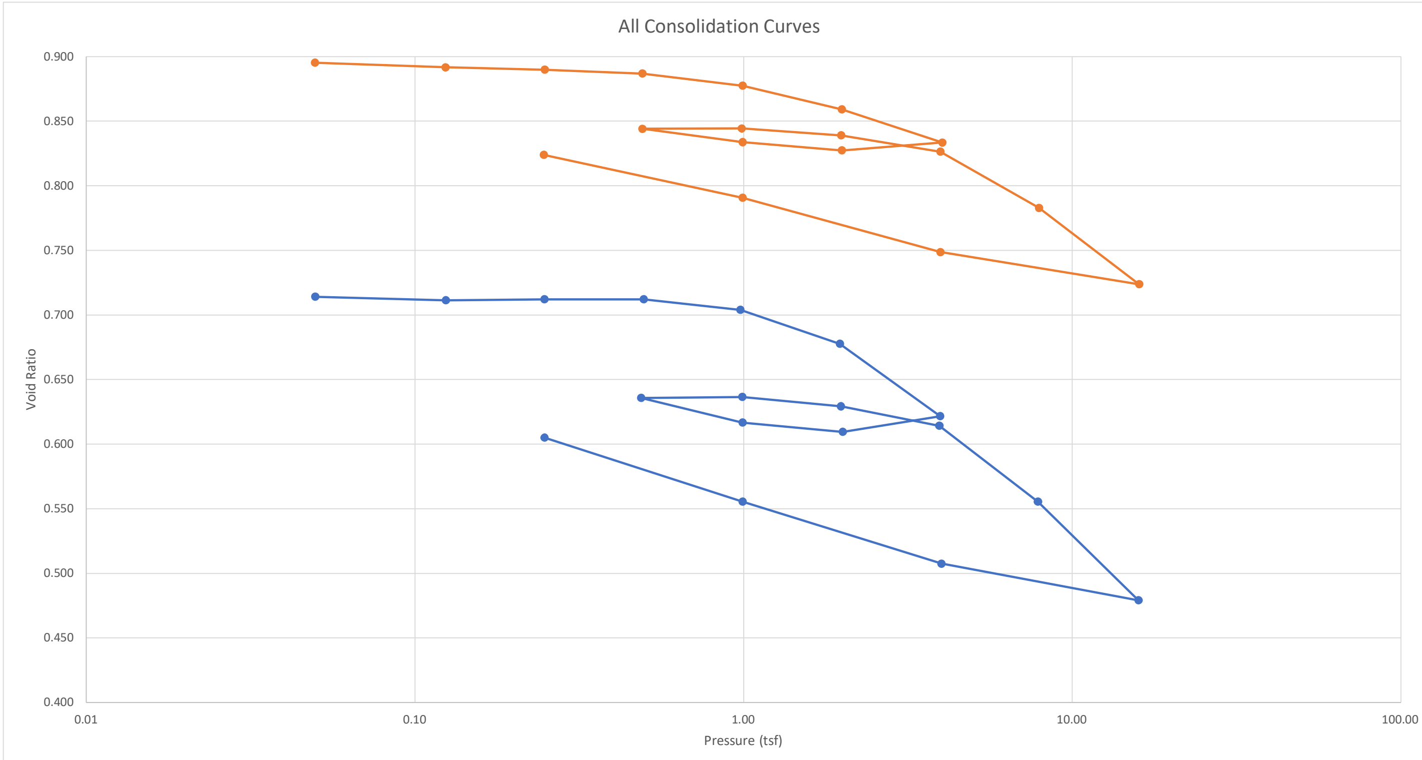
		Material	Dry Density (pcf)	Moisture Content (%)	Atterbergs			Confining Pressure (psf)	Failure Stress (psf)	c-p ratio	Cohesion (psf)
B-1	7-8	CH	85.1	34.2	89	22	67	840	2384	2.84	1192
B-2	14-15	CH with Sand	101.8	20.7	52	14	38	1700	2841	1.67	1420.5
B-3	3-4	CH	95	24.5	73	17	56	340	7069	20.79	3534.5
B-4	19-20	CH with Sand	102.9	21.9				2304	3668	1.59	1834
B-5	9-10	CH	99.9	24.6	58	16	42	1093	8673	7.94	4336.5
B-6	18-19	CH with Sand	89.3	19.5	52	15	37	2307	4977	2.16	2488.5
B-8	7-8	CH with Sand	105.1	21	55	15	40	851	11745	13.80	5872.5



0-10 feet	Min	1192
	Max	5873
	Average	3734
	Median	3936
Below 10 feet	Min	1421
	Max	2489
	Average	1914
	Median	1834

B-6	
18'-19'	
ST-7	
PL	15
LL	52
PI	37
Fines	
DD	98.3
MC	19.5
Load (tsf)	Void Ratio
0.05	0.714
0.12	0.711
0.25	0.712
0.50	0.712
0.98	0.704
1.96	0.678
3.97	0.622
2.00	0.609
0.99	0.617
0.49	0.636
0.99	0.637
1.98	0.629
3.94	0.614
7.87	0.555
15.90	0.479
4.00	0.507
0.99	0.555
0.25	0.605
eo	0.715
Cc	0.250
Cr	0.024
p'c (tsf)	2.3
OCR	2.1

B-7	
19'-20'	
ST-7	
PL	70
LL	21
PI	49
Fines	86
DD	88.9
MC	29.2
Load (tsf)	Void Ratio
0.05	0.895
0.12	0.892
0.25	0.890
0.49	0.887
0.99	0.877
1.99	0.859
4.02	0.833
1.99	0.827
0.99	0.834
0.49	0.844
0.99	0.844
1.98	0.839
3.97	0.826
7.92	0.783
15.98	0.724
3.97	0.749
0.99	0.791
0.25	0.824
eo	0.897
Cc	0.194
Cr	0.020
p'c (tsf)	3
OCR	2.6



Shear Strength of Municipal Solid Waste (MSW): Beyond the Raw Values of "Cohesion" and Friction Angles

Jaime J. Díaz-Beltrán[1]; Juan J. Iguarán-Fernández[2];
Joan M. Larrahondo, Ph.D., A.M.ASCE[3]; and Luis A. Jaramillo[4]

[1]Project Engineer, SIEMENS, Autopista Medellín KM 8.5 Costado Sur, Colombia; formerly, Student Research Assistant, Dept. of Civil Engineering, Pontificia Universidad Javeriana. E-mail: julian.diaz_beltran@siemens.com
[2]Student Research Assistant, Dept. of Civil Engineering, Pontificia Universidad Javeriana, Bogotá-Colombia. E-mail: j.iguaran@javeriana.edu.co
[3]Assistant Professor, Dept. of Civil Engineering, Pontificia Universidad Javeriana, Ed. No. 42 Artes Oriental, Segundo Piso, Bogotá-Colombia. E-mail: jlarrahondo@javeriana.edu.co
[4]Assistant Professor, Dept. of Civil Engineering, Pontificia Universidad Javeriana, Bogotá-Colombia. E-mail: jaramillo.l@javeriana.edu.co

Abstract: Understanding the mechanical behavior of municipal solid waste (MSW) is still a major challenge in engineering. The purpose of this paper is to critically review published literature on MSW shear strength from the past 20 years, including the major strength mechanisms and failure criteria, so a landfill engineer can access key behavioral concepts, beyond just the raw values of friction angle and "cohesion" parameters that are required for design. In addition, this paper explores the relationship of shear strength parameters with MSW composition and urban population, which are useful proxies for economic development. To revisit the state of the practice since the introduction of commonly used design charts, an enhanced database of shear strength parameters as well as Mohr-Coulomb envelopes was compiled. Also, a relationship was developed between strength parameters, MSW composition, and population data for a number of cities in a developing country. This study supports the concept that the consumption habits of an urban area are very relevant when it comes to designing landfills. Furthermore, instead of introducing a new recommended range of design parameters or a new strength envelope, the compiled data are interpreted under a simple statistical basis, so the designer can make informed decisions on which parameters to choose for design.

INTRODUCTION

Municipal solid wastes (MSW) are typically disposed of in engineered landfills obeying geotechnical design criteria. The characterization of MSW normally includes determining or estimating geotechnical-equivalent properties and strength parameters, including unit weight, friction angle, and the "cohesion" intercept. In reality, MSW are highly complex materials of strong spatial and temporal variability. The factors that influence MSW shear strength include composition, age or degree of probabilities of exceedance, calculated using the 181 data points compiled. The cohesion histogram clearly skews towards the left-hand side of the distribution, the mean is around 15 kPa, the standard deviation is 22 kPa, and the coefficient of variation is 94.3%. On the other hand, unlike the cohesion histogram, the friction angle distribution appears significantly more symmetrical, with mean around 27°, standard deviation of 9°, and coefficient of variation of 34.2%. This simple representation of strength parameters may allow engineers to make more informed decisions about which design parameters to use, perhaps over the traditional *c*'-ϕ' charts, or even the strength envelope plots.

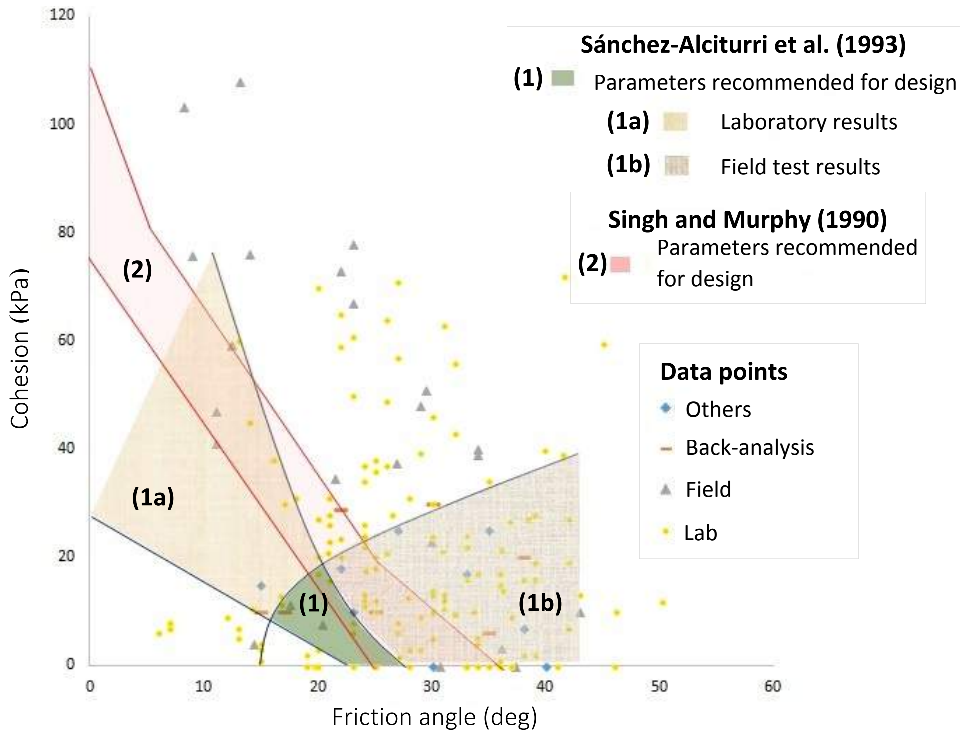


FIG 8. Compilation of *c*' vs. ϕ' parameters. Data are classified according to their method of determination. Common design regions are superimposed.

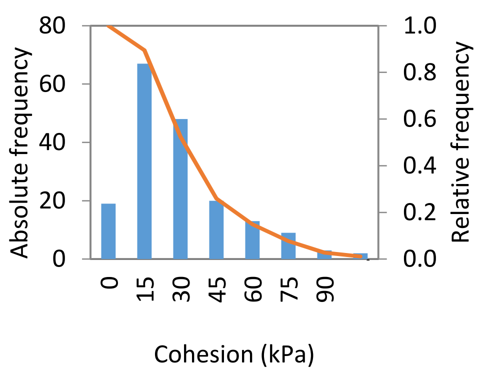


FIG 9. Histogram and probability of exceedance for cohesion

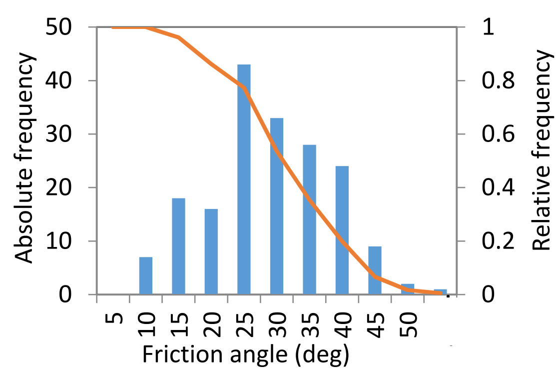


FIG 10. Histogram and probability of exceedance for friction angle

Attachment C –Liner Strength Determination

Appendix Table 1. Summary of interface shear strengths.

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
HDPE-S	Granular Soil	1a	21	0	162	0.93	1b	17	0	128	0.92
HDPE-S	Cohesive Soil										
	Saturated	1c	11	7	79	0.94	1d	11	0	59	0.95
	Unsaturated	1c	22	0	44	0.93	1d	18	0	32	0.93
HDPE-S	NW-NP GT	1e	11	0	149	0.93	1f	9	0	82	0.96
HDPE-S	Geonet	1g	11	0	196	0.90	1h	9	0	118	0.93
HDPE-S	Geocomposite	1i	15	0	36	0.97	1j	12	0	30	0.93
HDPE-T	Granular Soil	2a	34	0	251	0.98	2b	31	0	239	0.96
HDPE-T	Cohesive Soil										
	Saturated	2c	18	10	167	0.93	2d	16	0	150	0.90
	Unsaturated	2c	19	23	62	0.91	2d	22	0	35	0.93
HDPE-T	NW-NP GT	2e	25	8	254	0.96	2f	17	0	217	0.95
HDPE-T	Geonet	2g	13	0	31	0.99	2h	10	0	27	0.99
HDPE-T	Geocomposite	2i	26	0	168	0.95	2j	15	0	164	0.94
LLDPE-S	Granular Soil	3a	27	0	6	1.00	3b	24	0	9	1.00
LLDPE-S	Cohesive Soil	3c	11	12.4	12	0.94	3d	12	3.7	9	0.93
LLDPE-S	NW-NP GT	3e	10	0	23	0.63	3f	9	0	23	0.49
LLDPE-S	Geonet	3g	11	0	9	0.99	3h	10	0	9	1.00
LLDPE-T	Granular Soil	4a	26	7.7	12	0.95	4b	25	5.2	12	0.95
LLDPE-T	Cohesive Soil	4c	21	5.8	12	1.00	4d	13	7.0	9	0.98
LLDPE-T	NW-NP GT	4e	26	8.1	9	1.00	4f	17	9.5	9	0.96
LLDPE-T	Geonet	4g	15	3.6	6	0.97	4h	11	0	6	0.98
PVC-S	Granular Soil	5a	26	0.4	6	0.99	5b	19	0	6	0.99
PVC-S	Cohesive Soil	5c	22	0.9	11	0.88	5d	15	0	9	0.95
PVC-S	NW-NP GT	5e	20	0	89	0.91	5f	16	0	83	0.74
PVC-S	NW-HB GT	5g	18	0	3	1.00	5h	12	0.1	3	1.00
PVC-S	Woven GT	5i	17	0	6	0.54	5j	7	0	6	0.93
PVC-S	Geonet	5k	18	0.1	3	1.00	5l	16	0.6	3	1.00

Appendix Table 1. (continued)

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
PVC-F	NW-NP GT	6a	27	0.2	26	0.95	6b	23	0	26	0.95
PVC-F	NW-HB GT	6c	30	0	8	0.97	6d	27	0	8	0.90
PVC-F	Woven GT	6e	15	0	6	0.78	6f	10	0	6	0.76
PVC-F	Geonet	6g	25	0	11	1.00	6h	19	0	11	0.99
PVC-F	Geocomposite	6i	27	1.1	5	1.00	6j	22	4.7	6	1.00
CSPE-R	Granular Soil	7a	36	0	3	1.00	7b	16	0	3	1.00
CSPE-R	Cohesive Soil	7c	31	5.7	6	0.71	7d	18	0	6	0.99
CSPE-R	NW-NP GT	7e	14	0	6	0.97	7f	10	0	6	0.98
CSPE-R	NW-HB GT	7g	21	0	3	1.00	7h	10	0	3	1.00
CSPE-R	Woven GT	7i	11	0	6	0.92	7j	11	0	3	1.00
CSPE-R	Geonet	7k	28	0	9	0.87	7l	16	0	9	0.80
NW-NP GT	Granular Soil	8a	33	0	290	0.97	8b	33	0	117	0.96
NW-HB GT	Granular Soil	8c	28	0	6	0.99	8d	16	0	6	0.91
Woven GT	Granular Soil	8e	32	0	81	0.99	8f	29	0	28	0.98
NW-NP GT	Cohesive Soil	9a	30	5	79	0.96	9b	21	0	28	0.79
NW-HB GT	Cohesive Soil	9c	29	0.9	15	0.71	9d	10	0	15	0.83
Woven GT	Cohesive Soil	9e	29	0	34	0.94	9f	19	0	16	0.86
GCL Reinforced (internal)	N/A	10a	16	38	406	0.85	10b	6	12	182	0.91
GCL (NW-NP GT)	HDPE-T	11a	23	8	180	0.95	11b	13	0	157	0.90
GCL (W-SF GT)	HDPE-T	11c	18	11	196	0.96	11d	12	0	153	0.92
Geonet	NW-NP GT	12a	23	0	52	0.97	12b	16	0	32	0.97
Geocomposite (NW-NP GT)	Granular Soil	13a	27	14	14	0.86	13b	21	8	10	0.92

Geosynthetic Research Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces

by

George R. Koerner, Ph.D., P.E.
Geosynthetic Research Institute
Folsom, PA 19033-1208
gkoerner@dca.net

and

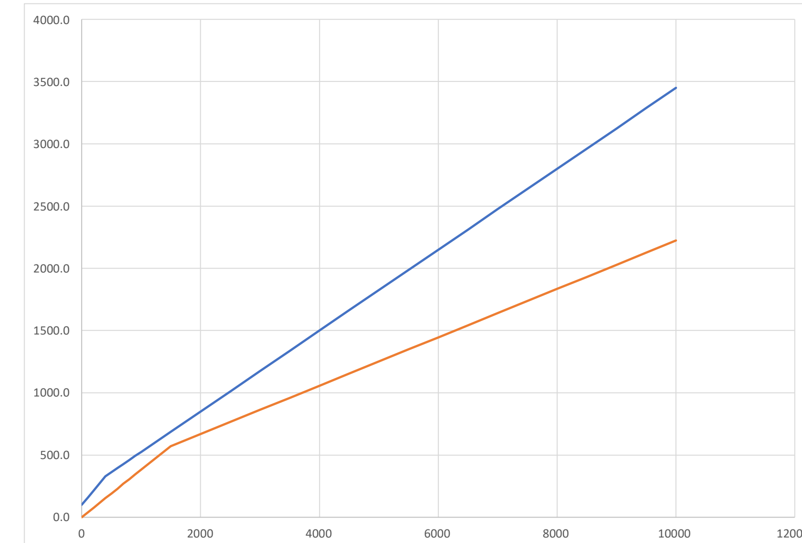
Dhani Narejo, Ph.D.
GSE Lining Technology, Inc.
Houston, TX 77073
dnarejo@gseworld.com

GRI Report #30

June 14, 2005

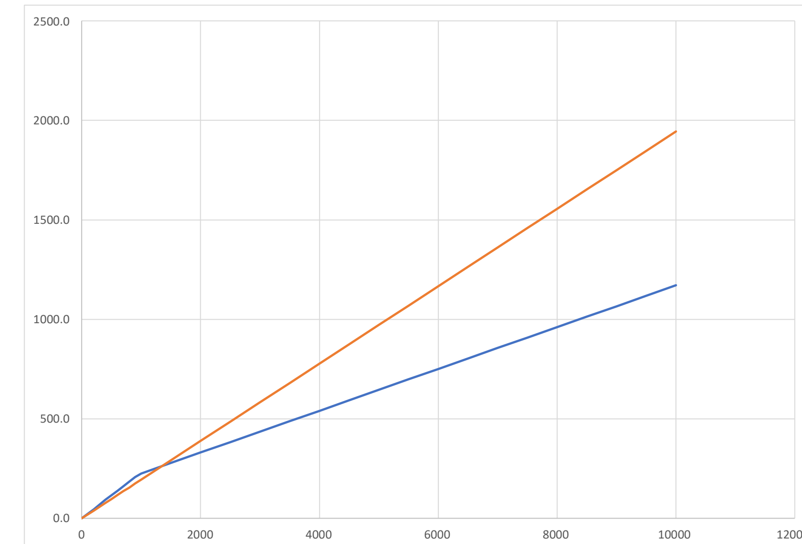
	Cover Material - Geotextile/Geocomposite	Granular Material - Geotextile	Geocomposite - Geomembrane (textured)	Geomembrane (textured) - GCL	GCL Internal	Geomembrane (textured) - Clay Subgrade	Geomembrane (smooth) - Granular	Geomembrane (smooth) - Clay Subgrade
Cohesion	100	0	160	160	760	200	0	280
Friction Angle	30	33	25	23	16	18	21	11
Effective Stress (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)
0	100.0	0.0	160.0	160.0	760.0	200.0	0.0	280.0
100	157.7	64.9	206.6	202.4	788.7	232.5	38.4	299.4
200	215.5	129.9	253.3	244.9	817.3	265.0	76.8	318.9
300	273.2	194.8	299.9	287.3	846.0	297.5	115.2	338.3
400	330.9	259.8	346.5	329.8	874.7	330.0	153.5	357.8
500	388.7	324.7	393.2	372.2	903.4	362.5	191.9	377.2
600	446.4	389.6	439.8	414.7	932.0	395.0	230.3	396.6
700	504.1	454.6	486.4	457.1	960.7	427.4	268.7	416.1
800	561.9	519.5	533.0	499.6	989.4	459.9	307.1	435.5
900	619.6	584.5	579.7	542.0	1018.1	492.4	345.5	454.9
1000	677.4	649.4	626.3	584.5	1046.7	524.9	383.9	474.4
1500	966.0	974.1	859.5	796.7	1190.1	687.4	575.8	571.6
2000	1254.7	1298.8	1092.6	1008.9	1333.5	849.8	767.7	668.8
2500	1543.4	1623.5	1325.8	1221.2	1476.9	1012.3	959.7	766.0
3000	1832.1	1948.2	1558.9	1433.4	1620.2	1174.8	1151.6	863.1
3500	2120.7	2272.9	1792.1	1645.7	1763.6	1337.2	1343.5	960.3
4000	2409.4	2597.6	2025.2	1857.9	1907.0	1499.7	1535.5	1057.5
4500	2698.1	2922.3	2258.4	2070.1	2050.4	1662.1	1727.4	1154.7
5000	2986.8	3247.0	2491.5	2282.4	2193.7	1824.6	1919.3	1251.9
5500	3275.4	3571.7	2724.7	2494.6	2337.1	1987.1	2111.3	1349.1
6000	3564.1	3896.4	2957.8	2706.8	2480.5	2149.5	2303.2	1446.3
6500	3852.8	4221.1	3191.0	2919.1	2623.8	2312.0	2495.1	1543.5
7000	4141.5	4545.9	3424.2	3131.3	2767.2	2474.4	2687.0	1640.7
7500	4430.1	4870.6	3657.3	3343.6	2910.6	2636.9	2879.0	1737.9
8000	4718.8	5195.3	3890.5	3555.8	3054.0	2799.4	3070.9	1835.0
8500	5007.5	5520.0	4123.6	3768.0	3197.3	2961.8	3262.8	1932.2
9000	5296.2	5844.7	4356.8	3980.3	3340.7	3124.3	3454.8	2029.4
9500	5584.8	6169.4	4589.9	4192.5	3484.1	3286.7	3646.7	2126.6
10000	5873.5	6494.1	4823.1	4404.7	3627.5	3449.2	3838.6	2223.8
	New and Existing	Existing	New	New	New	New	Existing	Existing

New Cell		Existing Cell	
100.0	Cover Material - Geocomposite	0.0	Geomembrane (smooth) - Granular
157.7		38.4	
215.5		76.8	
273.2		115.2	
329.8		153.5	
362.5		191.9	
395.0	Geomembrane (textured) - Clay Subgrade	230.3	
427.4		268.7	
459.9		307.1	
492.4		345.5	
524.9		383.9	
687.4		571.6	
849.8		668.8	Geomembrane (smooth) - Clay Subgrade
1012.3		766.0	
1174.8		863.1	
1337.2		960.3	
1499.7		1057.5	
1662.1		1154.7	
1824.6		1251.9	
1987.1		1349.1	
2149.5		1446.3	
2312.0		1543.5	
2474.4		1640.7	
2636.9		1737.9	
2799.4		1835.0	
2961.8		1932.2	
3124.3		2029.4	
3286.7		2126.6	
3449.2		2223.8	



	Cover Material - Geotextile/Geocomposite	Granular Material - Geotextile	Geocomposite - Geomembrane (textured)	Geomembrane (textured) - GCL	GCL Internal	Geomembrane (textured) - Clay Subgrade	Geomembrane (smooth) - Granular	Geomembrane (smooth) - Clay Subgrade
Cohesion	0	0	0	0	120	0	0	0
Friction Angle	21	33	17	13	6	16	17	11
Effective Stress (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)	Liner Strength (psf)
0	0.0	0.0	0.0	0.0	120.0	0.0	0.0	0.0
100	38.4	64.9	30.6	23.1	130.5	28.7	30.6	19.4
200	76.8	129.9	61.1	46.2	141.0	57.3	61.1	38.9
300	115.2	194.8	91.7	69.3	151.5	86.0	91.7	58.3
400	153.5	259.8	122.3	92.3	162.0	114.7	122.3	77.8
500	191.9	324.7	152.9	115.4	172.6	143.4	152.9	97.2
600	230.3	389.6	183.4	138.5	183.1	172.0	183.4	116.6
700	268.7	454.6	214.0	161.6	193.6	200.7	214.0	136.1
800	307.1	519.5	244.6	184.7	204.1	229.4	244.6	155.5
900	345.5	584.5	275.2	207.8	214.6	258.1	275.2	174.9
1000	383.9	649.4	305.7	230.9	225.1	286.7	305.7	194.4
1500	575.8	974.1	458.6	346.3	277.7	430.1	458.6	291.6
2000	767.7	1298.8	611.5	461.7	330.2	573.5	611.5	388.8
2500	959.7	1623.5	764.3	577.2	382.8	716.9	764.3	486.0
3000	1151.6	1948.2	917.2	692.6	435.3	860.2	917.2	583.1
3500	1343.5	2272.9	1070.1	808.0	487.9	1003.6	1070.1	680.3
4000	1535.5	2597.6	1222.9	923.5	540.4	1147.0	1222.9	777.5
4500	1727.4	2922.3	1375.8	1038.9	593.0	1290.4	1375.8	874.7
5000	1919.3	3247.0	1528.7	1154.3	645.5	1433.7	1528.7	971.9
5500	2111.3	3571.7	1681.5	1269.8	698.1	1577.1	1681.5	1069.1
6000	2303.2	3896.4	1834.4	1385.2	750.6	1720.5	1834.4	1166.3
6500	2495.1	4221.1	1987.2	1500.6	803.2	1863.8	1987.2	1263.5
7000	2687.0	4545.9	2140.1	1616.1	855.7	2007.2	2140.1	1360.7
7500	2879.0	4870.6	2293.0	1731.5	908.3	2150.6	2293.0	1457.9
8000	3070.9	5195.3	2445.8	1846.9	960.8	2294.0	2445.8	1555.0
8500	3262.8	5520.0	2598.7	1962.4	1013.4	2437.3	2598.7	1652.2
9000	3454.8	5844.7	2751.6	2077.8	1065.9	2580.7	2751.6	1749.4
9500	3646.7	6169.4	2904.4	2193.2	1118.5	2724.1	2904.4	1846.6
10000	3838.6	6494.1	3057.3	2308.7	1171.0	2867.5	3057.3	1943.8
	New and Existing	Existing	New	New	New	New	Existing	Existing

New Cell		Existing Cell	
0.0	Geomembrane (textured) - GCL	0.0	Geomembrane (smooth) - Clay Subgrade
23.1		19.4	
46.2		38.9	
69.3		58.3	
92.3		77.8	
115.4		97.2	
138.5		116.6	
161.6		136.1	
184.7		155.5	
207.8		174.9	
225.1		194.4	
277.7	GCL Internal	291.6	
330.2		388.8	
382.8		486.0	
435.3		583.1	
487.9		680.3	
540.4		777.5	
593.0		874.7	
645.5		971.9	
698.1		1069.1	
750.6		1166.3	
803.2		1263.5	
855.7		1360.7	
908.3		1457.9	
960.8		1555.0	
1013.4		1652.2	
1065.9		1749.4	
1118.5		1846.6	
1171.0		1943.8	



Attachment D – Sections

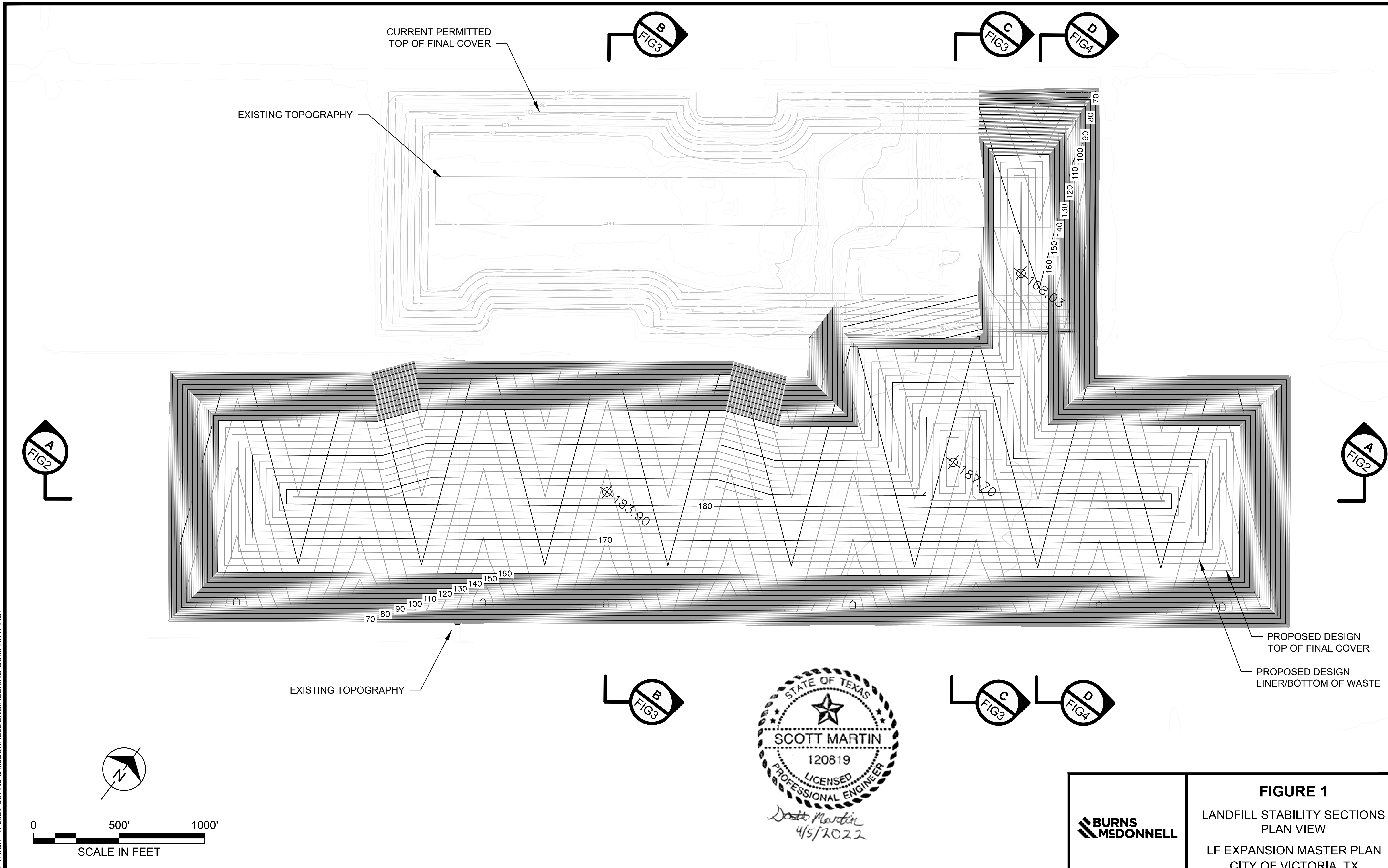


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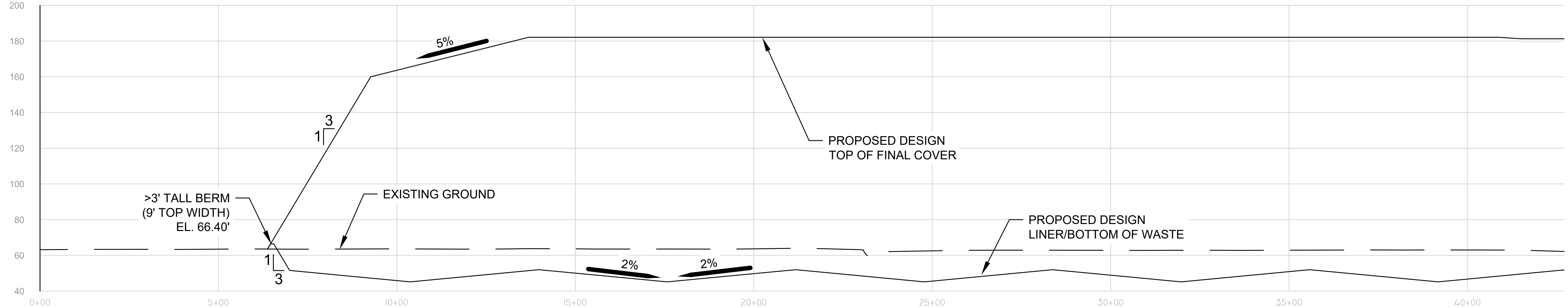
FIGURE 1

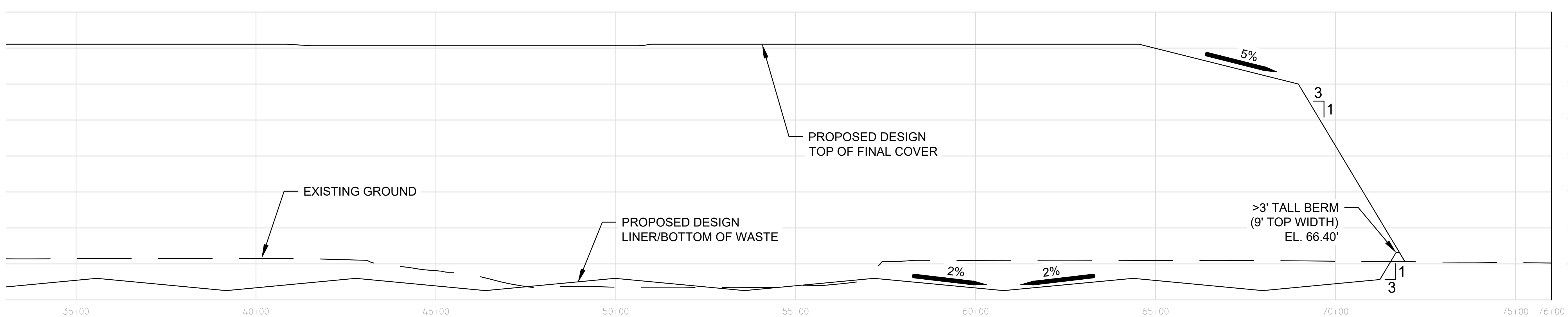
LANDFILL STABILITY SECTIONS
PLAN VIEW

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION A (PART 1)



SECTION A (PART 2)



STATE OF TEXAS
SCOTT MARTIN
120819
LICENSED
PROFESSIONAL ENGINEER

Scott Martin
4/5/2022

VERTICAL SCALE: 0 60' 120'
SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600'
SCALE IN FEET

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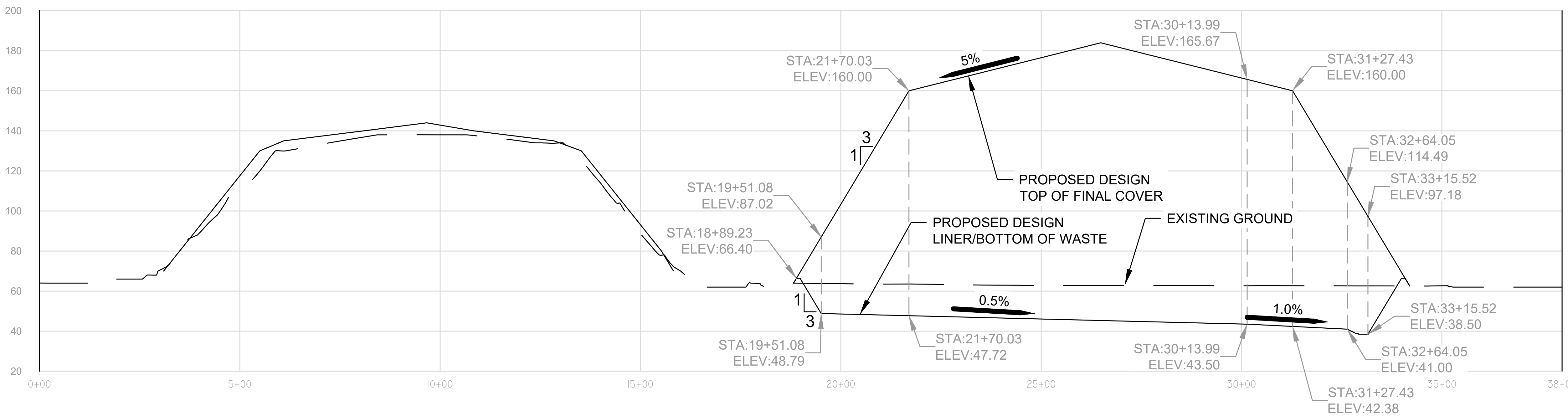
FIGURE 2

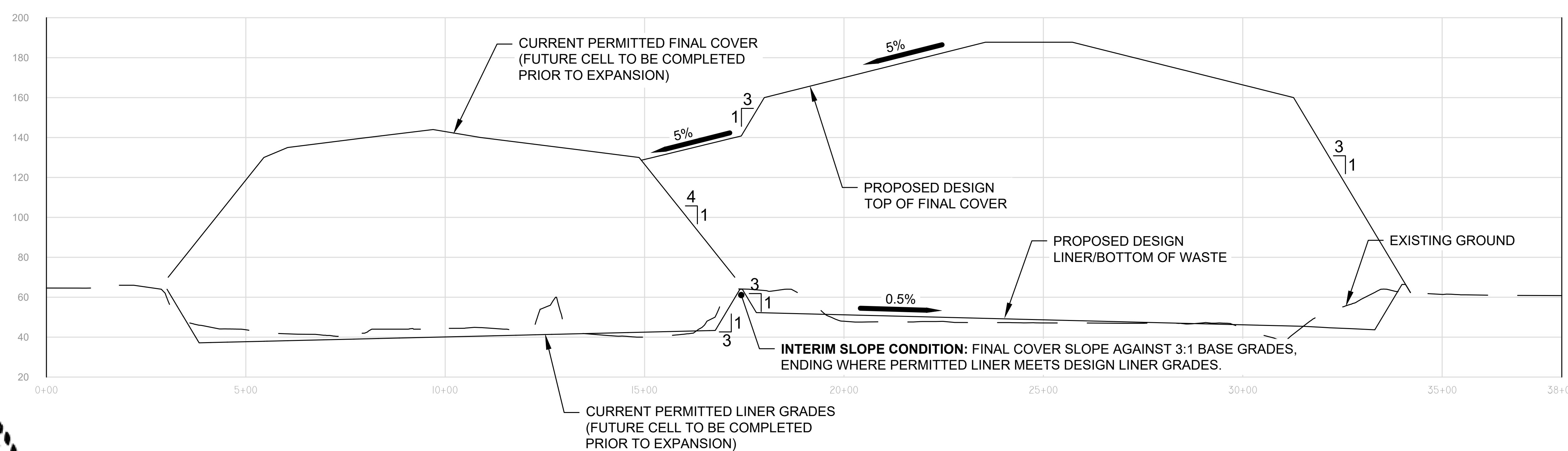
LANDFILL STABILITY SECTIONS
CROSS SECTION A

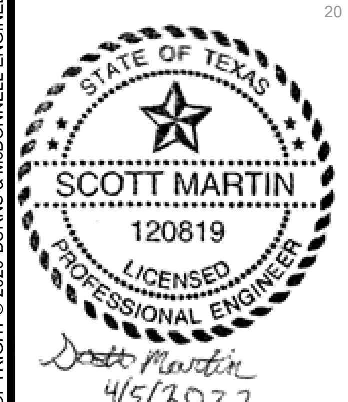
LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION B



SECTION C





VERTICAL SCALE: 0 60' 120'
SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600'
SCALE IN FEET

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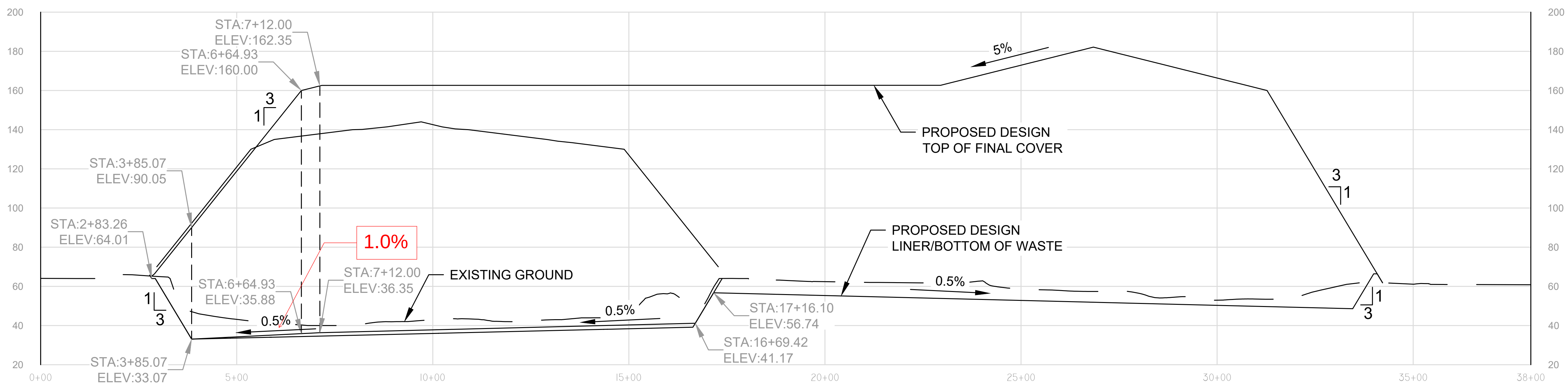
FIGURE 3

LANDFILL STABILITY SECTIONS
CROSS SECTIONS B AND C

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION D



VERTICAL SCALE: 0 60' 120' SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600' SCALE IN FEET

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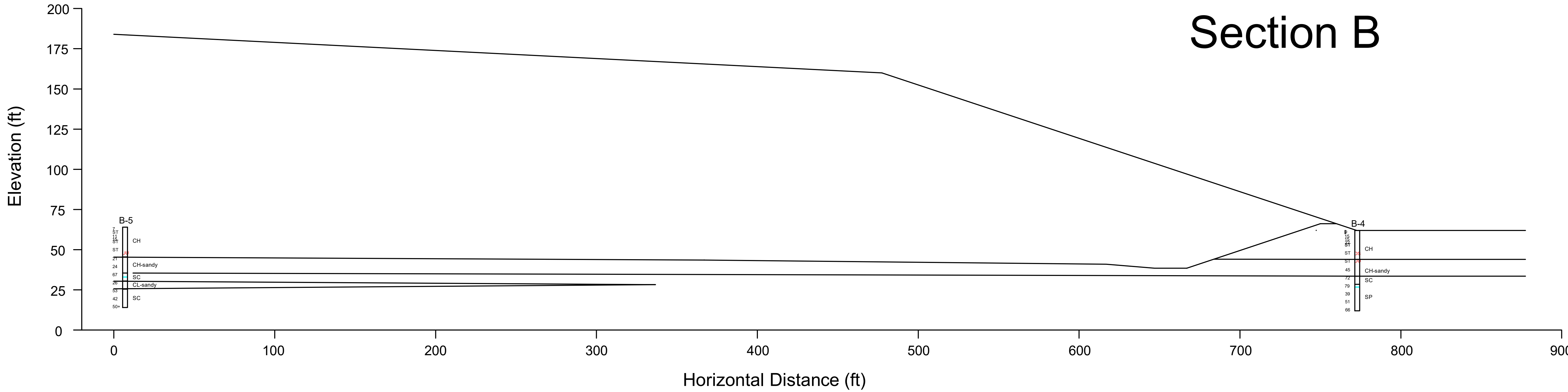
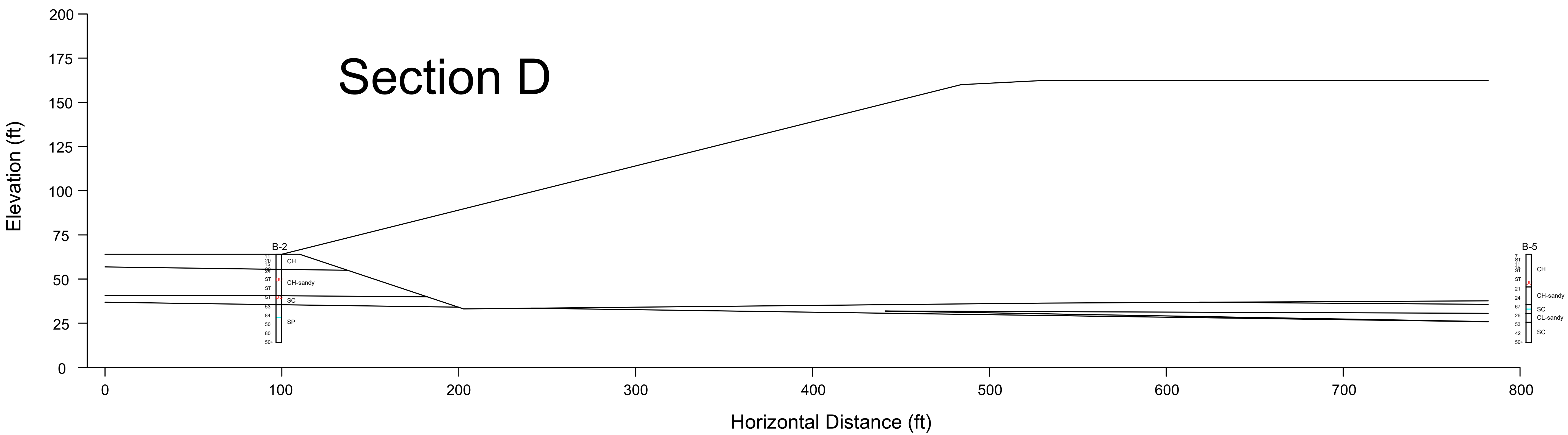
FIGURE 4

LANDFILL STABILITY SECTIONS
CROSS SECTIONS D AND E

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX


Section B
Elevation (ft)
Horizontal Distance (ft)
B-5
B-4
CH
CH-sandy
SC
CL-sandy
SP


Section D
Elevation (ft)
Horizontal Distance (ft)
B-2
CH
CH-sandy
SC
SP
B-5
CH
CH-sandy
SC
CL-sandy
SC

Attachment E – Utexas4 Input/Output and USGS Deaggregation

Profile: B Case: EOC

Unit Weight Average Effective Average Total Average

Fixed Grid Coordinates

x	y
400	165
400	365
750	365
750	165

Circle Exit

x 447.43 y 160

Tangent

Search Grid Subdivisions

25

Crack Depth

1

Seismic Acceleration

0

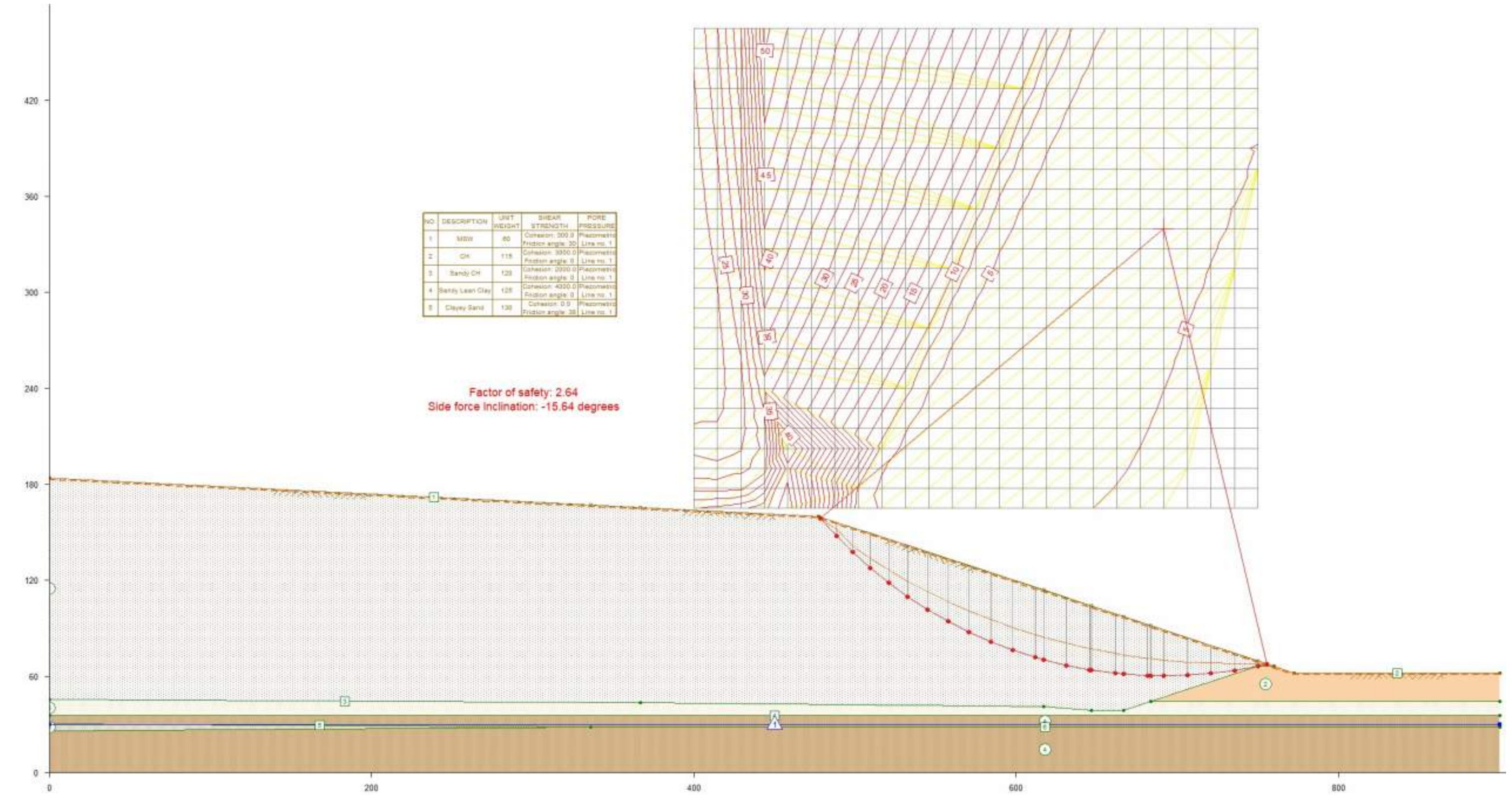
Minimum Weight

5000

Results

		Circle Center		Circle Exit	
Circles Attempted	Circles Completed	x	y	x	y
625	405	691.7	340	755.7	67.6

Factor of Safety	Errors
2.64	



Profile: B Case: EOC FINAL

Unit Weight Average Effective Average Total Average

Fixed Grid Coordinates

x	y
400	165
400	465
750	465
750	165

Circle Exit

x 750 y 66.2

Tangent

Search Grid Subdivisions

25

Crack Depth

0

Seismic Acceleration

0

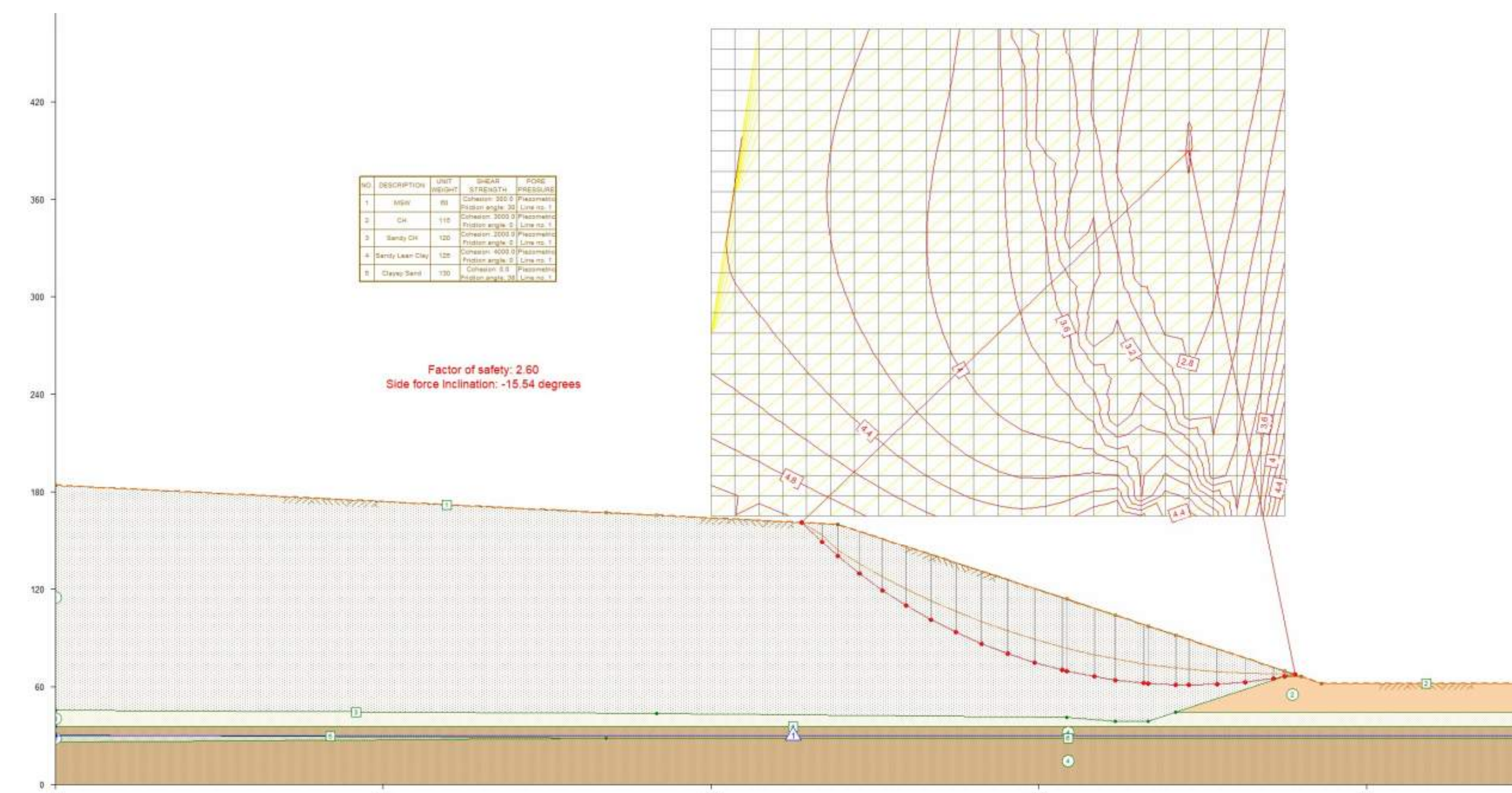
Minimum Weight

5000

Results

		Circle Center		Circle Exit	
Circles Attempted	Circles Completed	x	y	x	y
625	602	691.7	390	455.3	161.1

Factor of Safety	Errors
2.6	



Victoria, TX Landfill

Cross-Section: B
Case: End of Construction
Filename: 20210719 Profile B EOC_input (textor).docx

UTEXAS4 Input File
Page 1 of 2

```
GRAphics
HEAding follows -
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PROfile lines
   1 1 MSW
         0 184
         477.43 160
         760 66.2

   2 2 CH
         683.74 44.1
         750 66.2
         760 66.2
         772.6 62
         900 62

   3 3 Sandy CH
         0 45.33
         366.9 43.5
         616.9 41
         646.9 38.5
         666.9 38.5
         683.74 44.1
         900 44.1

   4 4 Clayey Sand
         0 35.5
         900 35.5

   5 5 Sandy CL
         0 30.4
         336 28.3

   6 4 Clayey Sand
         0 25.7
         336 28.3
         900 28.3


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         3000 0
      Piezometric Line
         1
   3 Sandy CH
```

```
      120 = unit weight
      Conventional Shear Strength
         2000 0
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         4000 0
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         900 30


LABel
Victoria, TX Landfill Evaluation - Section B EOC
ANALYSIS/COMPUTATION
   Circular Search 2
     25 25
     400 165 400 465 750 465 750 165
     5 5
   Point
     750 66.2

   Minimum
     5000
   Crack
     0 D
   Short

COMpute
```

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
* RESULTS OF COMPUTATIONS PERFORMED USING THIS SOFTWARE         *
* SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY HAVE       *
* BEEN VERIFIED BY INDEPENDENT ANALYSES, EXPERIMENTAL DATA      *
* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
* AND ANALYTICAL PROCEDURES USED IN THIS SOFTWARE AND MUST HAVE  *
* READ ALL DOCUMENTATION FOR THIS SOFTWARE BEFORE ATTEMPTING    *
* TO USE IT.  NEITHER SHINOAK SOFTWARE NOR STEPHEN G. WRIGHT    *
* MAKE OR ASSUME LIABILITY FOR ANY WARRANTIES, EXPRESSED OR     *
* IMPLIED, CONCERNING THE ACCURACY, RELIABILITY, USEFULNESS     *
* OR ADAPTABILITY OF THIS SOFTWARE.                             *
*****************************************************************
```

```
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
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tion B EOC.dat

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TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1        0.00      184.00
   2      477.43      160.00
   3      760.00       66.20

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1      683.74       44.10
   2      750.00       66.20
   3      760.00       66.20
   4      772.60       62.00
   5      900.00       62.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH

Point        X           Y

   1        0.00       45.33
   2      366.90       43.50
   3      616.90       41.00
   4      646.90       38.50
   5      666.90       38.50
   6      683.74       44.10
   7      900.00       44.10

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       35.50
```

```
   2      900.00       35.50

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 5 -----
----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1        0.00       30.40
   2      336.00       28.30

----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       25.70
   2      336.00       28.30
   3      900.00       28.30
```

```
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TABLE NO. 4
**********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 3000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 2000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 4000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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TABLE NO. 6
*********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      900.00       30.00
```

```
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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************


Search will be conducted using a fixed grid.
Number of Points Across Grid: 25
Number of Points Up Grid: 25

Grid Corner
   Number           X              Y

     1           400.00         165.00
     2           400.00         465.00
     3           750.00         465.00
     4           750.00         165.00

----- Control Parameters for Finding "Critical" Radius -----
Initial number of subdivisions between maximum and minimum
radius for finding a critical radius/radii: 5

Minimum radius increment for terminating subdivision of radii: 5.000

The following criteria will be used for determining
the maximum and minimum radii:
     Point circles pass through - X: 750.00     Y: 66.20
Minimum weight required for computations to be performed: 5000

Depth of crack: 0.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Subtended angle for slice subdivision: 3.00(degrees)
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Search will be continued after the initial mode to find a most critical circle.
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Radii for each grid point will be sorted in the order of increasing radius.
Critical circles for grid points will be output in the order of increasing factor of safety.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Initial trial factor of safety: 3.000
```

```
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00      184.00
        2     336.00      167.11
        3     366.90      165.56
        4     477.43      160.00
        5     616.90      113.70
        6     646.90      103.74
        7     666.90       97.10
        8     683.74       91.51
        9     750.00       69.52
       10     760.00       66.20
       11     772.60       62.00
       12     900.00       62.00
```

```
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TABLE NO. 38
************************************************
* FINAL SUMMARY OF COMPUTATIONS WITH FIXED-GRID *
************************************************


Number of circles attempted: 625
Number of circles for which F calculated: 602
Circle with Lowest Factor of Safety:
     X coordinate for center: 691.67
     Y coordinate for center: 390.00
     Radius of circle: 329.012
Factor of safety: 2.597
Side force inclination: -15.54
Time Required for Computations: 0.0 seconds
```

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Victoria, TX Landfill Evaluation - Section B EOC
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TABLE NO. 43

```
*********************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
*********************************************************
```

Slice No.	X	Y	Slice Weight	Matl. No.	Cohesion	Friction Angle	Pore Pressure
	455.32	161.11					
1	461.47	155.08	4221	1	300.0	30.00	0.0
	467.62	149.06					
2	472.53	144.68	9161	1	300.0	30.00	0.0
	477.43	140.30					
3	484.11	134.86	18376	1	300.0	30.00	0.0
	490.79	129.43					
4	497.75	124.35	24130	1	300.0	30.00	0.0
	504.70	119.27					
5	511.92	114.56	29417	1	300.0	30.00	0.0
	519.13	109.86					
6	526.58	105.53	34103	1	300.0	30.00	0.0
	534.03	101.21					
7	541.69	97.28	38065	1	300.0	30.00	0.0
	549.36	93.36					
8	557.22	89.84	41198	1	300.0	30.00	0.0
	565.08	86.32					
9	573.11	83.21	43408	1	300.0	30.00	0.0
	581.15	80.11					
10	589.33	77.43	44620	1	300.0	30.00	0.0
	597.52	74.75					
11	605.83	72.50	44775	1	300.0	30.00	0.0
	614.14	70.25					
12	615.52	69.92	7316	1	300.0	30.00	0.0
	616.90	69.60					
13	625.34	67.86	43572	1	300.0	30.00	0.0
	633.77	66.12					
14	640.34	65.08	32170	1	300.0	30.00	0.0
	646.90	64.05					
15	655.46	63.10	38832	1	300.0	30.00	0.0
	664.02	62.15					
16	665.46	62.04	6142	1	300.0	30.00	0.0
	666.90	61.92					
17	675.32	61.50	33149	1	300.0	30.00	0.0
	683.74	61.08					
18	687.70	61.04	13870	1	300.0	30.00	0.0
	691.67	60.99					
19	700.28	61.21	25635	1	300.0	30.00	0.0
	708.89	61.44					
20	717.47	62.11	18755	1	300.0	30.00	0.0
	726.06	62.79					

21	734.60	63.91	10983	1	300.0	30.00	0.0
	743.14	65.04					
22	746.57	65.62	2076	1	300.0	30.00	0.0
	750.00	66.20					
23	750.00	66.20	0	2	3000.0	0.00	0.0
	750.00	66.20					
24	750.00	66.20	0	2	3000.0	0.00	0.0
	750.00	66.20					
25	753.18	66.80	633	1	300.0	30.00	0.0
	756.36	67.41					

No water in crack.

```
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Victoria, TX Landfill Evaluation - Section B EOC
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TABLE NO. 44
*********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.              *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                         *
*********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************
Allowable force imbalance for convergence:  6
Allowable moment imbalance for convergence: 3374

        Trial     Trial
       Factor   Side Force     Force       Moment                Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -2.156e+004   5.276e+006
First-order corrections to F and Theta ............   -0.3616    -8.4424
Reduced values - Deltas were too large ............   -0.1227    -2.8648

   2   2.87728   -20.0535  -1.389e+004   3.171e+006
First-order corrections to F and Theta ............   -0.4238    16.4297
Reduced values - Deltas were too large ............   -0.0739     2.8648

   3   2.80339   -17.1887  -1.139e+004   2.653e+006
First-order corrections to F and Theta ............   -0.2481     4.4369
Reduced values - Deltas were too large ............   -0.1602     2.8648

   4   2.64317   -14.3239  -3.583e+003   1.032e+006
First-order corrections to F and Theta ............   -0.0445    -1.5401
Second-order corrections to F and Theta ...........   -0.0463    -1.2192

   5   2.59690   -15.5432   2.689e+000  -1.385e+003
First-order corrections to F and Theta ............    0.0000     0.0043
```

```
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TABLE NO. 55
*********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
*********************************************************************

Summation of Horizontal Forces: 3.20593e-011

Summation of Vertical Forces: 5.24042e-011

Summation of Moments: 1.49579e-001

Mohr Coulomb Shear Force/Shear Strength Check Summation: 2.05015e-011
```

```
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TABLE NO. 58
*********************************************************************
* Final Results for Stresses Along the Shear Surface                *
* (Results are for the critical shear surface in the case of a search.) *
*********************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 2.597     Side Force Inclination: -15.54
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	461.47	155.08	183.4	183.4	156.3
2	472.53	144.68	623.1	623.1	254.1
3	484.11	134.86	976.3	976.3	332.6
4	497.75	124.35	1290.6	1290.6	402.4
5	511.92	114.56	1578.2	1578.2	466.4
6	526.58	105.53	1834.8	1834.8	523.4
7	541.69	97.28	2056.0	2056.0	572.6
8	557.22	89.84	2237.9	2237.9	613.0
9	573.11	83.21	2376.5	2376.5	643.9
10	589.33	77.43	2468.2	2468.2	664.3
11	605.83	72.50	2509.3	2509.3	673.4
12	615.52	69.92	2514.9	2514.9	674.7
13	625.34	67.86	2488.4	2488.4	668.8
14	640.34	65.08	2422.4	2422.4	654.1
15	655.46	63.10	2302.2	2302.2	627.4
16	665.46	62.04	2203.8	2203.8	605.5
17	675.32	61.50	2071.3	2071.3	576.0
18	687.70	61.04	1885.8	1885.8	534.8
19	700.28	61.21	1647.3	1647.3	481.8
20	717.47	62.11	1261.0	1261.0	395.9
21	734.60	63.91	791.5	791.5	291.5
22	746.57	65.62	414.8	414.8	207.7
23	750.00	66.20	688.7	688.7	1155.2
24	750.00	66.20	869.6	869.6	1155.2
25	753.18	66.80	182.3	182.3	156.1

```
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Name of input data file:
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tion B EOC.dat

Victoria, TX Landfill Evaluation - Section B EOC
#107608

TABLE NO. 59
*********************************************************************
* Final Results for Side Forces and Stresses Between Slices            *
* (Results are for the critical shear surface in the case of a search.) *
*********************************************************************
```

--------------- VALUES AT RIGHT SIDE OF SLICE ---------------

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	467.62	299	153.37	0.377	6.7	43.8
2	477.43	3379	143.96	0.186	-146.0	476.4
3	490.79	9782	135.51	0.233	-217.9	939.0
4	504.70	17574	127.55	0.261	-231.0	1300.1
5	519.13	26012	119.98	0.279	-226.1	1606.9
6	534.03	34383	112.82	0.290	-214.1	1870.3
7	549.36	42033	106.12	0.298	-198.4	2092.2
8	565.08	48386	99.90	0.305	-180.3	2271.2
9	581.15	52963	94.18	0.310	-160.1	2404.8
10	597.52	55407	88.99	0.314	-137.9	2490.0
11	614.14	55493	84.34	0.318	-113.4	2523.6
12	616.90	55275	83.63	0.318	-109.2	2523.9
13	633.77	52537	79.64	0.322	-81.5	2492.9
14	646.90	48839	76.96	0.325	-58.1	2428.7
15	664.02	42222	73.99	0.330	-24.1	2289.7
16	666.90	40938	73.56	0.331	-17.9	2260.0
17	683.74	32672	71.33	0.337	21.0	2047.7
18	691.67	28459	70.49	0.341	42.4	1923.4
19	708.89	19078	69.08	0.352	93.5	1598.2
20	726.06	10253	68.25	0.372	156.1	1190.0
21	743.14	3239	67.75	0.401	187.1	736.1
22	750.00	1258	67.69	0.448	252.1	478.4
23	750.00	1258	67.69	0.448	252.1	478.4
24	750.00	1258	67.69	0.448	252.1	478.4
25	756.36	-0	67.41	1.000	0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Profile: B   Case: LTSS

Unit Weight Average Effective Average Total Average

Fixed Grid Coordinates

x	y
400	165
400	465
750	465
750	165

Circle Exit

x	y
447.43	160

Tangent

Search Grid Subdivisions
25

Crack Depth
1

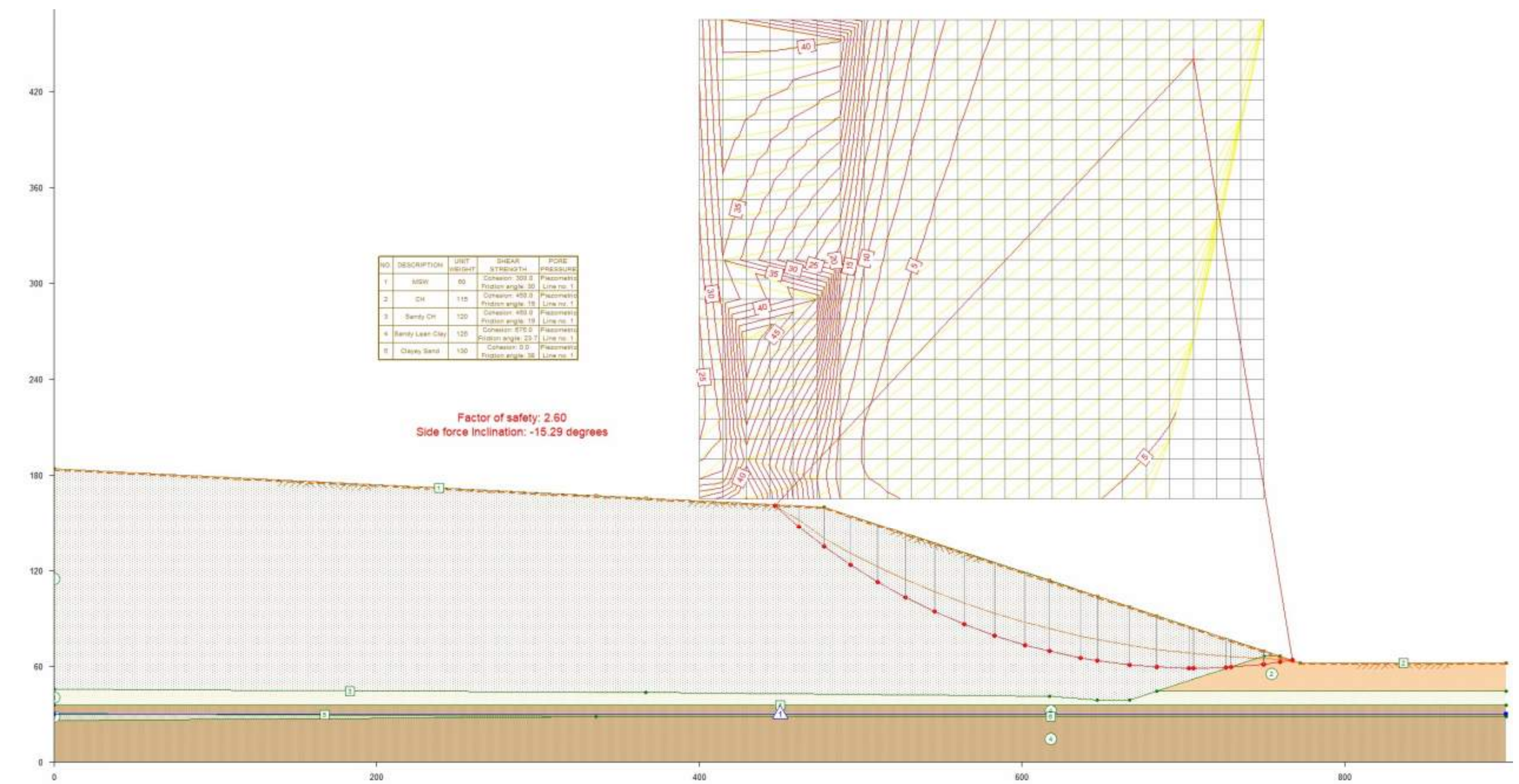
Seismic Acceleration

Minimum Weight
5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	475	706.3	440	767.6	63.7

Factor of Safety	Errors
2.6	



Profile: B   Case: LTSS

Unit Weight Average Effective Average Total Average FINAL

Fixed Grid Coordinates

x	y
400	165
400	465
750	465
750	165

Circle Exit

x	y
750	66.2

Tangent

Search Grid Subdivisions
25

Crack Depth
1

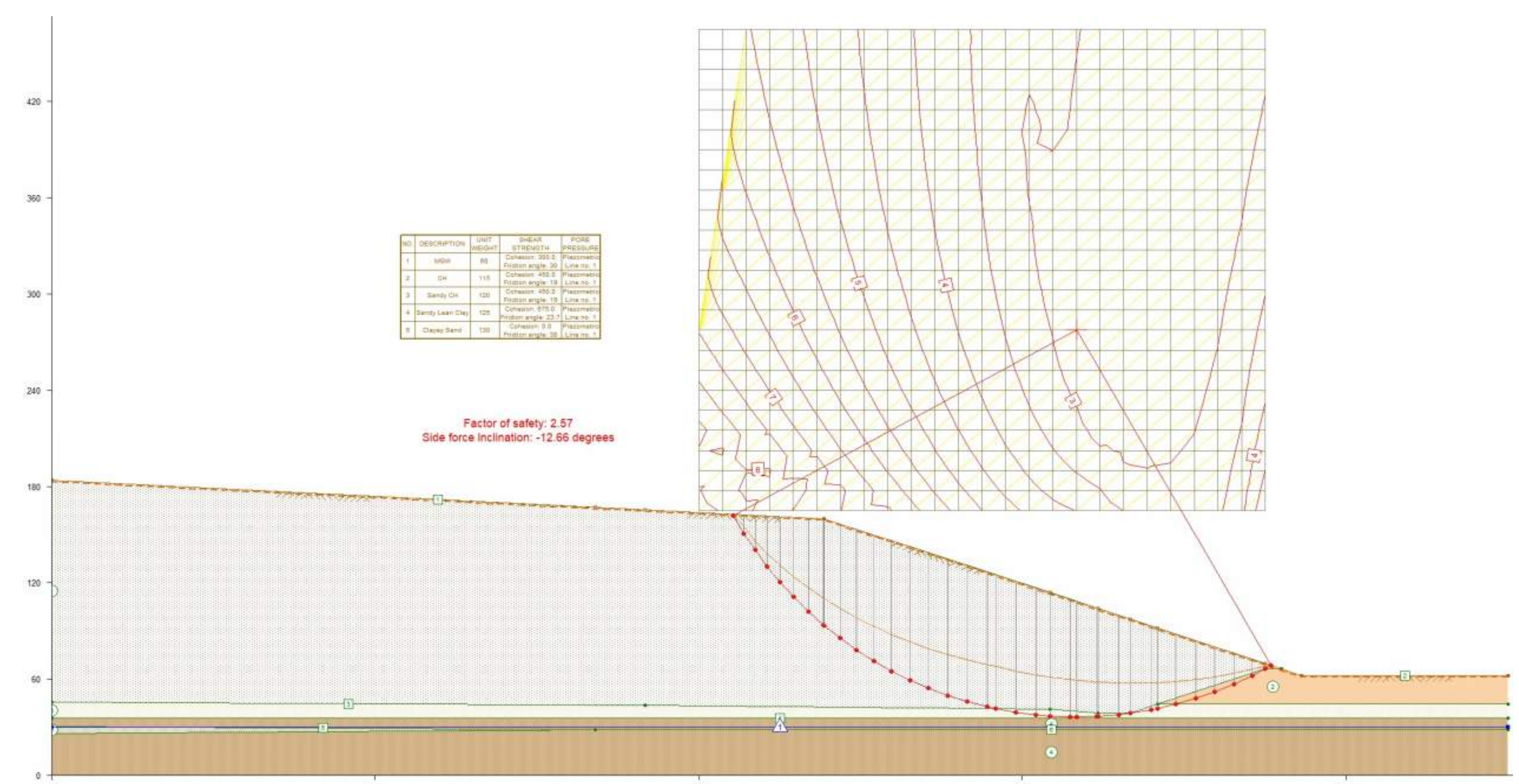
Seismic Acceleration

Minimum Weight
5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	602	633.3	277.5	421.5	161.8

Factor of Safety	Errors
2.57	



Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State
Filename: 20210719 Profile B LTSS - 1_input (textor).docx

UTEXAS4 Input File


```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section B LTSS
#107608

PROfile lines
   1 1 MSW
         0 184
         477.43 160
         760 66.2

   2 2 CH
         683.74 44.1
         750 66.2
         760 66.2
         772.6 62
         900 62

   3 3 Sandy CH
         0 45.33
         366.9 43.5
         616.9 41
         646.9 38.5
         666.9 38.5
         683.74 44.1
         900 44.1

   4 4 Clayey Sand
         0 35.5
         900 35.5

   5 5 Sandy CL
         0 30.4
         336 28.3

   6 4 Clayey Sand
         0 25.7
         336 28.3
         900 28.3


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
```

```
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         900 30


LABel
Victoria, TX Landfill Evaluation - Section B LTSS
ANALYSIS/COMPUTATION
   Circular Search 2
     25 25
     400 165 400 465 750 465 750 165
     5 5
   Point
     750 66.2

   Minimum
     5000
   Crack
     1 D
   Short

COMpute
```

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
* RESULTS OF COMPUTATIONS PERFORMED USING THIS SOFTWARE         *
* SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY HAVE       *
* BEEN VERIFIED BY INDEPENDENT ANALYSES, EXPERIMENTAL DATA      *
* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
* AND ANALYTICAL PROCEDURES USED IN THIS SOFTWARE AND MUST HAVE  *
* READ ALL DOCUMENTATION FOR THIS SOFTWARE BEFORE ATTEMPTING    *
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* OR ADAPTABILITY OF THIS SOFTWARE.                             *
*****************************************************************
```

```
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Licensed for use by: Nathan Textor, Burns & McDonnell
Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
Z:\Clients\ENS\CityVictoria\107608_LandfillPermit\Design\GeoTech\Working\Dsgn\Sections\202107\Sec
tion B LTSS.dat

Victoria, TX Landfill Evaluation - Section B LTSS
#107608

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1        0.00      184.00
   2      477.43      160.00
   3      760.00       66.20

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1      683.74       44.10
   2      750.00       66.20
   3      760.00       66.20
   4      772.60       62.00
   5      900.00       62.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH

Point        X           Y

   1        0.00       45.33
   2      366.90       43.50
   3      616.90       41.00
   4      646.90       38.50
   5      666.90       38.50
   6      683.74       44.10
   7      900.00       44.10

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       35.50
```

```
   2      900.00       35.50

-----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 5 -----
-----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1        0.00       30.40
   2      336.00       28.30

-----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 4 -----
-----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       25.70
   2      336.00       28.30
   3      900.00       28.30
```

```
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TABLE NO. 4
*********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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tion B LTSS.dat

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TABLE NO. 6
********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
********************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      900.00       30.00
```

```
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tion B LTSS.dat

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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************


Search will be conducted using a fixed grid.
Number of Points Across Grid: 25
Number of Points Up Grid: 25

Grid Corner
   Number           X              Y

     1           400.00         165.00
     2           400.00         465.00
     3           750.00         465.00
     4           750.00         165.00

----- Control Parameters for Finding "Critical" Radius -----
Initial number of subdivisions between maximum and minimum
radius for finding a critical radius/radii: 5

Minimum radius increment for terminating subdivision of radii: 5.000

The following criteria will be used for determining
the maximum and minimum radii:
     Point circles pass through - X: 750.00     Y: 66.20
Minimum weight required for computations to be performed: 5000

Depth of crack: 1.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Subtended angle for slice subdivision: 3.00(degrees)
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Search will be continued after the initial mode to find a most critical circle.
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Radii for each grid point will be sorted in the order of increasing radius.
Critical circles for grid points will be output in the order of increasing factor of safety.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Initial trial factor of safety: 3.000
```

```
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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tion B LTSS.dat

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TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00      184.00
        2     336.00      167.11
        3     366.90      165.56
        4     477.43      160.00
        5     616.90      113.70
        6     646.90      103.74
        7     666.90       97.10
        8     683.74       91.51
        9     750.00       69.52
       10     760.00       66.20
       11     772.60       62.00
       12     900.00       62.00
```

```
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Victoria, TX Landfill Evaluation - Section B LTSS
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TABLE NO. 38
*************************************************
* FINAL SUMMARY OF COMPUTATIONS WITH FIXED-GRID *
*************************************************


Number of circles attempted: 625
Number of circles for which F calculated: 602
Circle with Lowest Factor of Safety:
     X coordinate for center: 633.33
     Y coordinate for center: 277.50
     Radius of circle: 241.369
Factor of safety: 2.574
Side force inclination: -12.66
Time Required for Computations: 1.0 seconds
```

```
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tion B LTSS.dat

Victoria, TX Landfill Evaluation - Section B LTSS
#107608

TABLE NO. 43
************************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
************************************************************
```

Slice No.	X	Y	Slice Weight	Matl. No.	Cohesion	Friction Angle	Pore Pressure
	421.50	161.81					
1	424.67	156.35	2400	1	300.0	30.00	0.0
	427.84	150.88					
2	431.30	145.59	6933	1	300.0	30.00	0.0
	434.75	140.30					
3	438.48	135.20	11965	1	300.0	30.00	0.0
	442.20	130.10					
4	446.19	125.20	17408	1	300.0	30.00	0.0
	450.18	120.30					
5	454.42	115.61	23169	1	300.0	30.00	0.0
	458.66	110.93					
6	463.14	106.47	29155	1	300.0	30.00	0.0
	467.61	102.01					
7	472.32	97.80	35271	1	300.0	30.00	0.0
	477.03	93.58					
8	477.23	93.41	1618	1	300.0	30.00	0.0
	477.43	93.24					
9	482.36	89.28	40857	1	300.0	30.00	0.0
	487.29	85.33					
10	492.42	81.64	45165	1	300.0	30.00	0.0
	497.54	77.95					
11	502.86	74.53	49126	1	300.0	30.00	0.0
	508.17	71.12					
12	513.66	67.98	52663	1	300.0	30.00	0.0
	519.15	64.85					
13	524.79	62.01	55710	1	300.0	30.00	0.0
	530.43	59.16					
14	536.22	56.62	58207	1	300.0	30.00	0.0
	542.00	54.08					
15	547.91	51.84	60104	1	300.0	30.00	0.0
	553.82	49.60					
16	559.84	47.68	61359	1	300.0	30.00	0.0
	565.86	45.76					
17	571.97	44.15	61939	1	300.0	30.00	0.0
	578.08	42.54					
18	580.78	41.94	27200	1	300.0	30.00	0.0
	583.49	41.33					
19	589.70	40.19	62355	3	450.0	19.00	0.0
	595.92	39.05					
20	602.18	38.23	62605	3	450.0	19.00	0.0
	608.45	37.42					

21	612.67	37.05	41604	3	450.0	19.00	0.0
	616.90	36.69					
22	623.21	36.43	60017	3	450.0	19.00	0.0
	629.53	36.16					
23	631.43	36.15	17450	3	450.0	19.00	0.0
	633.33	36.13					
24	639.65	36.30	55073	3	450.0	19.00	0.0
	645.97	36.46					
25	646.43	36.49	3894	3	450.0	19.00	0.0
	646.90	36.51					
26	653.20	37.03	49937	3	450.0	19.00	0.0
	659.49	37.55					
27	663.20	38.02	27020	3	450.0	19.00	0.0
	666.90	38.48					
28	673.13	39.52	42304	3	450.0	19.00	0.0
	679.36	40.56					
29	681.55	41.01	14075	3	450.0	19.00	0.0
	683.74	41.45					
30	689.29	42.78	33248	3	450.0	19.00	0.0
	694.84	44.10					
31	700.91	45.87	31715	2	450.0	19.00	0.0
	706.97	47.64					
32	712.94	49.72	25675	2	450.0	19.00	0.0
	718.90	51.81					
33	724.75	54.20	18930	2	450.0	19.00	0.0
	730.60	56.60					
34	736.31	59.29	11601	2	450.0	19.00	0.0
	742.02	61.99					
35	746.01	64.09	3570	2	450.0	19.00	0.0
	750.00	66.20					
36	751.85	67.24	369	1	300.0	30.00	0.0
	753.71	68.29					

No water in crack.

```
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Victoria, TX Landfill Evaluation - Section B LTSS
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TABLE NO. 44
*********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.              *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
*********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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tion B LTSS.dat

Victoria, TX Landfill Evaluation - Section B LTSS
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************
Allowable force imbalance for convergence:  12
Allowable moment imbalance for convergence: 6945

        Trial     Trial
       Factor   Side Force     Force      Moment                  Delta
Iter-    of    Inclination  Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)     (lbs.)    (ft.-lbs.)             (degrees)

   1   3.00000   -17.1887  -3.017e+004   4.071e+006
First-order corrections to F and Theta ............   -0.5977     7.9219
Reduced values - Deltas were too large ............   -0.2162     2.8648

   2   2.78385   -14.3239  -1.787e+004   2.579e+006
First-order corrections to F and Theta ............   -0.2424     2.2769
Second-order corrections to F and Theta ...........   -0.2121     1.7103

   3   2.57171   -12.6136   1.199e+002   3.816e+003
First-order corrections to F and Theta ............    0.0020    -0.0424
Second-order corrections to F and Theta ...........    0.0020    -0.0424

   4   2.57371   -12.6561  -1.163e-004  -6.293e-002
First-order corrections to F and Theta ............   -0.0000     0.0000
```

```
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Victoria, TX Landfill Evaluation - Section B LTSS
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TABLE NO. 55
********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
********************************************************************

Summation of Horizontal Forces: 1.21011e-010

Summation of Vertical Forces: 7.75198e-011

Summation of Moments: 2.31172e-008

Mohr Coulomb Shear Force/Shear Strength Check Summation: 3.22483e-011
```

```
UTEXAS4 S/N:10001  - Version: 4.1.0.8 - Latest Revision: 11/9/2009
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
Z:\Clients\ENS\CityVictoria\107608_LandfillPermit\Design\GeoTech\Working\Dsgn\Sections\202107\Sec
tion B LTSS.dat

Victoria, TX Landfill Evaluation - Section B LTSS
#107608

TABLE NO. 58
*******************************************************************
* Final Results for Stresses Along the Shear Surface              *
* (Results are for the critical shear surface in the case of a search.) *
*******************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 2.574     Side Force Inclination: -12.66

       -------- VALUES AT CENTER OF BASE OF SLICE --------
```

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	424.67	156.35	118.2	118.2	143.1
2	431.30	145.59	519.9	519.9	233.2
3	438.48	135.20	941.0	941.0	327.7
4	446.19	125.20	1375.8	1375.8	425.2
5	454.42	115.61	1819.2	1819.2	524.7
6	463.14	106.47	2266.8	2266.8	625.1
7	472.32	97.80	2714.4	2714.4	725.5
8	477.23	93.41	2949.4	2949.4	778.2
9	482.36	89.28	3113.3	3113.3	815.0
10	492.42	81.64	3414.7	3414.7	882.6
11	502.86	74.53	3693.1	3693.1	945.0
12	513.66	67.98	3946.0	3946.0	1001.8
13	524.79	62.01	4170.8	4170.8	1052.2
14	536.22	56.62	4365.1	4365.1	1095.8
15	547.91	51.84	4526.6	4526.6	1132.0
16	559.84	47.68	4653.2	4653.2	1160.4
17	571.97	44.15	4742.8	4742.8	1180.5
18	580.78	41.94	4787.2	4787.2	1190.4
19	589.70	40.19	4850.4	4850.4	823.8
20	602.18	38.23	4930.7	4930.7	834.5
21	612.67	37.05	4942.9	4942.9	836.1
22	623.21	36.43	4858.5	4858.5	824.8
23	631.43	36.15	4749.7	4749.7	810.3
24	639.65	36.30	4584.3	4584.3	788.2
25	646.43	36.49	4436.2	4436.2	768.3
26	653.20	37.03	4273.9	4273.9	746.6
27	663.20	38.02	4008.9	4008.9	711.2
28	673.13	39.52	3805.1	3805.1	683.9
29	681.55	41.01	3669.1	3669.1	665.7
30	689.29	42.78	3477.4	3477.4	640.1
31	700.91	45.87	3125.3	3125.3	593.0
32	712.94	49.72	2666.7	2666.7	531.6
33	724.75	54.20	2100.8	2100.8	455.9
34	736.31	59.29	1419.6	1419.6	364.8
35	746.01	64.09	741.8	741.8	274.1
36	751.85	67.24	274.9	274.9	178.2

```
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tion B LTSS.dat

Victoria, TX Landfill Evaluation - Section B LTSS
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TABLE NO. 59
**********************************************************************
* Final Results for Side Forces and Stresses Between Slices          *
* (Results are for the critical shear surface in the case of a search.) *
**********************************************************************
```

--------------- VALUES AT RIGHT SIDE OF SLICE ---------------

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	427.84	394	155.64	0.409	15.1	51.1
2	434.75	4381	145.65	0.245	-103.9	495.3
3	442.20	11721	137.96	0.248	-184.6	906.7
4	450.18	22065	130.60	0.251	-259.1	1307.4
5	458.66	34977	123.52	0.252	-334.1	1698.7
6	467.61	49947	116.70	0.251	-411.1	2077.8
7	477.03	66408	110.16	0.250	-490.2	2440.7
8	477.43	67123	109.89	0.249	-493.6	2455.6
9	487.29	84120	103.74	0.258	-520.8	2819.9
10	497.54	100669	97.99	0.266	-527.3	3133.6
11	508.17	116238	92.62	0.273	-518.9	3401.9
12	519.15	130320	87.63	0.280	-498.7	3626.6
13	530.43	142449	83.02	0.287	-468.3	3807.7
14	542.00	152212	78.81	0.293	-427.9	3943.6
15	553.82	159256	75.03	0.299	-377.2	4031.7
16	565.86	163299	71.68	0.305	-314.9	4068.7
17	578.08	164135	68.80	0.312	-238.9	4049.8
18	583.49	163456	67.69	0.316	-200.4	4022.3
19	595.92	164322	64.77	0.315	-215.0	4143.7
20	608.45	161849	62.34	0.315	-218.8	4212.1
21	616.90	158285	60.99	0.315	-214.9	4225.7
22	629.53	150251	59.39	0.317	-199.9	4197.1
23	633.33	147235	59.00	0.317	-193.7	4177.8
24	645.97	135477	58.01	0.319	-170.3	4081.5
25	646.90	134510	57.96	0.319	-168.5	4072.7
26	659.49	120316	57.43	0.321	-145.4	3931.6
27	666.90	111123	57.30	0.321	-135.4	3834.1
28	679.36	94258	57.44	0.322	-119.2	3629.0
29	683.74	87917	57.60	0.323	-110.2	3537.3
30	694.84	71202	58.30	0.325	-82.3	3259.6
31	706.97	52494	59.52	0.329	-41.0	2873.5
32	718.90	34600	61.21	0.336	15.7	2392.7
33	730.60	18827	63.36	0.349	91.6	1805.6
34	742.02	6708	65.83	0.378	170.6	1115.4
35	750.00	1266	67.66	0.440	238.2	505.8
36	753.71	-0	68.29	1.000	0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State
Filename: 20210719 Profile B LTSS - 1_output (textor).docx

UTEXAS4 Output File
Page 18 of 18

Profile: B Case: LTSS NC - Peak Textured

Unit Weight Average Effective Average Total Average

Noncircular Surface Coordinates

x	y	
390	164.5	
500	43.2	-0.573 deg
616.9	42	fixed
646.9	39.5	fixed
666.9	39.5	fixed
683.74	45.1	fixed
750	67.2	fixed
760	66.2	fixed

Shifting Points
20
5

Crack Depth
5

Seismic Acceleration

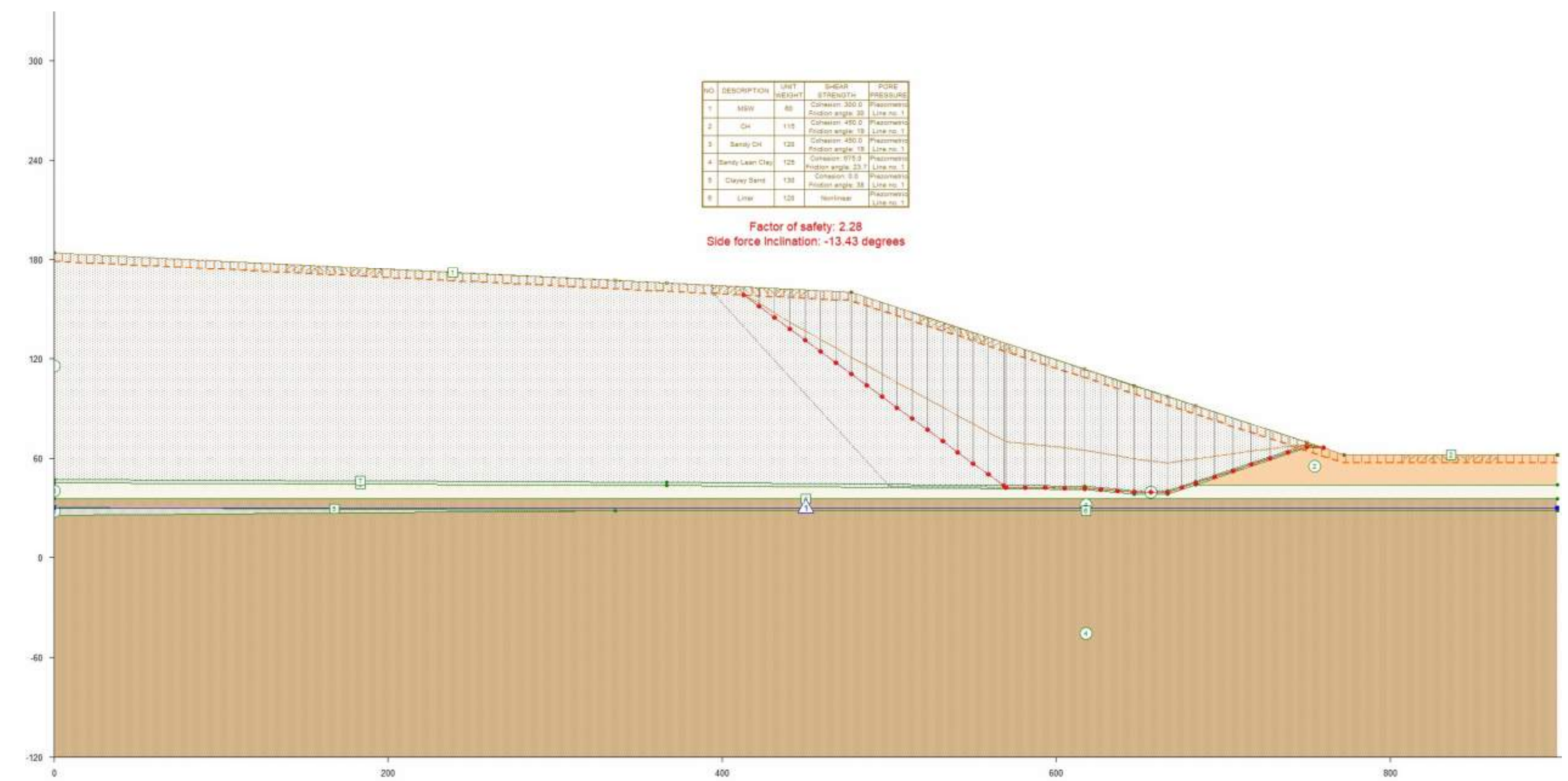
Minimum Weight

Results

Noncircular Shear Surface

413	158.2
569.8	42.5
616.9	42
646.9	39.5
666.9	39.5
683.74	45.1
750	67.2
760	66.2

Factor of Safety
2.28



Profile: B Case: LTSS NC - Residual Textured

Unit Weight Average Effective Average Total Average

Noncircular Surface Coordinates

x	y	
390	164.5	
500	43.2	-0.573 deg
616.9	42	fixed
646.9	39.5	fixed
666.9	39.5	fixed
683.74	45.1	fixed
750	67.2	fixed
760	66.2	fixed

Shifting Points
5
1

Crack Depth
9

Seismic Acceleration

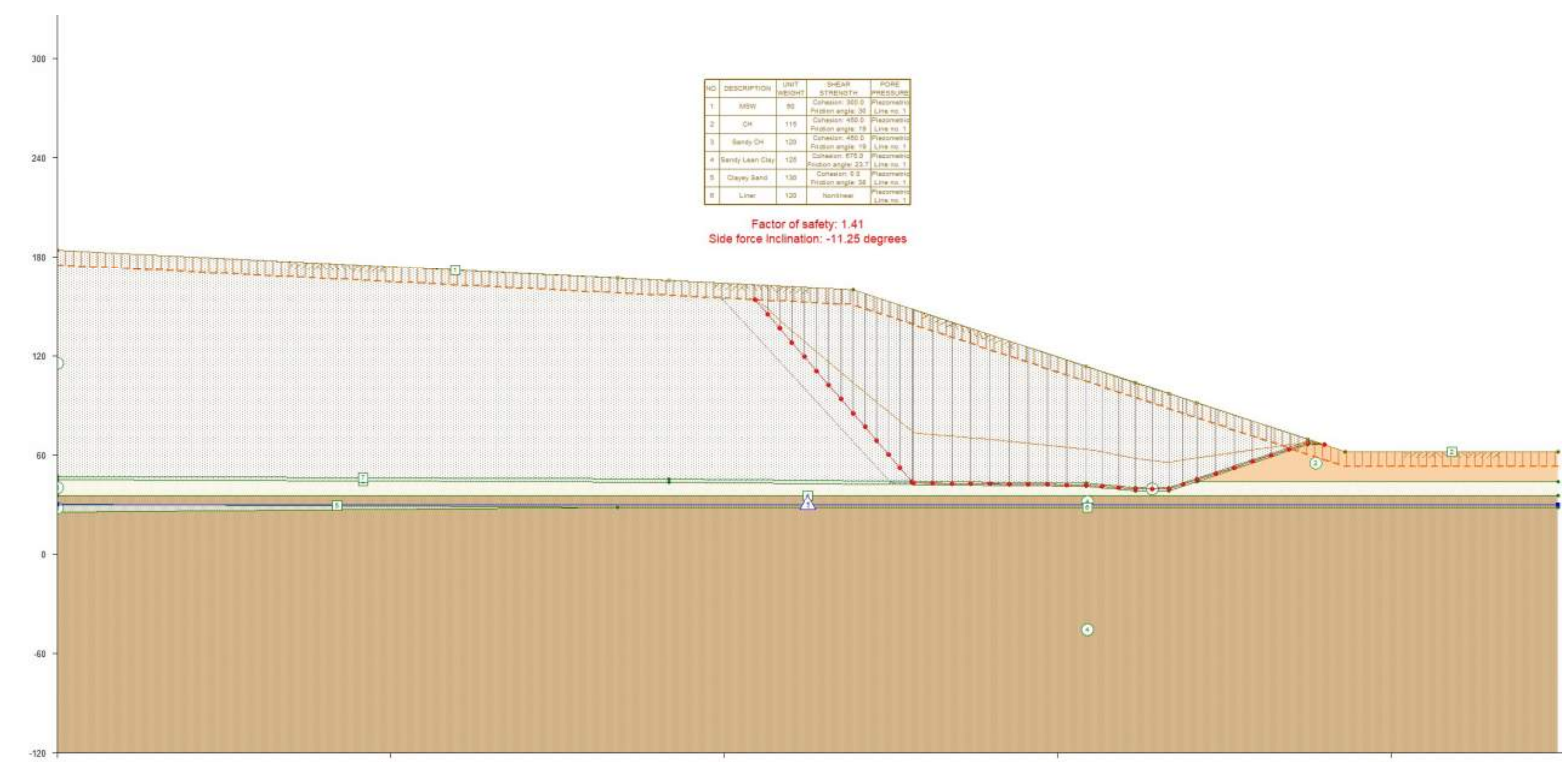
Minimum Weight

Results

Noncircular Shear Surface

418.6	154
513.5	73.1
616.9	42
646.9	39.5
666.9	39.5
683.74	45.1
750	67.2
760	66.2

Factor of Safety
1.41



Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State – Noncircular Liner Textured Peak
Filename: 20210719 Profile B LTSS – 2 Peak_input (textor).docx

UTEXAS4 Input File


```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

PROfile lines
   1 1 MSW
         0 184
         477.43 160
         760 66.2

   2 2 CH
         683.74 44.1
         750 66.2
         760 66.2
         772.6 62
         900 62

   3 3 Sandy CH
         0 45.33
         366.9 43.5
         616.9 41
         646.9 38.5
         666.9 38.5
         683.74 44.1
         900 44.1

   4 4 Clayey Sand
         0 35.5
         900 35.5

   5 5 Sandy CL
         0 30.4
         336 28.3

   6 4 Clayey Sand
         0 25.7
         336 28.3
         900 28.3

   7 6 Liner
         0 47.33
         366.9 45.5
         616.9 43
         646.9 40.5
         666.9 40.5
         683.74 46.1
         750 68.2
         760 66.2


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
```

```
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1
   6 Liner
      120 = unit weight
      Non Linear Mohr Coulomb Envelope
         0 100
         500 362.5
         10000 3449

      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         900 30


LABel
Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
ANALYSIS/COMPUTATION
   Noncircular Search 2
     390 164.5
     500 43.2 -0.573
     616.9 42 fixed
     646.9 39.5 fixed
     666.9 39.5 fixed
     683.74 45.1 fixed
     750 67.2 fixed
     760 66.2 fixed
```

```
     20 5
   Crack
     5 D
   Short

COMpute
```

Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State State – Noncircular Liner Textured Peak
Filename: 20210719 Profile B LTSS – 2 Peak_output (textor).docx

UTEXAS4 Output File
Page 1 of 24

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
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* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
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*****************************************************************
```

```
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tion B LTSS NC text peak.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1        0.00      184.00
   2      477.43      160.00
   3      760.00       66.20

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1      683.74       44.10
   2      750.00       66.20
   3      760.00       66.20
   4      772.60       62.00
   5      900.00       62.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH

Point        X           Y

   1        0.00       45.33
   2      366.90       43.50
   3      616.90       41.00
   4      646.90       38.50
   5      666.90       38.50
   6      683.74       44.10
   7      900.00       44.10

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       35.50
```

```
   2      900.00       35.50

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 5 -----
----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1        0.00       30.40
   2      336.00       28.30

----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       25.70
   2      336.00       28.30
   3      900.00       28.30

----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 6 -----
----------------------------------------------------------
Description: Liner

Point        X           Y

   1        0.00       47.33
   2      366.90       45.50
   3      616.90       43.00
   4      646.90       40.50
   5      666.90       40.50
   6      683.74       46.10
   7      750.00       68.20
   8      760.00       66.20
```

```
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#107608

TABLE NO. 4
**********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 6 -------------------
------------------------------------------------------------------
Description: Liner

Constant unit weight of soil (material): 120.0

---- NONLINEAR SHEAR STRENGTH ENVELOPE ----
     Point     Normal Stress     Shear Stress

       1                0.0           100.0
       2              500.0           362.5
       3            10000.0          3449.0

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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tion B LTSS NC text peak.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

TABLE NO. 6
*******************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*******************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      900.00       30.00
```

```
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tion B LTSS NC text peak.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1         390.00         164.50   angle to be computed - moveable
   2         500.00          43.20     -0.57              - moveable
   3         616.90          42.00                        - fixed
   4         646.90          39.50                        - fixed
   5         666.90          39.50                        - fixed
   6         683.74          45.10                        - fixed
   7         750.00          67.20                        - fixed
   8         760.00          66.20                        - fixed

Initial distance for shifting points on shear surface = 20.000
Final distance for shifting points on shear surface = 5.000
Maximum steepness permitted for toe of shear surface = 50.00


Depth of crack: 5.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Maximum increment for slice subdivision: 30
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Maximum number of passes for noncircular search: 50
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Minimum weight required for computations to be performed: 100
Initial trial factor of safety: 3.000
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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tion B LTSS NC text peak.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00      184.00
        2     336.00      167.11
        3     366.90      165.56
        4     477.43      160.00
        5     616.90      113.70
        6     646.90      103.74
        7     666.90       97.10
        8     683.74       91.51
        9     750.00       69.52
       10     760.00       66.20
       11     772.60       62.00
       12     900.00       62.00

Left end point on noncircular shear surface adjusted to:
X: 394.85, Y: 159.15
Adjustment was made to put end point at bottom of crack.

Noncircular Shear Surface Points After End Point Adjustment
Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1        394.85        159.15   angle to be computed - moveable
   2        500.00         43.20     -0.57              - moveable
   3        616.90         42.00                        - fixed
   4        646.90         39.50                        - fixed
   5        666.90         39.50                        - fixed
   6        683.74         45.10                        - fixed
   7        750.00         67.20                        - fixed
   8        760.00         66.20                        - fixed
Computed crack depth: 5.00
```

```
UTEXAS4 S/N:10001  - Version: 4.1.0.8 - Latest Revision: 11/9/2009
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
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tion B LTSS NC text peak.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
#107608

TABLE NO. 40
*******************************************************************
* Short-Form Output Table for Search with Noncircular Shear Surfaces *
*******************************************************************

  Shift    Factor of
Distance    Safety      Point      X          Y        Point      X          Y
  20.000     2.439         1     394.85     159.15        5     666.90      39.50
                           2     500.00      43.20        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 1
  20.000     2.348         1     374.88     160.16        5     666.90      39.50
                           2     520.00      43.00        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 2
  20.000     2.301         1     394.85     159.15        5     666.90      39.50
                           2     540.00      42.80        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 3
  20.000     2.285         1     400.51     158.87        5     666.90      39.50
                           2     560.00      42.60        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 4
  20.000     2.280         1     420.48     157.86        5     666.90      39.50
                           2     560.50      42.59        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 5
  10.000     2.278         1     412.96     158.24        5     666.90      39.50
                           2     569.81      42.50        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
End of Trial: 6
   5.000     2.278         1     412.96     158.24        5     666.90      39.50
                           2     569.81      42.50        6     683.74      45.10
                           3     616.90      42.00        7     750.00      67.20
                           4     646.90      39.50        8     760.00      66.20
   Failed to compute factor of safety:  See explanation on next line(s):
                                                                  UTEXAS ERROR NUMBER 9280
                                                                  The side force inclination
fell outside the range of values allowed.
                                                                  The minimum value allowed is:
-8.00000e+001 degrees.
                                                                  The maximum value allowed is:
1.00000e+001 degrees.

   Failed to compute factor of safety:  See explanation on next line(s):
                                                                  UTEXAS ERROR NUMBER 9280
```

The side force inclination
fell outside the range of values allowed.

The minimum value allowed is:
-8.00000e+001 degrees.

The maximum value allowed is:
1.00000e+001 degrees.

End of Trial: 7

```
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Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
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TABLE NO. 41
****************************************
*  Critical Noncircular Shear Surface  *
****************************************

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****
X:     412.96     Y:     158.24
X:     569.81     Y:      42.50
X:     616.90     Y:      42.00
X:     646.90     Y:      39.50
X:     666.90     Y:      39.50
X:     683.74     Y:      45.10
X:     750.00     Y:      67.20
X:     760.00     Y:      66.20

Minimum factor of safety: 2.278
Side force inclination: -13.43

CAUTION - THE FACTOR OF SAFETY WAS NOT COMPUTED WHEN SOME OF THE
POINTS ON THE MOST CRITICAL NONCIRCULAR SHEAR SURFACE WERE SHIFTED.

Time required to find most critical surface:      0.0 seconds
Number of passes required to find most critical surface: 7
Total number of shear surfaces attempted: 35
Total number of shear surfaces for which the factor of safety
was successfully calculated: 33

      |   Shift     |      Max. Dist.| Minimum |   n        n     |
 Pass | Distance    | Pt.    Moved   |    F    | Tried  Computed |
      |             |                |         |                 |
    1 |    20.0000 |  1      20.000 |  2.3475 |     5        5  |
    2 |    20.0000 |  1      20.000 |  2.3008 |    10       10  |
    3 |    20.0000 |  2      20.000 |  2.2849 |    15       15  |
    4 |    20.0000 |  1      20.000 |  2.2804 |    20       20  |
    5 |    20.0000 |  2       9.318 |  2.2783 |    25       25  |
    6 |    10.0000 |  1      10.000 |  2.2783 |    30       30  |
    7 |     5.0000 |  0       0.000 |  2.2783 |    35       33  |
```

```
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TABLE NO. 43
************************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
************************************************************

Slice                         Slice   Matl.             Friction     Pore
  No.      X          Y       Weight   No.    Cohesion    Angle    Pressure
        412.96     158.24
   1    417.57     154.84       4512    1       300.0    30.00         0.0
        422.17     151.45
   2    426.78     148.05       8012    1       300.0    30.00         0.0
        431.38     144.65
   3    435.99     141.25      11511    1       300.0    30.00         0.0
        440.59     137.85
   4    445.20     134.46      15010    1       300.0    30.00         0.0
        449.80     131.06
   5    454.41     127.66      18509    1       300.0    30.00         0.0
        459.01     124.26
   6    463.62     120.86      22008    1       300.0    30.00         0.0
        468.22     117.47
   7    472.83     114.07      25507    1       300.0    30.00         0.0
        477.43     110.67
   8    481.98     107.31      27958    1       300.0    30.00         0.0
        486.54     103.95
   9    491.09     100.59      29978    1       300.0    30.00         0.0
        495.64      97.23
  10    500.19      93.87      31997    1       300.0    30.00         0.0
        504.75      90.52
  11    509.30      87.16      34016    1       300.0    30.00         0.0
        513.85      83.80
  12    518.40      80.44      36036    1       300.0    30.00         0.0
        522.96      77.08
  13    527.51      73.72      38055    1       300.0    30.00         0.0
        532.06      70.36
  14    536.61      67.00      40074    1       300.0    30.00         0.0
        541.17      63.64
  15    545.72      60.28      42094    1       300.0    30.00         0.0
        550.27      56.92
  16    554.82      53.56      44113    1       300.0    30.00         0.0
        559.38      50.20
  17    563.93      46.84      46132    1       300.0    30.00         0.0
        568.48      43.48
  18    569.15      42.99       6953    6   NONLINEAR ENVELOPE         0.0
        569.81      42.50
  19    575.70      42.44      60680    6   NONLINEAR ENVELOPE         0.0
        581.59      42.38
  20    587.47      42.31      58014    6   NONLINEAR ENVELOPE         0.0
        593.36      42.25
```

```
  21    599.24     42.19        55348    6   NONLINEAR ENVELOPE         0.0
        605.13     42.13
  22    611.01     42.06        52682    6   NONLINEAR ENVELOPE         0.0
        616.90     42.00
  23    621.90     41.58        42876    6   NONLINEAR ENVELOPE         0.0
        626.90     41.17
  24    631.90     40.75        41384    6   NONLINEAR ENVELOPE         0.0
        636.90     40.33
  25    641.90     39.92        39892    6   NONLINEAR ENVELOPE         0.0
        646.90     39.50
  26    651.90     39.50        38150    6   NONLINEAR ENVELOPE         0.0
        656.90     39.50
  27    661.90     39.50        36159    6   NONLINEAR ENVELOPE         0.0
        666.90     39.50
  28    671.11     40.90        28194    6   NONLINEAR ENVELOPE         0.0
        675.32     42.30
  29    679.53     43.70        25367    6   NONLINEAR ENVELOPE         0.0
        683.74     45.10
  30    689.26     46.94        28982    6   NONLINEAR ENVELOPE         0.0
        694.78     48.78
  31    700.30     50.63        24113    6   NONLINEAR ENVELOPE         0.0
        705.83     52.47
  32    711.35     54.31        19243    6   NONLINEAR ENVELOPE         0.0
        716.87     56.15
  33    722.39     57.99        14373    6   NONLINEAR ENVELOPE         0.0
        727.91     59.83
  34    733.43     61.68         9504    6   NONLINEAR ENVELOPE         0.0
        738.96     63.52
  35    744.48     65.36         4634    6   NONLINEAR ENVELOPE         0.0
        750.00     67.20
  36    755.00     66.70          996    6   NONLINEAR ENVELOPE         0.0
        760.00     66.20

No water in crack.
```

```
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Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
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TABLE NO. 44
**********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.               *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
**********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, peak)
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 1 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  11
Allowable moment imbalance for convergence: 6167

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F      Theta
ation  Safety   (degrees)     (lbs.)     (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -5.414e+004   1.097e+007
First-order corrections to F and Theta ...........    1.0368   -54.0312
Reduced values - Deltas were too large ...........    0.0550    -2.8648

   2   3.05497   -20.0535  -5.109e+004   1.022e+007
First-order corrections to F and Theta ...........   -4.9344   113.0373
Reduced values - Deltas were too large ...........   -0.1251     2.8648

   3   2.92992   -17.1887  -4.936e+004   9.851e+006
First-order corrections to F and Theta ...........   -5.1992   136.8860
Reduced values - Deltas were too large ...........   -0.1088     2.8648

   4   2.82111   -14.3239  -4.796e+004   9.558e+006
First-order corrections to F and Theta ...........   19.4153  -673.9530
Reduced values - Deltas were too large ...........    0.0825    -2.8648

   5   2.90364   -17.1887  -4.750e+004   9.416e+006
First-order corrections to F and Theta ...........   -2.5350    57.7930
Reduced values - Deltas were too large ...........   -0.1257     2.8648

   6   2.77798   -14.3239  -4.468e+004   8.877e+006
First-order corrections to F and Theta ...........   -0.9657    13.3683
Reduced values - Deltas were too large ...........   -0.2069     2.8648

   7   2.57104   -11.4592  -3.381e+004   6.969e+006
First-order corrections to F and Theta ...........   -0.1892    -7.7193
Reduced values - Deltas were too large ...........   -0.0702    -2.8648

   8   2.50082   -14.3239  -2.096e+004   3.950e+006
First-order corrections to F and Theta ...........   -0.2593     1.5933
Second-order corrections to F and Theta ..........   -0.2242     0.9386

   9   2.27663   -13.3853   1.723e+002  -1.741e+004
First-order corrections to F and Theta ...........    0.0023    -0.0377
Second-order corrections to F and Theta ..........    0.0023    -0.0378

  10   2.27891   -13.4231  -2.281e-004  -5.513e-002
```

```
First-order corrections to F and Theta ............   -0.0000     0.0000

After trial 1 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:     -3.233 (percent)
     Maximum change occurred for slice 35
     Normal stress where max. change occurred:       564.00
     Old strength at this slice:       396.10
     New strength at this slice:       383.29
```

```
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TABLE NO. 47
*********************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
*********************************************************

Trial No. 2 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  11
Allowable moment imbalance for convergence: 6167

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -5.421e+004   1.099e+007
First-order corrections to F and Theta ...........    0.9616   -52.0409
Reduced values - Deltas were too large ...........    0.0529    -2.8648

   2   3.05293   -20.0535  -5.104e+004   1.022e+007
First-order corrections to F and Theta ...........   -4.9460   113.8810
Reduced values - Deltas were too large ...........   -0.1244     2.8648

   3   2.92851   -17.1887  -4.933e+004   9.847e+006
First-order corrections to F and Theta ...........   -5.2644   139.4482
Reduced values - Deltas were too large ...........   -0.1082     2.8648

   4   2.82036   -14.3239  -4.795e+004   9.558e+006
First-order corrections to F and Theta ...........   11.7309  -417.2136
Reduced values - Deltas were too large ...........    0.0806    -2.8648

   5   2.90091   -17.1887  -4.738e+004   9.390e+006
First-order corrections to F and Theta ...........   -2.4816    56.4875
Reduced values - Deltas were too large ...........   -0.1259     2.8648

   6   2.77506   -14.3239  -4.451e+004   8.843e+006
First-order corrections to F and Theta ...........   -0.9429    12.7497
Reduced values - Deltas were too large ...........   -0.2119     2.8648

   7   2.56319   -11.4592  -3.315e+004   6.850e+006
First-order corrections to F and Theta ...........   -0.1906    -7.3448
Reduced values - Deltas were too large ...........   -0.0743    -2.8648

   8   2.48884   -14.3239  -1.990e+004   3.732e+006
First-order corrections to F and Theta ...........   -0.2441     1.5217
Second-order corrections to F and Theta ..........   -0.2125     0.9279

   9   2.27631   -13.3961   1.484e+002  -1.437e+004
First-order corrections to F and Theta ...........    0.0020    -0.0340
Second-order corrections to F and Theta ..........    0.0020    -0.0341

  10   2.27831   -13.4302  -1.523e-004  -3.942e-002
```

```
First-order corrections to F and Theta ............   -0.0000     0.0000

After trial 2 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:      0.000 (percent)
     Maximum change occurred for slice 31
     Normal stress where max. change occurred:      2663.18
     Old strength at this slice:      1065.30
     New strength at this slice:      1065.30
Strengths from nonlinear envelope have converged.
Final computations will be performed next.
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Final Trial with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  11
Allowable moment imbalance for convergence: 6167

        Trial     Trial
       Factor   Side Force     Force      Moment                 Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -5.421e+004   1.099e+007
First-order corrections to F and Theta ...........    0.9616   -52.0409
Reduced values - Deltas were too large ...........    0.0529    -2.8648

   2   3.05293   -20.0535  -5.104e+004   1.022e+007
First-order corrections to F and Theta ...........   -4.9460   113.8810
Reduced values - Deltas were too large ...........   -0.1244     2.8648

   3   2.92851   -17.1887  -4.933e+004   9.847e+006
First-order corrections to F and Theta ...........   -5.2644   139.4482
Reduced values - Deltas were too large ...........   -0.1082     2.8648

   4   2.82036   -14.3239  -4.795e+004   9.558e+006
First-order corrections to F and Theta ...........   11.7309  -417.2136
Reduced values - Deltas were too large ...........    0.0806    -2.8648

   5   2.90091   -17.1887  -4.738e+004   9.390e+006
First-order corrections to F and Theta ...........   -2.4816    56.4875
Reduced values - Deltas were too large ...........   -0.1259     2.8648

   6   2.77506   -14.3239  -4.451e+004   8.843e+006
First-order corrections to F and Theta ...........   -0.9429    12.7497
Reduced values - Deltas were too large ...........   -0.2119     2.8648

   7   2.56319   -11.4592  -3.315e+004   6.850e+006
First-order corrections to F and Theta ...........   -0.1906    -7.3448
Reduced values - Deltas were too large ...........   -0.0743    -2.8648

   8   2.48884   -14.3239  -1.990e+004   3.732e+006
First-order corrections to F and Theta ...........   -0.2441     1.5217
Second-order corrections to F and Theta ..........   -0.2125     0.9279

   9   2.27631   -13.3961   1.484e+002  -1.437e+004
First-order corrections to F and Theta ...........    0.0020    -0.0340
Second-order corrections to F and Theta ..........    0.0020    -0.0341

  10   2.27831   -13.4302  -1.523e-004  -3.942e-002
```

```
First-order corrections to F and Theta ............   -0.0000     0.0000
```

```
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TABLE NO. 55
*********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
*********************************************************************

Summation of Horizontal Forces: 1.07057e-010

Summation of Vertical Forces: 8.65055e-011

Summation of Moments: -3.16370e-008

Mohr Coulomb Shear Force/Shear Strength Check Summation: 2.59996e-011

***** CAUTION ***** Some of the Forces Between Slices Act at Points
Above the Surface of the Slope or Below the Shear Surface -
Either a Tension Crack may be Needed or the SOLUTION MAY NOT
BE A VALID SOLUTION
```

```
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TABLE NO. 58
*******************************************************************
* Final Results for Stresses Along the Shear Surface              *
* (Results are for the critical shear surface in the case of a search.) *
*******************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 2.278     Side Force Inclination: -13.43
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	417.57	154.84	325.7	325.7	214.2
2	426.78	148.05	617.4	617.4	288.1
3	435.99	141.25	909.0	909.0	362.0
4	445.20	134.46	1200.7	1200.7	435.9
5	454.41	127.66	1492.4	1492.4	509.9
6	463.62	120.86	1784.0	1784.0	583.8
7	472.83	114.07	2075.7	2075.7	657.7
8	481.98	107.31	2306.7	2306.7	716.2
9	491.09	100.59	2476.9	2476.9	759.4
10	500.19	93.87	2647.2	2647.2	802.5
11	509.30	87.16	2817.4	2817.4	845.6
12	518.40	80.44	2987.7	2987.7	888.8
13	527.51	73.72	3157.9	3157.9	931.9
14	536.61	67.00	3328.1	3328.1	975.1
15	545.72	60.28	3498.4	3498.4	1018.2
16	554.82	53.56	3668.6	3668.6	1061.4
17	563.93	46.84	3838.9	3838.9	1104.5
18	569.15	42.99	4151.8	4151.8	679.9
19	575.70	42.44	5334.8	5334.8	848.6
20	587.47	42.31	5101.3	5101.3	815.3
21	599.24	42.19	4867.9	4867.9	782.0
22	611.01	42.06	4634.4	4634.4	748.7
23	621.90	41.58	4311.0	4311.0	702.6
24	631.90	40.75	4161.5	4161.5	681.3
25	641.90	39.92	4012.0	4012.0	659.9
26	651.90	39.50	3971.2	3971.2	654.1
27	661.90	39.50	3765.1	3765.1	624.7
28	671.11	40.90	4050.2	4050.2	665.4
29	679.53	43.70	3650.1	3650.1	608.3
30	689.26	46.94	3188.9	3188.9	542.6
31	700.30	50.63	2663.2	2663.2	467.6
32	711.35	54.31	2137.4	2137.4	392.6
33	722.39	57.99	1611.7	1611.7	317.6
34	733.43	61.68	1086.0	1086.0	242.7
35	744.48	65.36	560.2	560.2	167.7
36	755.00	66.70	106.5	106.5	68.4

```
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TABLE NO. 59
*************************************************************************
* Final Results for Side Forces and Stresses Between Slices            *
* (Results are for the critical shear surface in the case of a search.) *
*************************************************************************

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------
```

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	422.17	247	153.74	0.203	-16.6	59.1
2	431.38	1832	147.57	0.165	-101.8	303.6
3	440.59	4756	142.16	0.180	-177.9	563.4
4	449.80	9017	136.84	0.191	-247.5	825.8
5	459.01	14616	131.55	0.199	-313.3	1088.8
6	468.22	21553	126.26	0.205	-376.7	1351.8
7	477.43	29828	120.99	0.209	-438.4	1614.7
8	486.54	39057	115.84	0.224	-469.4	1902.3
9	495.64	49058	110.78	0.239	-477.3	2159.8
10	504.75	59832	105.76	0.252	-468.6	2395.1
11	513.85	71377	100.75	0.264	-447.8	2613.5
12	522.96	83695	95.75	0.275	-418.1	2819.1
13	532.06	96784	90.74	0.285	-381.7	3014.7
14	541.17	110646	85.73	0.294	-340.4	3202.5
15	550.27	125280	80.71	0.301	-295.3	3384.1
16	559.38	140686	75.68	0.308	-247.3	3560.8
17	568.48	156864	70.64	0.315	-197.2	3733.5
18	569.81	160127	69.77	0.314	-208.3	3795.6
19	581.59	150545	68.60	0.316	-185.4	3711.7
20	593.36	141336	67.41	0.317	-165.2	3633.8
21	605.13	132500	66.19	0.319	-148.6	3563.2
22	616.90	124037	64.93	0.320	-136.4	3501.6
23	626.90	120507	63.19	0.318	-153.5	3540.3
24	636.90	117068	61.43	0.316	-176.1	3588.8
25	646.90	113721	59.64	0.313	-205.1	3648.5
26	656.90	106996	58.44	0.311	-229.8	3646.1
27	666.90	100573	57.19	0.307	-267.8	3664.1
28	675.32	83153	58.38	0.309	-225.7	3335.8
29	683.74	67379	59.57	0.312	-183.0	3007.0
30	694.78	49143	61.13	0.316	-127.2	2574.3
31	705.83	33749	62.68	0.322	-70.1	2140.1
32	716.87	21197	64.22	0.331	-10.7	1703.0
33	727.91	11488	65.73	0.347	52.9	1260.2
34	738.96	4620	67.17	0.378	124.9	804.6
35	750.00	594	67.89	0.299	-51.1	549.3
36	760.00	-0	66.20	0.000	0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State State – Noncircular Liner Textured Peak
Filename: 20210719 Profile B LTSS – 2 Peak_output (textor).docx

UTEXAS4 Output File
Page 24 of 24

Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State – Noncircular Liner Textured Residual
Filename: 20210719 Profile B LTSS – 2 Resi_input (textor).docx

UTEXAS4 Input File
Page 1 of 3

```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, res)
#107608

PROfile lines
   1 1 MSW
         0 184
         477.43 160
         760 66.2

   2 2 CH
         683.74 44.1
         750 66.2
         760 66.2
         772.6 62
         900 62

   3 3 Sandy CH
         0 45.33
         366.9 43.5
         616.9 41
         646.9 38.5
         666.9 38.5
         683.74 44.1
         900 44.1

   4 4 Clayey Sand
         0 35.5
         900 35.5

   5 5 Sandy CL
         0 30.4
         336 28.3

   6 4 Clayey Sand
         0 25.7
         336 28.3
         900 28.3

   7 6 Liner
         0 47.33
         366.9 45.5
         616.9 43
         646.9 40.5
         666.9 40.5
         683.74 46.1
         750 68.2
         760 66.2


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
```

```
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1
   6 Liner
      120 = unit weight
       Non Linear Mohr Coulomb Envelope
         0 0
         1000 225
         10000 1171

      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         900 30


LABel
Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, res)
ANALYSIS/COMPUTATION
   Noncircular Search 2
     390 164.5
     500 43.2 -0.573
     616.9 42 fixed
     646.9 39.5 fixed
     666.9 39.5 fixed
     683.74 45.1 fixed
     750 67.2 fixed
     760 66.2 fixed
```

```
     20 5
   Crack
     9 D
   Short

COMpute
```

Cross-Section: B
Case: Long-Term Steady State State – Noncircular Liner Textured Residual
Filename: 20210719 Profile B LTSS – 2 Resi_output (textor).docx

UTEXAS4 Output File


```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
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* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
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* READ ALL DOCUMENTATION FOR THIS SOFTWARE BEFORE ATTEMPTING    *
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*****************************************************************
```

```
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TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1        0.00      184.00
   2      477.43      160.00
   3      760.00       66.20

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1      683.74       44.10
   2      750.00       66.20
   3      760.00       66.20
   4      772.60       62.00
   5      900.00       62.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH

Point        X           Y

   1        0.00       45.33
   2      366.90       43.50
   3      616.90       41.00
   4      646.90       38.50
   5      666.90       38.50
   6      683.74       44.10
   7      900.00       44.10

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       35.50
```

```
   2      900.00       35.50

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 5 -----
----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1        0.00       30.40
   2      336.00       28.30

----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       25.70
   2      336.00       28.30
   3      900.00       28.30

----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 6 -----
----------------------------------------------------------
Description: Liner

Point        X           Y

   1        0.00       47.33
   2      366.90       45.50
   3      616.90       43.00
   4      646.90       40.50
   5      666.90       40.50
   6      683.74       46.10
   7      750.00       68.20
   8      760.00       66.20
```

```
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TABLE NO. 4
*********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

-----------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
-----------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

-----------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
-----------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

-----------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
-----------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

-----------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 6 -------------------
------------------------------------------------------------------
Description: Liner

Constant unit weight of soil (material): 120.0

---- NONLINEAR SHEAR STRENGTH ENVELOPE ----
     Point     Normal Stress     Shear Stress

       1                0.0             0.0
       2             1000.0           225.0
       3            10000.0          1171.0

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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TABLE NO. 6
*********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      900.00       30.00
```

```
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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1         390.00        164.50   angle to be computed - moveable
   2         500.00         43.20     -0.57              - moveable
   3         616.90         42.00                        - fixed
   4         646.90         39.50                        - fixed
   5         666.90         39.50                        - fixed
   6         683.74         45.10                        - fixed
   7         750.00         67.20                        - fixed
   8         760.00         66.20                        - fixed

Initial distance for shifting points on shear surface = 20.000
Final distance for shifting points on shear surface = 5.000
Maximum steepness permitted for toe of shear surface = 50.00


Depth of crack: 9.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Maximum increment for slice subdivision: 30
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Maximum number of passes for noncircular search: 50
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Minimum weight required for computations to be performed: 100
Initial trial factor of safety: 3.000
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1        0.00      184.00
        2      336.00      167.11
        3      366.90      165.56
        4      477.43      160.00
        5      616.90      113.70
        6      646.90      103.74
        7      666.90       97.10
        8      683.74       91.51
        9      750.00       69.52
       10      760.00       66.20
       11      772.60       62.00
       12      900.00       62.00

Left end point on noncircular shear surface adjusted to:
X: 398.65, Y: 154.96
Adjustment was made to put end point at bottom of crack.

Noncircular Shear Surface Points After End Point Adjustment
Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1         398.65         154.96   angle to be computed - moveable
   2         500.00          43.20     -0.57              - moveable
   3         616.90          42.00                        - fixed
   4         646.90          39.50                        - fixed
   5         666.90          39.50                        - fixed
   6         683.74          45.10                        - fixed
   7         750.00          67.20                        - fixed
   8         760.00          66.20                        - fixed
Computed crack depth: 9.00
```

```
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TABLE NO. 40
**********************************************************************
* Short-Form Output Table for Search with Noncircular Shear Surfaces *
**********************************************************************

  Shift    Factor of
Distance    Safety       Point       X          Y       Point       X          Y
  20.000     1.425          1     398.65     154.96        5     666.90      39.50
                            2     500.00      43.20        6     683.74      45.10
                            3     616.90      42.00        7     750.00      67.20
                            4     646.90      39.50        8     760.00      66.20
End of Trial: 1
  20.000     1.421          1     418.63     153.96        5     666.90      39.50
                            2     499.94      43.20        6     683.74      45.10
                            3     616.90      42.00        7     750.00      67.20
                            4     646.90      39.50        8     760.00      66.20
End of Trial: 2
  10.000     1.421          1     418.63     153.96        5     666.90      39.50
                            2     499.94      43.20        6     683.74      45.10
                            3     616.90      42.00        7     750.00      67.20
                            4     646.90      39.50        8     760.00      66.20
End of Trial: 3
  10.000     1.417          1     408.64     154.46        5     666.90      39.50
                            2     509.94      43.10        6     683.74      45.10
                            3     616.90      42.00        7     750.00      67.20
                            4     646.90      39.50        8     760.00      66.20
End of Trial: 4
  10.000     1.414          1     418.63     153.96        5     666.90      39.50
                            2     505.02      43.15        6     683.74      45.10
                            3     616.90      42.00        7     750.00      67.20
                            4     646.90      39.50        8     760.00      66.20
   Failed to compute factor of safety:  See explanation on next line(s):
                                                                    UTEXAS ERROR NUMBER 9280
                                                                    The side force inclination
fell outside the range of values allowed.
                                                                    The minimum value allowed is:
-8.00000e+001 degrees.
                                                                    The maximum value allowed is:
1.00000e+001 degrees.

   Failed to compute factor of safety:  See explanation on next line(s):
                                                                    UTEXAS ERROR NUMBER 9280
                                                                    The side force inclination
fell outside the range of values allowed.
                                                                    The minimum value allowed is:
-8.00000e+001 degrees.
                                                                    The maximum value allowed is:
1.00000e+001 degrees.

End of Trial: 5
   5.000     1.414          1     418.63     153.96        5     666.90      39.50
                            2     505.02      43.15        6     683.74      45.10
```

```
                            3     616.90      42.00         7     750.00      67.20
                            4     646.90      39.50         8     760.00      66.20
End of Trial: 6
   5.000     1.413          1     413.63     154.21         5     666.90      39.50
                            2     510.02      43.10         6     683.74      45.10
                            3     616.90      42.00         7     750.00      67.20
                            4     646.90      39.50         8     760.00      66.20
End of Trial: 7
   5.000     1.411          1     418.63     153.96         5     666.90      39.50
                            2     508.45      43.12         6     683.74      45.10
                            3     616.90      42.00         7     750.00      67.20
                            4     646.90      39.50         8     760.00      66.20
   Failed to compute factor of safety:  See explanation on next line(s):
                                                                    UTEXAS ERROR NUMBER 9280
                                                                    The side force inclination
fell outside the range of values allowed.
                                                                    The minimum value allowed is:
-8.00000e+001 degrees.
                                                                    The maximum value allowed is:
1.00000e+001 degrees.

   Failed to compute factor of safety:  See explanation on next line(s):
                                                                    UTEXAS ERROR NUMBER 9280
                                                                    The side force inclination
fell outside the range of values allowed.
                                                                    The minimum value allowed is:
-8.00000e+001 degrees.
                                                                    The maximum value allowed is:
1.00000e+001 degrees.

End of Trial: 8
```

```
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TABLE NO. 41
****************************************
*  Critical Noncircular Shear Surface  *
****************************************

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****
X:     418.63     Y:     153.96
X:     513.45     Y:      43.07
X:     616.90     Y:      42.00
X:     646.90     Y:      39.50
X:     666.90     Y:      39.50
X:     683.74     Y:      45.10
X:     750.00     Y:      67.20
X:     760.00     Y:      66.20

Minimum factor of safety: 1.411
Side force inclination: -11.25

CAUTION - THE FACTOR OF SAFETY WAS NOT COMPUTED WHEN SOME OF THE
POINTS ON THE MOST CRITICAL NONCIRCULAR SHEAR SURFACE WERE SHIFTED.

Time required to find most critical surface:      0.0 seconds
Number of passes required to find most critical surface: 8
Total number of shear surfaces attempted: 40
Total number of shear surfaces for which the factor of safety
was successfully calculated: 36

      |   Shift    |      Max. Dist.| Minimum |   n        n    |
 Pass | Distance   | Pt.    Moved   |    F    | Tried  Computed |
      |            |                |         |                 |
    1 |    20.0000 |  1      20.000 |  1.4211 |     5        5  |
    2 |    20.0000 |  2      20.000 |  1.4211 |    10       10  |
    3 |    10.0000 |  2      10.000 |  1.4174 |    15       15  |
    4 |    10.0000 |  1      10.000 |  1.4139 |    20       20  |
    5 |    10.0000 |  0       0.000 |  1.4139 |    25       23  |
    6 |     5.0000 |  2       5.000 |  1.4129 |    30       28  |
    7 |     5.0000 |  1       5.000 |  1.4114 |    35       33  |
    8 |     5.0000 |  2       5.000 |  1.4107 |    40       36  |
```

```
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TABLE NO. 43
*********************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
*********************************************************

Slice                         Slice   Matl.            Friction     Pore
  No.      X         Y        Weight   No.    Cohesion    Angle    Pressure
        418.63    153.96
   1    422.30    149.66        5783    1       300.0    30.00         0.0
        425.98    145.36
   2    429.65    141.06        9411    1       300.0    30.00         0.0
        433.33    136.76
   3    437.00    132.47       13039    1       300.0    30.00         0.0
        440.68    128.17
   4    444.35    123.87       16667    1       300.0    30.00         0.0
        448.03    119.57
   5    451.70    115.28       20295    1       300.0    30.00         0.0
        455.38    110.98
   6    459.05    106.68       23923    1       300.0    30.00         0.0
        462.73    102.38
   7    466.40     98.08       27552    1       300.0    30.00         0.0
        470.08     93.79
   8    473.75     89.49       31180    1       300.0    30.00         0.0
        477.43     85.19
   9    480.95     81.08       32832    1       300.0    30.00         0.0
        484.47     76.96
  10    487.99     72.85       35320    1       300.0    30.00         0.0
        491.50     68.73
  11    495.02     64.62       37808    1       300.0    30.00         0.0
        498.54     60.50
  12    502.06     56.39       40297    1       300.0    30.00         0.0
        505.58     52.27
  13    509.10     48.16       42785    1       300.0    30.00         0.0
        512.62     44.04
  14    513.03     43.55        5271    6   NONLINEAR ENVELOPE         0.0
        513.45     43.07
  15    519.20     43.01       71792    6   NONLINEAR ENVELOPE         0.0
        524.95     42.95
  16    530.69     42.89       69245    6   NONLINEAR ENVELOPE         0.0
        536.44     42.83
  17    542.19     42.77       66698    6   NONLINEAR ENVELOPE         0.0
        547.93     42.71
  18    553.68     42.65       64150    6   NONLINEAR ENVELOPE         0.0
        559.43     42.59
  19    565.18     42.53       61603    6   NONLINEAR ENVELOPE         0.0
        570.92     42.47
  20    576.67     42.41       59055    6   NONLINEAR ENVELOPE         0.0
        582.42     42.36
```

```
  21    588.16     42.30        56508    6   NONLINEAR ENVELOPE        0.0
        593.91     42.24
  22    599.66     42.18        53961    6   NONLINEAR ENVELOPE        0.0
        605.41     42.12
  23    611.15     42.06        51413    6   NONLINEAR ENVELOPE        0.0
        616.90     42.00
  24    621.90     41.58        42876    6   NONLINEAR ENVELOPE        0.0
        626.90     41.17
  25    631.90     40.75        41384    6   NONLINEAR ENVELOPE        0.0
        636.90     40.33
  26    641.90     39.92        39892    6   NONLINEAR ENVELOPE        0.0
        646.90     39.50
  27    651.90     39.50        38150    6   NONLINEAR ENVELOPE        0.0
        656.90     39.50
  28    661.90     39.50        36159    6   NONLINEAR ENVELOPE        0.0
        666.90     39.50
  29    671.11     40.90        28194    6   NONLINEAR ENVELOPE        0.0
        675.32     42.30
  30    679.53     43.70        25367    6   NONLINEAR ENVELOPE        0.0
        683.74     45.10
  31    689.26     46.94        28982    6   NONLINEAR ENVELOPE        0.0
        694.78     48.78
  32    700.30     50.63        24113    6   NONLINEAR ENVELOPE        0.0
        705.83     52.47
  33    711.35     54.31        19243    6   NONLINEAR ENVELOPE        0.0
        716.87     56.15
  34    722.39     57.99        14373    6   NONLINEAR ENVELOPE        0.0
        727.91     59.83
  35    733.43     61.68         9504    6   NONLINEAR ENVELOPE        0.0
        738.96     63.52
  36    744.48     65.36         4634    6   NONLINEAR ENVELOPE        0.0
        750.00     67.20
  37    755.00     66.70          996    6   NONLINEAR ENVELOPE        0.0
        760.00     66.20
```

No water in crack.

```
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Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, res)
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TABLE NO. 44
*********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.              *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
*********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, res)
#107608

TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 1 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  13
Allowable moment imbalance for convergence: 7109

        Trial     Trial
       Factor   Side Force     Force      Moment                 Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)             (degrees)

   1   3.00000   -17.1887  -1.251e+005   2.546e+007
First-order corrections to F and Theta ...........   -2.6532    -4.0314
Reduced values - Deltas were too large ...........   -0.5000    -0.7597

   2   2.50000   -17.9485  -9.765e+004   1.961e+007
First-order corrections to F and Theta ...........   -1.3176    -7.4699
Reduced values - Deltas were too large ...........   -0.5000    -2.8347

   3   2.00000   -20.7832  -5.405e+004   9.570e+006
First-order corrections to F and Theta ...........   -5.9952   213.7616
Reduced values - Deltas were too large ...........   -0.0803     2.8648

   4   1.91965   -17.9184  -5.291e+004   9.318e+006
First-order corrections to F and Theta ...........   26.3391 -1193.0681
Reduced values - Deltas were too large ...........    0.0632    -2.8648

   5   1.98290   -20.7832  -5.249e+004   9.172e+006
First-order corrections to F and Theta ...........   -3.7404   127.7211
Reduced values - Deltas were too large ...........   -0.0839     2.8648

   6   1.89900   -17.9184  -5.086e+004   8.845e+006
First-order corrections to F and Theta ...........   -4.6506   188.1780
Reduced values - Deltas were too large ...........   -0.0708     2.8648

   7   1.82820   -15.0536  -4.972e+004   8.615e+006
First-order corrections to F and Theta ...........   18.9922  -978.5165
Reduced values - Deltas were too large ...........    0.0556    -2.8648

   8   1.88380   -17.9184  -4.932e+004   8.491e+006
First-order corrections to F and Theta ...........   -2.6669   100.8003
Reduced values - Deltas were too large ...........   -0.0758     2.8648

   9   1.80801   -15.0536  -4.750e+004   8.160e+006
First-order corrections to F and Theta ...........   -2.1912    90.8599
Reduced values - Deltas were too large ...........   -0.0691     2.8648

  10   1.73892   -12.1888  -4.562e+004   7.839e+006
```

```
First-order corrections to F and Theta ...........   -0.9628    33.2765
Reduced values - Deltas were too large ...........   -0.0829     2.8648

  11   1.65603    -9.3240  -4.112e+004   7.147e+006
First-order corrections to F and Theta ...........    0.0493   -22.9904
Reduced values - Deltas were too large ...........    0.0061    -2.8648

  12   1.66217   -12.1888  -3.601e+004   6.103e+006
First-order corrections to F and Theta ...........   -0.3407     4.0702
Reduced values - Deltas were too large ...........   -0.2398     2.8648

  13   1.42240    -9.3240  -5.677e+003   1.652e+006
First-order corrections to F and Theta ...........   -0.0084    -2.2237
Second-order corrections to F and Theta ..........   -0.0116    -1.9207

  14   1.41075   -11.2447   6.518e+000  -1.540e+003
First-order corrections to F and Theta ...........    0.0000     0.0010
Second-order corrections to F and Theta ..........    0.0000     0.0010

  15   1.41078   -11.2437  -3.388e-009   1.189e-006
First-order corrections to F and Theta ...........   -0.0000    -0.0000

After trial 1 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:     -0.731 (percent)
     Maximum change occurred for slice 35
     Normal stress where max. change occurred:      1013.91
     Old strength at this slice:       228.13
     New strength at this slice:       226.46
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 2 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  13
Allowable moment imbalance for convergence: 7109

        Trial     Trial
       Factor   Side Force     Force      Moment                  Delta
Iter-    of     Inclination  Imbalance   Imbalance    Delta-F     Theta
ation  Safety    (degrees)     (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -1.251e+005   2.546e+007
First-order corrections to F and Theta ...........   -2.6552    -4.0251
Reduced values - Deltas were too large ...........   -0.5000    -0.7580

   2   2.50000   -17.9467  -9.768e+004   1.962e+007
First-order corrections to F and Theta ...........   -1.3207    -7.4439
Reduced values - Deltas were too large ...........   -0.5000    -2.8183

   3   2.00000   -20.7650  -5.417e+004   9.606e+006
First-order corrections to F and Theta ...........   -6.6122   239.2503
Reduced values - Deltas were too large ...........   -0.0792     2.8648

   4   1.92083   -17.9002  -5.312e+004   9.368e+006
First-order corrections to F and Theta ...........   12.0980  -562.8304
Reduced values - Deltas were too large ...........    0.0616    -2.8648

   5   1.98240   -20.7650  -5.257e+004   9.198e+006
First-order corrections to F and Theta ...........   -3.8942   134.5840
Reduced values - Deltas were too large ...........   -0.0829     2.8648

   6   1.89951   -17.9002  -5.100e+004   8.881e+006
First-order corrections to F and Theta ...........   -5.2897   217.9747
Reduced values - Deltas were too large ...........   -0.0695     2.8648

   7   1.82999   -15.0354  -4.998e+004   8.670e+006
First-order corrections to F and Theta ...........    6.4543  -348.6614
Reduced values - Deltas were too large ...........    0.0530    -2.8648

   8   1.88302   -17.9002  -4.933e+004   8.498e+006
First-order corrections to F and Theta ...........   -2.7270   104.1396
Reduced values - Deltas were too large ...........   -0.0750     2.8648

   9   1.80801   -15.0354  -4.757e+004   8.175e+006
First-order corrections to F and Theta ...........   -2.3068    97.2062
Reduced values - Deltas were too large ...........   -0.0680     2.8648

  10   1.74002   -12.1706  -4.580e+004   7.870e+006
```

```
First-order corrections to F and Theta ...........   -1.0656    39.1253
Reduced values - Deltas were too large ...........   -0.0780     2.8648

  11   1.66200    -9.3058  -4.193e+004   7.273e+006
First-order corrections to F and Theta ...........    0.1498   -29.8343
Reduced values - Deltas were too large ...........    0.0144    -2.8648

  12   1.67638   -12.1706  -3.789e+004   6.445e+006
First-order corrections to F and Theta ...........   -0.3730     4.8441
Reduced values - Deltas were too large ...........   -0.2206     2.8648

  13   1.45579    -9.3058  -1.136e+004   2.538e+006
First-order corrections to F and Theta ...........   -0.0382    -2.6271
Second-order corrections to F and Theta ..........   -0.0451    -1.9453

  14   1.41066   -11.2511   1.839e+001  -5.656e+003
First-order corrections to F and Theta ...........    0.0000     0.0061
Second-order corrections to F and Theta ..........    0.0000     0.0061

  15   1.41069   -11.2450  -2.167e-007   6.013e-005
First-order corrections to F and Theta ...........   -0.0000    -0.0000

After trial 2 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:     -0.000 (percent)
     Maximum change occurred for slice 24
     Normal stress where max. change occurred:      4263.43
     Old strength at this slice:       568.02
     New strength at this slice:       568.02
Strengths from nonlinear envelope have converged.
Final computations will be performed next.
```

```
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TABLE NO. 47
*************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
*************************************************************

Final Trial with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  13
Allowable moment imbalance for convergence: 7109

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F      Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000   -17.1887  -1.251e+005   2.546e+007
First-order corrections to F and Theta ...........   -2.6552    -4.0251
Reduced values - Deltas were too large ...........   -0.5000    -0.7580

   2   2.50000   -17.9467  -9.768e+004   1.962e+007
First-order corrections to F and Theta ...........   -1.3207    -7.4439
Reduced values - Deltas were too large ...........   -0.5000    -2.8183

   3   2.00000   -20.7650  -5.417e+004   9.606e+006
First-order corrections to F and Theta ...........   -6.6122   239.2503
Reduced values - Deltas were too large ...........   -0.0792     2.8648

   4   1.92083   -17.9002  -5.312e+004   9.368e+006
First-order corrections to F and Theta ...........   12.0980  -562.8304
Reduced values - Deltas were too large ...........    0.0616    -2.8648

   5   1.98240   -20.7650  -5.257e+004   9.198e+006
First-order corrections to F and Theta ...........   -3.8942   134.5840
Reduced values - Deltas were too large ...........   -0.0829     2.8648

   6   1.89951   -17.9002  -5.100e+004   8.881e+006
First-order corrections to F and Theta ...........   -5.2897   217.9747
Reduced values - Deltas were too large ...........   -0.0695     2.8648

   7   1.82999   -15.0354  -4.998e+004   8.670e+006
First-order corrections to F and Theta ...........    6.4543  -348.6614
Reduced values - Deltas were too large ...........    0.0530    -2.8648

   8   1.88302   -17.9002  -4.933e+004   8.498e+006
First-order corrections to F and Theta ...........   -2.7270   104.1396
Reduced values - Deltas were too large ...........   -0.0750     2.8648

   9   1.80801   -15.0354  -4.757e+004   8.175e+006
First-order corrections to F and Theta ...........   -2.3068    97.2062
Reduced values - Deltas were too large ...........   -0.0680     2.8648

  10   1.74002   -12.1706  -4.580e+004   7.870e+006
```

```
First-order corrections to F and Theta ............   -1.0656    39.1253
Reduced values - Deltas were too large ............   -0.0780     2.8648

  11   1.66200    -9.3058  -4.193e+004   7.273e+006
First-order corrections to F and Theta ............    0.1498   -29.8343
Reduced values - Deltas were too large ............    0.0144    -2.8648

  12   1.67638   -12.1706  -3.789e+004   6.445e+006
First-order corrections to F and Theta ............   -0.3730     4.8441
Reduced values - Deltas were too large ............   -0.2206     2.8648

  13   1.45579    -9.3058  -1.136e+004   2.538e+006
First-order corrections to F and Theta ............   -0.0382    -2.6271
Second-order corrections to F and Theta ...........   -0.0451    -1.9453

  14   1.41066   -11.2511   1.839e+001  -5.656e+003
First-order corrections to F and Theta ............    0.0000     0.0061
Second-order corrections to F and Theta ...........    0.0000     0.0061

  15   1.41069   -11.2450  -2.167e-007   6.012e-005
First-order corrections to F and Theta ............   -0.0000    -0.0000
```

```
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TABLE NO. 55
**********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
**********************************************************************

Summation of Horizontal Forces: 9.01623e-011

Summation of Vertical Forces: 7.54009e-011

Summation of Moments: -8.88701e-009

Mohr Coulomb Shear Force/Shear Strength Check Summation: 2.44976e-011
```

```
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TABLE NO. 58
*********************************************************************
* Final Results for Stresses Along the Shear Surface                *
* (Results are for the critical shear surface in the case of a search.) *
*********************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 1.411     Side Force Inclination: -11.25

      -------- VALUES AT CENTER OF BASE OF SLICE --------
                                 Total     Effective
Slice                            Normal     Normal       Shear
  No.    X-Center   Y-Center     Stress     Stress       Stress

   1       422.30     149.66       356.1       356.1       358.4
   2       429.65     141.06       659.0       659.0       482.4
   3       437.00     132.47       961.8       961.8       606.3
   4       444.35     123.87      1264.7      1264.7       730.3
   5       451.70     115.28      1567.5      1567.5       854.2
   6       459.05     106.68      1870.4      1870.4       978.2
   7       466.40      98.08      2173.3      2173.3      1102.1
   8       473.75      89.49      2476.1      2476.1      1226.1
   9       480.95      81.08      2736.0      2736.0      1332.4
  10       487.99      72.85      2953.0      2953.0      1421.2
  11       495.02      64.62      3170.0      3170.0      1510.0
  12       502.06      56.39      3386.9      3386.9      1598.8
  13       509.10      48.16      3603.9      3603.9      1687.6
  14       513.03      43.55      4770.2      4770.2       440.4
  15       519.20      43.01      6338.0      6338.0       557.2
  16       530.69      42.89      6113.7      6113.7       540.5
  17       542.19      42.77      5889.4      5889.4       523.8
  18       553.68      42.65      5665.1      5665.1       507.1
  19       565.18      42.53      5440.8      5440.8       490.4
  20       576.67      42.41      5216.4      5216.4       473.7
  21       588.16      42.30      4992.1      4992.1       457.0
  22       599.66      42.18      4767.8      4767.8       440.2
  23       611.15      42.06      4543.5      4543.5       423.5
  24       621.90      41.58      4263.4      4263.4       402.7
  25       631.90      40.75      4115.4      4115.4       391.6
  26       641.90      39.92      3967.4      3967.4       380.6
  27       651.90      39.50      3889.6      3889.6       374.8
  28       661.90      39.50      3687.4      3687.4       359.7
  29       671.11      40.90      3794.7      3794.7       367.7
  30       679.53      43.70      3419.3      3419.3       339.8
  31       689.26      46.94      2986.1      2986.1       307.5
  32       700.30      50.63      2492.9      2492.9       270.7
  33       711.35      54.31      1999.7      1999.7       234.0
  34       722.39      57.99      1506.4      1506.4       197.2
  35       733.43      61.68      1013.2      1013.2       160.5
  36       744.48      65.36       494.4       494.4        78.9
  37       755.00      66.70        99.2        99.2        15.8
```

```
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tion B LTSS NC text residual.dat

Victoria, TX Landfill Evaluation - Section B LTSS Noncircular (textured, res)
#107608

TABLE NO. 59
*************************************************************************
* Final Results for Side Forces and Stresses Between Slices             *
* (Results are for the critical shear surface in the case of a search.) *
*************************************************************************

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------
```

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	425.98	435	148.93	0.207	-18.8	68.3
2	433.33	2595	141.53	0.187	-87.7	287.7
3	440.68	6481	135.07	0.205	-145.4	522.8
4	448.03	12092	128.75	0.219	-194.1	760.1
5	455.38	19428	122.48	0.229	-237.0	997.2
6	462.73	28490	116.22	0.237	-276.2	1233.8
7	470.08	39277	109.98	0.243	-312.8	1469.9
8	477.43	51789	103.74	0.248	-347.5	1705.5
9	484.47	65185	97.83	0.259	-355.2	1939.6
10	491.50	79765	91.99	0.269	-350.8	2157.7
11	498.54	95528	86.19	0.278	-337.8	2363.8
12	505.58	112475	80.41	0.286	-318.6	2561.2
13	512.62	130605	74.63	0.293	-295.0	2751.9
14	513.45	134983	73.46	0.290	-331.6	2853.9
15	524.95	129218	72.48	0.292	-313.4	2816.1
16	536.44	123621	71.48	0.294	-296.0	2781.0
17	547.93	118194	70.46	0.296	-279.6	2749.1
18	559.43	112935	69.42	0.297	-264.4	2720.7
19	570.92	107844	68.35	0.299	-250.7	2696.6
20	582.42	102923	67.25	0.301	-238.9	2677.4
21	593.91	98171	66.12	0.302	-229.6	2664.2
22	605.41	93587	64.95	0.303	-223.2	2658.0
23	616.90	89172	63.74	0.303	-220.7	2660.2
24	626.90	88689	61.87	0.299	-258.5	2772.0
25	636.90	88193	59.99	0.295	-301.4	2893.9
26	646.90	87683	58.11	0.290	-350.2	3027.5
27	656.90	83862	56.93	0.286	-382.9	3083.0
28	666.90	80194	55.69	0.281	-428.1	3158.9
29	675.32	66204	56.97	0.282	-384.6	2881.5
30	683.74	53525	58.24	0.283	-341.4	2603.5
31	694.78	38849	59.89	0.284	-286.4	2237.2
32	705.83	26439	61.53	0.286	-233.0	1868.2
33	716.87	16295	63.15	0.287	-181.1	1492.9
34	727.91	8417	64.76	0.289	-128.2	1098.4
35	738.96	2805	66.53	0.312	-37.0	606.1
36	750.00	60	67.69	0.213	-18.4	69.2
37	760.00	0	66.20	0.000	0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Victoria, TX Landfill

Cross-Section: B
Case: Long-Term Steady State State – Noncircular Liner Textured Residual
Filename: 20210719 Profile B LTSS – 2 Resi_output (textor).docx

UTEXAS4 Output File
Page 24 of 24

Profile: D Case: EOC

Unit Weight Average Effective Average Total Average

Fixed Grid Coordinates

x	y
50	165
50	565
475	565
475	165

Circle Exit

x y

484 160

Tangent

Search Grid Subdivisions

25

Crack Depth

0

Seismic Acceleration

0

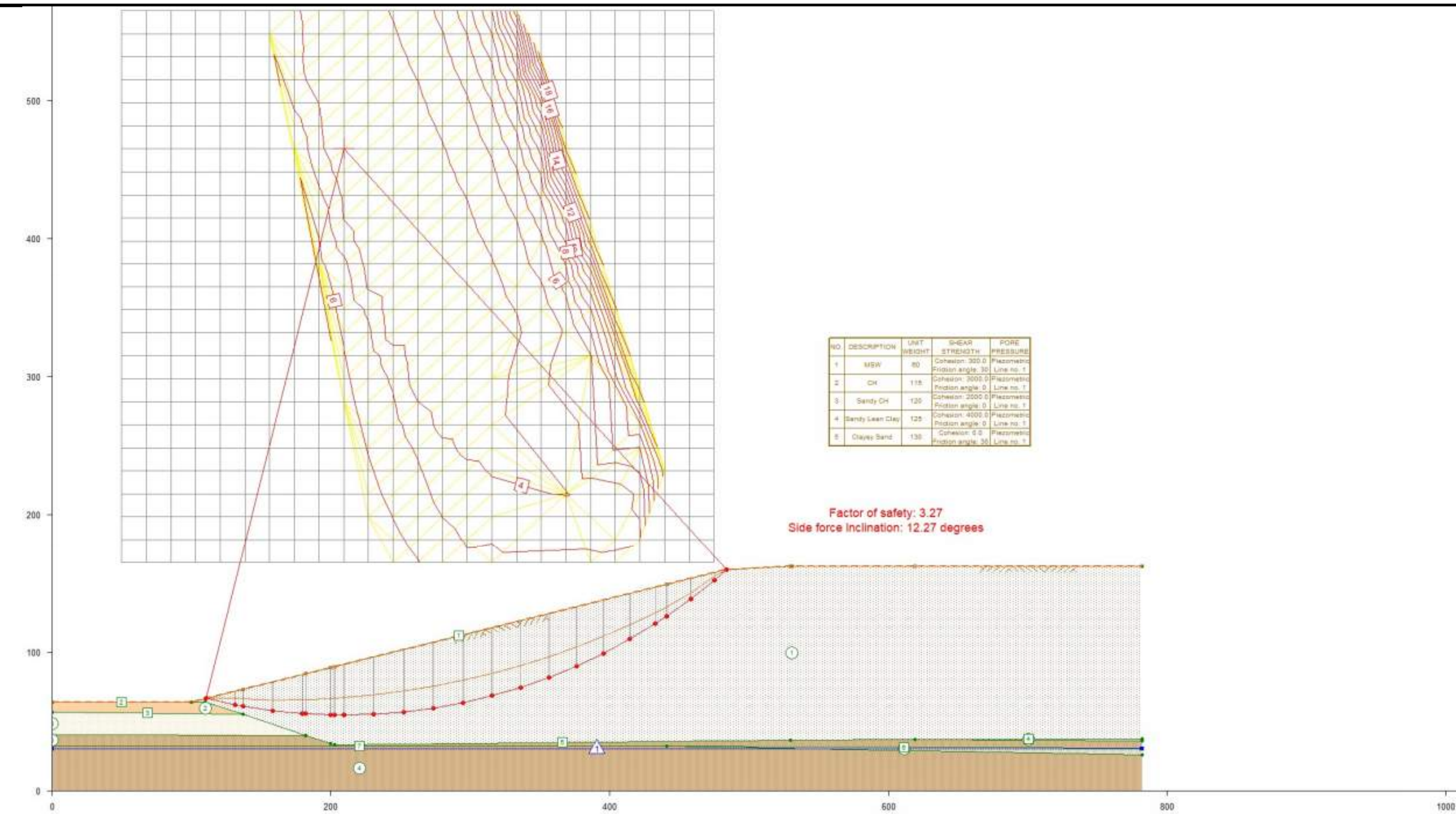
Minimum Weight

5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	232	209.4	465	110.6	66.7

Factor of Safety	Errors
3.27	



Profile: D Case: EOC FINAL

Unit Weight Average Effective Average Total Average

Fixed Grid Coordinates

x	y
50	265
50	565
475	565
475	265

Circle Exit

x y

110 64

Tangent

Search Grid Subdivisions

25

Crack Depth

4

Seismic Acceleration

0

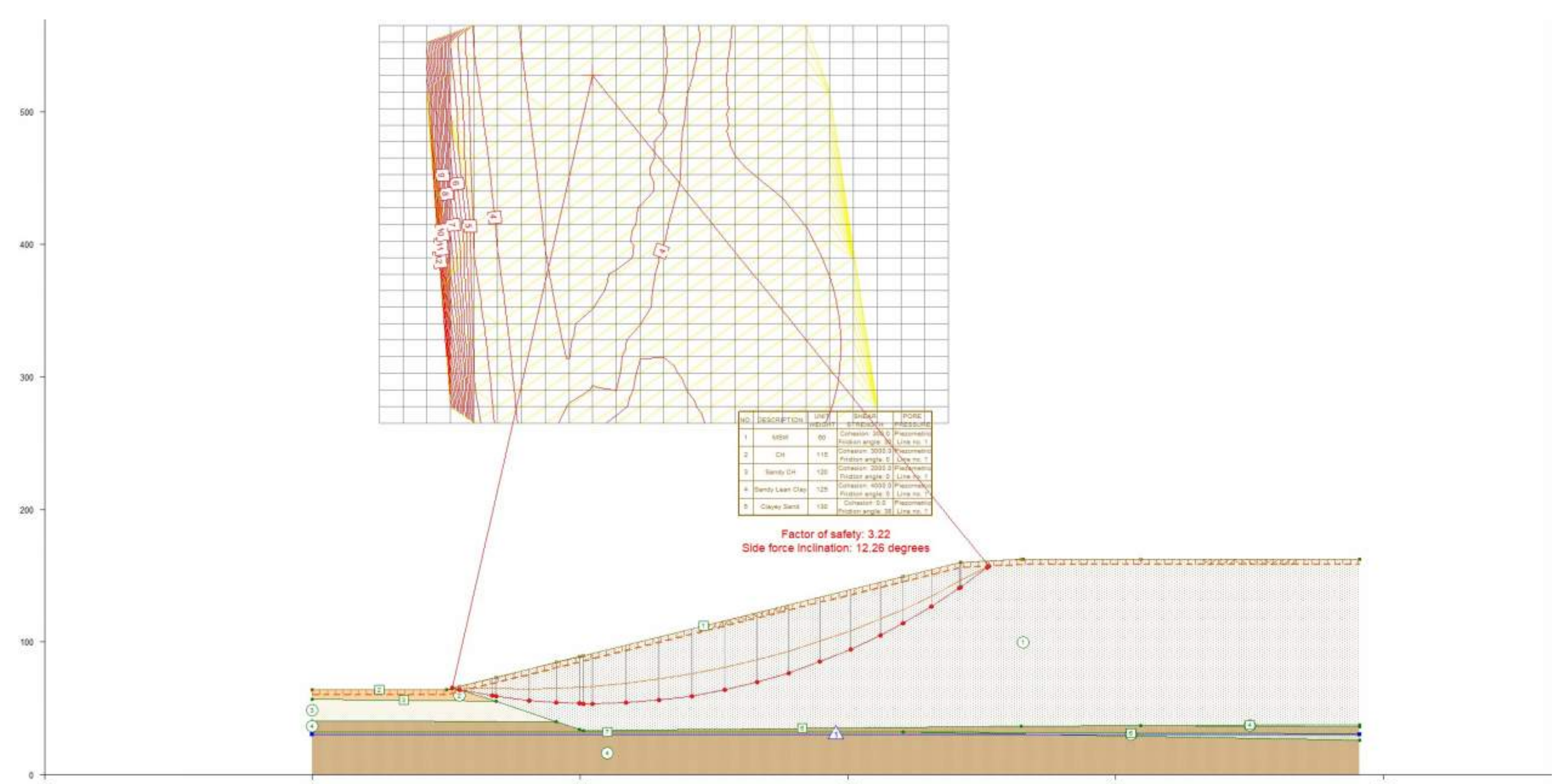
Minimum Weight

5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	420	209.4	527.5	505.1	157.1

Factor of Safety	Errors
3.22	



Victoria, TX Landfill

Cross-Section: D
Case: End of Construction
Filename: 20210719 Profile D EOC_input (textor).docx

UTEXAS4 Input File
Page 1 of 2

```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section D EOC
#107608

PROfile lines
   1 1 MSW
         100 64
         484 160
         531 162.35
         782 162.35

   2 2 CH
         0 64
         100 64
         110 64
         137.2 55

   3 3 Sandy CH - 1
         0 56.9
         137.2 55
         182.3  39.9

   4 3 Sandy CH - 2
         618.9 36.8
         782 37.6

   5 4 Clayey Sand - 1
         0 40.5
         182.3 39.9
         199.8 34.1
         202.7 33.1
         529.6 36.4
         618.9 36.8
         782 35.7

   6 5 Sandy CL
         441 31.9
         782 30.6

   7 4 Clayey Sand
         0 31.9
         441 31.9
         782 25.9


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
```

```
      Conventional Shear Strength
         3000 0
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         2000 0
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         4000 0
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         782 30


LABel
Victoria, TX Landfill Evaluation - Section D EOC
ANALYSIS/COMPUTATION
   Circular Search 2
     25 25
     50 265 50 565 475 565 475 265
     5 5
   Point
     110 64

   Minimum
     5000
   Crack
     4 D
   Short

COMpute
```

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
* RESULTS OF COMPUTATIONS PERFORMED USING THIS SOFTWARE         *
* SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY HAVE       *
* BEEN VERIFIED BY INDEPENDENT ANALYSES, EXPERIMENTAL DATA      *
* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
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*****************************************************************
```

```
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1      100.00       64.00
   2      484.00      160.00
   3      531.00      162.35
   4      782.00      162.35

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1        0.00       64.00
   2      100.00       64.00
   3      110.00       64.00
   4      137.20       55.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 1

Point        X           Y

   1        0.00       56.90
   2      137.20       55.00
   3      182.30       39.90

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 2

Point        X           Y

   1      618.90       36.80
   2      782.00       37.60

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 4 -----
```

```
-----------------------------------------------------------
Description: Clayey Sand - 1

Point        X           Y

   1        0.00       40.50
   2      182.30       39.90
   3      199.80       34.10
   4      202.70       33.10
   5      529.60       36.40
   6      618.90       36.80
   7      782.00       35.70

-----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 5 -----
-----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1      441.00       31.90
   2      782.00       30.60

-----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 4 -----
-----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       31.90
   2      441.00       31.90
   3      782.00       25.90
```

```
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 4
**********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 3000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 2000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 4000.0
Friction angle - - - - - 0.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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tion D EOC.dat

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#107608

TABLE NO. 6
*********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      782.00       30.00
```

```
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tion D EOC.dat

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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************


Search will be conducted using a fixed grid.
Number of Points Across Grid: 25
Number of Points Up Grid: 25

Grid Corner
   Number           X              Y

     1            50.00         265.00
     2            50.00         565.00
     3           475.00         565.00
     4           475.00         265.00

----- Control Parameters for Finding "Critical" Radius -----
Initial number of subdivisions between maximum and minimum
radius for finding a critical radius/radii: 5

Minimum radius increment for terminating subdivision of radii: 5.000

The following criteria will be used for determining
the maximum and minimum radii:
     Point circles pass through - X: 110.00     Y: 64.00
Minimum weight required for computations to be performed: 5000

Depth of crack: 4.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Subtended angle for slice subdivision: 3.00(degrees)
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Search will be continued after the initial mode to find a most critical circle.
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Radii for each grid point will be sorted in the order of increasing radius.
Critical circles for grid points will be output in the order of increasing factor of safety.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Initial trial factor of safety: 3.000
```

```
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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tion D EOC.dat

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#107608

TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00       64.00
        2     100.00       64.00
        3     110.00       66.50
        4     137.20       73.30
        5     182.30       84.58
        6     199.80       88.95
        7     202.70       89.67
        8     441.00      149.25
        9     484.00      160.00
       10     529.60      162.28
       11     531.00      162.35
       12     618.90      162.35
       13     782.00      162.35
```

```
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tion D EOC.dat

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TABLE NO. 38
*************************************************
* FINAL SUMMARY OF COMPUTATIONS WITH FIXED-GRID *
*************************************************


Number of circles attempted: 625
Number of circles for which F calculated: 420
Circle with Lowest Factor of Safety:
     X coordinate for center: 209.38
     Y coordinate for center: 527.50
     Radius of circle: 474.033
Factor of safety: 3.220
Side force inclination: 12.26
Time Required for Computations: 1.0 seconds
```

```
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tion D EOC.dat

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#107608

TABLE NO. 43
*********************************************************
* Coordinate, Weight, Strength and Pore Water Pressure    *
* Information for Individual Slices for Conventional      *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the   *
* case of an automatic search.)                           *
*********************************************************
```

Slice No.	X	Y	Slice Weight	Matl. No.	Cohesion	Friction Angle	Pore Pressure
	104.69	65.17					
1	107.34	64.59	399	1	300.0	30.00	0.0
	110.00	64.00					
2	110.00	64.00	0	1	300.0	30.00	0.0
	110.00	64.00					
3	122.20	61.72	11463	1	300.0	30.00	0.0
	134.39	59.43					
4	135.80	59.21	2313	1	300.0	30.00	0.0
	137.20	58.99					
5	149.51	57.43	27994	1	300.0	30.00	0.0
	161.82	55.86					
6	172.06	55.05	33137	1	300.0	30.00	0.0
	182.30	54.24					
7	191.05	53.90	34504	1	300.0	30.00	0.0
	199.80	53.56					
8	201.25	53.54	6225	1	300.0	30.00	0.0
	202.70	53.51					
9	206.04	53.49	14826	1	300.0	30.00	0.0
	209.38	53.47					
10	221.78	53.79	60514	1	300.0	30.00	0.0
	234.18	54.12					
11	246.55	55.09	67615	1	300.0	30.00	0.0
	258.92	56.06					
12	271.23	57.68	72522	1	300.0	30.00	0.0
	283.53	59.30					
13	295.73	61.56	75210	1	300.0	30.00	0.0
	307.93	63.83					
14	320.00	66.72	75693	1	300.0	30.00	0.0
	332.06	69.62					
15	343.96	73.14	74024	1	300.0	30.00	0.0
	355.86	76.67					
16	367.56	80.81	70294	1	300.0	30.00	0.0
	379.25	84.95					
17	390.72	89.70	64629	1	300.0	30.00	0.0
	402.18	94.45					
18	413.38	99.79	57193	1	300.0	30.00	0.0
	424.58	105.13					
19	432.79	109.52	37115	1	300.0	30.00	0.0
	441.00	113.91					
20	451.66	120.25	40518	1	300.0	30.00	0.0
	462.33	126.60					

21	472.65	133.49	29305	1	300.0	30.00	0.0
	482.96	140.39					
22	483.48	140.75	1189	1	300.0	30.00	0.0
	484.00	141.12					
23	493.92	148.57	14198	1	300.0	30.00	0.0
	503.85	156.02					
24	504.50	156.54	350	1	300.0	30.00	0.0
	505.14	157.06					

No water in crack.

```
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 44
**********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.               *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
**********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 47
***************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
***************************************************************
Allowable force imbalance for convergence:  9
Allowable moment imbalance for convergence: 2749

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887  -1.868e+004   1.253e+006
First-order corrections to F and Theta ............    0.1730    -6.9215
Reduced values - Deltas were too large ............    0.0716    -2.8648

   2   3.07159    14.3239  -1.124e+004   6.292e+005
First-order corrections to F and Theta ............    0.1346    -2.5351
Second-order corrections to F and Theta ...........    0.1493    -2.0496

   3   3.22094    12.2744   4.297e+001   5.723e+003
First-order corrections to F and Theta ............   -0.0009    -0.0192
Second-order corrections to F and Theta ...........   -0.0009    -0.0192

   4   3.22002    12.2552  -5.043e-006   1.425e-003
First-order corrections to F and Theta ............    0.0000    -0.0000
```

```
UTEXAS4 S/N:10001  - Version: 4.1.0.8 - Latest Revision: 11/9/2009
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Name of input data file:
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 55
**********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
**********************************************************************

Summation of Horizontal Forces: 4.31880e-011

Summation of Vertical Forces: 6.67269e-011

Summation of Moments: 2.13548e-009

Mohr Coulomb Shear Force/Shear Strength Check Summation: 1.74101e-011
```

```
UTEXAS4 S/N:10001  - Version: 4.1.0.8 - Latest Revision: 11/9/2009
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 58
*************************************************************************
* Final Results for Stresses Along the Shear Surface                    *
* (Results are for the critical shear surface in the case of a search.) *
*************************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 3.220     Side Force Inclination:  12.26
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	107.34	64.59	132.5	132.5	116.9
2	110.00	64.00	271.1	271.1	141.8
3	122.20	61.72	572.4	572.4	195.8
4	135.80	59.21	955.8	955.8	264.5
5	149.51	57.43	1284.0	1284.0	323.4
6	172.06	55.05	1769.9	1769.9	410.5
7	191.05	53.90	2110.0	2110.0	471.5
8	201.25	53.54	2272.2	2272.2	500.6
9	206.04	53.49	2339.7	2339.7	512.7
10	221.78	53.79	2529.2	2529.2	546.7
11	246.55	55.09	2767.3	2767.3	589.3
12	271.23	57.68	2916.7	2916.7	616.1
13	295.73	61.56	2982.1	2982.1	627.9
14	320.00	66.72	2967.6	2967.6	625.3
15	343.96	73.14	2877.6	2877.6	609.1
16	367.56	80.81	2716.4	2716.4	580.2
17	390.72	89.70	2488.6	2488.6	539.4
18	413.38	99.79	2198.8	2198.8	487.4
19	432.79	109.52	1902.0	1902.0	434.2
20	451.66	120.25	1557.7	1557.7	372.5
21	472.65	133.49	1124.1	1124.1	294.7
22	483.48	140.75	886.6	886.6	252.1
23	493.92	148.57	528.8	528.8	188.0
24	504.50	156.54	168.6	168.6	123.4

```
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Name of input data file:
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tion D EOC.dat

Victoria, TX Landfill Evaluation - Section D EOC
#107608

TABLE NO. 59
*********************************************************************
* Final Results for Side Forces and Stresses Between Slices         *
* (Results are for the critical shear surface in the case of a search.) *
*********************************************************************
```

--------------- VALUES AT RIGHT SIDE OF SLICE ---------------

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	110.00	795	65.16	0.465	245.7	375.6
2	110.00	795	65.16	0.465	245.7	375.6
3	134.39	8356	64.95	0.419	317.7	922.9
4	137.20	9547	64.80	0.406	284.6	1019.7
5	161.82	21814	64.50	0.366	178.0	1628.8
6	182.30	33348	64.91	0.352	118.5	2030.0
7	199.80	43254	65.75	0.345	80.2	2308.7
8	202.70	44855	65.94	0.344	74.4	2349.8
9	209.38	48469	66.41	0.342	62.0	2439.0
10	234.18	60666	68.72	0.336	23.3	2706.8
11	258.92	70073	71.90	0.332	-9.4	2882.5
12	283.53	75918	75.94	0.329	-37.9	2971.4
13	307.93	77795	80.83	0.326	-63.2	2978.3
14	332.06	75641	86.55	0.323	-86.0	2907.4
15	355.86	69718	93.08	0.320	-106.6	2762.9
16	379.25	60580	100.40	0.316	-125.4	2548.6
17	402.18	49049	108.48	0.311	-142.2	2267.9
18	424.58	36182	117.30	0.304	-155.7	1923.0
19	441.00	26396	124.41	0.297	-159.1	1618.9
20	462.33	14298	134.51	0.283	-151.5	1150.1
21	482.96	4661	145.73	0.276	-80.5	551.2
22	484.00	4261	146.44	0.282	-68.6	509.7
23	503.85	14	156.40	0.076	-4.3	9.9
24	505.14	0	157.06	Below	-0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Profile: D Case: LTSS

Unit Weight: Average; Effective: Average; Total: Average

Fixed Grid Coordinates

x	y
50	165
50	365
475	365
475	165

Circle Exit

x	y
484	160

Tangent

Search Grid Subdivisions
25

Crack Depth
2

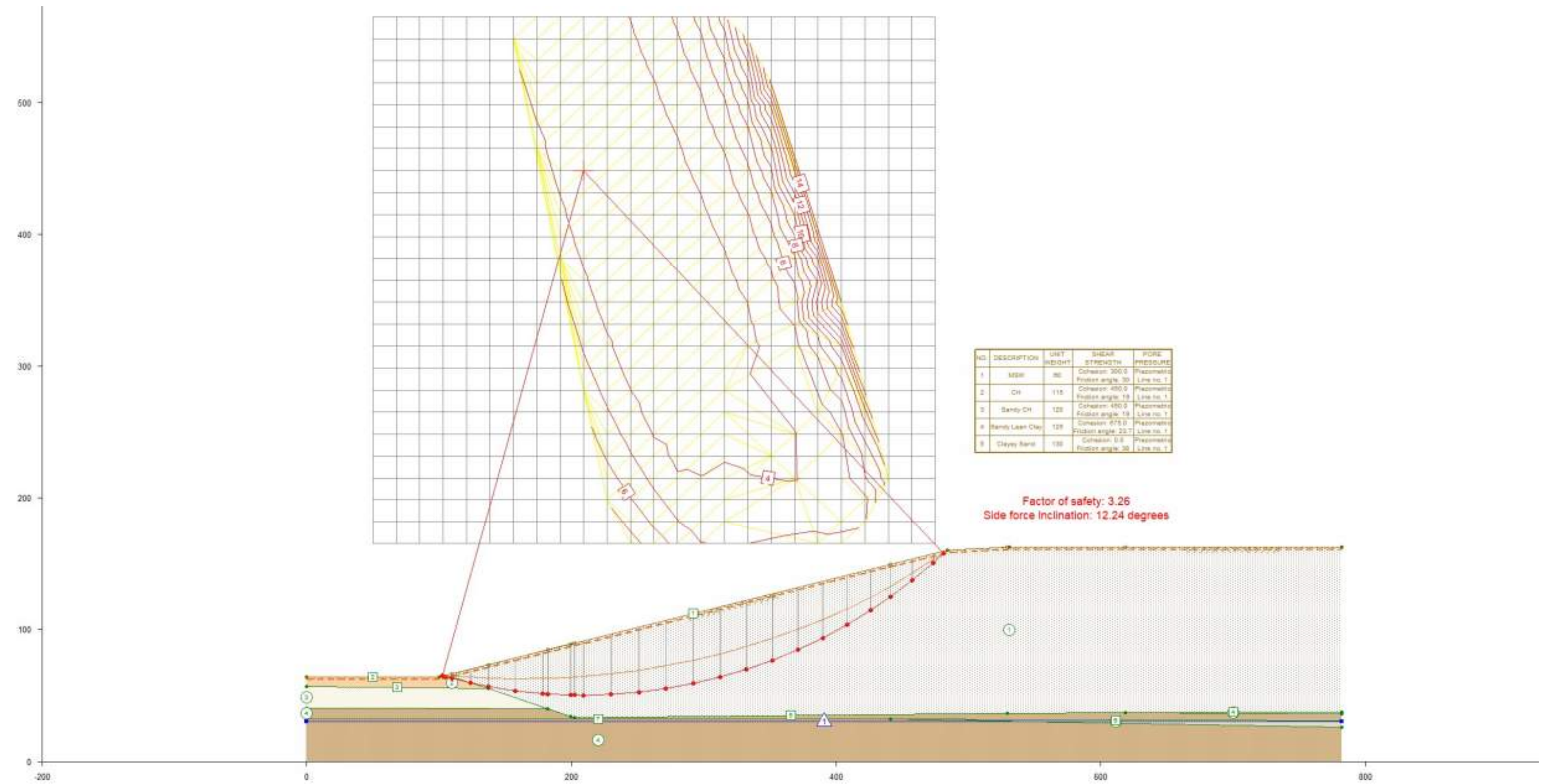
Seismic Acceleration

Minimum Weight
5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	237	209.4	448.3	102.8	64.7

Factor of Safety	Errors
3.26	



Profile: D Case: LTSS FINAL

Unit Weight: Average; Effective: Average; Total: Average

Fixed Grid Coordinates

x	y
50	165
50	565
475	565
475	165

Circle Exit

x	y
100	66

Tangent

Search Grid Subdivisions
25

Crack Depth
3

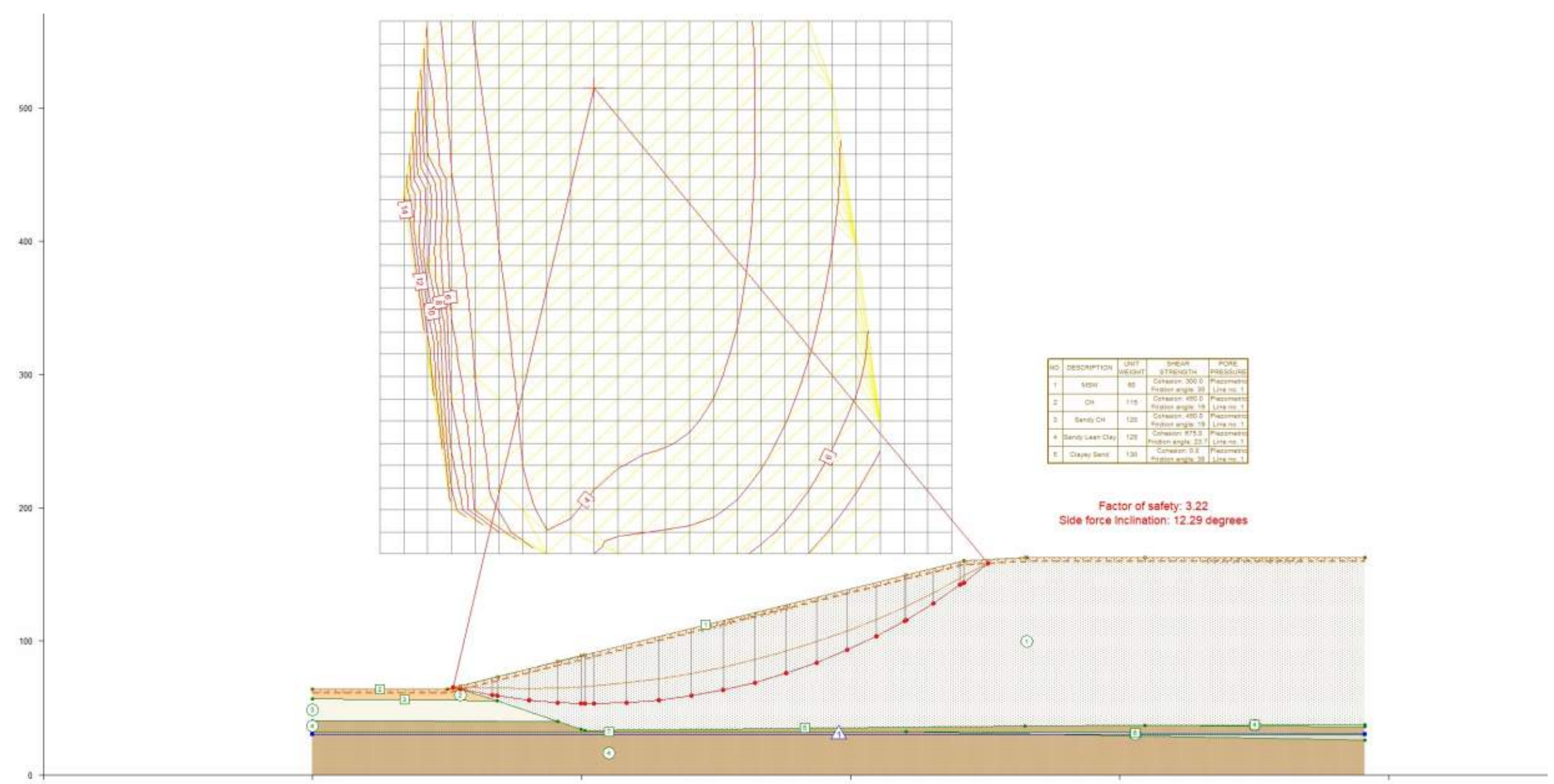
Seismic Acceleration

Minimum Weight
5000

Results

Circles Attempted	Circles Completed	Circle Center x	Circle Center y	Circle Exit x	Circle Exit y
625	436	209.4	515	502.2	157.9

Factor of Safety	Errors
3.22	



Victoria, TX Landfill

Cross-Section: D
Case: Long-Term Steady State
Filename: 20210719 Profile D LTSS - 1_input (textor).docx

UTEXAS4 Input File
Page 1 of 2

```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section D LTSS
#107608

PROfile lines
   1 1 MSW
         100 64
         484 160
         531 162.35
         782 162.35

   2 2 CH
         0 64
         100 64
         110 64
         137.2 55

   3 3 Sandy CH - 1
         0 56.9
         137.2 55
         182.3  39.9

   4 3 Sandy CH - 2
         618.9 36.8
         782 37.6

   5 4 Clayey Sand - 1
         0 40.5
         182.3 39.9
         199.8 34.1
         202.7 33.1
         529.6 36.4
         618.9 36.8
         782 35.7

   6 5 Sandy CL
         441 31.9
         782 30.6

   7 4 Clayey Sand
         0 31.9
         441 31.9
         782 25.9


MATerial properties
   1 MSW
      60 = unit weight
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
```

```
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         782 30


LABel
Victoria, TX Landfill Evaluation - Section D LTSS
ANALYSIS/COMPUTATION
   Circular Search 2
     25 25
     50 165 50 565 475 565 475 165
     5 5
   Point
     110 64

   Minimum
     5000
   Crack
     3 D
   Short

COMpute
```

Victoria, TX Landfill

Cross-Section: D
Case: Long-Term Steady State
Filename: 20210719 Profile D LTSS - 1_output (textor).docx

UTEXAS4 Output File
Page 1 of 17

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
* RESULTS OF COMPUTATIONS PERFORMED USING THIS SOFTWARE         *
* SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY HAVE       *
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* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
* AND ANALYTICAL PROCEDURES USED IN THIS SOFTWARE AND MUST HAVE  *
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*****************************************************************
```

```
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1      100.00       64.00
   2      484.00      160.00
   3      531.00      162.35
   4      782.00      162.35

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1        0.00       64.00
   2      100.00       64.00
   3      110.00       64.00
   4      137.20       55.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 1

Point        X           Y

   1        0.00       56.90
   2      137.20       55.00
   3      182.30       39.90

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 2

Point        X           Y

   1      618.90       36.80
   2      782.00       37.60

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 4 -----
```

```
----------------------------------------------------------
Description: Clayey Sand - 1

Point        X           Y

   1        0.00       40.50
   2      182.30       39.90
   3      199.80       34.10
   4      202.70       33.10
   5      529.60       36.40
   6      618.90       36.80
   7      782.00       35.70

----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 5 -----
----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1      441.00       31.90
   2      782.00       30.60

----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       31.90
   2      441.00       31.90
   3      782.00       25.90
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
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TABLE NO. 4
*********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
-----------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

-----------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
-----------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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tion D LTSS.dat

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#107608

TABLE NO. 6
**********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

---------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
---------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      782.00       30.00
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************


Search will be conducted using a fixed grid.
Number of Points Across Grid: 25
Number of Points Up Grid: 25

Grid Corner
   Number           X              Y

     1            50.00         165.00
     2            50.00         565.00
     3           475.00         565.00
     4           475.00         165.00

----- Control Parameters for Finding "Critical" Radius -----
Initial number of subdivisions between maximum and minimum
radius for finding a critical radius/radii: 5

Minimum radius increment for terminating subdivision of radii: 5.000

The following criteria will be used for determining
the maximum and minimum radii:
     Point circles pass through - X: 110.00     Y: 64.00
Minimum weight required for computations to be performed: 5000

Depth of crack: 3.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Subtended angle for slice subdivision: 3.00(degrees)
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Search will be continued after the initial mode to find a most critical circle.
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Radii for each grid point will be sorted in the order of increasing radius.
Critical circles for grid points will be output in the order of increasing factor of safety.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Initial trial factor of safety: 3.000
```

```
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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tion D LTSS.dat

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TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00       64.00
        2     100.00       64.00
        3     110.00       66.50
        4     137.20       73.30
        5     182.30       84.58
        6     199.80       88.95
        7     202.70       89.67
        8     441.00      149.25
        9     484.00      160.00
       10     529.60      162.28
       11     531.00      162.35
       12     618.90      162.35
       13     782.00      162.35
```

```
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tion D LTSS.dat

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#107608

TABLE NO. 38
************************************************
* FINAL SUMMARY OF COMPUTATIONS WITH FIXED-GRID *
************************************************


Number of circles attempted: 625
Number of circles for which F calculated: 436
Circle with Lowest Factor of Safety:
     X coordinate for center: 209.38
     Y coordinate for center: 515.00
     Radius of circle: 461.819
Factor of safety: 3.221
Side force inclination: 12.29
Time Required for Computations: 2.0 seconds
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 43
**********************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
**********************************************************

Slice                        Slice   Matl.             Friction     Pore
  No.      X          Y      Weight   No.    Cohesion    Angle    Pressure
        104.75      65.19
   1    107.38      64.59       394    1       300.0    30.00         0.0
        110.00      64.00
   2    110.00      64.00         0    2       450.0    19.00         0.0
        110.00      64.00
   3    110.00      64.00         0    2       450.0    19.00         0.0
        110.00      64.00
   4    121.87      61.71     11052    1       300.0    30.00         0.0
        133.74      59.42
   5    135.47      59.14      2851    1       300.0    30.00         0.0
        137.20      58.86
   6    149.19      57.28     27351    1       300.0    30.00         0.0
        161.17      55.70
   7    171.74      54.84     34347    1       300.0    30.00         0.0
        182.30      53.98
   8    191.05      53.63     34791    1       300.0    30.00         0.0
        199.80      53.28
   9    201.25      53.26      6274    1       300.0    30.00         0.0
        202.70      53.23
  10    206.04      53.21     14940    1       300.0    30.00         0.0
        209.38      53.18
  11    221.46      53.50     59265    1       300.0    30.00         0.0
        233.54      53.81
  12    245.60      54.76     66000    1       300.0    30.00         0.0
        257.65      55.71
  13    269.63      57.29     70647    1       300.0    30.00         0.0
        281.62      58.87
  14    293.51      61.07     73183    1       300.0    30.00         0.0
        305.39      63.27
  15    317.15      66.10     73621    1       300.0    30.00         0.0
        328.90      68.92
  16    340.49      72.35     72012    1       300.0    30.00         0.0
        352.08      75.78
  17    363.48      79.82     68442    1       300.0    30.00         0.0
        374.88      83.86
  18    386.04      88.48     63032    1       300.0    30.00         0.0
        397.21      93.11
  19    408.12      98.31     55935    1       300.0    30.00         0.0
        419.04     103.52
  20    429.66     109.29     47336    1       300.0    30.00         0.0
        440.28     115.05
```

```
  21    440.64    115.26         1456    1       300.0    30.00         0.0
        441.00    115.47
  22    451.30    121.80        37093    1       300.0    30.00         0.0
        461.59    128.14
  23    471.54    135.00        26130    1       300.0    30.00         0.0
        481.49    141.87
  24    482.75    142.79         2541    1       300.0    30.00         0.0
        484.00    143.71
  25    493.12    150.81        10551    1       300.0    30.00         0.0
        502.23    157.91

No water in crack.
```

```
UTEXAS4 S/N:10001  - Version: 4.1.0.8 - Latest Revision: 11/9/2009
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Name of input data file:
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 44
**********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.               *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
**********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************
Allowable force imbalance for convergence:  9
Allowable moment imbalance for convergence: 2690

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F      Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887  -1.857e+004   1.231e+006
First-order corrections to F and Theta ............    0.1731    -6.8620
Reduced values - Deltas were too large ............    0.0722    -2.8648

   2   3.07225    14.3239  -1.112e+004   6.123e+005
First-order corrections to F and Theta ............    0.1345    -2.4835
Second-order corrections to F and Theta ...........    0.1492    -2.0114

   3   3.22141    12.3126   4.191e+001   5.482e+003
First-order corrections to F and Theta ............   -0.0009    -0.0186
Second-order corrections to F and Theta ...........   -0.0009    -0.0186

   4   3.22051    12.2940  -4.759e-006   1.335e-003
First-order corrections to F and Theta ............    0.0000    -0.0000
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 55
*********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
*********************************************************************

Summation of Horizontal Forces: 4.60080e-011

Summation of Vertical Forces: 5.90117e-011

Summation of Moments: -2.38333e-009

Mohr Coulomb Shear Force/Shear Strength Check Summation: 2.61649e-011
```

```
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tion D LTSS.dat

Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 58
*************************************************************************
* Final Results for Stresses Along the Shear Surface                    *
* (Results are for the critical shear surface in the case of a search.) *
*************************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 3.221     Side Force Inclination:  12.29
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	107.38	64.59	133.6	133.6	117.1
2	110.00	64.00	240.5	240.5	165.4
3	110.00	64.00	252.4	252.4	166.7
4	121.87	61.71	569.8	569.8	195.3
5	135.47	59.14	958.4	958.4	265.0
6	149.19	57.28	1291.4	1291.4	324.7
7	171.74	54.84	1781.0	1781.0	412.4
8	191.05	53.63	2128.8	2128.8	474.8
9	201.25	53.26	2290.9	2290.9	503.8
10	206.04	53.21	2358.1	2358.1	515.9
11	221.46	53.50	2542.8	2542.8	549.0
12	245.60	54.76	2772.8	2772.8	590.2
13	269.63	57.29	2916.6	2916.6	616.0
14	293.51	61.07	2978.5	2978.5	627.1
15	317.15	66.10	2962.7	2962.7	624.3
16	340.49	72.35	2873.3	2873.3	608.2
17	363.48	79.82	2714.6	2714.6	579.8
18	386.04	88.48	2491.0	2491.0	539.7
19	408.12	98.31	2207.1	2207.1	488.8
20	429.66	109.29	1867.7	1867.7	428.0
21	440.64	115.26	1680.0	1680.0	394.3
22	451.30	121.80	1463.8	1463.8	355.6
23	471.54	135.00	1027.6	1027.6	277.4
24	482.75	142.79	771.0	771.0	231.4
25	493.12	150.81	414.4	414.4	167.4

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Victoria, TX Landfill Evaluation - Section D LTSS
#107608

TABLE NO. 59

```
*********************************************************************
* Final Results for Side Forces and Stresses Between Slices         *
* (Results are for the critical shear surface in the case of a search.) *
*********************************************************************
```

--------------- VALUES AT RIGHT SIDE OF SLICE ---------------

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	110.00	791	65.17	0.466	246.8	371.8
2	110.00	791	65.17	0.466	246.8	371.8
3	110.00	791	65.17	0.466	246.8	371.8
4	133.74	8209	64.88	0.419	318.5	913.8
5	137.20	9698	64.69	0.404	278.5	1033.5
6	161.17	21830	64.35	0.366	179.1	1629.3
7	182.30	33899	64.75	0.352	121.1	2043.8
8	199.80	43917	65.59	0.345	84.6	2321.4
9	202.70	45532	65.77	0.344	79.1	2362.2
10	209.38	49173	66.24	0.342	67.3	2450.6
11	233.54	61106	68.51	0.337	31.7	2708.9
12	257.65	70284	71.62	0.334	1.8	2877.5
13	281.62	75977	75.58	0.331	-23.9	2961.7
14	305.39	77804	80.36	0.328	-46.5	2966.1
15	328.90	75710	85.94	0.325	-66.5	2894.9
16	352.08	69948	92.32	0.323	-84.4	2752.1
17	374.88	61050	99.47	0.320	-100.2	2541.7
18	397.21	49800	107.38	0.316	-114.0	2267.2
19	419.04	37205	116.00	0.310	-124.8	1931.4
20	440.28	24460	125.34	0.302	-130.1	1535.2
21	441.00	24037	125.68	0.302	-129.7	1520.1
22	461.59	12550	135.77	0.291	-120.0	1053.8
23	481.49	3759	146.96	0.291	-53.4	473.0
24	484.00	2900	148.82	0.314	-20.2	368.0
25	502.23	0	157.91	Above	-0.0	0.0

Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.

Profile: D Case: LTSS NC - Smooth Peak

Unit Weight Average Effective Average Total Average

Noncircular Surface Coordinates

x	y	
484	160	
425	36.3	0.573
202.7	34.1	fixed
110	65	fixed
100	64	fixed

Shifting Points
5
1

Crack Depth
3

Seismic Acceleration

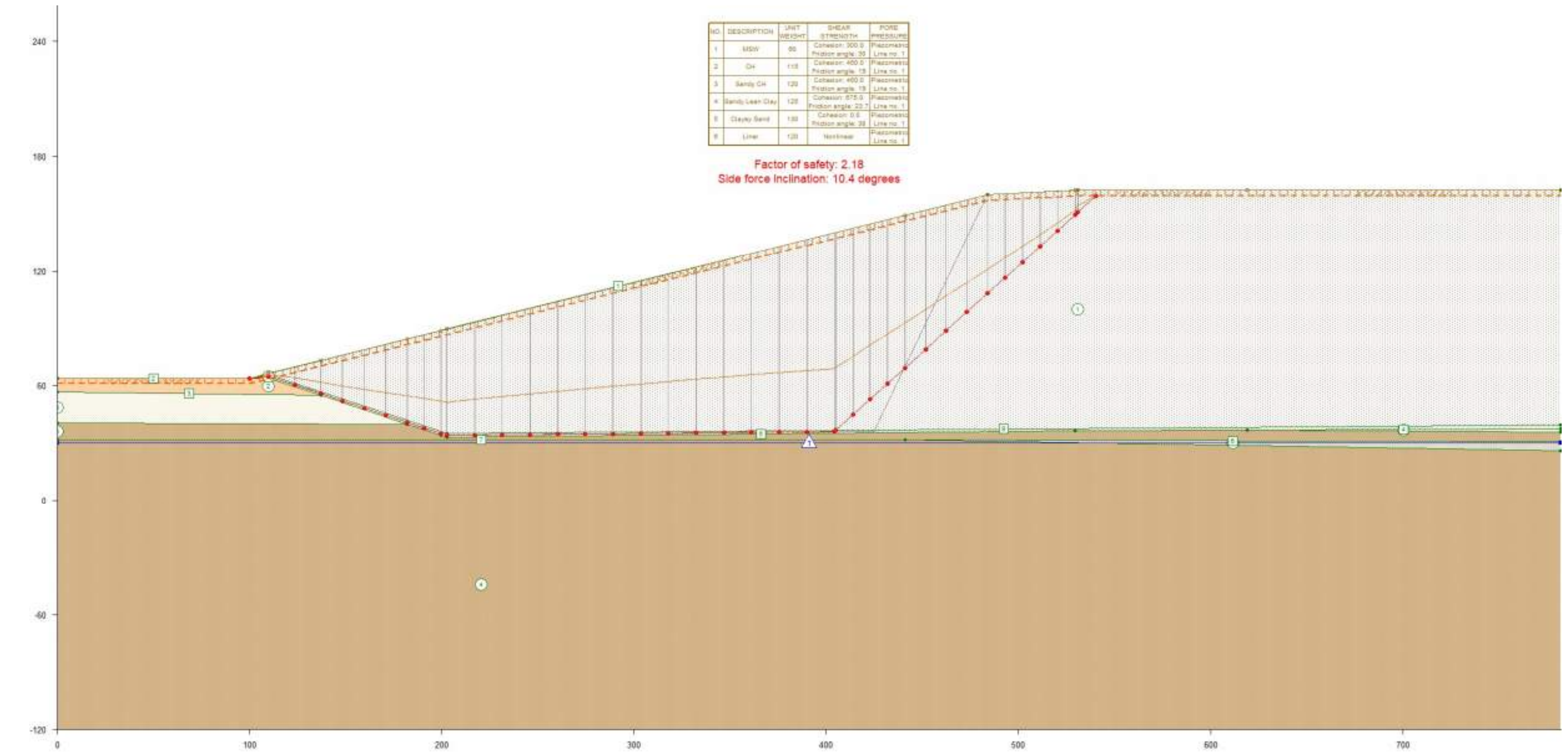
Minimum Weight

Results

Noncircular Shear Surface

100	66
110	65
202.7	34.1
404.4	36.1
540.4	159.4

Factor of Safety
2.18



Profile: D Case: LTSS NC - Smooth Residual

Unit Weight Average Effective Average Total Average

Noncircular Surface Coordinates

x	y	
484	160	
425	36.3	1.15 deg
202.7	34.1	fixed
110	65	fixed
100	64	fixed

Shifting Points
5
1

Crack Depth
7

Seismic Acceleration

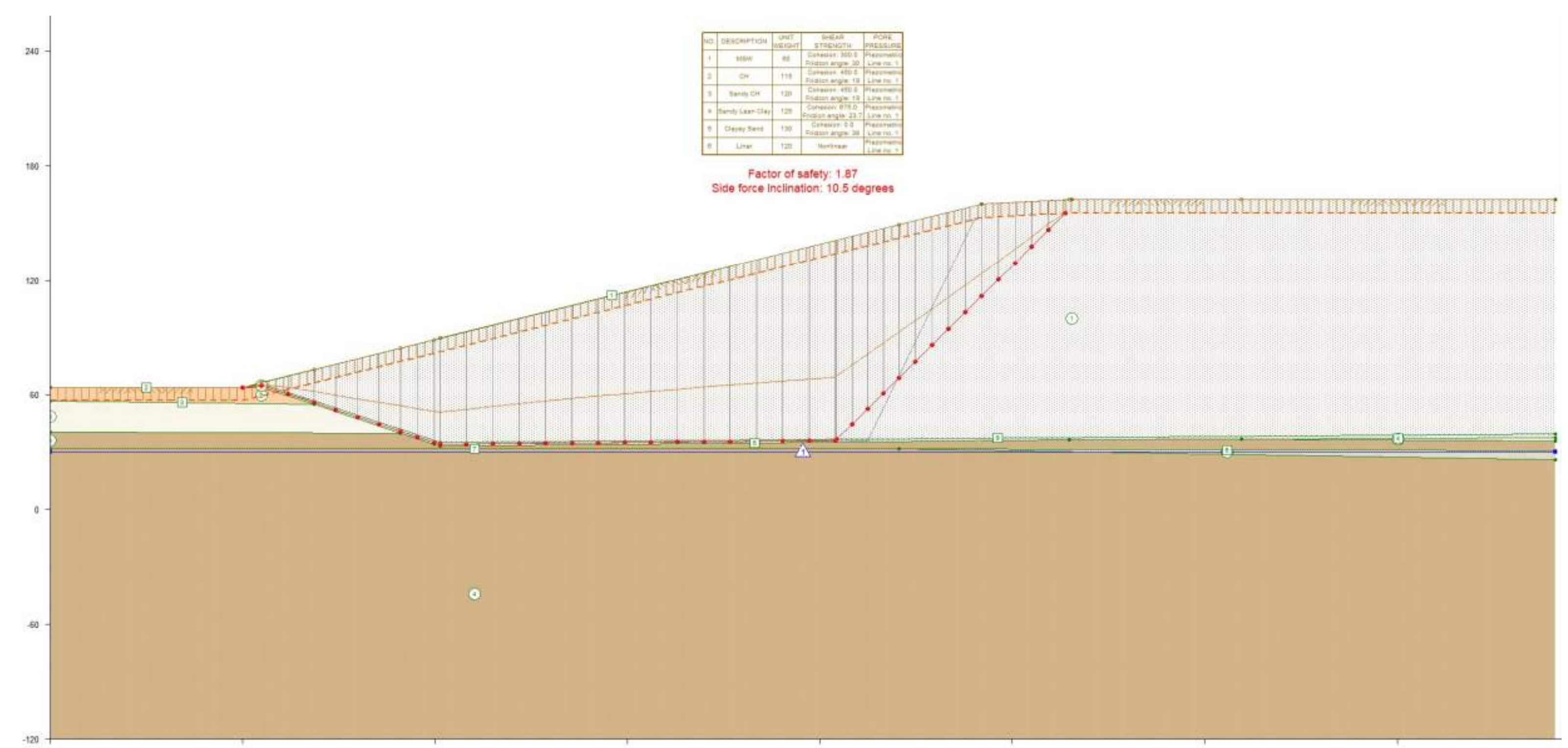
Minimum Weight

Results

Noncircular Shear Surface

100	64
110	65
202.7	34.1
408.1	36.1
527.6	155.2

Factor of Safety
1.87



Victoria, TX Landfill

Cross-Section: D
Case: Long-Term Steady State – Noncircular Liner Smooth Peak
Filename: 20210719 Profile D LTSS – 2 Peak_input (textor).docx

UTEXAS4 Input File
Page 1 of 3

```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
#107608

PROfile lines
   1 1 MSW
         100 64
         484 160
         531 162.35
         782 162.35

   2 2 CH
         0 64
         100 64
         110 64
         137.2 55

   3 3 Sandy CH - 1
         0 56.9
         137.2 55
         182.3  39.9

   4 3 Sandy CH - 2
         618.9 36.8
         782 37.6

   5 4 Clayey Sand - 1
         0 40.5
         182.3 39.9
         199.8 34.1
         202.7 33.1
         529.6 36.4
         618.9 36.8
         782 35.7

   6 5 Sandy CL
         441 31.9
         782 30.6

   7 4 Clayey Sand
         0 31.9
         441 31.9
         782 25.9

   9 6 Liner
         100 64
         110 66
         202.7 35.1
         782 39.6


MATerial properties
   1 MSW
      60 = unit weight
```

```
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1
   6 Liner
      120 = unit weight
      Non Linear Mohr Coulomb Envelope
         0 0
         1500 572
         10000 2224

      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         782 30


LABel
Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
ANALYSIS/COMPUTATION
   Noncircular Search 2
     484 160
     425 36.3 0.573
     202.7 34.1 fixed
     110 65 fixed
     100 64 fixed

     5 1
```

```
   Crack
     3 D
   Short

COMpute
```

Victoria, TX Landfill

Cross-Section: D
Case: Long-Term Steady State State – Noncircular Liner Smooth Peak
Filename: 20210719 Profile D LTSS – 2 Peak_output (textor).docx

UTEXAS4 Output File
Page 1 of 22

```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
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```

```
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tion D LTSS NC smooth peak.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
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TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
----------------------------------------------------------
Description: MSW

Point        X           Y

   1      100.00       64.00
   2      484.00      160.00
   3      531.00      162.35
   4      782.00      162.35

----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
----------------------------------------------------------
Description: CH

Point        X           Y

   1        0.00       64.00
   2      100.00       64.00
   3      110.00       64.00
   4      137.20       55.00

----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 1

Point        X           Y

   1        0.00       56.90
   2      137.20       55.00
   3      182.30       39.90

----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 3 -----
----------------------------------------------------------
Description: Sandy CH - 2

Point        X           Y

   1      618.90       36.80
   2      782.00       37.60

----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 4 -----
```

```
----------------------------------------------------------
Description: Clayey Sand - 1

Point        X           Y

   1        0.00       40.50
   2      182.30       39.90
   3      199.80       34.10
   4      202.70       33.10
   5      529.60       36.40
   6      618.90       36.80
   7      782.00       35.70

----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 5 -----
----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1      441.00       31.90
   2      782.00       30.60

----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 4 -----
----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       31.90
   2      441.00       31.90
   3      782.00       25.90

----------------------------------------------------------
----- Profile Line No. 9 - Material Type (Number): 6 -----
----------------------------------------------------------
Description: Liner

Point        X           Y

   1      100.00       64.00
   2      110.00       66.00
   3      202.70       35.10
   4      782.00       39.60
```

```
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TABLE NO. 4
*******************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
*******************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 6 -------------------
------------------------------------------------------------------
Description: Liner

Constant unit weight of soil (material): 120.0

---- NONLINEAR SHEAR STRENGTH ENVELOPE ----
     Point     Normal Stress     Shear Stress

       1                0.0              0.0
       2             1500.0            572.0
       3            10000.0           2224.0

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
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TABLE NO. 6
**********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

----------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
----------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      782.00       30.00
```

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1        484.00         160.00   angle to be computed - moveable
   2        425.00          36.30     0.57               - moveable
   3        202.70          34.10                        - fixed
   4        110.00          65.00                        - fixed
   5        100.00          64.00                        - fixed

Initial distance for shifting points on shear surface = 5.000
Final distance for shifting points on shear surface = 1.000
Maximum steepness permitted for toe of shear surface = 50.00


Depth of crack: 3.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Maximum increment for slice subdivision: 30
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Maximum number of passes for noncircular search: 50
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Minimum weight required for computations to be performed: 100
Initial trial factor of safety: 3.000
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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tion D LTSS NC smooth peak.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
#107608

TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00       64.00
        2     100.00       64.00
        3     110.00       66.50
        4     137.20       73.30
        5     182.30       84.58
        6     199.80       88.95
        7     202.70       89.67
        8     441.00      149.25
        9     484.00      160.00
       10     529.60      162.28
       11     531.00      162.35
       12     618.90      162.35
       13     782.00      162.35

********** ERROR(S) OR WARNING(S) IN ANALYSIS/COMPUTATION DATA **********
UTEXAS WARNING NUMBER 7330
The following points are out of order for noncircular shear surface
Point: 1, X: 484.00, Y: 160.00
Point: 2, X: 425.00, Y: 36.30
Points were successfully reversed.

Right end point on noncircular shear surface adjusted to:
X: 482.38, Y: 156.59
Adjustment was made to put end point at bottom of crack.

Noncircular Shear Surface Points After Reversal of Order and End Point Adjustment
Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1        100.00          64.00                        - fixed
   2        110.00          65.00                        - fixed
   3        202.70          34.10                        - fixed
   4        425.00          36.30      0.57              - moveable
   5        482.38         156.59   angle to be computed - moveable
Computed crack depth: 3.00
```

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
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TABLE NO. 40
*******************************************************************
* Short-Form Output Table for Search with Noncircular Shear Surfaces *
*******************************************************************

  Shift    Factor of
Distance    Safety       Point       X          Y        Point       X          Y
   5.000     2.620          1     100.00      64.00        4     425.00      36.30
                            2     110.00      65.00        5     482.38     156.59
                            3     202.70      34.10
End of Trial: 1
   5.000     2.478          1     100.00      64.00        4     420.00      36.25
                            2     110.00      65.00        5     487.34     157.17
                            3     202.70      34.10
End of Trial: 2
   5.000     2.377          1     100.00      64.00        4     415.00      36.20
                            2     110.00      65.00        5     492.34     157.42
                            3     202.70      34.10
End of Trial: 3
   5.000     2.306          1     100.00      64.00        4     410.00      36.15
                            2     110.00      65.00        5     497.33     157.67
                            3     202.70      34.10
End of Trial: 4
   5.000     2.257          1     100.00      64.00        4     405.00      36.10
                            2     110.00      65.00        5     502.32     157.92
                            3     202.70      34.10
End of Trial: 5
   5.000     2.223          1     100.00      64.00        4     400.00      36.05
                            2     110.00      65.00        5     507.32     158.17
                            3     202.70      34.10
End of Trial: 6
   5.000     2.202          1     100.00      64.00        4     395.00      36.00
                            2     110.00      65.00        5     512.31     158.42
                            3     202.70      34.10
End of Trial: 7
   5.000     2.191          1     100.00      64.00        4     390.00      35.95
                            2     110.00      65.00        5     517.30     158.67
                            3     202.70      34.10
End of Trial: 8
   5.000     2.187          1     100.00      64.00        4     385.00      35.90
                            2     110.00      65.00        5     522.30     158.91
                            3     202.70      34.10
End of Trial: 9
   5.000     2.183          1     100.00      64.00        4     390.00      35.95
                            2     110.00      65.00        5     527.29     159.16
                            3     202.70      34.10
End of Trial: 10
   5.000     2.180          1     100.00      64.00        4     395.00      36.00
                            2     110.00      65.00        5     532.29     159.35
                            3     202.70      34.10
End of Trial: 11
   5.000     2.178          1     100.00      64.00        4     400.00      36.05
```

```
                                2     110.00      65.00         5     537.29     159.35
                                3     202.70      34.10
End of Trial: 12
   5.000     2.178              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     537.29     159.35
                                3     202.70      34.10
End of Trial: 13
   5.000     2.177              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     542.29     159.35
                                3     202.70      34.10
End of Trial: 14
   2.500     2.177              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     542.29     159.35
                                3     202.70      34.10
End of Trial: 15
   2.500     2.177              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     539.79     159.35
                                3     202.70      34.10
End of Trial: 16
   1.250     2.177              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     539.79     159.35
                                3     202.70      34.10
End of Trial: 17
   0.625     2.177              1     100.00      64.00         4     405.00      36.10
                                2     110.00      65.00         5     539.79     159.35
                                3     202.70      34.10
End of Trial: 18
```

```
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TABLE NO. 41
****************************************
*  Critical Noncircular Shear Surface  *
****************************************

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****
X:     100.00     Y:      64.00
X:     110.00     Y:      65.00
X:     202.70     Y:      34.10
X:     404.38     Y:      36.09
X:     540.41     Y:     159.35

Minimum factor of safety: 2.177
Side force inclination: 10.40

Time required to find most critical surface:      0.0 seconds
Number of passes required to find most critical surface: 18
Total number of shear surfaces attempted: 90
Total number of shear surfaces for which the factor of safety
was successfully calculated: 90
```

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	5.0000	4	5.000	2.4785	5	5
2	5.0000	4	5.000	2.3775	10	10
3	5.0000	4	5.000	2.3064	15	15
4	5.0000	4	5.000	2.2566	20	20
5	5.0000	4	5.000	2.2233	25	25
6	5.0000	4	5.000	2.2022	30	30
7	5.0000	5	5.000	2.1907	35	35
8	5.0000	5	5.000	2.1869	40	40
9	5.0000	5	5.000	2.1828	45	45
10	5.0000	4	5.000	2.1796	50	50
11	5.0000	4	5.000	2.1777	55	55
12	5.0000	4	5.000	2.1777	60	60
13	5.0000	5	5.000	2.1773	65	65
14	5.0000	0	0.000	2.1773	70	70
15	2.5000	5	2.500	2.1772	75	75
16	2.5000	0	0.000	2.1772	80	80
17	1.2500	5	1.250	2.1772	85	85
18	0.6250	5	0.625	2.1772	90	90

```
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TABLE NO. 43
************************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
************************************************************

Slice                      Slice   Matl.            Friction     Pore
  No.      X         Y       Weight   No.   Cohesion    Angle    Pressure
        100.00     64.00
   1    105.00     64.50        750    6   NONLINEAR ENVELOPE         0.0
        110.00     65.00
   2    116.80     62.73       5277    6   NONLINEAR ENVELOPE         0.0
        123.60     60.47
   3    130.40     58.20      11750    6   NONLINEAR ENVELOPE         0.0
        137.20     55.93
   4    142.84     54.05      14650    6   NONLINEAR ENVELOPE         0.0
        148.47     52.17
   5    154.11     50.30      19099    6   NONLINEAR ENVELOPE         0.0
        159.75     48.42
   6    165.39     46.54      23549    6   NONLINEAR ENVELOPE         0.0
        171.03     44.66
   7    176.66     42.78      27998    6   NONLINEAR ENVELOPE         0.0
        182.30     40.90
   8    186.68     39.44      24794    6   NONLINEAR ENVELOPE         0.0
        191.05     37.98
   9    195.43     36.52      27474    6   NONLINEAR ENVELOPE         0.0
        199.80     35.07
  10    201.25     34.58       9697    6   NONLINEAR ENVELOPE         0.0
        202.70     34.10
  11    209.90     34.17      50381    6   NONLINEAR ENVELOPE         0.0
        217.11     34.24
  12    224.31     34.31      53344    6   NONLINEAR ENVELOPE         0.0
        231.51     34.38
  13    238.71     34.46      56307    6   NONLINEAR ENVELOPE         0.0
        245.92     34.53
  14    253.12     34.60      59271    6   NONLINEAR ENVELOPE         0.0
        260.32     34.67
  15    267.52     34.74      62234    6   NONLINEAR ENVELOPE         0.0
        274.73     34.81
  16    281.93     34.88      65197    6   NONLINEAR ENVELOPE         0.0
        289.13     34.95
  17    296.34     35.03      68161    6   NONLINEAR ENVELOPE         0.0
        303.54     35.10
  18    310.74     35.17      71124    6   NONLINEAR ENVELOPE         0.0
        317.94     35.24
  19    325.15     35.31      74087    6   NONLINEAR ENVELOPE         0.0
        332.35     35.38
  20    339.55     35.45      77050    6   NONLINEAR ENVELOPE         0.0
        346.75     35.52
```

```
  21    353.96     35.60        80014    6   NONLINEAR ENVELOPE         0.0
        361.16     35.67
  22    368.36     35.74        82977    6   NONLINEAR ENVELOPE         0.0
        375.57     35.81
  23    382.77     35.88        85940    6   NONLINEAR ENVELOPE         0.0
        389.97     35.95
  24    397.17     36.02        88904    6   NONLINEAR ENVELOPE         0.0
        404.38     36.09
  25    404.69     36.38         3983    6   NONLINEAR ENVELOPE         0.0
        405.01     36.67
  26    409.51     40.75        54320    1       300.0    30.00         0.0
        414.01     44.82
  27    418.51     48.90        51134    1       300.0    30.00         0.0
        423.01     52.97
  28    427.51     57.05        47948    1       300.0    30.00         0.0
        432.00     61.13
  29    436.50     65.20        44762    1       300.0    30.00         0.0
        441.00     69.28
  30    446.38     74.15        49308    1       300.0    30.00         0.0
        451.75     79.02
  31    457.13     83.89        44760    1       300.0    30.00         0.0
        462.50     88.76
  32    467.88     93.63        40211    1       300.0    30.00         0.0
        473.25     98.50
  33    478.63    103.37        35662    1       300.0    30.00         0.0
        484.00    108.24
  34    488.56    112.37        26189    1       300.0    30.00         0.0
        493.12    116.50
  35    497.68    120.63        21917    1       300.0    30.00         0.0
        502.24    124.76
  36    506.80    128.89        17645    1       300.0    30.00         0.0
        511.36    133.03
  37    515.92    137.16        13373    1       300.0    30.00         0.0
        520.48    141.29
  38    525.04    145.42         9101    1       300.0    30.00         0.0
        529.60    149.55
  39    530.30    150.19         1019    1       300.0    30.00         0.0
        531.00    150.82
  40    535.71    155.09         4103    1       300.0    30.00         0.0
        540.41    159.35
```

No water in crack.

```
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TABLE NO. 44
**********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.               *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
**********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 1 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  16
Allowable moment imbalance for convergence: 5444

        Trial     Trial
       Factor   Side Force     Force       Moment                   Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887   6.386e+004   8.399e+006
First-order corrections to F and Theta ...........   -1.0347    -4.3668
Reduced values - Deltas were too large ...........   -0.5000    -2.1102

   2   2.50000    15.0785   2.582e+004   4.497e+006
First-order corrections to F and Theta ...........   -0.3470    -3.7821
Reduced values - Deltas were too large ...........   -0.2628    -2.8648

   3   2.23717    12.2137   3.049e+003   1.413e+006
First-order corrections to F and Theta ...........   -0.0604    -1.7565
Second-order corrections to F and Theta ..........   -0.0597    -1.8131

   4   2.17750    10.4006  -4.814e+000   2.459e+003
First-order corrections to F and Theta ...........   -0.0000    -0.0034
Second-order corrections to F and Theta ..........   -0.0000    -0.0034

   5   2.17747    10.3973   2.173e-008  -1.275e-007
First-order corrections to F and Theta ...........   -0.0000     0.0000

After trial 1 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:     -1.012 (percent)
     Maximum change occurred for slice 4
     Normal stress where max. change occurred:      1531.61
     Old strength at this slice:       584.06
     New strength at this slice:       578.14
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 2 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  16
Allowable moment imbalance for convergence: 5444

        Trial     Trial
       Factor   Side Force     Force       Moment                  Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887   6.394e+004   8.398e+006
First-order corrections to F and Theta ...........   -1.0358    -4.3610
Reduced values - Deltas were too large ...........   -0.5000    -2.1052

   2   2.50000    15.0835   2.590e+004   4.500e+006
First-order corrections to F and Theta ...........   -0.3474    -3.7820
Reduced values - Deltas were too large ...........   -0.2632    -2.8648

   3   2.23682    12.2187   3.060e+003   1.415e+006
First-order corrections to F and Theta ...........   -0.0603    -1.7596
Second-order corrections to F and Theta ..........   -0.0596    -1.8163

   4   2.17725    10.4025  -4.834e+000   2.455e+003
First-order corrections to F and Theta ...........   -0.0000    -0.0034
Second-order corrections to F and Theta ..........   -0.0000    -0.0034

   5   2.17722    10.3991   2.167e-008  -2.300e-007
First-order corrections to F and Theta ...........   -0.0000     0.0000

After trial 2 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:     -0.000 (percent)
     Maximum change occurred for slice 15
     Normal stress where max. change occurred:      4402.80
     Old strength at this slice:      1136.17
     New strength at this slice:      1136.17
Strengths from nonlinear envelope have converged.
Final computations will be performed next.
```

```
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TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Final Trial with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  16
Allowable moment imbalance for convergence: 5444

        Trial     Trial
       Factor   Side Force     Force       Moment                 Delta
Iter-    of    Inclination   Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)      (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887   6.394e+004   8.398e+006
First-order corrections to F and Theta ............   -1.0358    -4.3610
Reduced values - Deltas were too large ............   -0.5000    -2.1052

   2   2.50000    15.0835   2.590e+004   4.500e+006
First-order corrections to F and Theta ............   -0.3474    -3.7820
Reduced values - Deltas were too large ............   -0.2632    -2.8648

   3   2.23682    12.2187   3.060e+003   1.415e+006
First-order corrections to F and Theta ............   -0.0603    -1.7596
Second-order corrections to F and Theta ...........   -0.0596    -1.8163

   4   2.17725    10.4025  -4.834e+000   2.455e+003
First-order corrections to F and Theta ............   -0.0000    -0.0034
Second-order corrections to F and Theta ...........   -0.0000    -0.0034

   5   2.17722    10.3991   2.159e-008  -2.308e-007
First-order corrections to F and Theta ............   -0.0000     0.0000
```

```
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TABLE NO. 55
*********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
*********************************************************************

Summation of Horizontal Forces: 1.63352e-010

Summation of Vertical Forces: 1.37721e-010

Summation of Moments: 1.56904e-008

Mohr Coulomb Shear Force/Shear Strength Check Summation: 2.69868e-011
```

```
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TABLE NO. 58
*******************************************************************
* Final Results for Stresses Along the Shear Surface              *
* (Results are for the critical shear surface in the case of a search.) *
*******************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 2.177     Side Force Inclination:  10.40
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	105.00	64.50	74.7	74.7	13.1
2	116.80	62.73	457.4	457.4	80.1
3	130.40	58.20	1018.5	1018.5	178.4
4	142.84	54.05	1530.1	1530.1	265.4
5	154.11	50.30	1972.2	1972.2	304.9
6	165.39	46.54	2414.2	2414.2	344.3
7	176.66	42.78	2856.3	2856.3	383.8
8	186.68	39.44	3248.8	3248.8	418.8
9	195.43	36.52	3591.9	3591.9	449.5
10	201.25	34.58	3820.3	3820.3	469.8
11	209.90	34.17	3568.6	3568.6	447.4
12	224.31	34.31	3777.1	3777.1	466.0
13	238.71	34.46	3985.7	3985.7	484.6
14	253.12	34.60	4194.2	4194.2	503.2
15	267.52	34.74	4402.8	4402.8	521.8
16	281.93	34.88	4611.4	4611.4	540.5
17	296.34	35.03	4819.9	4819.9	559.1
18	310.74	35.17	5028.5	5028.5	577.7
19	325.15	35.31	5237.0	5237.0	596.3
20	339.55	35.45	5445.6	5445.6	614.9
21	353.96	35.60	5654.2	5654.2	633.5
22	368.36	35.74	5862.7	5862.7	652.2
23	382.77	35.88	6071.3	6071.3	670.8
24	397.17	36.02	6279.8	6279.8	689.4
25	404.69	36.38	4998.1	4998.1	575.0
26	409.51	40.75	4373.2	4373.2	1297.5
27	418.51	48.90	4112.4	4112.4	1228.3
28	427.51	57.05	3851.6	3851.6	1159.2
29	436.50	65.20	3590.8	3590.8	1090.0
30	446.38	74.15	3304.6	3304.6	1014.1
31	457.13	83.89	2993.0	2993.0	931.5
32	467.88	93.63	2681.4	2681.4	848.8
33	478.63	103.37	2369.8	2369.8	766.2
34	488.56	112.37	2041.5	2041.5	679.1
35	497.68	120.63	1696.5	1696.5	587.7
36	506.80	128.89	1351.5	1351.5	496.2
37	515.92	137.16	1006.5	1006.5	404.7
38	525.04	145.42	661.6	661.6	313.2

39	530.30	150.19	462.6	462.6	260.5
40	535.71	155.09	247.7	247.7	203.5

```
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tion D LTSS NC smooth peak.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, peak)
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TABLE NO. 59
*************************************************************************
* Final Results for Side Forces and Stresses Between Slices             *
* (Results are for the critical shear surface in the case of a search.) *
*************************************************************************

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------
```

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	110.00	57	65.42	0.278	-12.3	87.2
2	123.60	3273	64.05	0.380	95.2	587.3
3	137.20	10434	61.67	0.331	-9.8	1191.6
4	148.47	19323	59.76	0.317	-78.4	1665.9
5	159.75	30353	58.02	0.314	-110.6	2066.9
6	171.03	43525	56.30	0.314	-135.6	2443.6
7	182.30	58839	54.58	0.313	-160.0	2810.2
8	191.05	72199	53.24	0.313	-180.4	3092.1
9	199.80	86849	51.89	0.312	-201.4	3372.0
10	202.70	91989	51.44	0.312	-208.7	3464.8
11	217.11	98024	52.94	0.317	-163.3	3429.7
12	231.51	104302	54.38	0.320	-131.8	3415.0
13	245.92	110823	55.77	0.322	-110.9	3416.4
14	260.32	117586	57.12	0.323	-98.4	3430.9
15	274.73	124591	58.43	0.324	-92.5	3455.9
16	289.13	131839	59.71	0.324	-91.8	3489.5
17	303.54	139330	60.96	0.324	-95.2	3530.3
18	317.94	147062	62.17	0.324	-102.0	3577.1
19	332.35	155038	63.37	0.323	-111.5	3628.9
20	346.75	163256	64.54	0.322	-123.2	3685.0
21	361.16	171716	65.69	0.321	-136.7	3744.6
22	375.57	180419	66.83	0.320	-151.7	3807.4
23	389.97	189364	67.95	0.318	-167.9	3872.9
24	404.38	198552	69.05	0.317	-185.1	3940.7
25	405.01	195988	69.60	0.318	-172.7	3894.8
26	414.01	171613	75.46	0.314	-203.8	3659.9
27	423.01	148767	81.32	0.309	-234.2	3422.8
28	432.00	127449	87.17	0.303	-263.3	3182.8
29	441.00	107661	93.01	0.297	-290.6	2938.8
30	451.75	86020	99.98	0.287	-319.6	2640.1
31	462.50	66562	106.94	0.276	-341.5	2329.4
32	473.25	49286	113.93	0.262	-351.2	1999.6
33	484.00	34194	120.99	0.246	-338.7	1638.1
34	493.12	23340	127.07	0.240	-291.1	1335.6
35	502.24	14537	133.15	0.232	-240.6	1031.7
36	511.36	7784	139.24	0.219	-185.1	725.3
37	520.48	3080	145.36	0.198	-119.4	414.4
38	529.60	426	151.89	0.184	-29.5	95.4
39	531.00	200	154.22	0.295	-3.9	38.1
40	540.41	-0	159.35	Above	0.0	-0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

Cross-Section: D
Case: Long-Term Steady State – Noncircular Liner Smooth Residual
Filename: 20210719 Profile D LTSS – 2 Resi_input (textor).docx

UTEXAS4 Input File


```
GRAphics
HEAding follows -
Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

PROfile lines
   1 1 MSW
         100 64
         484 160
         531 162.35
         782 162.35

   2 2 CH
         0 64
         100 64
         110 64
         137.2 55

   3 3 Sandy CH - 1
         0 56.9
         137.2 55
         182.3  39.9

   4 3 Sandy CH - 2
         618.9 36.8
         782 37.6

   5 4 Clayey Sand - 1
         0 40.5
         182.3 39.9
         199.8 34.1
         202.7 33.1
         529.6 36.4
         618.9 36.8
         782 35.7

   6 5 Sandy CL
         441 31.9
         782 30.6

   7 4 Clayey Sand
         0 31.9
         441 31.9
         782 25.9

   9 6 Liner
         100 64
         110 66
         202.7 35.1
         782 39.6


MATerial properties
   1 MSW
      60 = unit weight
```

```
      Conventional Shear Strength
         300 30
      Piezometric Line
         1
   2 CH
      115 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   3 Sandy CH
      120 = unit weight
      Conventional Shear Strength
         450 19
      Piezometric Line
         1
   4 Sandy Lean Clay
      125 = unit weight
      Conventional Shear Strength
         675 23.7
      Piezometric Line
         1
   5 Clayey Sand
      130 = unit weight
      Conventional Shear Strength
         0 38
      Piezometric Line
         1
   6 Liner
      120 = unit weight
     Non Linear Mohr Coulomb Envelope
         0 0
         10000 1944

      Piezometric Line
         1

PIEzometric line
     1 Piezometric Line
         0 30
         782 30


LABel
Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
ANALYSIS/COMPUTATION
   Noncircular Search 2
     484 160
     425 36.3 0.573
     202.7 34.1 fixed
     110 65 fixed
     100 64 fixed

     5 1
   Crack
```

```
     7 D
   Short

COMpute
```

Victoria, TX Landfill

Cross-Section: D
Case: Long-Term Steady State State – Noncircular Liner Smooth Residual
Filename: 20210719 Profile D LTSS – 2 Resi_output (textor).docx

UTEXAS4 Output File


```
TABLE NO. 1
COMPUTER PROGRAM DESIGNATION: UTEXAS4
Originally Coded By Stephen G. Wright
Version No. 4.1.0.8 - Last Revision Date: 11/9/2009
(C) Copyright 1985-2008 S. G. Wright - All rights reserved
*****************************************************************
* RESULTS OF COMPUTATIONS PERFORMED USING THIS SOFTWARE         *
* SHOULD NOT BE USED FOR DESIGN PURPOSES UNLESS THEY HAVE       *
* BEEN VERIFIED BY INDEPENDENT ANALYSES, EXPERIMENTAL DATA      *
* OR FIELD EXPERIENCE. THE USER SHOULD UNDERSTAND THE ALGORITHMS *
* AND ANALYTICAL PROCEDURES USED IN THIS SOFTWARE AND MUST HAVE  *
* READ ALL DOCUMENTATION FOR THIS SOFTWARE BEFORE ATTEMPTING    *
* TO USE IT.  NEITHER SHINOAK SOFTWARE NOR STEPHEN G. WRIGHT    *
* MAKE OR ASSUME LIABILITY FOR ANY WARRANTIES, EXPRESSED OR     *
* IMPLIED, CONCERNING THE ACCURACY, RELIABILITY, USEFULNESS     *
* OR ADAPTABILITY OF THIS SOFTWARE.                             *
*****************************************************************
```

```
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Time and date of run: Mon Jul 19 10:45:52 2021
Name of input data file:
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tion D LTSS NC smooth residual.dat

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TABLE NO. 3
*************************
* NEW PROFILE LINE DATA *
*************************

-----------------------------------------------------------
----- Profile Line No. 1 - Material Type (Number): 1 -----
-----------------------------------------------------------
Description: MSW

Point        X           Y

   1      100.00       64.00
   2      484.00      160.00
   3      531.00      162.35
   4      782.00      162.35

-----------------------------------------------------------
----- Profile Line No. 2 - Material Type (Number): 2 -----
-----------------------------------------------------------
Description: CH

Point        X           Y

   1        0.00       64.00
   2      100.00       64.00
   3      110.00       64.00
   4      137.20       55.00

-----------------------------------------------------------
----- Profile Line No. 3 - Material Type (Number): 3 -----
-----------------------------------------------------------
Description: Sandy CH - 1

Point        X           Y

   1        0.00       56.90
   2      137.20       55.00
   3      182.30       39.90

-----------------------------------------------------------
----- Profile Line No. 4 - Material Type (Number): 3 -----
-----------------------------------------------------------
Description: Sandy CH - 2

Point        X           Y

   1      618.90       36.80
   2      782.00       37.60

-----------------------------------------------------------
----- Profile Line No. 5 - Material Type (Number): 4 -----
```

```
-----------------------------------------------------------
Description: Clayey Sand - 1

Point        X           Y

   1        0.00       40.50
   2      182.30       39.90
   3      199.80       34.10
   4      202.70       33.10
   5      529.60       36.40
   6      618.90       36.80
   7      782.00       35.70

-----------------------------------------------------------
----- Profile Line No. 6 - Material Type (Number): 5 -----
-----------------------------------------------------------
Description: Sandy CL

Point        X           Y

   1      441.00       31.90
   2      782.00       30.60

-----------------------------------------------------------
----- Profile Line No. 7 - Material Type (Number): 4 -----
-----------------------------------------------------------
Description: Clayey Sand

Point        X           Y

   1        0.00       31.90
   2      441.00       31.90
   3      782.00       25.90

-----------------------------------------------------------
----- Profile Line No. 9 - Material Type (Number): 6 -----
-----------------------------------------------------------
Description: Liner

Point        X           Y

   1      100.00       64.00
   2      110.00       66.00
   3      202.70       35.10
   4      782.00       39.60
```

```
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TABLE NO. 4
**********************************************************************
* NEW MATERIAL PROPERTY DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 1 -------------------
------------------------------------------------------------------
Description: MSW

Constant unit weight of soil (material): 60.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 300.0
Friction angle - - - - - 30.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 2 -------------------
------------------------------------------------------------------
Description: CH

Constant unit weight of soil (material): 115.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 3 -------------------
------------------------------------------------------------------
Description: Sandy CH

Constant unit weight of soil (material): 120.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 450.0
Friction angle - - - - - 19.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
------------------- DATA FOR MATERIAL NUMBER 4 -------------------
```

```
------------------------------------------------------------------
Description: Sandy Lean Clay

Constant unit weight of soil (material): 125.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 675.0
Friction angle - - - - - 23.70 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
-------------------- DATA FOR MATERIAL NUMBER 5 -------------------
------------------------------------------------------------------
Description: Clayey Sand

Constant unit weight of soil (material): 130.0

CONVENTIONAL (ISOTROPIC) SHEAR STRENGTHS
Cohesion - - - - - - - - 0.0
Friction angle - - - - - 38.00 (degrees)

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.

------------------------------------------------------------------
-------------------- DATA FOR MATERIAL NUMBER 6 -------------------
------------------------------------------------------------------
Description: Liner

Constant unit weight of soil (material): 120.0

---- NONLINEAR SHEAR STRENGTH ENVELOPE ----
     Point     Normal Stress     Shear Stress

       1                0.0              0.0
       2            10000.0           1944.0

Pore water pressures are defined by a piezometric line.
Piezometric line number: 1
Negative pore water pressures are NOT allowed - set to zero.
```

```
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TABLE NO. 6
**********************************************************************
* NEW PIEZOMETRIC LINE DATA - CONVENTIONAL/FIRST-STAGE COMPUTATIONS *
**********************************************************************

----------------------------------------------------------
--------------- Piezometric Line Number 1 ---------------
----------------------------------------------------------
Description: Piezometric Line
Unit weight of fluid (water): 62.4

Point        X           Y

  1        0.00       30.00
  2      782.00       30.00
```

```
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TABLE NO. 16
*********************************
* NEW ANALYSIS/COMPUTATION DATA *
*********************************

Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1         484.00         160.00   angle to be computed - moveable
   2         425.00          36.30      0.57              - moveable
   3         202.70          34.10                        - fixed
   4         110.00          65.00                        - fixed
   5         100.00          64.00                        - fixed

Initial distance for shifting points on shear surface = 5.000
Final distance for shifting points on shear surface = 1.000
Maximum steepness permitted for toe of shear surface = 50.00


Depth of crack: 7.000
Automatic search output will be in short form.

--------------------------------------------------------------------------------
The following represent default values or values that were prevously defined:
Maximum increment for slice subdivision: 30
There is no water in a crack.
Conventional (single-stage) computations will be performed.
Seismic coefficient: 0.000
Unit weight of water (or other fluid) in crack: 62.4
Maximum number of passes for noncircular search: 50
No restrictions exist on the lateral extent of the search.
No shear surfaces other than the most critical will be saved for display later.
Neither slope face was explicitly designated for analysis.
Standard sign convention used for direction of shear stress on shear surface.
Procedure of Analysis: Spencer

Iteration limit: 100
Force imbalance: 1.000000e-005 (fraction of total weight)
Moment imbalance: 1.000000e-005 (fraction of moment due to total weight)
Minimum weight required for computations to be performed: 100
Initial trial factor of safety: 3.000
Initial trial side force inclination: 17.189 (degrees)
Minimum (most negative) side force inclination allowed in Spencer's procedure: -10.00
```

```
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TABLE NO. 26
*************************************
* NEW, COMPUTED SLOPE GEOMETRY DATA *
*************************************

These slope geometry were generated from the Profile Lines.

     Point       X           Y

        1       0.00       64.00
        2     100.00       64.00
        3     110.00       66.50
        4     137.20       73.30
        5     182.30       84.58
        6     199.80       88.95
        7     202.70       89.67
        8     441.00      149.25
        9     484.00      160.00
       10     529.60      162.28
       11     531.00      162.35
       12     618.90      162.35
       13     782.00      162.35

********** ERROR(S) OR WARNING(S) IN ANALYSIS/COMPUTATION DATA **********
UTEXAS WARNING NUMBER 7330
The following points are out of order for noncircular shear surface
Point: 1, X: 484.00, Y: 160.00
Point: 2, X: 425.00, Y: 36.30
Points were successfully reversed.

Right end point on noncircular shear surface adjusted to:
X: 480.21, Y: 152.05
Adjustment was made to put end point at bottom of crack.

Noncircular Shear Surface Points After Reversal of Order and End Point Adjustment
Coordinates of points on shear surface which are to be shifted

Point         X              Y      Shift Angle

   1         100.00          64.00                        - fixed
   2         110.00          65.00                        - fixed
   3         202.70          34.10                        - fixed
   4         425.00          36.30      0.57              - moveable
   5         480.21         152.05   angle to be computed - moveable
Computed crack depth: 7.00
```

```
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TABLE NO. 40
*******************************************************************
* Short-Form Output Table for Search with Noncircular Shear Surfaces *
*******************************************************************

  Shift    Factor of
Distance    Safety       Point       X          Y       Point       X          Y
   5.000     2.201         1     100.00      64.00        4     425.00      36.30
                           2     110.00      65.00        5     480.21     152.05
                           3     202.70      34.10
End of Trial: 1
   5.000     2.085         1     100.00      64.00        4     420.00      36.25
                           2     110.00      65.00        5     485.11     153.06
                           3     202.70      34.10
End of Trial: 2
   5.000     2.002         1     100.00      64.00        4     415.00      36.20
                           2     110.00      65.00        5     490.10     153.31
                           3     202.70      34.10
End of Trial: 3
   5.000     1.947         1     100.00      64.00        4     410.00      36.15
                           2     110.00      65.00        5     495.10     153.55
                           3     202.70      34.10
End of Trial: 4
   5.000     1.912         1     100.00      64.00        4     405.00      36.10
                           2     110.00      65.00        5     500.09     153.80
                           3     202.70      34.10
End of Trial: 5
   5.000     1.891         1     100.00      64.00        4     400.00      36.05
                           2     110.00      65.00        5     505.08     154.05
                           3     202.70      34.10
End of Trial: 6
   5.000     1.882         1     100.00      64.00        4     395.00      36.00
                           2     110.00      65.00        5     510.08     154.30
                           3     202.70      34.10
End of Trial: 7
   5.000     1.879         1     100.00      64.00        4     395.00      36.00
                           2     110.00      65.00        5     515.07     154.55
                           3     202.70      34.10
End of Trial: 8
   5.000     1.877         1     100.00      64.00        4     400.00      36.05
                           2     110.00      65.00        5     520.06     154.80
                           3     202.70      34.10
End of Trial: 9
   2.500     1.877         1     100.00      64.00        4     400.00      36.05
                           2     110.00      65.00        5     520.06     154.80
                           3     202.70      34.10
End of Trial: 10
   2.500     1.876         1     100.00      64.00        4     402.50      36.07
                           2     110.00      65.00        5     522.56     154.93
                           3     202.70      34.10
End of Trial: 11
   2.500     1.875         1     100.00      64.00        4     405.00      36.10
```

```
                              2     110.00      65.00          5     525.06     155.05
                              3     202.70      34.10
End of Trial: 12
   2.500     1.875            1     100.00      64.00          4     407.50      36.12
                              2     110.00      65.00          5     525.06     155.05
                              3     202.70      34.10
End of Trial: 13
   2.500     1.875            1     100.00      64.00          4     407.50      36.12
                              2     110.00      65.00          5     527.55     155.18
                              3     202.70      34.10
End of Trial: 14
   1.250     1.875            1     100.00      64.00          4     407.50      36.12
                              2     110.00      65.00          5     527.55     155.18
                              3     202.70      34.10
End of Trial: 15
   0.625     1.875            1     100.00      64.00          4     407.50      36.12
                              2     110.00      65.00          5     527.55     155.18
                              3     202.70      34.10
End of Trial: 16
```

```
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TABLE NO. 41
****************************************
*  Critical Noncircular Shear Surface  *
****************************************

***** CRITICAL NONCIRCULAR SHEAR SURFACE *****
X:     100.00     Y:      64.00
X:     110.00     Y:      65.00
X:     202.70     Y:      34.10
X:     408.13     Y:      36.13
X:     527.55     Y:     155.18

Minimum factor of safety: 1.875
Side force inclination: 10.50

Time required to find most critical surface:      0.0 seconds
Number of passes required to find most critical surface: 16
Total number of shear surfaces attempted: 80
Total number of shear surfaces for which the factor of safety
was successfully calculated: 80
```

Pass	Shift Distance	Pt.	Max. Dist. Moved	Minimum F	n Tried	n Computed
1	5.0000	4	5.000	2.0852	5	5
2	5.0000	4	5.000	2.0025	10	10
3	5.0000	4	5.000	1.9473	15	15
4	5.0000	4	5.000	1.9119	20	20
5	5.0000	4	5.000	1.8913	25	25
6	5.0000	4	5.000	1.8819	30	30
7	5.0000	5	5.000	1.8790	35	35
8	5.0000	5	5.000	1.8766	40	40
9	5.0000	0	0.000	1.8766	45	45
10	2.5000	4	2.500	1.8758	50	50
11	2.5000	4	2.500	1.8752	55	55
12	2.5000	4	2.500	1.8752	60	60
13	2.5000	5	2.500	1.8749	65	65
14	2.5000	0	0.000	1.8749	70	70
15	1.2500	0	0.000	1.8749	75	75
16	0.6250	4	0.625	1.8749	80	80

```
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tion D LTSS NC smooth residual.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 43
************************************************************
* Coordinate, Weight, Strength and Pore Water Pressure     *
* Information for Individual Slices for Conventional       *
* Computations or First Stage of Multi-Stage Computations. *
* (Information is for the critical shear surface in the    *
* case of an automatic search.)                            *
************************************************************

Slice                         Slice   Matl.            Friction     Pore
  No.       X          Y       Weight   No.   Cohesion    Angle    Pressure
        100.00      64.00
   1    105.00      64.50         750    6   NONLINEAR ENVELOPE        0.0
        110.00      65.00
   2    116.80      62.73        5277    6   NONLINEAR ENVELOPE        0.0
        123.60      60.47
   3    130.40      58.20       11750    6   NONLINEAR ENVELOPE        0.0
        137.20      55.93
   4    142.84      54.05       14650    6   NONLINEAR ENVELOPE        0.0
        148.47      52.17
   5    154.11      50.30       19099    6   NONLINEAR ENVELOPE        0.0
        159.75      48.42
   6    165.39      46.54       23549    6   NONLINEAR ENVELOPE        0.0
        171.03      44.66
   7    176.66      42.78       27998    6   NONLINEAR ENVELOPE        0.0
        182.30      40.90
   8    186.68      39.44       24794    6   NONLINEAR ENVELOPE        0.0
        191.05      37.98
   9    195.43      36.52       27474    6   NONLINEAR ENVELOPE        0.0
        199.80      35.07
  10    201.25      34.58        9697    6   NONLINEAR ENVELOPE        0.0
        202.70      34.10
  11    209.55      34.17       47827    6   NONLINEAR ENVELOPE        0.0
        216.40      34.24
  12    223.24      34.30       50505    6   NONLINEAR ENVELOPE        0.0
        230.09      34.37
  13    236.94      34.44       53183    6   NONLINEAR ENVELOPE        0.0
        243.79      34.51
  14    250.63      34.57       55862    6   NONLINEAR ENVELOPE        0.0
        257.48      34.64
  15    264.33      34.71       58540    6   NONLINEAR ENVELOPE        0.0
        271.18      34.78
  16    278.02      34.84       61218    6   NONLINEAR ENVELOPE        0.0
        284.87      34.91
  17    291.72      34.98       63896    6   NONLINEAR ENVELOPE        0.0
        298.57      35.05
  18    305.41      35.12       66574    6   NONLINEAR ENVELOPE        0.0
        312.26      35.18
  19    319.11      35.25       69252    6   NONLINEAR ENVELOPE        0.0
        325.96      35.32
  20    332.80      35.39       71931    6   NONLINEAR ENVELOPE        0.0
        339.65      35.45
```

21	346.50	35.52	74609	6	NONLINEAR ENVELOPE		0.0
	353.35	35.59					
22	360.19	35.66	77287	6	NONLINEAR ENVELOPE		0.0
	367.04	35.72					
23	373.89	35.79	79965	6	NONLINEAR ENVELOPE		0.0
	380.74	35.86					
24	387.58	35.93	82643	6	NONLINEAR ENVELOPE		0.0
	394.43	36.00					
25	401.28	36.06	85322	6	NONLINEAR ENVELOPE		0.0
	408.13	36.13					
26	408.41	36.42	3595	6	NONLINEAR ENVELOPE		0.0
	408.70	36.70					
27	412.73	40.73	49162	1	300.0	30.00	0.0
	416.77	44.75					
28	420.81	48.78	46239	1	300.0	30.00	0.0
	424.85	52.80					
29	428.89	56.83	43317	1	300.0	30.00	0.0
	432.92	60.85					
30	436.96	64.88	40395	1	300.0	30.00	0.0
	441.00	68.90					
31	445.30	73.19	39804	1	300.0	30.00	0.0
	449.60	77.47					
32	453.90	81.76	36490	1	300.0	30.00	0.0
	458.20	86.05					
33	462.50	90.33	33176	1	300.0	30.00	0.0
	466.80	94.62					
34	471.10	98.90	29862	1	300.0	30.00	0.0
	475.40	103.19					
35	479.70	107.48	26548	1	300.0	30.00	0.0
	484.00	111.76					
36	488.36	116.10	23056	1	300.0	30.00	0.0
	492.71	120.45					
37	497.07	124.79	18746	1	300.0	30.00	0.0
	501.42	129.13					
38	505.78	133.47	14435	1	300.0	30.00	0.0
	510.13	137.81					
39	514.49	142.15	10124	1	300.0	30.00	0.0
	518.84	146.49					
40	523.20	150.84	5814	1	300.0	30.00	0.0
	527.55	155.18					

No water in crack.

```
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tion D LTSS NC smooth residual.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 44
*********************************************************
* Seismic Forces and Forces Due to Distributed Loads for *
* Individual Slices for Conventional Computations or the *
* First Stage of Multi-Stage Computations.              *
* (Information is for the critical shear surface in the  *
* case of an automatic search.)                          *
*********************************************************

There are no seismic forces or forces due to distributed loads
for the current shear surface
```

```
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tion D LTSS NC smooth residual.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Trial No. 1 with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  16
Allowable moment imbalance for convergence: 5333

        Trial     Trial
       Factor   Side Force     Force       Moment                 Delta
Iter-    of     Inclination  Imbalance   Imbalance    Delta-F     Theta
ation  Safety    (degrees)     (lbs.)     (ft.-lbs.)             (degrees)

   1   3.00000    17.1887   9.080e+004   9.315e+006
First-order corrections to F and Theta ............   -1.6404    -3.5066
Reduced values - Deltas were too large ............   -0.5000    -1.0688

   2   2.50000    16.1199   5.719e+004   6.401e+006
First-order corrections to F and Theta ............   -0.7661    -3.5476
Reduced values - Deltas were too large ............   -0.5000    -2.3154

   3   2.00000    13.8045   9.416e+003   2.486e+006
First-order corrections to F and Theta ............   -0.1280    -2.9716
Reduced values - Deltas were too large ............   -0.1234    -2.8648

   4   1.87663    10.9397  -8.199e+002   2.764e+005
First-order corrections to F and Theta ............   -0.0018    -0.4387
Second-order corrections to F and Theta ...........   -0.0017    -0.4360

   5   1.87492    10.5037   5.605e-002  -2.447e+000
First-order corrections to F and Theta ............   -0.0000     0.0000

After trial 1 the following changes were computed for the nonlinear
strength envelopes:
     Maximum change in shear strength:      0.000 (percent)
     Maximum change occurred for slice 25
     Normal stress where max. change occurred:      6333.76
     Old strength at this slice:      1231.28
     New strength at this slice:      1231.28
Strengths from nonlinear envelope have converged.
Final computations will be performed next.
```

```
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Name of input data file:
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tion D LTSS NC smooth residual.dat

Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 47
**************************************************************
*  Information for the Iterative Solution for the Factor of  *
*  Safety and Side Force Inclination by Spencer's Procedure  *
**************************************************************

Final Trial with Nonlinear Strength Envelope
Allowable force imbalance for convergence:  16
Allowable moment imbalance for convergence: 5333

        Trial     Trial
       Factor  Side Force     Force      Moment                 Delta
Iter-    of    Inclination  Imbalance   Imbalance    Delta-F     Theta
ation  Safety   (degrees)     (lbs.)    (ft.-lbs.)              (degrees)

   1   3.00000    17.1887   9.080e+004   9.315e+006
First-order corrections to F and Theta ............   -1.6404    -3.5066
Reduced values - Deltas were too large ............   -0.5000    -1.0688

   2   2.50000    16.1199   5.719e+004   6.401e+006
First-order corrections to F and Theta ............   -0.7661    -3.5476
Reduced values - Deltas were too large ............   -0.5000    -2.3154

   3   2.00000    13.8045   9.416e+003   2.486e+006
First-order corrections to F and Theta ............   -0.1280    -2.9716
Reduced values - Deltas were too large ............   -0.1234    -2.8648

   4   1.87663    10.9397  -8.199e+002   2.764e+005
First-order corrections to F and Theta ............   -0.0018    -0.4387
Second-order corrections to F and Theta ...........   -0.0017    -0.4360

   5   1.87492    10.5037   5.605e-002  -2.447e+000
First-order corrections to F and Theta ............   -0.0000     0.0000
```

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 55
**********************************************************************
* Check of Computations by Spencer's Procedure (Results are for the *
* critical shear surface in the case of an automatic search.)       *
**********************************************************************

Summation of Horizontal Forces: 1.25281e-010

Summation of Vertical Forces: 1.47066e-010

Summation of Moments: 1.63616e-006

Mohr Coulomb Shear Force/Shear Strength Check Summation: 4.00161e-011
```

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 58
*******************************************************************
* Final Results for Stresses Along the Shear Surface              *
* (Results are for the critical shear surface in the case of a search.) *
*******************************************************************

SPENCER'S PROCEDURE USED TO COMPUTE THE FACTOR OF SAFETY
Factor of Safety: 1.875     Side Force Inclination:  10.50
```

-------- VALUES AT CENTER OF BASE OF SLICE --------

Slice No.	X-Center	Y-Center	Total Normal Stress	Effective Normal Stress	Shear Stress
1	105.00	64.50	74.3	74.3	7.7
2	116.80	62.73	438.7	438.7	45.5
3	130.40	58.20	976.9	976.9	101.3
4	142.84	54.05	1469.1	1469.1	152.3
5	154.11	50.30	1915.3	1915.3	198.6
6	165.39	46.54	2361.5	2361.5	244.9
7	176.66	42.78	2807.7	2807.7	291.1
8	186.68	39.44	3204.0	3204.0	332.2
9	195.43	36.52	3550.2	3550.2	368.1
10	201.25	34.58	3780.8	3780.8	392.0
11	209.55	34.17	3550.4	3550.4	368.1
12	223.24	34.30	3749.2	3749.2	388.7
13	236.94	34.44	3948.0	3948.0	409.3
14	250.63	34.57	4146.8	4146.8	430.0
15	264.33	34.71	4345.6	4345.6	450.6
16	278.02	34.84	4544.4	4544.4	471.2
17	291.72	34.98	4743.3	4743.3	491.8
18	305.41	35.12	4942.1	4942.1	512.4
19	319.11	35.25	5140.9	5140.9	533.0
20	332.80	35.39	5339.7	5339.7	553.6
21	346.50	35.52	5538.5	5538.5	574.3
22	360.19	35.66	5737.3	5737.3	594.9
23	373.89	35.79	5936.1	5936.1	615.5
24	387.58	35.93	6134.9	6134.9	636.1
25	401.28	36.06	6333.8	6333.8	656.7
26	408.41	36.42	4963.3	4963.3	514.6
27	412.73	40.73	4152.7	4152.7	1438.7
28	420.81	48.78	3900.4	3900.4	1361.1
29	428.89	56.83	3648.2	3648.2	1283.4
30	436.96	64.88	3396.0	3396.0	1205.7
31	445.30	73.19	3135.6	3135.6	1125.6
32	453.90	81.76	2867.0	2867.0	1042.8
33	462.50	90.33	2598.4	2598.4	960.1
34	471.10	98.90	2329.8	2329.8	877.4
35	479.70	107.48	2061.2	2061.2	794.7
36	488.36	116.10	1754.4	1754.4	700.2
37	497.07	124.79	1409.5	1409.5	594.0
38	505.78	133.47	1064.6	1064.6	487.8

39	514.49	142.15	719.6	719.6	381.6
40	523.20	150.84	374.7	374.7	275.4

```
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Victoria, TX Landfill Evaluation - Section D LTSS Noncircular (smooth, res)
#107608

TABLE NO. 59
*******************************************************************
* Final Results for Side Forces and Stresses Between Slices       *
* (Results are for the critical shear surface in the case of a search.) *
*******************************************************************

       --------------- VALUES AT RIGHT SIDE OF SLICE ---------------
```

Slice No.	X-Right	Side Force	Y-Coord. of Side Force Location	Fraction of Height	Sigma at Top	Sigma at Bottom
1	110.00	3	65.43	0.285	-0.5	4.2
2	123.60	2655	64.00	0.374	68.1	485.3
3	137.20	8560	61.65	0.329	-12.1	981.4
4	148.47	15922	59.74	0.316	-67.4	1375.1
5	159.75	25521	57.89	0.310	-113.4	1757.8
6	171.03	37355	56.05	0.307	-155.8	2135.9
7	182.30	51425	54.22	0.305	-196.2	2511.7
8	191.05	63886	52.81	0.304	-227.7	2803.2
9	199.80	77693	51.39	0.303	-258.5	3093.9
10	202.70	82566	50.92	0.303	-268.9	3190.4
11	216.40	87205	52.50	0.310	-201.3	3114.6
12	230.09	92103	54.00	0.316	-152.4	3066.5
13	243.79	97261	55.44	0.320	-118.0	3040.7
14	257.48	102678	56.81	0.323	-95.0	3032.9
15	271.18	108355	58.12	0.324	-81.1	3039.8
16	284.87	114293	59.39	0.325	-74.4	3059.0
17	298.57	120489	60.61	0.325	-73.5	3088.2
18	312.26	126946	61.79	0.325	-77.3	3126.1
19	325.96	133662	62.93	0.324	-85.0	3171.1
20	339.65	140638	64.04	0.323	-95.7	3222.2
21	353.35	147874	65.12	0.322	-109.1	3278.6
22	367.04	155369	66.18	0.320	-124.6	3339.5
23	380.74	163125	67.21	0.319	-141.8	3404.4
24	394.43	171139	68.22	0.317	-160.5	3472.6
25	408.13	179414	69.22	0.315	-180.5	3543.8
26	408.70	176841	69.81	0.317	-164.3	3492.9
27	416.77	154659	75.58	0.313	-186.7	3276.2
28	424.85	133905	81.35	0.309	-208.6	3058.0
29	432.92	114578	87.11	0.304	-229.5	2837.9
30	441.00	96678	92.86	0.298	-249.2	2615.3
31	449.60	79185	98.98	0.291	-268.0	2374.3
32	458.20	63310	105.09	0.282	-283.1	2127.4
33	466.80	49054	111.21	0.272	-292.4	1871.7
34	475.40	36416	117.35	0.259	-292.0	1602.1
35	484.00	25397	123.57	0.245	-274.8	1310.1
36	492.71	16107	129.96	0.238	-226.5	1018.6
37	501.42	8923	136.40	0.229	-173.1	725.9
38	510.13	3844	142.94	0.218	-110.9	432.6
39	518.84	869	150.03	0.232	-34.2	146.3
40	527.55	0	155.18	Below	-0.0	0.0

```
Read end-of-file on input while looking for another command word.
End of input data assumed - normal termination.
```

U.S. Geological Survey - Earthquake Hazards Program

Unified Hazard Tool

Please do not use this tool to obtain ground motion parameter values for the design code reference documents covered by the U.S. Seismic Design Maps web tools (e.g., the International Building Code and the ASCE 7 or 41 Standard). The values returned by the two applications are not identical.

Input

Edition

Dynamic: Conterminous U.S. 2014 (v…

Latitude

Decimal degrees

28.806

Longitude

Decimal degrees, negative values for western longitudes

-97.004

Site Class

760 m/s (B/C boundary)

Spectral Period

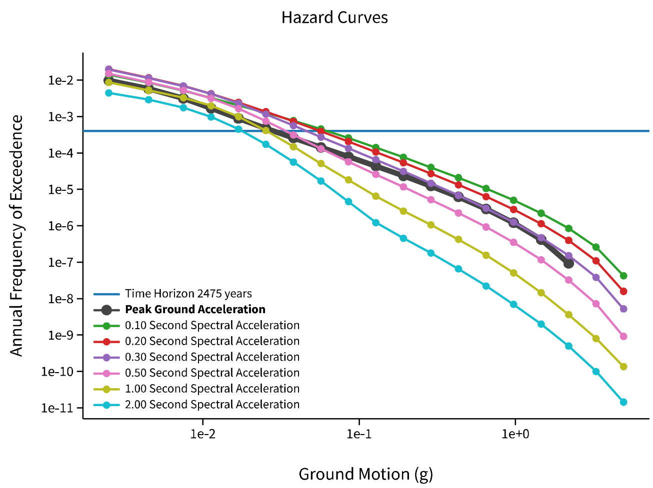
Peak Ground Acceleration

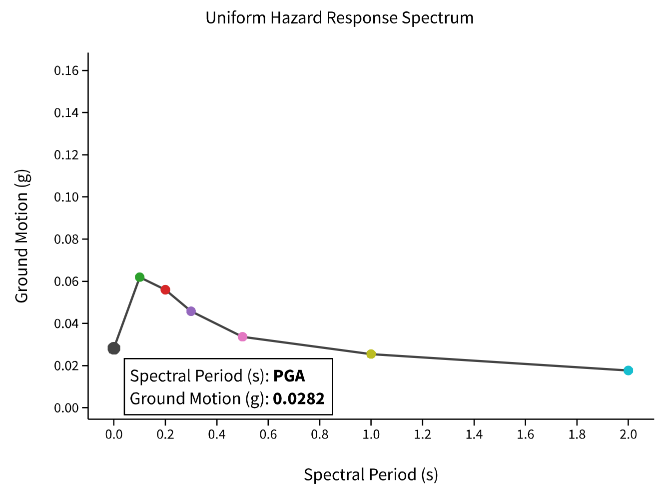
Time Horizon

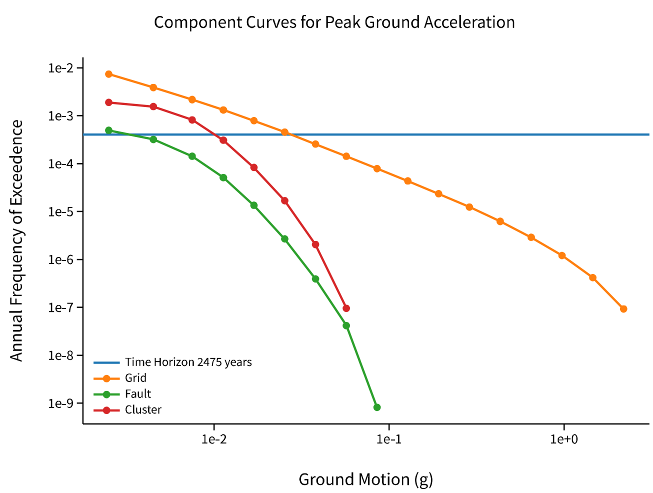
Return period in years

2475

Hazard Curve





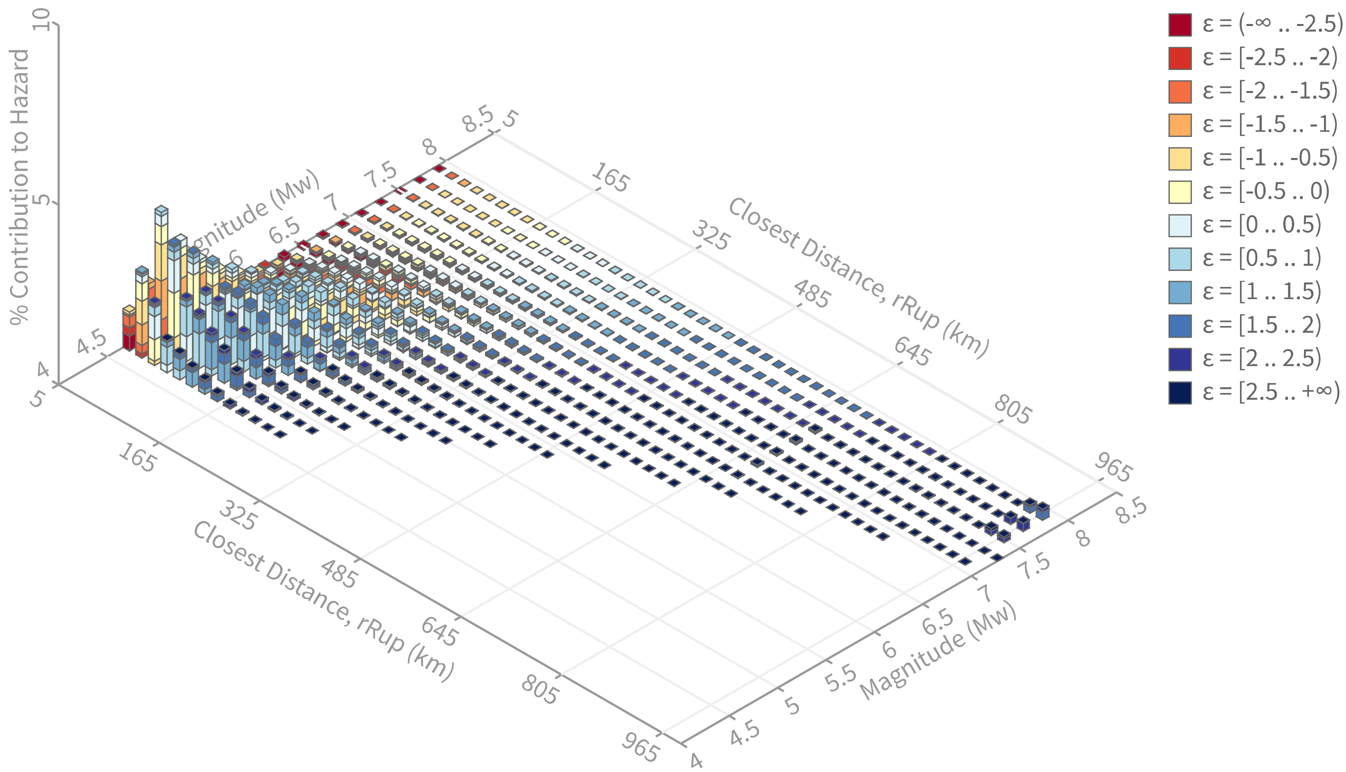


View Raw Data

Deaggregation

Component

Total



Summary statistics for, Deaggregation: Total

Deaggregation targets

Return period: 2475 yrs
Exceedance rate: 0.0004040404 yr^{-1}
PGA ground motion: 0.028234025 g

Recovered targets

Return period: 2486.9402 yrs
Exceedance rate: 0.00040210054 yr^{-1}

Totals

Binned: 98.91 %
Residual: 1.09 %
Trace: 2.7 %

Mean (over all sources)

m: 5.6
r: 118.54 km
ε_0: -0.13 σ

Mode (largest m-r bin)

m: 4.9
r: 30.4 km
ε_0: -0.94 σ
Contribution: 3.74 %

Mode (largest m-r-ε_0 bin)

m: 4.9
r: 49.54 km
ε_0: -0.22 σ
Contribution: 1.24 %

Discretization

r: min = 0.0, max = 1000.0, Δ = 20.0 km
m: min = 4.4, max = 9.4, Δ = 0.2
ε: min = -3.0, max = 3.0, Δ = 0.5 σ

Epsilon keys

ε0: [-∞ .. -2.5)
ε1: [-2.5 .. -2.0)
ε2: [-2.0 .. -1.5)
ε3: [-1.5 .. -1.0)
ε4: [-1.0 .. -0.5)
ε5: [-0.5 .. 0.0)
ε6: [0.0 .. 0.5)
ε7: [0.5 .. 1.0)
ε8: [1.0 .. 1.5)
ε9: [1.5 .. 2.0)
ε10: [2.0 .. 2.5)
ε11: [2.5 .. +∞]

Deaggregation Contributors

Source Set ↳ Source	Type	r	m	ε0	lon	lat	az	%
USGS Fixed Smoothing Zone 2 (opt)	Grid							25.75
PointSourceFinite: -97.004, 29.143		37.51	5.22	-0.95	97.004°W	29.143°N	0.00	1.12
PointSourceFinite: -97.004, 29.323		57.17	5.33	-0.32	97.004°W	29.323°N	0.00	1.08
PointSourceFinite: -97.004, 29.008		22.83	5.15	-1.84	97.004°W	29.008°N	0.00	1.07
SSCn Fixed Smoothing Zone 2 (opt)	Grid							25.72
PointSourceFinite: -97.004, 29.143		37.51	5.22	-0.95	97.004°W	29.143°N	0.00	1.12
PointSourceFinite: -97.004, 29.323		57.17	5.33	-0.32	97.004°W	29.323°N	0.00	1.08
PointSourceFinite: -97.004, 29.008		22.83	5.15	-1.84	97.004°W	29.008°N	0.00	1.07
USGS Adaptive Smoothing Zone 2 (opt)	Grid							20.40
SSCn Adaptive Smoothing Zone 2 (opt)	Grid							20.37
SSCn New Madrid	Cluster							1.38
SSCn Adaptive Smoothing Zone 1 (opt)	Grid							1.01

Landfill Liner Interface Strengths from Torsional-Ring-Shear Tests

By Timothy D. Stark[1] and Alan R. Poeppel[2]

Abstract: A torsional-ring-shear apparatus and test procedure are described for measuring soil/geosynthetic and geosynthetic/geosynthetic interface strengths. Typical interface strengths are presented for a double-composite liner system and the relevancy of ring-shear strengths is illustrated using the slope failure at the Kettleman Hills Waste Repository, Kettleman City, Calif. The results of undrained ring-shear tests show that for a clay/geomembrane interface: (1) Interface strength depends on plasticity and compaction water content of the clay, and the applied normal stress; (2) interface strengths measured with the torsional-ring-shear apparatus are in excellent agreement with back-calculated field strengths; and (3) peak and residual interface failure envelopes are nonlinear, and the nonlinearity should be modeled in stability analyses instead of as a combination of cohesion and friction angle. Design recommendations for interface strengths and stability analyses are also presented.

INTRODUCTION

Hazardous-waste landfills and new municipal solid-waste landfills in this country are required to have a low-hydraulic-conductivity liner and a drainage system consisting of compacted clay and geosynthetic materials. The stability of these systems is controlled by the shear strength of each component and the various component interfaces. The importance of interface strengths was illustrated by the slope-stability failure in Phase IA of Landfill B-19 at the Kettleman Hills Class I hazardous-waste treatment-and-storage facility in Kettleman City, Calif. The landfill area is an oval-shaped bowl carved into an existing valley to a depth of approximately 30 m and covering an area of 120,000 m^2. A slope-stability failure occurred during filling on 19 March 1988 that resulted in 11 m lateral displacements of the waste fill and 4.3 m vertical settlements. Byrne et al. (1992) concluded that sliding primarily occurred along the 1.1-m-thick secondary clay liner/secondary high-density polyethylene (HDPE) geomembrane interface in the double-composite liner system (Fig. 1). As a result, the majority of the ring-shear tests described here focus on the secondary clay liner/secondary HDPE geomembrane (SC/SG) interface. This paper reviews current interface test procedures, describes the torsional-ring-shear apparatus and test procedure used to measure interface strengths of various soil/geosynthetic and geosynthetic/geosynthetic interfaces, presents some typical ring-shear test results, and illustrates the relevancy of ring-shear interface-strengths using the Kettleman Hills case history.

REVIEW OF DIRECT-SHEAR INTERFACE TESTS

Direct-shear and pullout tests have been widely used to measure liner interface strengths (Martin et al. 1984; Saxena and Wong 1984; Koerner

[1]Asst. Prof. of Civ. Engrg., MC-250, Univ. of Illinois, 205 N. Mathews Ave., Urbana, IL 61801-2352.

[2]Proj. Engr., Langan Engrg. Assoc., Inc., New York, NY 10001.

Note. Discussion open until August 1, 1994. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on October 27, 1992. This paper is part of the ***Journal of Geotechnical Engineering***, Vol. 120, No. 3, March, 1994. ©ASCE, ISSN 0733-9410/94/0003-0597/$2.00 + $.25 per page. Paper No. 4992.

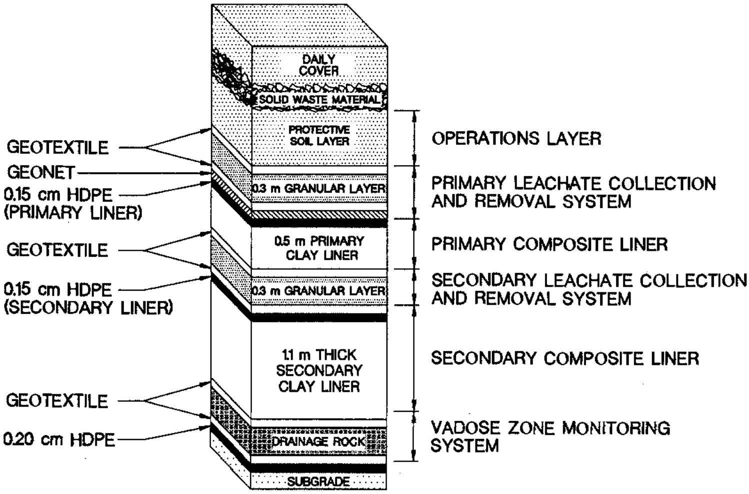


FIG. 1. Composite Double-Liner System at Base of Landfill (from Mitchell et al. 1990)

et al. 1986; Williams and Houlihan 1986; Seed et al. 1988; Giroud and Beech 1989; O'Rourke et al. 1990; Bove 1990; Seed and Boulanger 1991; Takasumi et al. 1991). Conventional direct-shear specimens range in size from 7 cm × 7 cm to 10 cm × 10 cm. Therefore, the specimen is subjected to only 0.6–0.8 cm of continuous displacement. Since the peak interface-strength is usually mobilized at a shear displacement of less than 0.5 cm, conventional direct-shear tests provide a good estimate of the peak strength. However, a shear displacement of 40–60 cm is typically required to mobilize a residual interface-strength in the ring-shear tests described here. To achieve these large displacements, the shear box must be reversed a number of times. These reversals do not apply continuous displacement in one direction, and thus do not simulate field shearing conditions that lead to a residual strength-condition.

In an effort to increase the magnitude of continuous-shear displacement, larger direct-shear boxes have been developed. These large-scale shear boxes range in size from 30 cm × 30 cm to 28 cm × 43 cm. ASTM Test Standard D5321 ("Determining" 1992) requires a shear box with a minimum dimension of 30 cm to be used to measure the coefficient of soil/geosynthetic or geosynthetic/geosynthetic friction. In this test, a geosynthetic is secured with glue to a horizontal substrate (e.g., plywood) and the shear box containing soil or a geosynthetic is moved along the substrate for a displacement of 2.5–7.5 cm. As a result, virgin geosynthetic material is sheared along the bottom substrate instead of being sheared along the same interface. Other disadvantages of 30 cm × 30 cm direct-shear boxes include the lack of vertical displacement information during consolidation or shear; the cost of the apparatus; and the need to secure large geosynthetics, compact large soil-specimens, and apply large normal forces.

Fig. 2 presents typical shear stress-displacement relationships from large-scale (30 cm × 30 cm) direct-shear tests on the SC/SG interface from landfill B-19 at Kettleman Hills (Byrne et al. 1992; "Draft" 1991). The water content of the clay specimens ranged from 30.0% to 30.6%. The tests were stopped

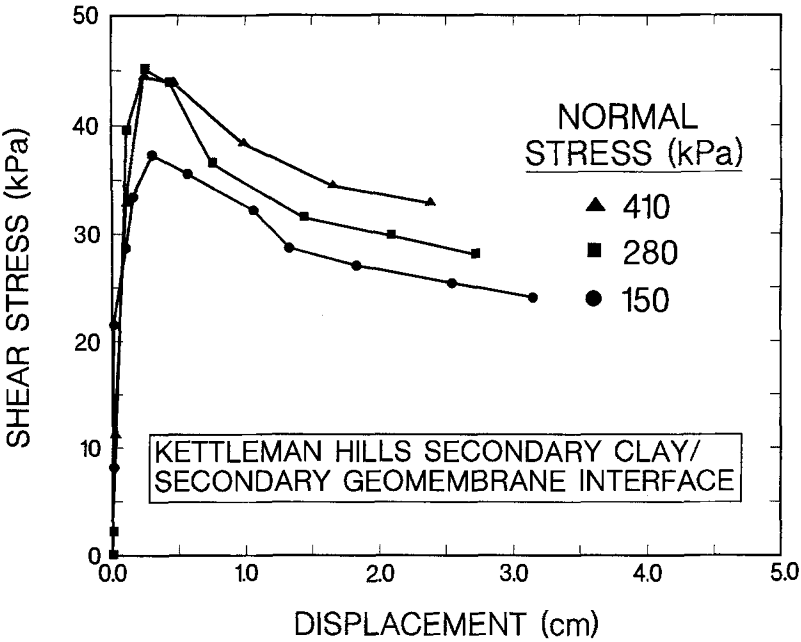


FIG. 2. Large-Scale Direct-Shear Tests Results for Secondary Clay/Secondary Geomembrane Interface (after Byrne et al. 1992)

at a shear displacement of approximately 2.5–3.0 cm, even though the shear-stress/horizontal-displacement relationships had not reached a minimum or residual strength condition. Therefore, large-scale direct-shear boxes appear applicable to the measurement of the peak interface strength, however, the limited shear displacement restricts their use in measuring the residual interface-strength.

Due to the limitations of current direct-shear testing, the suitability of a torsional-ring-shear apparatus to measure peak and residual interface-strengths was investigated. Negussey et al. (1989) also used a torsional-ring-shear apparatus to measure the strength of sand/geomembrane and nonwoven geotextile/HDPE geomembrane interfaces.

TORSIONAL-RING-SHEAR APPARATUS

The main advantage of the torsional-ring-shear apparatus is that unlimited continuous-shear displacement can be applied in one direction to achieve a residual strength condition. Other advantages of the ring-shear apparatus include continuous-shear displacement along the same interface, a constant cross-sectional area during shear, minimal laboratory supervision (because there is no reversal of the shear box), applicability of data acquisition techniques, and a smaller specimen, which allows greater control of compaction conditions and the securing of the geosynthetics. However, the small specimen size is also a disadvantage for materials that are significantly anisotropic. Larger ring-shear specimen containers are being developed to investigate scale effects of some interfaces.

The Bromhead ring-shear apparatus is based on the original design de-

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veloped by Bromhead (1979) and manufactured by Wykeham-Farrance Ltd., Slough, England. The ring-shear specimen is annular with an inside diameter of 7 cm and an outside diameter of 10 cm. In the original apparatus, drainage is provided by two knurled, bronze, porous stones screwed to the bottom of the specimen container and to the top loading platen. The specimen is confined radially by the 0.5-cm-deep specimen container.

The Bromhead ring-shear apparatus was modified to facilitate testing of soil/geosynthetic and geosynthetic/geosynthetic interfaces. A specimen container that could accommodate a 1-cm-deep specimen was fabricated, and a Lucite ring was used to facilitate securing geosynthetics to the top platen with glue. In tests on soil/geosynthetic interfaces, the bottom porous stone was replaced with a knurled stainless-steel ring to minimize drainage. In tests on geosynthetic/geosynthetic interfaces, the bottom, bronze, porous stone was replaced by another Lucite ring to aid in securing the bottom geosynthetic with glue. Digital dial gages and a microcomputer data acquisition system were used to monitor vertical displacement and shear stress during the test. Average horizontal displacements were calculated by multiplying the average circumference of the specimen by the measured angular displacement.

RING-SHEAR TEST PROCEDURE AND SPECIMEN PREPARATION

Based on water contents of the secondary clay liner, which was measured during placement and after the slope failure, and based on the determination that the dissipation of excess pore-water pressures in the vicinity of the secondary-clay/secondary-geomembrane interface would be negligible prior to failure, the unconsolidated-undrained shear strength of the secondary clay/secondary geomembrane interface was determined to be representative of the Kettleman Hills field conditions (Mitchell et al. 1990; Byrne et al. 1992). As a result, an unconsolidated-undrained test procedure was used by Mitchell et al. (1990) and in "Draft" (1991) for direct-shear tests on the SC/SG interface. For consistency, an unconsolidated-undrained test procedure was used for the ring-shear tests performed on the SC/SG interface. Since the ring-shear specimen is not enclosed in a membrane, a displacement rate of 4.4 cm/min was applied to obtain an undrained condition in the ring-shear apparatus. This displacement rate is based on the coefficient of consolidation reported by Seed et al. (1988) of 3.5×10^{-3} cm^2/min, the procedure developed by Gibson and Henkel (1954), and a degree of consolidation of 0%. It is faster than the displacement rate in previous Kettleman Hills testing (Mitchell et al. 1990; "Draft" 1991), because the ring-shear specimen is thinner than previous direct-shear specimens.

All geosynthetic/geosynthetic interfaces were sheared immediately after application of the normal stress at a displacement rate of 0.1 cm/min. This displacement rate is in agreement with direct-shear testing performed by Mitchell et al. (1990) and "Draft" (1991), in which displacement rates of 0.01 cm/min to 0.1 cm/min, and 0.1 cm/min, respectively, were applied.

The secondary clay liner at Kettleman Hills consists of on-site claystone, siltstone, and sandstone with 2–5% sodium bentonite by weight added to decrease hydraulic conductivity. The clay-liner sample used in the ring-shear tests was obtained from on-site stockpiles during construction of the liner. The secondary clay classifies as a high-plasticity clay (CH) according to the Unified Soil Classification System with a liquid limit of 65% and a plasticity index of 44. Hydrometer tests conducted during this study revealed that

84% of the clay liner passes U.S. Standard sieve No. 200 and the clay-size fraction (percent by weight finer than 0.002 mm) is 49%. Byrne et al. (1992) reported that the as-built secondary clay liner at Kettleman Hills had a liquid limit of 60–70% and a plasticity index of 40–50; thus, the soil tested appears representative of average field conditions. Standard Proctor compaction tests revealed that the optimum water content of the secondary clay liner from Kettleman Hills is 22% and the maximum dry-unit weight is 15.6 kN/m^3. Quality-assurance records show that the secondary clay layer was placed at water contents from 27% to 33% with a median value of 29.7% (Byrne et al. 1992).

The ring-shear specimens were obtained by air drying a portion of the 18 kg sample of the secondary clay liner from landfill B-19. The air-dry soil was crushed with a ceramic pestle and processed through U.S. Standard sieve No. 40. The clay was mixed to the desired water content using distilled water. The ring-shear specimens were compacted directly into the ring-shear specimen container using a Harvard miniature compactor. The desired dry-unit weight was obtained by compacting the appropriate weight of moist soil into the specimen container using two lifts. After compaction, the top platen with a secured geosynthetic was placed on the compacted clay, and the specimen container was installed in the ring-shear apparatus. The desired normal stress was applied within 5 min and shearing commenced after the normal stress was obtained. The observations were made to ensure that specimen extrusion did not occur during application of the normal stress. The specimen was not inundated prior to or during shear. Moist cotton batting, however, was placed around the top platen to minimize changes in moisture content during testing. In accordance with field water contents and dry-unit weights, the ring-shear specimens were compacted to dry-unit weights of 14.5–15.4 kN/m^3 and initial water contents of 18–33% to investigate the effect of compaction water content on interface-shear strength.

The geosynthetics were glued to the Lucite ring using a thin coat of epoxy cement and allowed to cure for 24 h under a normal stress of 300 kPa. This aided bonding of the geosynthetics and minimized vertical displacements due to the glue during testing. The specimen container and geosynthetic were always marked to ensure that the geosynthetic did not slip during shear. The surface of the geomembrane was also wiped, if necessary, using a paper towel to minimize the effect of fingerprints and perspiration on the interface strengths (Yegian and Lahlaf 1992). The ring-shear tests were conducted at a laboratory temperature of 20°C.

The following interfaces were tested during this investigation: (1) Secondary clay/secondary HDPE geomembrane; (2) geonet/HDPE geomembrane; and (3) nonwoven geotextile/HDPE geomembrane. The other interfaces shown in Fig. 1 (i.e., geonet/nonwoven geotextile and nonwoven geotextile/secondary clay) were not tested, because Seed et al. (1988) concluded that these interfaces exhibited a large interface shear strength. The geomembrane used in the present study is a smooth 1.5-mm-thick HDPE liner (Gundle Lining Systems, Inc., Houston, Tex.). The HDPE drainage geonet is the Gundle Gundnet XL4 net with a thickness of 5 mm. The nonwoven geotextile used in the present study is Polyfelt TS 600, which is a nonwoven needle-punched geotextile made of polypropylene fibers. These geosynthetics are compatible with the geosynthetics used in the double-composite liner system at Kettleman Hills Landfill B-19.

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RING-SHEAR TEST RESULTS ON CLAY/GEOMEMBRANE INTERFACE

Fig. 3 presents a typical shear-stress/horizontal-displacement relationship for an unconsolidated-undrained ring-shear test on the SC/SG interface at a normal stress of 48 kPa. The final water content of the clay was approximately 32.5%. The interface exhibits a peak shear strength of approximately 13.5 kPa and a residual strength of about 8.5 kPa. The peak SC/SG-interface strength was usually mobilized at a shear displacement of 0.2–0.4 cm (Fig. 4). This is in good agreement with the large-scale direct-shear test results in Fig. 2 that indicate the peak interface strength is mobilized at a shear displacement of 0.2–0.3 cm. Fig. 3 also shows that the residual interface strength is reached at a horizontal displacement of approximately 60 cm. However, the majority of the strength loss occurs within a horizontal displacement of 35–40 cm. This displacement is larger than the 2.5–5 cm that is usually applied in a large-scale direct-shear apparatus. In addition, the specimen underwent a vertical displacement of less than 0.01 cm, less than 1% of the initial height, during undrained shearing. This small vertical deformation is probably due to a slight extrusion of soil during undrained shearing.

La Gatta (1970) recommended plotting the shear-stress/horizontal-displacement relationship from ring-shear tests using the logarithm of hori-

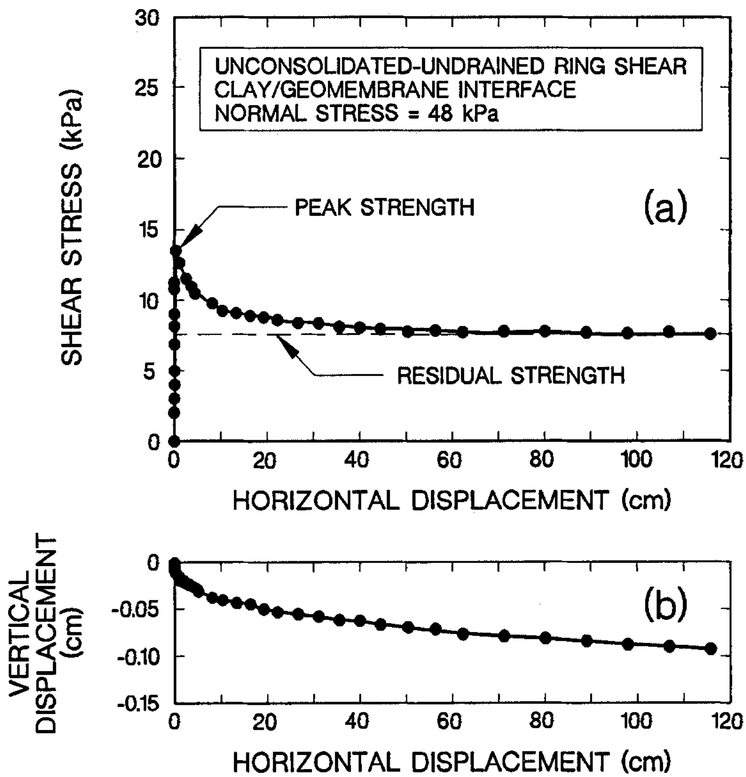

FIG. 3. Typical Undrained Ring-Shear Test Results for Secondary Clay/Secondary Geomembrane Interface: (*a*) Shear Stress; (*b*) Vertical Displacement

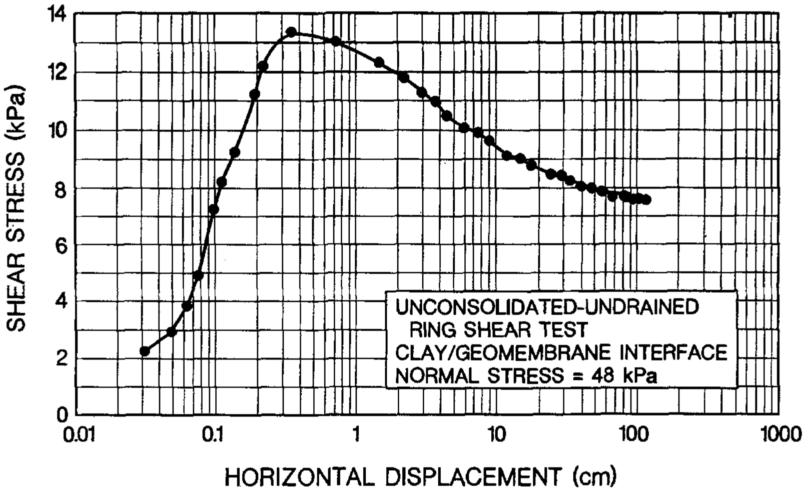

FIG. 4. Semilogarithmic Presentation of Secondary Clay/Secondary Geomembrane Ring-Shear Interface Test

zontal displacement. This plotting technique accentuates the slope of the shear stress-displacement curve at large deformations, allowing the horizontal portion of the curve to be clearly defined. Fig. 4 presents a semilogarithmic representation of the ring-shear test on the SC/SG interface presented in Fig. 3. The shear stress has reached a constant or residual value using a logarithmic scale. Therefore, to ensure that a residual strength condition is reached before a ring-shear or direct-shear test is stopped, it is recommended that the shear stress be plotted using the logarithm of horizontal displacement. Once the shear stress becomes essentially constant on a semilogarithmic plot, the test can be stopped.

Fig. 5 presents the peak SC/SG-interface strengths for the range of normal stresses and final water contents considered by Mitchell et al. (1990) and Byrne et al. (1992). At low normal stresses the peak interface strength is slightly influenced by final water content. However, as the normal stress increases, the peak interface strength becomes sensitive to compaction water content. The optimum water content of the Kettleman Hills secondary clay liner is 22%. Therefore, at placement water contents of 31–32% (9–10% above optimum), the peak interface strength converges to a range of 15–35 kPa. This is in good agreement with research on compacted cohesive soils presented by Seed et al. (1960). In summary, near the optimum water content the clay is stiffer and has more frictional resistance, which results in higher peak interface strengths. As the water content increases on the wet side of optimum, the peak interface strength decreases.

Fig. 6 presents the residual SC/SG-interface strengths for the same range of normal stresses and final water contents as Fig. 5. At low normal stresses, the residual interface strength is slightly influenced by final water content. As the normal stress increases, however, the residual interface strength becomes sensitive to compaction water content. At a water content of 31–32% the residual interface strength converges to a range of 8–24 kPa. These residual interface strengths are 30–50% lower than the peak interface strengths presented in Fig. 5.

Byrne et al. (1992) reported that the median-placed moisture content of

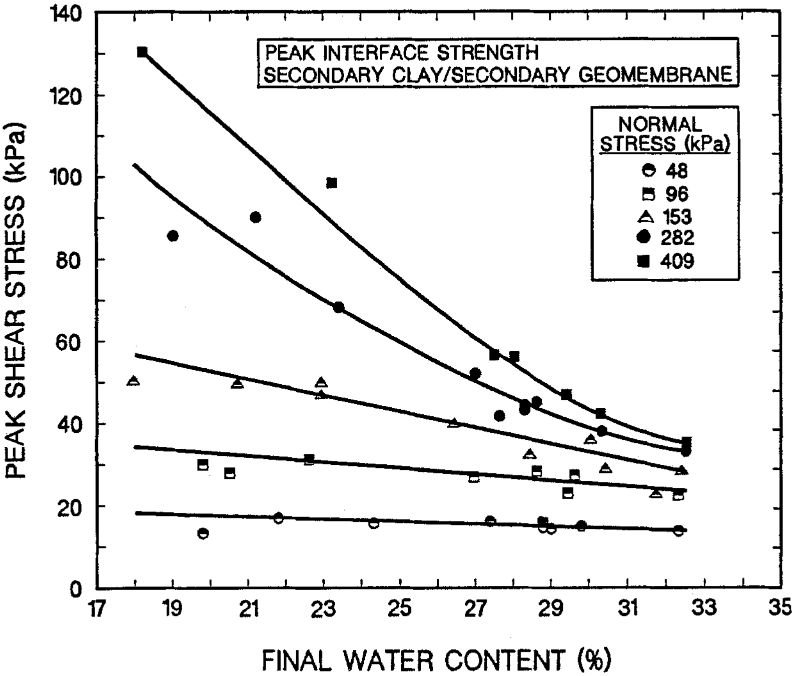

FIG. 5. Peak Secondary Clay/Secondary Geomembrane Interface Strengths

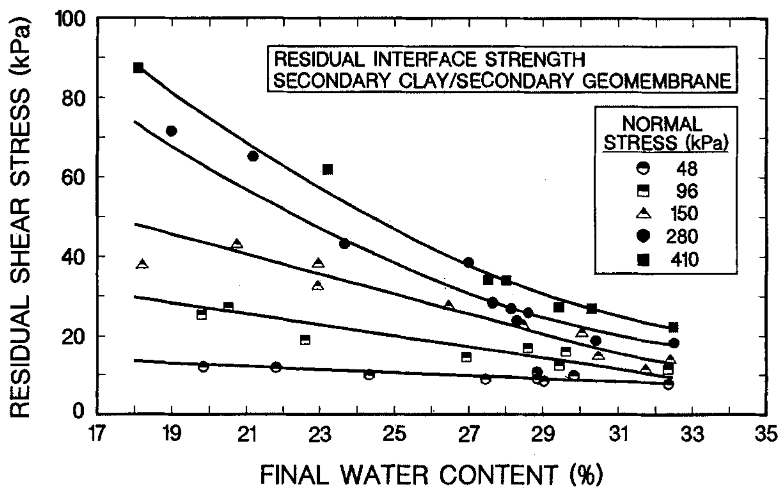

FIG. 6. Residual Secondary Clay/Secondary Geomembrane Interface Strengths

the secondary clay liner at Kettleman Hills was 29.7%. Therefore, peak and residual failure envelopes (Fig. 7) were obtained using Figs. 5 and 6 and a water content of 29.7%. Since ring-shear tests were not conducted at a water content of exactly 29.7%, data points are not shown on the ring-shear failure envelopes. Also the peak and residual ring-shear failure en-

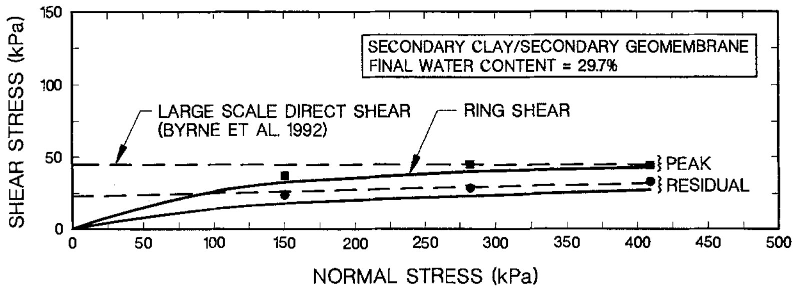

FIG. 7. Undrained Secondary Clay/Secondary Geomembrane Interface Failure Envelopes

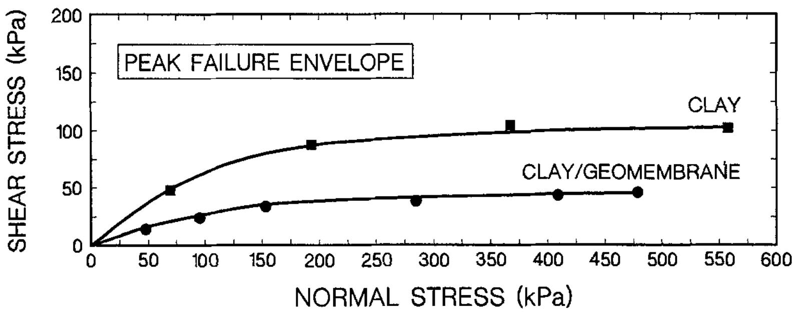

FIG. 8. Comparison of Peak Clay and Peak Clay/Geomembrane Interface Strengths

velopes are nonlinear. For comparison purposes, if a secant failure envelope is assumed to pass through the origin and the shear stress at a normal stress of 410 kPa, the peak friction angle is approximately 6°, and the residual friction angle is about 4°. Mitchell et al. (1990) reported that conventional direct-shear tests on the Kettleman Hills SC/SG interface yielded peak and residual friction angles of 13.6 ± 2.4° and 12.4 ± 1.1°, respectively, for water contents between 27–31%. However, an undrained residual strength of 43 ± 12 kPa was used by Seed et al. (1990) in post-failure stability analyses. Byrne et al. (1992) used "Draft" (1991) data from large-scale direct-shear tests to develop the following peak (τ_{peak}) and residual ($\tau_{residual}$) strength relations for the SC/SG interface at a water content of 29.7%:

$$\tau_{peak} = 45 \text{ kPa} \quad (1)$$

$$\tau_{residual} = 23.2 \text{ kPa} + 0.022\sigma_n \quad (2)$$

where σ_n = normal stress.

The failure envelopes from the large-scale direct-shear tests performed in "Draft" (1991) are superimposed on the ring-shear envelopes in Fig. 7. The three normal stresses used in "Draft" (1991) are 150, 280, and 410 kPa (Fig. 2), and the data points in Fig. 7 correspond to these tests. The ring-shear peak strength is slightly lower than the large-scale direct-shear tests at normal stresses greater than 150 kPa. This is in good agreement with previous research (Bishop et al. 1971; La Gatta 1970), suggesting that peak strengths measured in a ring-shear apparatus are slightly lower than direct-shear values for materials exhibiting a large post-peak strength loss. This is due to the nonuniformity of shear displacements radially across the specimen. If the material does not exhibit a significant post-peak strength loss, the peak strengths from direct-shear and ring-shear tests will be equal. The ring-shear residual interface strengths are 15–20% lower than the large-scale direct-shear test results for normal stresses greater than 150 kPa. The difference in residual interface strengths is probably due to the larger continuous-shear displacements that can be applied to the ring-shear tests. For stability analyses, there exist a number of cohesion and friction angle combinations that can be used to model the nonlinear peak and residual failure envelopes in Fig. 7. Therefore, it is recommended that the entire envelope or an appropriate value of the friction angle be incorporated in a stability analysis.

Fig. 8 provides a comparison of the peak SC/SG-interface failure envelope and the peak failure envelope of the clay-liner material at a water content of 29.7%. The envelopes have similar shapes but the SC/SG-interface strength is significantly less than the peak strength of the clay liner. If a secant envelope is assumed to pass through the origin and the shear stress at a normal stress of 480 kPa, the peak SC/SG-interface friction angle is about 6°, and the peak clay-liner friction angle is approximately 12°. These failure envelopes can be used to estimate the efficiency of the SC/SG interface by dividing the tangent of the interface friction angle by the tangent of the clay-liner friction angle. This yields an interface efficiency of 50–55% for normal stresses greater than approximately 190 kPa. This is in good agreement with the 45–60% range that has been reported for direct-shear tests on other clay-geomembrane interfaces at a normal stress near 500 kPa (Long et al. 1993). Therefore, it may be concluded that the peak strengths measured using a ring-shear apparatus are in agreement with direct-shear test results.

Fig. 9 provides a comparison of the residual SC/SG-interface strength and the residual strength of the clay-liner material. The envelopes have similar shapes but the SC/SG-interface strength is again significantly less than the residual clay-liner strength. A comparison of Figs. 8 and 9 reveals that the clay-liner material does not exhibit a large post-peak strength loss, thus the peak and residual failure envelopes of the clay liner are similar. If a secant envelope is assumed to pass through the origin and the shear stress at a normal stress of 480 kPa, the residual SC/SG-interface friction angle is approximately 4°, and the residual clay-liner friction angle is about 11°.

The residual interface efficiency was calculated to be approximately 35% at normal stresses greater than approximately 190 kPa, which is lower than the peak interface efficiency of 55%. Therefore, the SC/SG interface exhibits a larger post-peak strength loss than the clay-liner material. This is probably caused by some clay particles being oriented parallel to the direction of shear and by significant polishing of the geomembrane that occurs at large continuous-shear displacements. It should be noted that the excavated secondary HDPE geomembrane at Kettleman Hills exhibited a highly polished surface. Typical residual interface efficiencies reported for direct-shear tests range from 45% to 55% (Long et al. 1993). The difference between the ring-shear and direct-shear residual interface efficiencies is probably due to the larger continuous-shear displacement that can be applied in the ring-shear tests.

RING-SHEAR TESTS ON GEOSYNTHETIC/GEOSYNTHETIC INTERFACES

Torsional-ring-shear tests were also conducted on geonet/geomembrane and nonwoven geotextile/geomembrane interfaces. Fig. 10 presents the peak

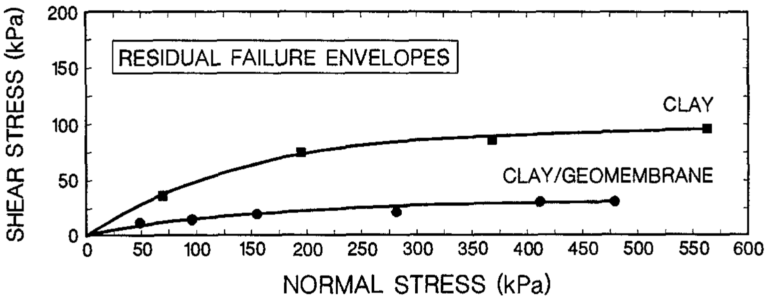

FIG. 9. Comparison of Residual Clay and Residual Clay/Geomembrane Interface Strengths

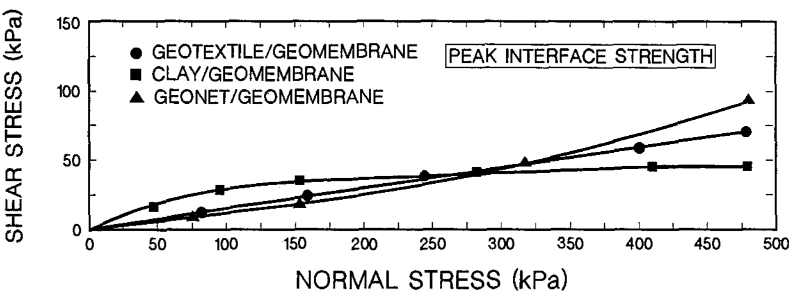

FIG. 10. Peak Failure Envelopes for Various Liner Interfaces

interface failure envelopes for these interfaces together with the SC/SG interface at a water content of 29.7%. The synthetic interfaces are critical (exhibit the lowest peak shear resistance) at normal stresses less than approximately 280 kPa. However, at normal stresses greater than approximately 280 kPa, the SC/SG interface is critical. The normal stress acting on the base of the Kettleman Hills Landfill at the time of failure ranged from 420 to 480 kPa. These stresses are based on a unit weight of 15.7–17.3 kN/m^3 and a fill depth of 27–28 m at the time of failure. Fig. 10 indicates that sliding should occur at the SC/SG interface for these normal stresses. This is in excellent agreement with field observations along the base of the landfill that showed striations only occurred along the SC/SG interface (Byrne et al. 1992).

Fig. 11 presents the residual interface failure envelopes for the geosynthetic/geosynthetic interfaces and the SC/SG interface at a water content of 29.7%. Fig. 11 suggests that in the upper 10–11 m of the sideslopes, that is, in areas with a normal stress less than or equal to 190 kPa, sliding could have occurred along any of these interfaces. However, below a depth 10–11 m along the sideslopes, that is, in areas with normal stresses greater than approximately 190 kPa, sliding should have occurred along the SC/SG interface. Again, this is in excellent agreement with field observations, which clearly showed sliding along the SC/SG interface at a depth of 10–15 m below the landfill rim. Above this depth, sliding occurred along the primary geomembrane/secondary geotextile interface.

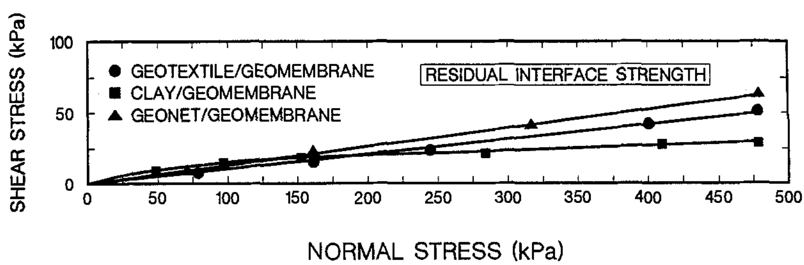

FIG. 11. Residual Failure Envelopes for Various Liner Interfaces

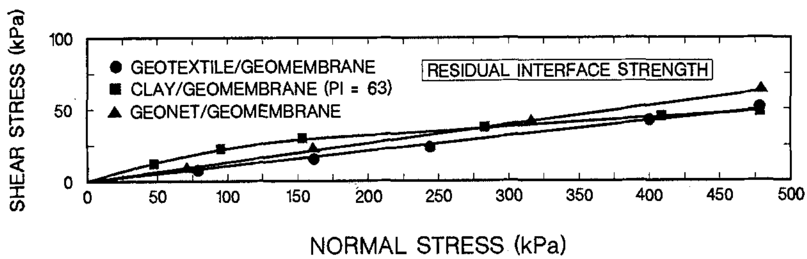

FIG. 12. Effect of Plasticity on Residual Clay/Geomembrane Interface Strength

EFFECT OF PLASTICITY ON CLAY/GEOMEMBRANE INTERFACE STRENGTH

For design considerations, the effect of increasing the percentage of sodium bentonite by weight in the secondary clay-liner mixture on the SC/SG-interface strength was also investigated. Additional sodium bentonite provides a lower hydraulic conductivity, but it may also decrease the interface strength. Fig. 12 presents the residual strength of a higher plasticity clay/geomembrane interface at a water content of 29.7%. This higher plasticity clay was obtained from the failed secondary clay liner on the base of the Kettleman Hills Landfill after waste excavation. A greater percentage of sodium bentonite was probably added to decrease hydraulic conductivity in this liner sample. This clay classifies as a CH according to the Unified Soil Classification System, having a liquid limit of 87% and a plasticity index of 63. Since both clay-liner samples classify as CH, this sample will be referred to as the higher plasticity clay liner. Hydrometer tests conducted during the present study revealed that 92% of the higher plasticity clay liner passes the U.S. Standard sieve No. 200 and the clay-size fraction (percent by weight finer than 0.002 mm) is 73%. For comparison purposes, the residual geosynthetic/geosynthetic failure envelopes from Fig. 11 are also presented in Fig. 12. The geotextile/geomembrane interface is critical for normal stresses less than approximately 450 kPa. Therefore, increasing the plasticity and clay-size fraction of the clay increases the residual interface strengths at a water content of 29.7%. The increase in interface strength with an increase in plasticity is attributed to differences in the optimum water content of the two clays. The optimum water content of the higher plasticity clay liner is 26% versus 22% for the secondary clay liner described previously. Therefore, a water content of 29.7% is slightly greater than the optimum water content of the higher plasticity clay liner. This higher optimum water content causes more frictional resistance, and thus higher interface strengths for the higher plasticity clay liner. Based on these results, it appears that clay/geosynthetic interface strengths are clay/site specific. Testing should be conducted to determine the critical interface for landfill-stability analyses.

STABILITY ANALYSIS OF KETTLEMAN HILLS PHASE IA OF LANDFILL B-19

Two- and three-dimensional slope-stability analyses of the Kettleman Hills failure were conducted to investigate the effect of complex landfill geometries on the calculated factor of safety and relevancy of ring-shear interface strengths. A three-dimensional analysis was conducted using a limit equilibrium technique based on Janbu's (1973) method. This analysis neglects the vertical component of interslice-shear forces and satisfies overall vertical and horizontal force equilibrium. The three-dimensional microcomputer slope-stability program, LF, developed by Golder Associates, Seattle, Wash., and the three-dimensional geometry in Fig. 13 were used for the analysis. The computer program allows the nonlinear-interface failure envelopes to be modeled using a trilinear failure envelope.

The two-dimensional cross section shown in Fig. 13 was used by Byrne et al. (1992) and was analyzed during the present study. Janbu's (1973) stability method was also used for the two-dimensional analysis. For comparison purposes, the two-dimensional hand calculations did not utilize Janbu's correction for neglecting the vertical component of interslice-shear forces. Therefore, the identical slope-stability method and assumptions were applied in the two- and three-dimensional stability analyses to permit comparison of the factors of safety. The same trilinear failure envelope was used to model the nonlinear-interface failure envelopes in the two- and three-dimensional analyses. The two- and three-dimensional stability analyses were performed assuming an average unit weight of the waste fill of 17.3 kN/m^3, a value based on bulk unit weight determinations conducted during waste excavation (Byrne et al. 1992). The basal operations layer, the primary

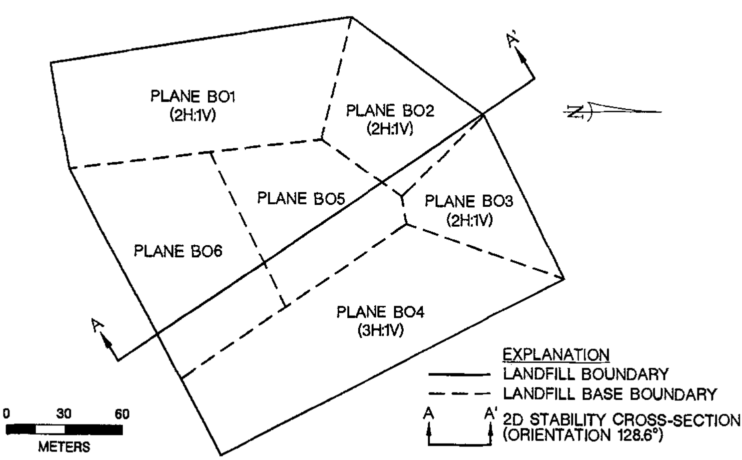

FIG. 13. Kettleman Hills Landfill B-19, Phase IA Geometry for Stability Analyses (after Byrne et al. 1992)

and secondary gravel-drainage layers, and the primary clay overlying the secondary clay/secondary geomembrane interface (Fig. 1) were also assigned an average unit weight of 17.3 kN/m^3.

Various combinations of peak and residual SC/SG-interface failure envelopes were applied in the analysis to determine the interface strength mobilized at the time of the Kettleman Hills failure. Byrne et al. (1992) reported that inspection of the liner system during removal of the waste from Phase IA of Landfill B-19 at Kettleman Hills showed that sliding occurred along the SC/SG interface on the base of the landfill. Fig. 13 presents the geometry of Kettleman Hills Landfill B-19 and the location of the basal panels BO5 and BO6. The basal panels are inclined at a 2% grade. Sliding along the northwest and southwest sideslopes (panels BO1 through BO3) was also concentrated on the SC/SG interface, except in the upper 10–15 m of the slope, where sliding occurred along the primary geomembrane/secondary geotextile interface. Inspection of the northwest and southwest sideslope toe areas showed evidence of a more complex sliding mechanism due to the sharp change in slope angle at the toe of the slope. Sliding appeared to have occurred on synthetic interfaces as well as on the SC/SG interface in these toe areas in order to accommodate the kinematic constraints of the grade change. Sliding along the northeast sideslope (Panel BO4) was concentrated on the SC/SG interface and was approximately parallel to the strike of this sideslope.

To model field conditions, the residual failure envelope for the primary geomembrane/secondary geotextile interface was assigned to the slip surface in the upper 10–15 m of the sideslope. There is only a slight difference between the residual failure envelopes for the SC/SG and geomembrane/geotextile interfaces in Fig. 12 for normal stresses less than 190 kPa. As a result, interchanging these failure envelopes had a negligible effect on the calculated factors of safety.

Table 1 presents the three- and two-dimensional stability analyses. The three-dimensional factor of safety for the post-failure geometry and residual interface strengths assigned to all landfill panels is 0.95. This is in excellent agreement with field observations and confirms the relevancy of residual interface strengths measured using the torsional-ring-shear apparatus. The three-dimensional factors of safety for the prefailure geometry range from 0.73 to 1.26 when the residual and peak interface strengths, respectively, are assigned to all sliding surfaces. This suggests that Phase IA of landfill B-19 was marginally stable during construction. If the peak interface strength is assigned to the basal panels (BO5 and BO6 in Fig. 13), and the residual interface strength is assigned to all of the sideslopes (BO1 through BO4), then the three-dimensional factor of safety for the prefailure geometry is 0.92. This factor of safety is slightly less than unity, but still in excellent

TABLE 1. Results of Two- and Three-Dimensional Slope-Stability Analyses of Kettleman Hills Landfill B-19

Slide geometry (1)	Interface strength (2)	3D factor of safety (3)	2D factor of safety (4)
Postfailure	Residual	0.95	0.88
Prefailure	Residual	0.73	0.71
Prefailure	Peak	1.26	1.18
Prefailure	Peak and residual	0.92	1.03

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agreement with the 19 March 1988 slide. Possible reasons for this factor of safety being slightly less than unity include neglecting the complex sliding that occurred in the toe areas on the northwest and southwest sideslopes and the interface strength being slightly greater than the residual value near the toe of the sideslopes. However, a factor of safety of 0.92 is in excellent agreement with field observations, and thus it is recommended that peak and residual interface strengths be assigned to the landfill base and sideslopes, respectively, for general design purposes.

The two-dimensional factors of safety are lower than the three-dimensional values and in excellent agreement with field observations. The two-dimensional factor of safety for the postfailure geometry and a residual interface strength assigned to all sliding surfaces is 0.88. This factor of safety is lower than 0.95 because of the absence of three-dimensional effects. This suggests that the residual interface strengths should be higher for field agreement. Neglecting three-dimensional effects, however, yields back-calculated strengths that are too high. In summary, it may be concluded that the residual interface strengths measured using a torsional-ring-shear apparatus are in excellent agreement with field observations. The two-dimensional factors of safety for the prefailure geometry range from 0.71–1.18 when the residual and peak interface strengths, respectively, are assigned to all sliding surfaces. It is important to note that these two-dimensional factors of safety are less than the corresponding three-dimensional factors of safety.

When peak and residual interface strengths are applied to the base and sideslopes, respectively, the two-dimensional factor of safety for the prefailure geometry is slightly larger than the three-dimensional factor of safety. It is anticipated that this result is due to the percentage of area that is assigned peak and residual strengths in the two- and three-dimensional analyses. For example, 35% of the slide surface was assigned a peak interface strength, while 65% received a residual interface strength in the three-dimensional analysis. Conversely, in the two-dimensional analysis, 36% of the slide surface was assigned the residual interface strength, while 64% of the base received the peak value. Further evidence of the importance of area balance is that the two- and three-dimensional factors of safety yield a consistent pattern when the same interface strength is applied to the entire slip surface.

Based on this reevaluation of the Kettleman Hills failure, it appears that a two-dimensional stability analysis can be used with a suitable factor of safety for landfill design. Considerable engineering judgment should be used, however, to determine the critical two-dimensional section. A three-dimensional analysis may provide insight into the location of the critical two-dimensional section. But a more important parameter in landfill-stability analyses is the measurement and selection of the interface-shear strength parameters. The difference in the two- and three-dimensional factors of safety is 10–15% (Table 1), while the variability in interface strengths is significantly larger (Figs. 5 or 6). Therefore, the majority of the design effort should focus on site-specific testing and careful selection of interface strengths.

SELECTION OF INTERFACE STRENGTHS FOR SLOPE-STABILITY ANALYSES

The regressive analysis of the Kettleman Hills failure indicates that peak and residual interface strengths are mobilized along a landfill's base and sideslopes, respectively, during construction and waste placement. Waste is typically placed in landfills using a 2-m-thick lift with little compaction. As a result, the waste usually settles a considerable amount during the filling operation. Review of field settlements from several landfills indicates that municipal solid-waste landfills usually settle approximately 10% of the initial height because of placement and decomposition (Chang and Hannon 1976; York et al. 1977; Dodt et al. 1987; Coduto and Huitric 1989). It was found that hazardous-waste landfills typically settle 2–6% of the initial height (Gray and Lin 1972; Seals et al. 1972; Leonards and Bailey 1982; McLaren and DiGioia 1987). Settlement of the fill induces shear stresses in the sideslope liner system, all of which tends to displace the liner downslope. These shear stresses induce shear displacements along specific interfaces in the liner system that may lead to the mobilization of a residual interface strength. In addition, thermal expansion and contraction of the sideslope liner system during construction and filling may also contribute to the accumulation of shear displacements and the mobilization of a residual interface strength. Therefore, it is recommended that a residual interface strength be assigned to all sideslopes for design purposes.

Fill settlement, and thus liner shear displacements, decrease with depth along the sideslopes. Therefore, at the toe of the sideslopes, the residual interface strength may not be mobilized due to small displacements. For design, however, it is recommended that the entire sideslope be assigned the residual interface strength. Since shear displacements may be small along the base of the landfill, it is possible that the peak interface strength can be mobilized along the base of the landfill. In summary, it appears that peak and residual interface strengths should be assigned to the base and sideslopes, respectively, for design purposes.

A second design scenario involves assigning ring-shear residual interface-strengths to all slip surfaces and requiring a factor of safety greater than unity. This scenario should be considered, because the interface peak strength is usually mobilized at a small laboratory displacement (Fig. 3). Since field interface displacements and the effect of progressive failure are not known, it is prudent to also consider this scenario. If the residual interface strength is measured in a direct-shear apparatus, a factor of safety greater than unity may be required to compensate for the limited continuous-shear displacement applied in the apparatus.

CONCLUSIONS

The following conclusions are based on the analysis, data, and interpretation presented in this paper:

1. Clay/geomembrane interface strengths are a function of compaction water content, normal stress, and soil type. Therefore, a geosynthetic/geosynthetic interface may be more critical than the clay/geomembrane interface depending on placement water content, applied normal stress, and clay composition. Site-specific testing should be conducted to identify the critical interface as a function of normal stress.
2. Based on field observations, the torsional-ring-shear apparatus appears to provide an excellent estimate of field peak and residual interface-shear strengths. The main advantage of a ring-shear apparatus is that large continuous-shear displacement can be applied in one direction in order to achieve a residual strength condition.
3. Undrained clay/geomembrane-interface failure envelopes are nonlin-

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ear. It is recommended that the entire failure envelope or an appropriate value of the friction angle be incorporated in stability analyses.

4. Design-stability analyses should utilize peak and residual interface strengths on the landfill base and sideslopes, respectively. Since field interface displacements and the effect of progressive failure are not known, a factor of safety greater than unity with a ring-shear residual interface strength assigned to all slip surfaces should also be satisfied.

5. A two-dimensional stability analysis can be used for the design of landfills with complex geometries. However, considerable judgment should be used in determining the critical two-dimensional cross section. A three-dimensional analysis may aid the selection of the critical two-dimensional cross section.

6. The most important aspect of a landfill-stability analysis is measurement and selection of the interface-shear strengths. Significant time and effort should be expended on estimating the critical interface-shear strengths.

ACKNOWLEDGMENTS

This study was funded by the Illinois Office of Solid Waste Research, Grant No. SENR-SWR2-92WR-01-001, and the National Science Foundation, Grant No. MSS-9114186. John Kendall of Chemical Waste Management, Inc., R. John Byrne of Golder Associates, Robert B. Gilbert of the University of Texas at Austin, and Robert H. Swan of GeoSyntec Consultants provided technical information and/or the bulk samples of the secondary clay-liner from Phase IA of Landfill B-19 at the Kettleman Hills Facility. Gundle Lining Systems, Inc., Houston, provided samples of the geosynthetics used in the study. The support of these individuals and organizations is gratefully acknowledged.

APPENDIX. REFERENCES

Bishop, A. W., Green, G. E., Garaga, V. K., Andresen, A., and Brown, J. D. (1971). "A new ring shear apparatus and its application to the measurement of residual strength." *Géotechnique*, London, England, 21(4), 273–328.

Bove, J. A. (1990). "Direct shear friction testing for geosynthetics in waste containment." *Proc., ASTM Symp. on Geosynthetic Testing for Waste Containment Applications, ASTM STP 1081*, ASTM, Philadelphia, Pa., 241–256.

Bromhead, E. N. (1979). "A simple ring shear apparatus." *Ground Engrg.*, 12(5), 40–44.

Byrne, R. J., Kendall, J., and Brown, S. (1992). "Cause and mechanism of failure, Kettleman Hills Landfill B-19, unit IA." *Proc., ASCE Spec. Conf. on Perf. and Stability of Slopes and Embankments—II*, Vol. 2, ASCE, New York, N.Y., 1188–1215.

Chang, J. C., and Hannon, J. B. (1976). "Settlement performance of two test highway embankments on sanitary landfill." *Proc., Int. Symp. on New Horizons in Constr. Mat.*, Vol. 1, Envo Publishing Co., Lehigh Valley, Pa., 139–157.

Coduto, D. P., and Huitric, R. (1989). "Monitoring landfill movements using precise instruments." *Proc., ASTM Symp. on Geotech. of Waste Fills: Theory and Practice, ASTM STP 1070*, ASTM, Philadelphia, Pa., 358–370.

"Determining the coefficient of soil and geosynthetic or geosynthetic and geosynthetic friction by the direct shear method." (1992). *Annual Book of Standards*, Vol. 04.08, Sect. 4, ASTM, Philadelphia, Pa., 1380–1384.

Dodt, M. E., Sweatman, M. B., and Bergstrom, W. R. (1987). "Field measurements of landfill surface settlements." *Proc., ASCE Spec. Conf. on Geotech. Pract. for Waste Disposal '87*, ASCE, New York, N.Y., 406–417.

"Draft final report landfill unit B-19, phase IA investigation, Kettleman Hills facility, Kettleman City, California." (1991). *Rep. Prepared for Chemical Waste Management, Inc.*, GeoSyntec Consultants, Atlanta, Ga.
Gibson, R. E., and Henkel, D. J. (1954). "Influence of duration of tests at constant rate of strain on measured 'drained' strength." *Géotechnique*, London, England, 4(1), 6–15.
Giroud, J. P., and Beech, J. F. (1989). "Stability of soil layers on geosynthetic lining systems." *Proc., Geosynthetics '89 Conf.*, Vol. 1, Industrial Fabrics Associates International, St. Paul, Minn., 35–46.
Gray, D. H., and Lin, Y. K. (1972). "Engineering properties of compacted fly ash." *J. Soil Mech. and Found. Div.*, ASCE, 98(4), 361–380.
Janbu, N. (1973). "Slope stability computations." *Embankment dam engineering: casagrande volume.* John Wiley and Sons, New York, N.Y., 47–86.
Koerner, R. M., Martin, J. P., and Koerner, G. R. (1986). "Shear strength parameters between geomembrane sand cohesive soils." *J. Geotextiles and Geomembranes*, 4(1), 21–30.
La Gatta, D. P. (1970). "Residual strength of clays and clay-shales by rotation shear tests." *Harvard Soil Mechanics Series No. 86*, Harvard University Press, Cambridge, Mass.
Leonards, G. A., and Bailey, B. (1982). "Pulverized coal ash as structural fill." *J. Geotech. Engrg. Div.*, ASCE, 108(4), 517–531.
Long, J. H., Daly, J. J., and Gilbert, R. B. (1993). "Structural integrity of geosynthetic liner and cover systems for solid waste landfills." *Rep. Prepared for Illinois Office of Solid Waste Research*, University of Illinois, Urbana, Ill.
Martin, J. P., Koerner, R. M., and Whitty, J. E. (1984). "Experimental friction evaluation of slippage between geomembranes, teotextiles, and soils." *Proc., Int. Conf. of Geomembranes*, Industrial Fabrics Association International, St. Paul, Minn., 191–196.
McLaren, R. J., and DiGioia, A. M. Jr. (1987). "The typical engineering properties of fly ash." *Proc., ASCE Spec. Conf. on Geotech. Pract. for Waste Disposal '87*, ASCE, New York, N.Y., 683–697.
Mitchell, J. K., Seed, R. B., and Seed, H. B. (1990). "Kettleman Hills Waste Landfill slope failure. I: liner-system properties." *J. Geotech. Engrg.*, ASCE, 116(4), 647–668.
Negussey, D., Wijewickreme, W. K. D., and Vaid, Y. P. (1989). "Geomembrane interface friction." *Can. Geotech. J.*, Ottawa, Canada, 26(1), 165–169.
O'Rourke, T. D., Druschel, S. J., and Netravali, A. N. (1990). "Shear strength characteristics of sand polymer interfaces." *J. Geotech. Engrg.*, ASCE, 116(3), 451–469.
Saxena, S. K., and Wong, Y. T. (1984). "Friction characteristics of a geomembrane." *Proc. Int. Conf. of Geomembranes*, Industrial Fabrics Association International, St. Paul, Minn., 187–190.
Seals, R. K., Moulton, L. K., and Ruth, B. E. (1972). "Bottom ash: an engineering material." *J. Soil Mech. and Found. Div.*, ASCE, 98(4), 311–325.
Seed, H. B., Mitchell, J. K., and Chan, C. K. (1960). "The strength of compacted cohesive soils." *Proc., ASCE Res. Conf. on Shear Strength of Cohesive Soils*, ASCE, New York, N.Y., 877–964.
Seed, R. B., and Boulanger, R. W. (1991). "Smooth HDPE-clay liner interface shear strengths: compaction effects." *J. Geotech. Engrg.*, ASCE, 117(4), 686–693.
Seed, R. B., Mitchell, J. K., and Seed, H. B. (1988). "Slope stability failure investigation: landfill unit B-19, phase I-A, Kettleman Hills, California." *Res. Rep. No. UCB/GT/88-01*, Univ. of California, Berkeley, Calif.
Seed, R. B., Mitchell, J. K., and Seed, H. B. (1990). "Kettleman Hills Waste Landfill slope failure. II: stability analysis." *J. Geotech. Engrg.*, 116(4), 669–689.
Takasumi, D. L., Green, K. R., and Holtz, R. D. (1991). "Soil-geosynthetic interface strength characteristics: a review of state-of-the-art testing procedures." *Proc., Geosynthetics '91 Conf.*, Vol. 1, International Fabrics Association International, St. Paul, Minn., 87–100.
Williams, N. D., and Houlihan, M. F. (1987). "Evaluation of interface friction

properties between geosynthetics and soils." *Proc. Geosynthetics '87 Conf.*, Vol. 2, International Fabrics Association International, St. Paul, Minn., 616–627.
Yegian, M. K., and Lahlaf, A. M. (1992). "Discussion of 'Kettleman Hills Waste Landfill slope failure. I: liner-system properties,' by James K. Mitchell et al." *J. Geotech. Engrg.*, ASCE, 118(4), 643–645.
York, D., Bellatty, T., Irsai, E., and Patel, A. (1977). "Terminal development of a refuse fill site." *Proc., ASCE Spec. Conf. on Geotech. Pract. for Disposal of Solid Waste Mat.*, ASCE, New York, N.Y., 810–830.

Attachment F – Settlement

Table D-3

Typical Elastic Moduli

Soil	E_s, tsf
Clay	
Very soft clay	5 - 50
Soft clay	50 - 200
Medium clay	200 - 500
Stiff clay, silty clay	500 - 1000
Sandy clay	250 - 2000
Clay shale	1000 - 2000
Sand	
Loose sand	100 - 250
Dense sand	250 - 1000
Dense sand and gravel	1000 - 2000
Silty sand	250 - 2000

c. Laboratory Tests on Cohesive Soil. The elastic modulus is sensitive to soil disturbance which may increase pore water pressure and, therefore, decrease the effective stress in the specimen and reduce the stiffness and strength. Fissures, which may have little influence on field settlement, may reduce the measured modulus compared with the in situ modulus if confining pressures are not applied to the soil specimen.

(1) Initial hyperbolic tangent modulus. Triaxial unconsolidated undrained (Q or UU) compression tests may be performed on the best available undisturbed specimens at confining pressures equal to the total vertical overburden pressure σ_o for that specimen when in the field using the Q test procedure described in EM 1110-2-1906, Laboratory Soils Testing. An appropriate measure of E_s is the initial tangent modulus $E_{ti} = 1/a$ where a is the intercept of a plot of strain/deviator stress versus strain, Figure D-3 (item 14).

(2) Reload modulus. A triaxial consolidated undrained (R or CU) compression test may be performed on the best available undisturbed specimens. The specimen is initially fully consolidated to an isotropic confining pressure equal to the vertical overburden pressure σ_o for that specimen in the field. The R test procedure described in EM 1110-2-1906 may be used except as follows: stress is increased to the magnitude estimated for the field loading condition. The axial stress may then be reduced to zero and the cycle repeated until the reload curve shows no further increase in slope. The tangent modulus at 1/2 of the maximum applied stress is determined for each loading cycle and plotted versus the number of cycles, Figure D-4. An appropriate measure of E_s is the reload tangent modulus that approaches the asymptotic value at large cycles.

d. Field Tests. The elastic modulus may be estimated from empirical and semiempirical relationships based on results of field soil tests. Refer to

CECW-EG Engineer Manual 1110-1-1904	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	EM 1110-1-1904 30 September 1990
	Engineering and Design SETTLEMENT ANALYSIS	
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Burns & McDonnell SINCE 1898

Project Title: Landfill
Client: Victoria
Project Number: 107608

Date: 7/19/2021
Designed By: Textor

Design Description: TABLE 1: Leachate Collection Settlement Calculations - Grading Design

ASSUMPTIONS:

Assume the same settlement will occur at these same locations:

Location ID	Delta P (psf)	Total S (inches)	Total S (feet)	Depth of Fill (feet)	Stress Distribution Location
A	2920	12.5	1.04	38.2	Toe of Slope
B	6740	26	2.17	112.3	3:1 to 5% TOFC Grade Break
C	8320	32.7	2.73	138.7	Landfill Peak
D	7330	30.2	2.52	122.2	0.5% to 1.0% Liner Grade Break
E	7060	25	2.08	117.7	5% to 3:1 TOFC Grade Break
F	4410	20	1.67	73.5	1.0% to 10% Sump Grade Break
G	3520	13	1.08	58.7	Sump Grade to Toe of Slope

Location ID	Final LF Grade (feet)	Const. Base Grade (feet)	Depth of Fill (feet)	Notes:
A	87.02	48.79	38.2	Toe of 4H:1V Slope of Base Grade Perimeter Berm
B	160.00	47.72	112.3	
C	183.90	45.30	138.7	
D	165.67	43.50	122.2	150' from C/L Base Grade Perimeter Berm
E	160.00	42.38	117.7	
F	114.49	41.00	73.5	
G	97.18	38.50	58.7	Center of LF Fill excludes Sump Elevations

SCENARIO #1 - STANDARD CELL ARRANGEMENT

Leachate Collection System Settlement - Standard Cell, Center Leachate Lines (Perpendicular) - Cell B through H and K through Q

U/S Node ID	D/S Node ID	Length	Const. Base Grades/Leachate System			Final LF Grades		Depth of Fill		Settlement Depth		Final Leachate System w/ Settlement		
			U/S Invert	D/S Invert	Const. Slope	U/S Invert	D/S Invert	U/S Invert	D/S Invert	U/S Total S	D/S Total S	U/S Invert	D/S Invert	Final Slope
		(feet)	(feet)	(feet)	(%)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(%)
A	B	219	48.79	47.72	0.49	87.02	160.00	38.2	112.3	1.0	2.2	47.75	45.55	1.00
B	C	480	47.72	45.33	0.50	160.00	183.90	112.3	138.6	2.2	2.7	45.55	42.61	0.61
C	D	364	45.33	43.50	0.50	183.90	165.67	138.6	122.2	2.7	2.5	42.61	40.98	0.45
D	E	113	43.50	42.38	0.99	165.67	160.00	122.2	117.6	2.5	2.1	40.98	40.30	0.60
E	F	137	42.38	41.00	1.01	160.00	114.49	117.6	73.5	2.1	1.7	40.30	39.33	0.70
F	G	52	41.00	38.50	4.81	114.49	97.18	73.5	58.7	1.7	1.1	39.33	37.42	3.69

Assume the same settlement will occur at these same locations:

Location ID	Delta P (psf)	Total S (inches)	Total S (feet)	Depth of Fill (feet)	Stress Distribution Location
A	3420	10.9	0.91	57.0	Toe of Slope
B	7400	24	2.00	123.3	3:1 to 5% TOFC Grade Break
C	7560	24.9	2.08	126.0	1.0% to 0.5% Liner Grade Break
D	7270	24.2	2.02	121.2	0.5% to 3:1 Liner Grade Break

Location ID	Final LF Grade (feet)	Const. Base Grade (feet)	Depth of Fill (feet)	Notes:
A	90.05	33.07	57.0	
B	160.00	35.88	123.3	
C	162.35	36.35	126.0	
D	162.35	41.17	121.2	

SCENARIO #1 - STANDARD CELL ARRANGEMENT

Leachate Collection System Settlement - Standard Cell, Center Leachate Lines (Perpendicular) - Cell B through H and K through Q

U/S Node ID	D/S Node ID	Length	Const. Base Grades/Leachate System			Final LF Grades		Depth of Fill		Settlement Depth		Final Leachate System w/ Settlement		
			U/S Invert	D/S Invert	Const. Slope	U/S Invert	D/S Invert	U/S Invert	D/S Invert	U/S Total S	D/S Total S	U/S Invert	D/S Invert	Final Slope
		(feet)	(feet)	(feet)	(%)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(%)
B	A	280	35.88	33.07	1.00	160.00	90.05	124.1	57.0	2.0	0.9	33.87	32.16	0.61
C	B	47	36.35	35.88	1.00	162.35	160.00	126.0	124.1	2.1	2.0	34.28	33.86	0.89
D	C	951	41.17	36.35	0.51	162.35	162.35	121.2	126.0	2.0	2.1	39.15	34.28	0.51

Settle3 Analysis Information

Victoria, TX Landfill

Project Settings

Document Name	20210712 Victoria Landfill
Project Title	Victoria, TX Landfill
Analysis	Landfill Settlement
Author	Textor
Company	Burns & McDonnell
Date Created	7/19/2021
Stress Computation Method	Boussinesq
Minimum settlement ratio for subgrade modulus	0.9
Use average properties to calculate layered stresses	
Improve consolidation accuracy	
Ignore negative effective stresses in settlement calculations	

Stage Settings

Stage #	Name
1	Stage 1

Loads

1. Rectangular Load: "Rectangular Load 5"

Length	700 ft
Width	102 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	71400 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
5809.35	3762.89	3.42
6509.35	3762.89	3.42
6509.35	3864.89	0
5809.35	3864.89	0

2. Rectangular Load: "Rectangular Load 6"

Length	700 ft
Width	280 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	196000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
5809.35	3482.89	7.44
6509.35	3482.89	7.44
6509.35	3762.89	3.42
5809.35	3762.89	3.42

3. Rectangular Load: "Rectangular Load 7"

Length	700 ft
Width	47 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	32900 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
5809.35	3435.89	7.56
6509.35	3435.89	7.56
6509.35	3482.89	7.44
5809.35	3482.89	7.44

4. Rectangular Load: "Rectangular Load 8"

Length	700 ft
Width	951 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	665700 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
5809.35	2484.89	7.27
6509.35	2484.89	7.27
6509.35	3435.89	7.56
5809.35	3435.89	7.56

5. Rectangular Load: "Rectangular Load 1"

Length	7000 ft
Width	62 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	434000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	1503.42	2.92
7008.42	1503.42	2.92
7008.42	1565.42	0
8.42	1565.42	0

6. Rectangular Load: "Rectangular Load 2"

Length	7000 ft
Width	219 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	1.533e+06 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	1284.42	6.74
7008.42	1284.42	6.74
7008.42	1503.42	2.92
8.42	1503.42	2.92

7. Rectangular Load: "Rectangular Load 3"

Length	7000 ft
Width	480 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	3.36e+06 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	804.419	8.32
7008.42	804.419	8.32
7008.42	1284.42	6.74
8.42	1284.42	6.74

8. Rectangular Load: "Rectangular Load 4"

Length	7000 ft
Width	364 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	2.548e+06 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	440.419	8.32
7008.42	440.419	8.32
7008.42	804.419	7.33
8.42	804.419	7.33

9. Rectangular Load: "Rectangular Load 9"

Length	7000 ft
Width	113 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	791000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	327.419	7.33
7008.42	327.419	7.33
7008.42	440.419	7.06
8.42	440.419	7.06

10. Rectangular Load: "Rectangular Load 10"

Length	7000 ft
Width	137 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	959000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	190.419	7.06
7008.42	190.419	7.06
7008.42	327.419	4.41
8.42	327.419	4.41

11. Rectangular Load: "Rectangular Load 11"

Length	7000 ft
Width	52 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	364000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	138.419	4.41
7008.42	138.419	4.41
7008.42	190.419	3.52
8.42	190.419	3.52

12. Rectangular Load: "Rectangular Load 12"

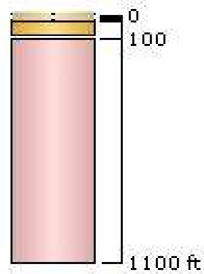
Length	7000 ft
Width	92 ft
Rotation angle	0 degrees
Load Type	Flexible
Area of Load	644000 ft2
Depth	0 ft
Installation Stage	Stage 1

Coordinates and Load

X [ft]	Y [ft]	Load Magnitude [ksf]
8.42	46.419	3.52
7008.42	46.419	3.52
7008.42	138.419	0
8.42	138.419	0

Soil Layers

Layer #	Type	Thickness [ft]	Depth [ft]
1	Fat Clay	0	0
2	Sandy Fat Clay	5	0
3	Clayey Sand	10	5
4	Sandy Fat Clay	10	15
5	Clayey Sand	0	25
6	Poorly Graded Sand	75	25
7	Deep Sand	1000	100



Soil Properties

Property	Fat Clay	Sandy Fat Clay	Clayey Sand	Poorly Graded Sand
Color				
Unit Weight [kips/ft3]	0.115	0.12	0.13	0.13
Saturated Unit Weight [kips/ft3]	0.115	0.12	0.13	0.13
K0	1	1	1	1
Immediate Settlement	Disabled	Disabled	Enabled	Enabled
Es [ksf]	-	-	1500	2000
Esur [ksf]	-	-	1500	2000
Primary Consolidation	Enabled	Enabled	Disabled	Disabled
Material Type	Non-Linear	Non-Linear		
Cc	0.194	0.25	-	-
Cr	0.02	0.024	-	-
e0	0.897	0.715	-	-
Pc [ksf]	6	4.6	-	-
Undrained Su A [kips/ft2]	0	0	0	0
Undrained Su S	0.2	0.2	0.2	0.2
Undrained Su m	0.8	0.8	0.8	0.8
Piezo Line ID	1	1	1	1

Property	Deep Sand
Color	
Unit Weight [kips/ft3]	0.13
Saturated Unit Weight [kips/ft3]	0.13
K0	1
Immediate Settlement	Enabled
Es [ksf]	4000
Esur [ksf]	4000
Undrained Su A [kips/ft2]	0
Undrained Su S	0.2
Undrained Su m	0.8
Piezo Line ID	1

Groundwater

Groundwater method	Piezometric Lines
Water Unit Weight	0.0624 kips/ft3

Piezometric Line Entities

ID	Depth (ft)
1	20 ft

Query Points

Point #	Query Point Name	(X,Y) Location	Number of Divisions
1	Query Point 1	6114.61, 3762.89	Auto
2	Query Point 2	6122.98, 3482.89	Auto
3	Query Point 3	6125.37, 3435.89	Auto
4	Query Point 4	6127.23, 2689.94	Auto
5	Query Point 5	3385.35, 1503.42	Auto
6	Query Point 6	3382.57, 1284.42	Auto
7	Query Point 7	3385.35, 804.419	Auto
8	Query Point 8	3388.13, 440.419	Auto
9	Query Point 9	3388.13, 327.419	Auto
10	Query Point 10	3385.35, 190.419	Auto
11	Query Point 11	3388.13, 138.419	Auto

Query Lines

Line #	Query Line Name	Start Location	End Location	Horizontal Divisions	Vertical Divisions
4	Query Line 4	6154.92, 3864.89	6154.92, 2484.89	20	Auto
5	Query Line 5	3498.73, 1565.42	3498.73, 46.419	20	Auto

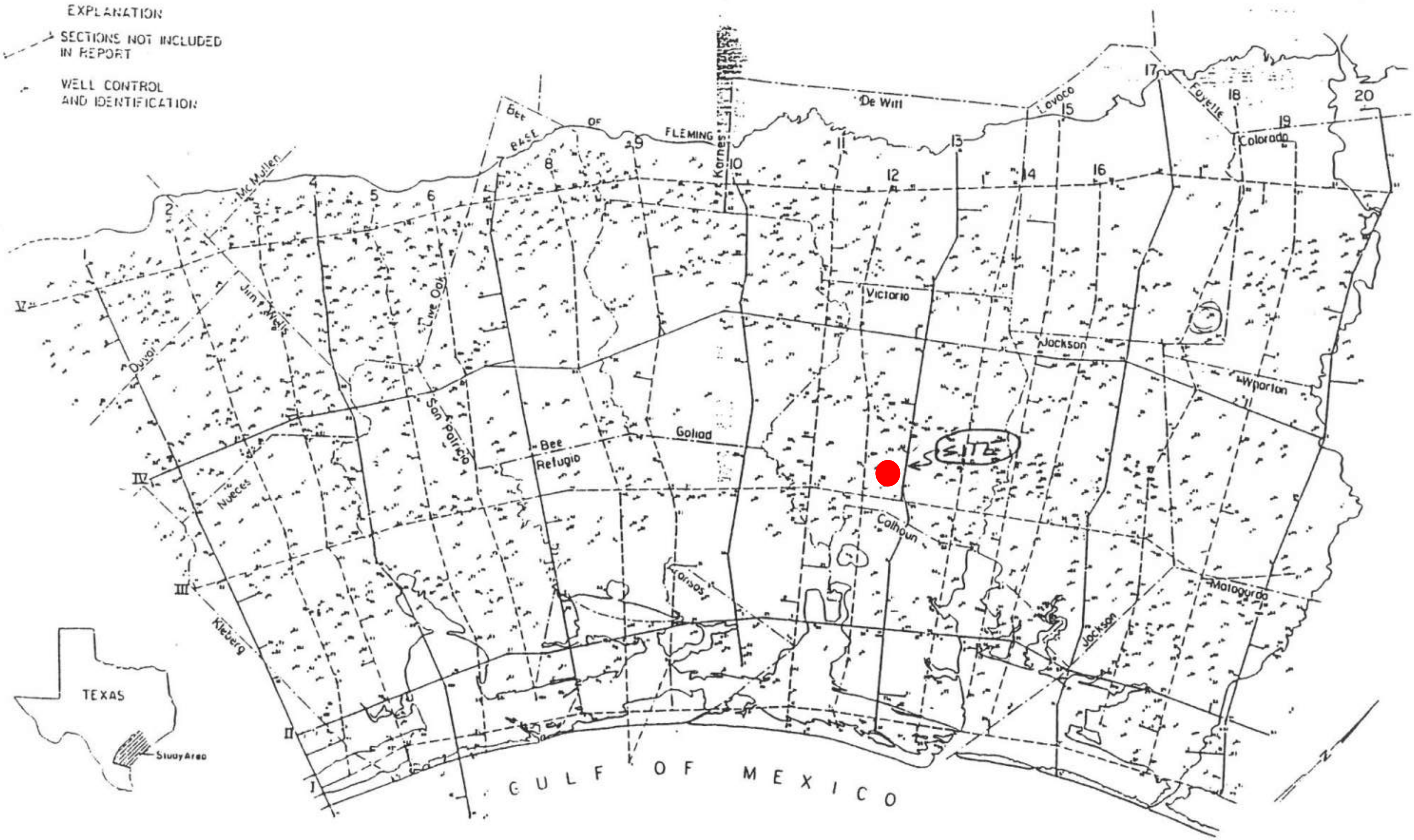


Figure 2 Well control and location of cross sections. For identification of wells on cross sections, see Appendix D. Names of other wells on file, Bureau of Economic Geology.

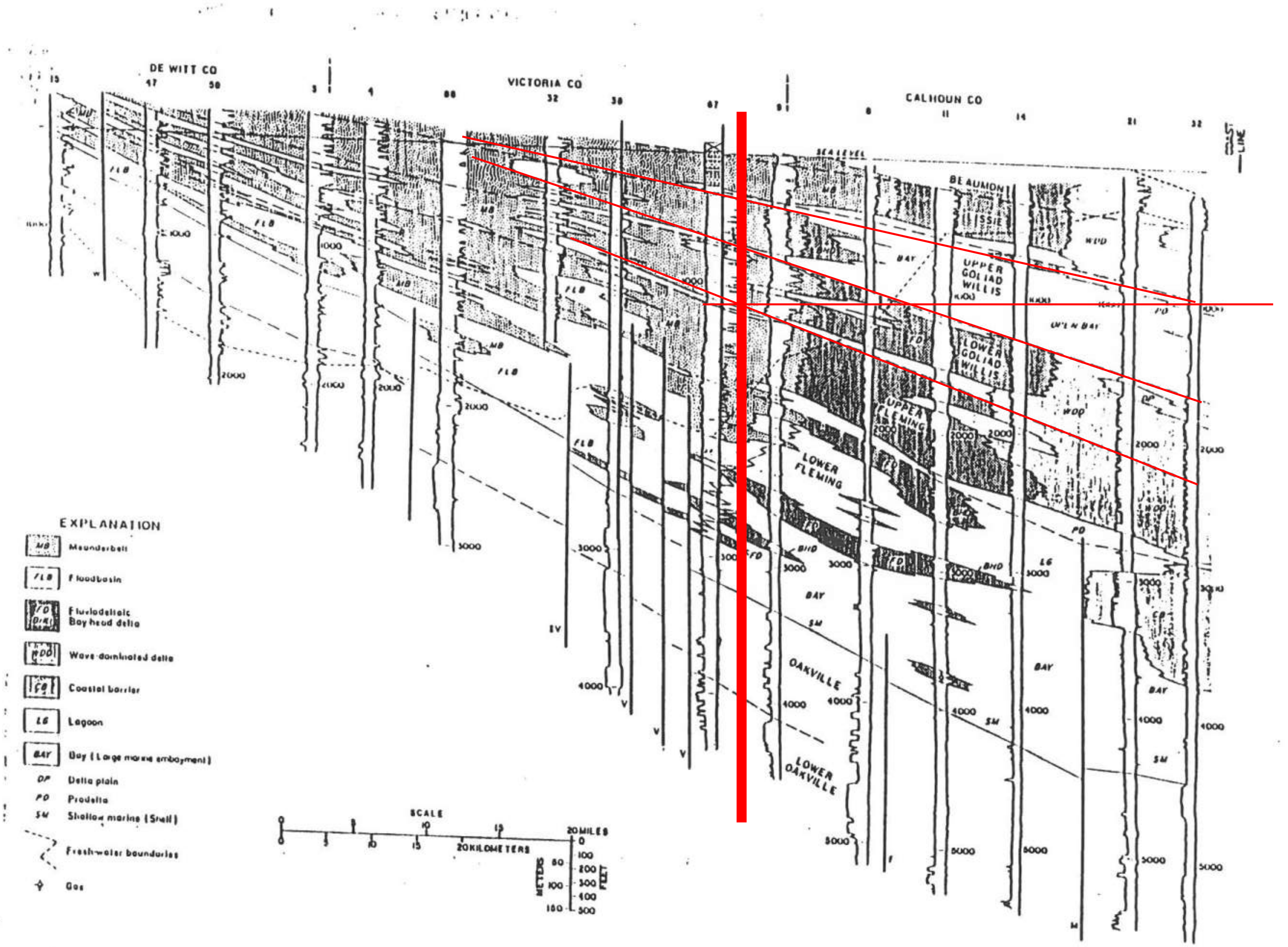


Figure 9. Dip cross section 13. Fault data courtesy of Geomap. See Appendix D for well names.

REPORT OF INVESTIGATIONS NO. 108
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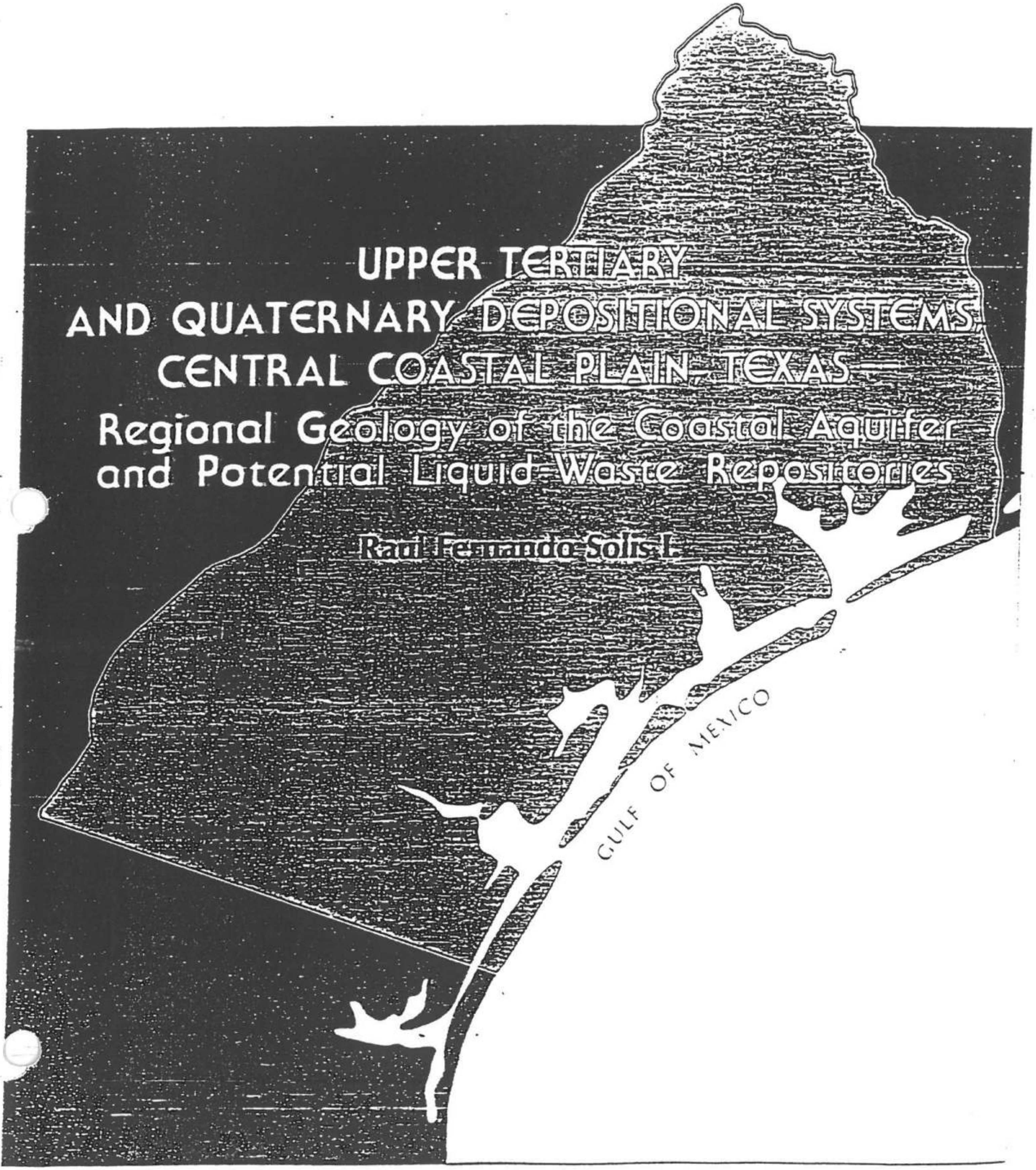
1981

UPPER TERTIARY AND QUATERNARY DEPOSITIONAL SYSTEMS CENTRAL COASTAL PLAIN, TEXAS—

Regional Geology of the Coastal Aquifer and Potential Liquid-Waste Repositories

Raul Fernando Solis I.



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Willis Formation

XML (/geology/state/xml/TXPOw;0)	JSON (/geology/state/json/TXPOw;0)

Willis Formation

State	Texas (/geology/state/state.php?state=TX)
Name	Willis Formation
Geologic age	Pliocene
Lithologic constituents	Major Unconsolidated > Fine-detrital *(Alluvial)* Unconsolidated > Coarse-detrital *(Alluvial)* Minor Unconsolidated > Coarse-detrital > Gravel *(Bed)*
Comments	Clay, silt, sand, siliceous granule to pebble gravel, some petrified wood; sand coarser than younger units, noncalcareous; deeply weathered, locally cemented by iron oxide; fluvitile; forms north-facing scarp. On Seguin Sheet (1974) thickness 100+- ft. On Austin 4 x 6-degree sheet (Moore and Wermund, 1993) unit consists of 1) channel facies--alluvial pebble gravel and sand, lt. gray to orange-brown, orange, gravelly coarse to fine sand which lenses of red, sandy silt and white to gray clay 10-60 m thick, pebbles mostly quartz, some chert and petrified wood, and 2) overbank facies--alluvial silt and clay made of brown, yellow, orange, fine silt and clay are intermixed and interbedded. 5-50+m thick.

References	Moore, D.W. and Wermund, E.G., Jr., 1993a, Quaternary geologic map of the Austin 4 x 6 degree quadrangle, United States: U.S. Geological Survey Miscellaneous Investigations Series Map I-1420 (NH-14), scale 1:1,000,000. https://pubs.er.usgs.gov/publication/i1420(NH14) (https://pubs.er.usgs.gov/publication/i1420(NH14))
	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000.
NGMDB product	NGMDB product page for 68390 (https://ngmdb.usgs.gov/Prodesc/proddesc_68390.htm)
Counties	Austin (/geology/state/fips-unit.php?code=f48015) - Bastrop (/geology/state/fips-unit.php?code=f48021) - Colorado (/geology/state/fips-unit.php?code=f48089) - DeWitt (/geology/state/fips-unit.php?code=f48123) - Fayette (/geology/state/fips-unit.php?code=f48149) - Gonzales (/geology/state/fips-unit.php?code=f48177) - Grimes (/geology/state/fips-unit.php?code=f48185) - Guadalupe (/geology/state/fips-unit.php?code=f48187) - Harris (/geology/state/fips-unit.php?code=f48201) - Hays (/geology/state/fips-unit.php?code=f48209) - Jasper (/geology/state/fips-unit.php?code=f48241) - Lavaca (/geology/state/fips-unit.php?code=f48285) - Liberty (/geology/state/fips-unit.php?code=f48291) - Montgomery (/geology/state/fips-unit.php?code=f48339) - Newton (/geology/state/fips-unit.php?code=f48351) - Polk (/geology/state/fips-unit.php?code=f48373) - Sabine (/geology/state/fips-unit.php?code=f48403) - San Jacinto (/geology/state/fips-unit.php?code=f48407) - Tyler (/geology/state/fips-unit.php?code=f48457) - Victoria (/geology/state/fips-unit.php?code=f48469) - Walker (/geology/state/fips-unit.php?code=f48471) - Waller (/geology/state/fips-unit.php?code=f48473) - Washington (/geology/state/fips-unit.php?code=f48477)

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/ Online Spatial Data (/) / Geology (/geology/) / by state (/geology/state/)
/ Texas (/geology/state/state.php?state=TX)

Fleming Formation

XML (/geology/state/xml/TXMIf;0) | JSON (/geology/state/json/TXMIf;0)

Fleming Formation

State	Texas (/geology/state/state.php?state=TX)
Name	Fleming Formation
Geologic age	Miocene
Lithologic constituents	Major Unconsolidated > Fine-detrital > Clay Sedimentary > Clastic > Sandstone
Comments	Clay and Sandstone. Clay, calcareous, forms brownish-black soil. Sandst. med. to coarse grained, calcar., thick bedded, some crossbedding. lt. yell-gray; weathers lt. gray to med. gray; reworked Cretaceous invertebrate fossils locally. Thickness 1200+- ft
References	Bureau of Economic Geology, 1974, Seguin Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1967, Palestine Sheet, Geologic Atlas of Texas, Bureau of Economic Geology, University of Texas at Austin, scale 1:250,000. Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000.
NGMDB product	NGMDB product page for 68390 (https://ngmdb.usgs.gov/Prodesc/proddesc_68390.htm)

Counties Austin (/geology/state/fips-unit.php?code=f48015) - Bee (/geology/state/fips-unit.php?code=f48025) - Colorado (/geology/state/fips-unit.php?code=f48089) - DeWitt (/geology/state/fips-unit.php?code=f48123) - Fayette (/geology/state/fips-unit.php?code=f48149) - Goliad (/geology/state/fips-unit.php?code=f48175) - Grimes (/geology/state/fips-unit.php?code=f48185) - Jasper (/geology/state/fips-unit.php?code=f48241) - Karnes (/geology/state/fips-unit.php?code=f48255) - Lavaca (/geology/state/fips-unit.php?code=f48285) - Liberty (/geology/state/fips-unit.php?code=f48291) - Montgomery (/geology/state/fips-unit.php?code=f48339) - Newton (/geology/state/fips-unit.php?code=f48351) - Polk (/geology/state/fips-unit.php?code=f48373) - San Jacinto (/geology/state/fips-unit.php?code=f48407) - Trinity (/geology/state/fips-unit.php?code=f48455) - Tyler (/geology/state/fips-unit.php?code=f48457) - Victoria (/geology/state/fips-unit.php?code=f48469) - Walker (/geology/state/fips-unit.php?code=f48471) - Waller (/geology/state/fips-unit.php?code=f48473) - Washington (/geology/state/fips-unit.php?code=f48477)

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Oakville Sandstone

XML (/geology/state/xml/TXMIo;0) | JSON (/geology/state/json/TXMIo;0)

Oakville Sandstone

State	Texas (/geology/state/state.php?state=TX)
Name	Oakville Sandstone
Geologic age	Miocene
Lithologic constituents	Major Unconsolidated > Fine-detrital > Clay Sedimentary > Clastic > Sandstone
Comments	Sandstone and clay. Sandst. med. grained, calcar., thick bedded, some crossbedding. fossil wood, chert, and quartz pebbles. vertebrate fossils and reworked Cretaceous invertebrate fossils. Clay, calcareous, yell-gray; forms cuesta of smoothly rounded hills. Thickness 200-500 ft
References	Bureau of Economic Geology, 1974, Seguin Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000.
NGMDB product	NGMDB product page for 68390 (https://ngmdb.usgs.gov/Prodesc/proddesc_68390.htm)

Counties	Bee (/geology/state/fips-unit.php?code=f48025) - Brazos (/geology/state/fips-unit.php?code=f48041) - DeWitt (/geology/state/fips-unit.php?code=f48123) - Fayette (/geology/state/fips-unit.php?code=f48149) - Gonzales (/geology/state/fips-unit.php?code=f48177) - Grimes (/geology/state/fips-unit.php?code=f48185) - Karnes (/geology/state/fips-unit.php?code=f48255) - Lavaca (/geology/state/fips-unit.php?code=f48285) - Washington (/geology/state/fips-unit.php?code=f48477)

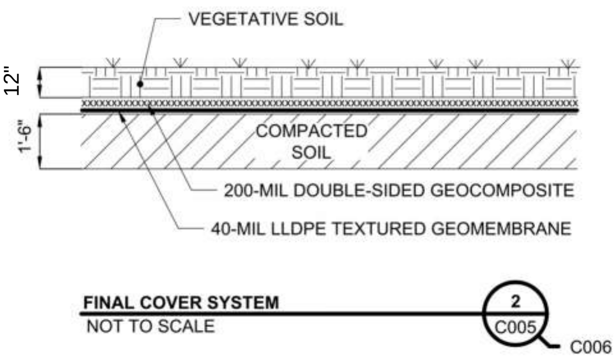
Attachment G – Cover Stability

Introduction

Previous calculations involving the mass stability of the planned Victoria, Texas MSW landfill were performed as part of the permitting process. Based on discussions with Texas DEQ, additional calculations were requested related to the final cover system, specifically for the planned stormwater ditches that will be constructed.

Cover System

The cover system is made up of the following system:



Based on this system including geosynthetics, the stability will be controlled by the strength along the interfaces of the controlling geosynthetic. The following interfaces will be evaluated:

- Vegetative soil (cohesive) – Geocomposite (Interface #1)
- Geocomposite – Textured Geomembrane (Interface #2)
- Textured Geomembrane – Compacted soil (cohesive) (Interface #3)

For the interface shear strengths of these geosynthetics interfaces, GRI Report #30 was reviewed. Based on this reference, the following interface shear strengths were used:

- Interface #1: Phi = 30 degrees, cohesion = 100 psf [peak]; phi = 21 degrees, cohesion = 0 psf [residual]
- Interface #2: Phi = 26 degrees, cohesion = 160 psf [peak]; phi = 17 degrees, cohesion = 190 psf [residual]
- Interface #3: Phi = 21 degrees, cohesion = 220 psf [peak]; phi = 13 degrees, cohesion = 140 psf [residual]

Final cover slope is 3H:1V and has crest and toe elevations of approximately 160 feet and 70 feet, respectively.

As noted, storm ditches are needed along the length of the cover system. These ditches will be spaced every 30 vertical feet along the cover system, with a total of approximately four. The ditch is made up of a triangular fill placed along the cover system that creates a 2 feet deep ditch. The interior and exterior slopes of the fill are 2H:1V. See below for storm ditch section:

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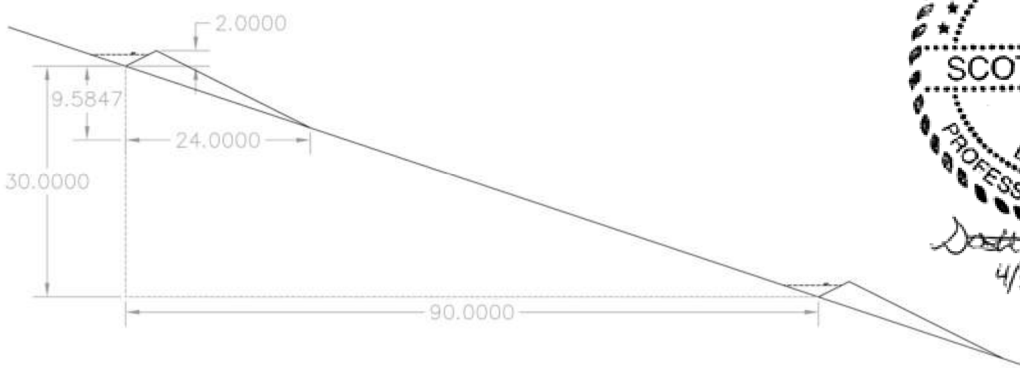
SCOTT MARTIN
120819
LICENSED PROFESSIONAL ENGINEER
Scott Martin
4/5/2022



Based on the use of geocomposite within the cover system and stormwater ditches as noted, it is assumed that no build-up of pore pressures within the cover system will occur.

Drawings are included in Attachment A. Interface shear strengths from GRI Report #30 are included in Attachment B.

<u>Cover Stability</u>
Previous calculations included evaluating the stability of the cover system by utilizing infinite slope calculations for a uniform thickness of soil. Based on the addition of the storm ditches and the driving force associated with them, further evaluations of the cover system are required.

Limit Equilibrium Method
An approach is put forth by Koerner and Daniel in *Final Covers for Solid Waste Landfills and Abandoned Dumps* that calculates the cover stability based on limit equilibrium, see below:

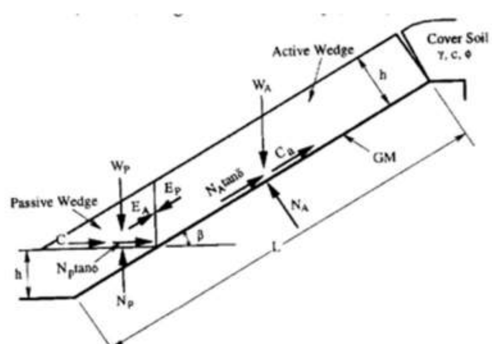


Figure 3. Limit equilibrium forces involved in a finite length slope analysis for a uniformly thick cover soil.

The symbols used in Figure 3 are defined below.

- W_A = total weight of the active wedge
- W_P = total weight of the passive wedge
- N_A = effective force normal to the failure plane of the active wedge
- N_P = effective force normal to the failure plane of the passive wedge
- γ = unit weight of the cover soil
- h = thickness of the cover soil
- L = length of slope measured along the geomembrane
- β = soil slope angle beneath the geomembrane
- ϕ = friction angle of the cover soil
- δ = interface friction angle between cover soil and geomembrane
- C_a = adhesive force between cover soil of the active wedge and the geomembrane
- c_a = adhesion between cover soil of the active wedge and the geomembrane
- C = cohesive force along the failure plane of the passive wedge
- c = cohesion of the cover soil
- E_A = interwedge force acting on the active wedge from the passive wedge
- E_P = interwedge force acting on the passive wedge from the active wedge
- FS = factor of safety against cover soil sliding on the geomembrane

Based on this method, stability along the interface of the cover system can be calculated based on the specific characteristics of the cover system.

This evaluation is meant to understand the effect of the stormwater ditches on the cover system stability. Further limit equilibrium calculation methods were considered. A further use of this approach is calculating the stability while accounting for equipment loads on the cover, see below:

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120819
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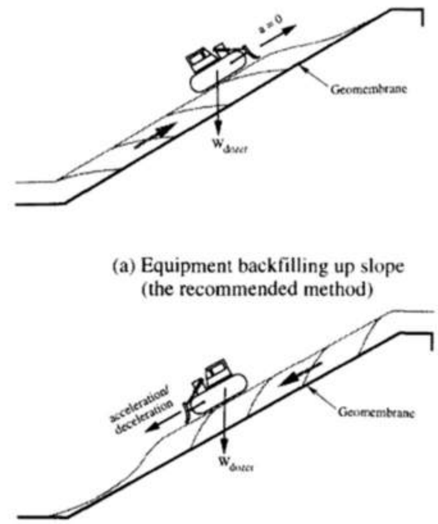
PROFESSIONAL ENGINEER
Scott Martin
4/5/2022



(a) Equipment backfilling up slope (the recommended method)

(b) Equipment backfilling down slope (method is not recommended)

Figure 5. Construction equipment placing cover soil on slopes containing geosynthetics.

For the uphill equipment situation, the weight of the construction equipment can be included in the calculations to understand the exact effect on the overall cover stability. The construction equipment is modeled as an additional vertical weight on the system. This same method can also be applied to stormwater ditches by modeling them as an additional vertical weight on the cover system.

The storm ditch fill volume is approximately 40.2 cubic feet per foot. Utilizing a unit weight of 120 pcf, the total weight of each storm ditch is approximately 5,000 pounds per foot, with total weight of four ditches of 20,000 pounds per foot over the full length of the slope.

Multiple slope lengths were evaluated to better understand the variation in calculated factors of safety depending on the assumptions in the calculations. The following cases were evaluated:

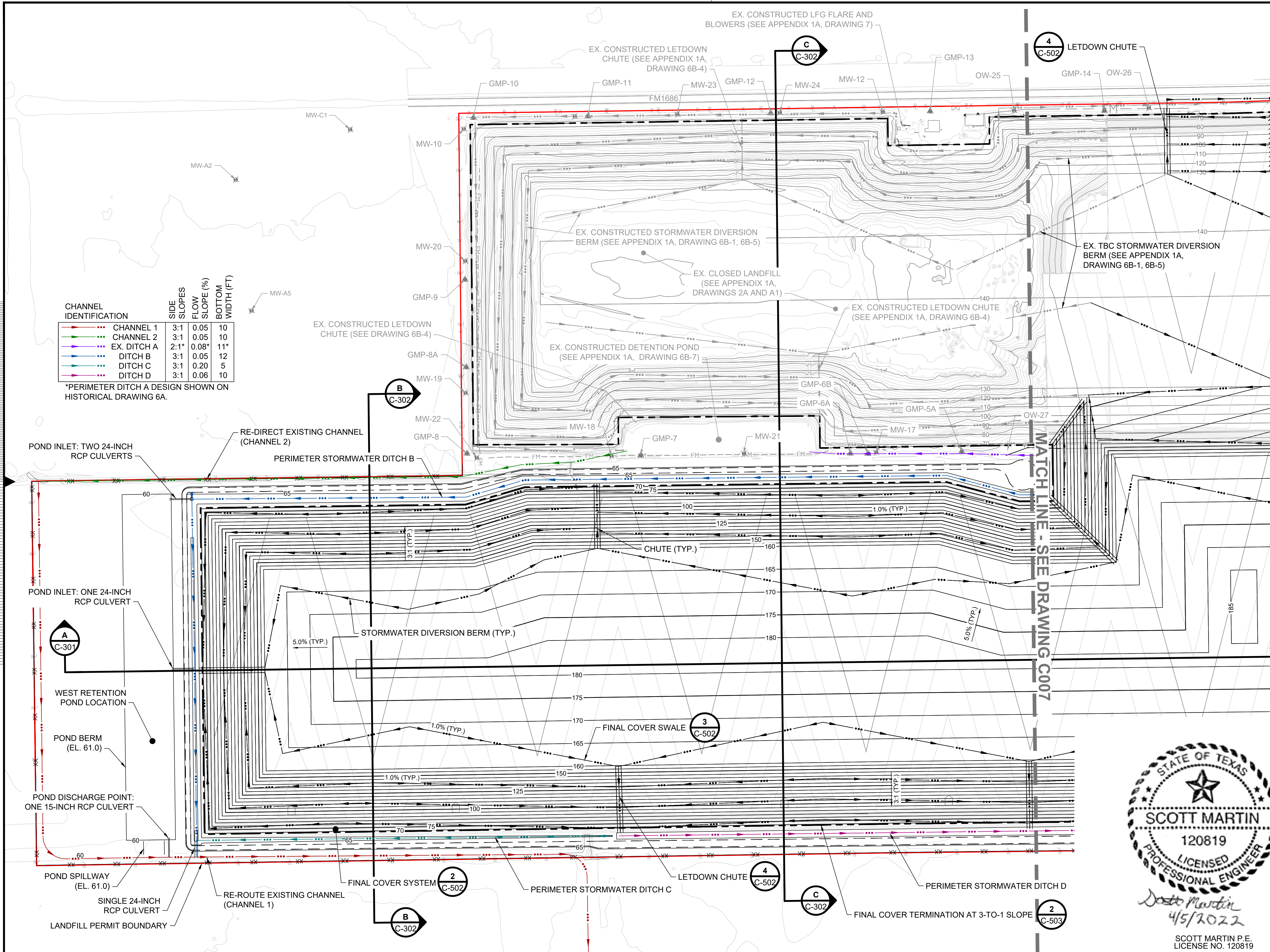
- Full length slope (284 feet), four stormwater ditches (20,000 pounds)
- Slope between stormwater ditches (95 feet), two stormwater ditches (10,000 pounds)
- Slope beneath stormwater ditch (25.3 feet), one stormwater ditch (5,000 pounds)

	L = 284 feet FoS	L = 95 feet FoS	L = 25.3 feet FoS
Interface #1	4.3	3.7	2.8
Interface #2	4.1	3.7	2.9
Interface #3	4.8	4.2	3.2

Based on these calculations, the cover system is considered stable with the addition of the stormwater ditches.

Spreadsheets showing limit equilibrium calculations are included in Attachment C. Hand calculations for one of the spreadsheets are included in Attachment D.

Attachment A – Related Drawings



CHANNEL IDENTIFICATION	SIDE SLOPES	FLOW SLOPE (%)	BOTTOM WIDTH (FT)
CHANNEL 1	3:1	0.05	10
CHANNEL 2	3:1	0.05	10
EX. DITCH A	2:1*	0.08*	11*
DITCH B	3:1	0.05	12
DITCH C	3:1	0.20	5
DITCH D	3:1	0.06	10

*PERIMETER DITCH A DESIGN SHOWN ON HISTORICAL DRAWING 6A.

no.	date	by	ckd	description
A	3/28/22	TJS	SAM	INITIAL SUBMITTAL

NOTES:

1. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER. DESIGN CONTOUR INTERVAL IS 5-FEET. BACKGROUND CONTOURS REPRESENT TOP OF SOIL LINER AND EXISTING GROUND (OUTSIDE OF TRENCHES 6-9, EASTERN PORTION OF TRENCH 5 AND CELLS A1-I2). BACKGROUND CONTOUR INTERVAL IS 2-FEET.

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9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
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date MARCH 2022 | detailed T. CAMMACK
designed T. SCHMIDT | checked S. MARTIN

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SCOTT MARTIN
120819
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FINAL GRADING PLAN - WEST

project 107608 | contract -

drawing C006 – rev. A

sheet 8 of 23 sheets

file 107608C006.dwg

no.	date	by	ckd	description
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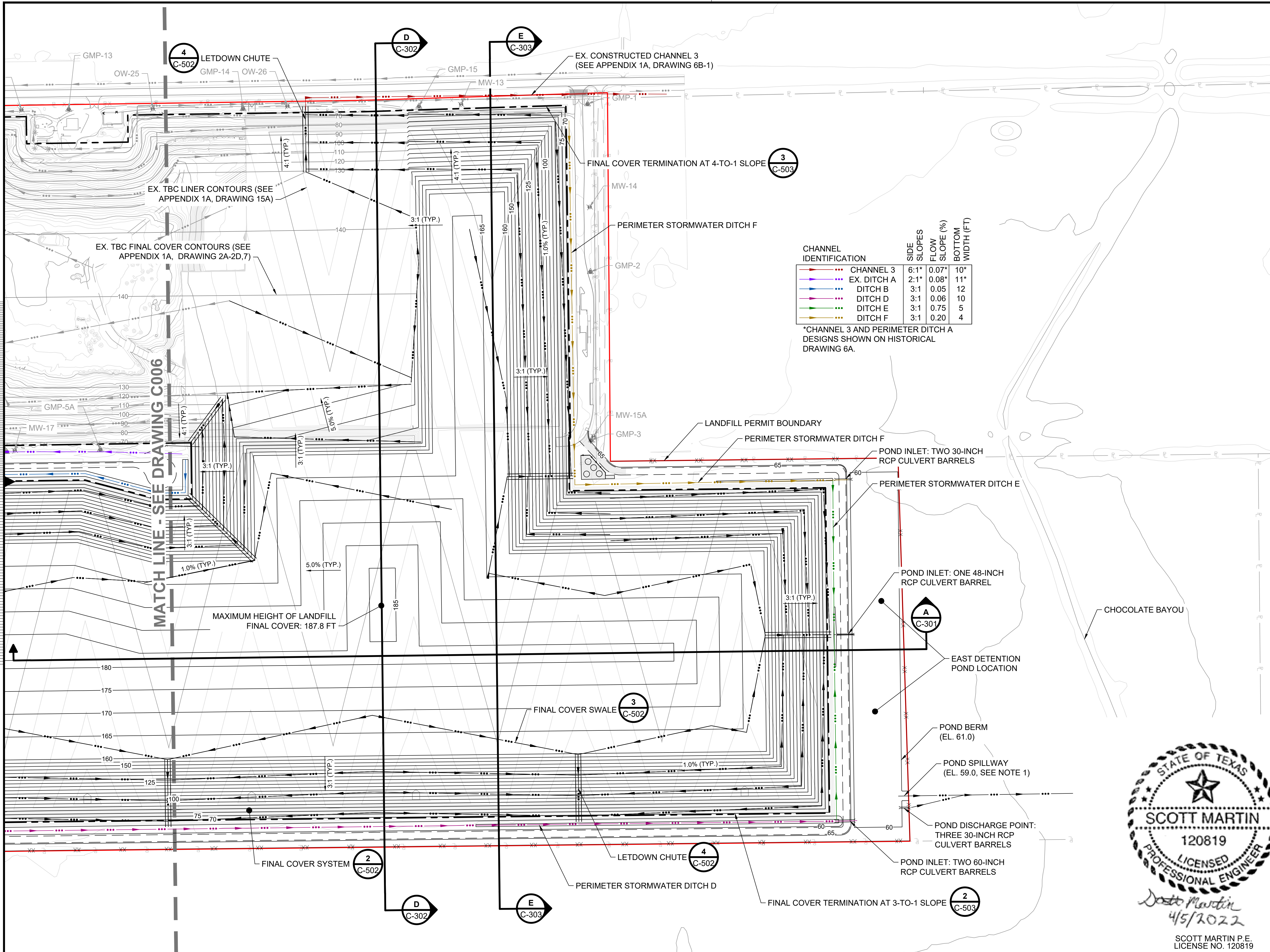

CHANNEL IDENTIFICATION	SIDE SLOPES	FLOW SLOPE (%)	BOTTOM WIDTH (FT)
CHANNEL 3	6:1*	0.07*	10*
EX. DITCH A	2:1*	0.08*	11*
DITCH B	3:1	0.05	12
DITCH D	3:1	0.06	10
DITCH E	3:1	0.75	5
DITCH F	3:1	0.20	4

*CHANNEL 3 AND PERIMETER DITCH A DESIGNS SHOWN ON HISTORICAL DRAWING 6A.

NOTES:

1. THE EAST POND DISCHARGES INTO AN EXISTING DITCH NOT SHOWN IN THE EXISTING TOPOGRAPHY.
2. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER. DESIGN CONTOUR INTERVAL IS 5-FEET. BACKGROUND CONTOURS REPRESENT TOP OF SOIL LINER AND EXISTING GROUND (OUTSIDE OF TRENCHES 6-9, EASTERN PORTION OF TRENCH 5 AND CELLS A1-I2). BACKGROUND CONTOUR INTERVAL IS 2-FEET.

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9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
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SCOTT MARTIN
120819
LICENSED PROFESSIONAL ENGINEER
Scott Martin 4/5/2022

SCOTT MARTIN P.E.
LICENSE NO. 120819

date	detailed
MARCH 2022	T. CAMMACK
designed	checked
T. SCHMIDT	S. MARTIN

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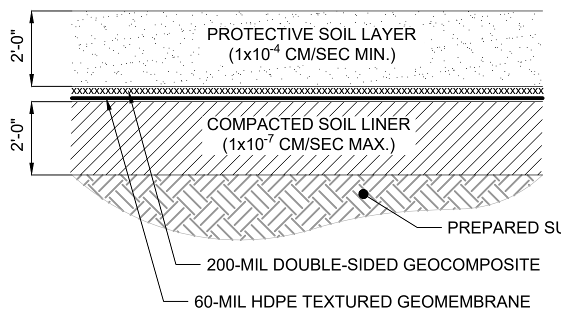
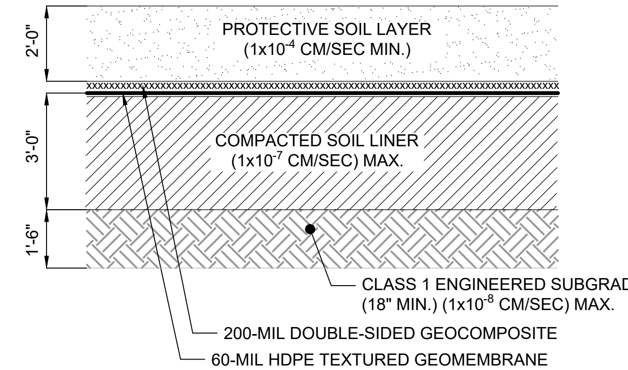
FINAL GRADING PLAN - EAST

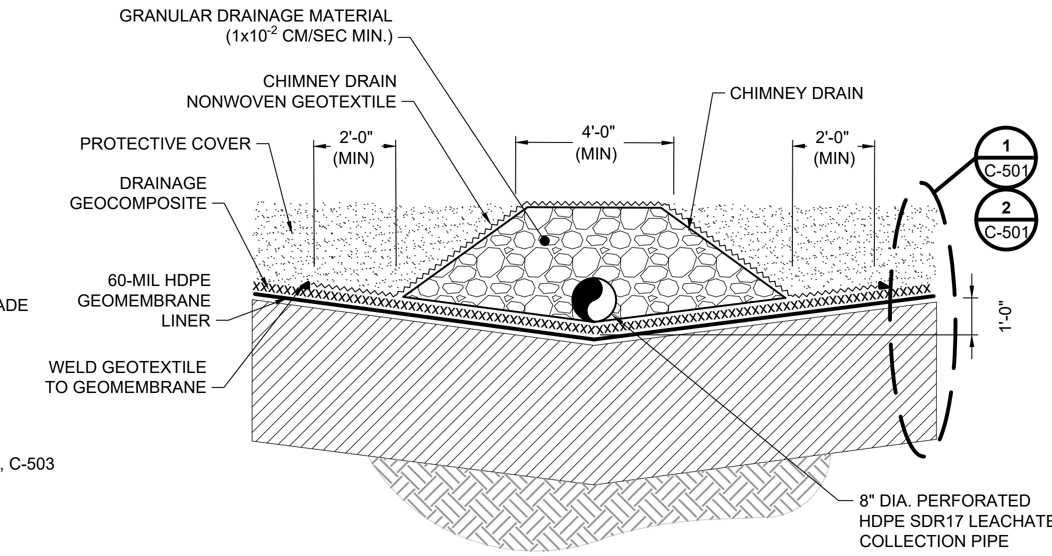
project 107608 | contract -
drawing C007 — rev. A
sheet 9 of 23 sheets
file 107608C007.dwg



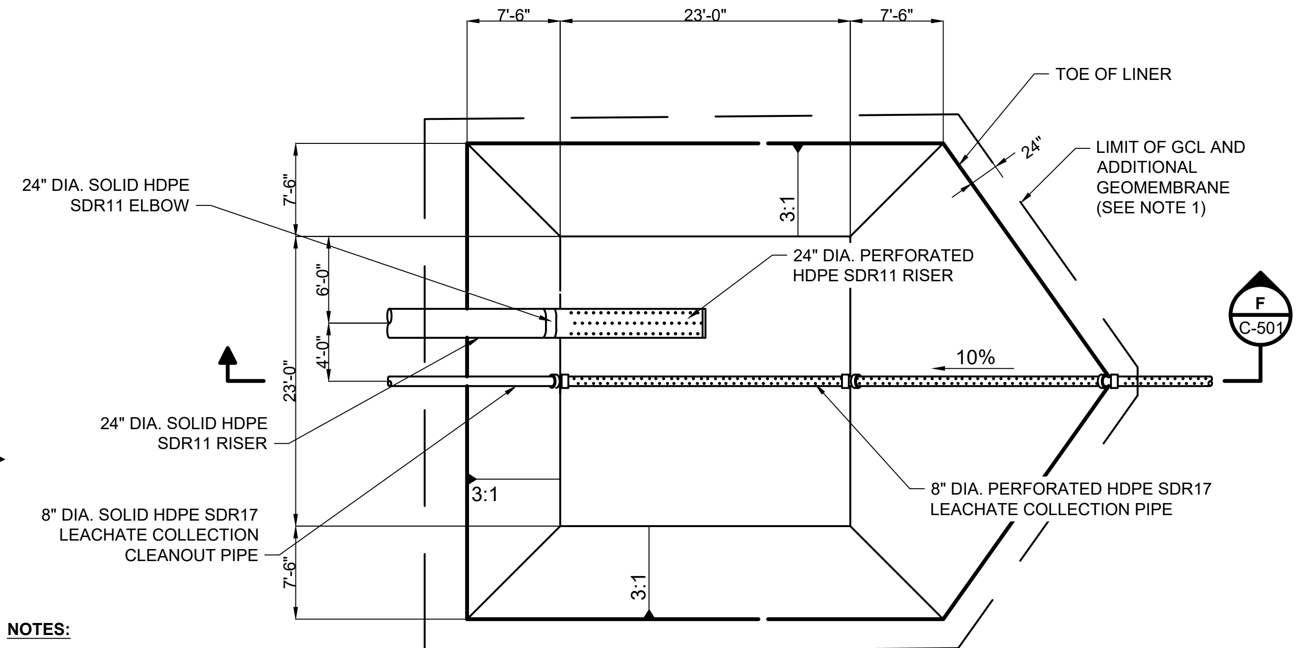
MSW LINER SYSTEM (1 / C004)
NOT TO SCALE
C005, C-501, C-503



CLASS 1 LINER SYSTEM (2 / C004)
NOT TO SCALE
C005, C-501, C-503



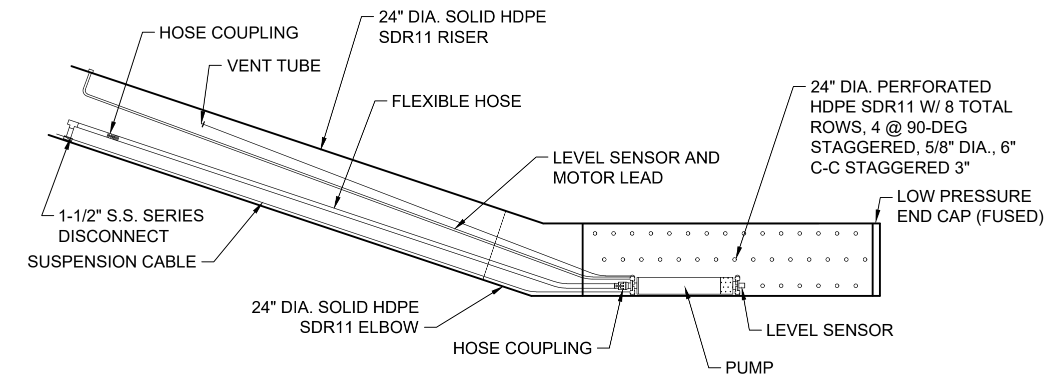
LEACHATE COLLECTION PIPE (3 / C004)
NOT TO SCALE
C005



NOTES:

1. GCL SHALL HAVE 6 NEEDLE-PUNCHED NON-WOVEN GEOTEXTILE FABRIC ON BOTH SIDES OR ENGINEER APPROVED EQUIVALENT.

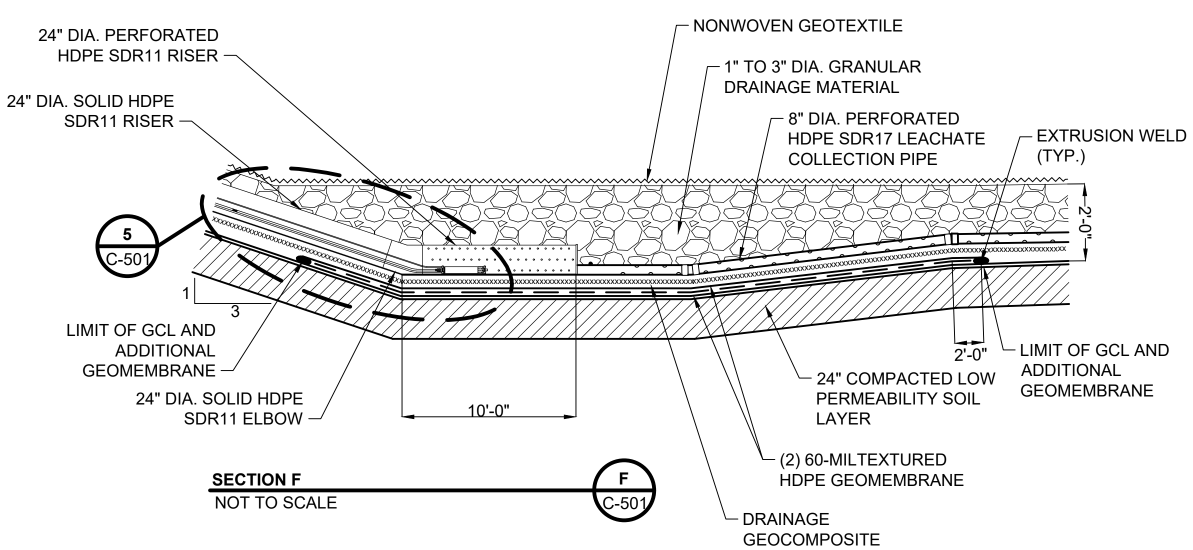
TYPICAL LEACHATE COLLECTION SUMP (4 / C004)
NOT TO SCALE
C005, C-302



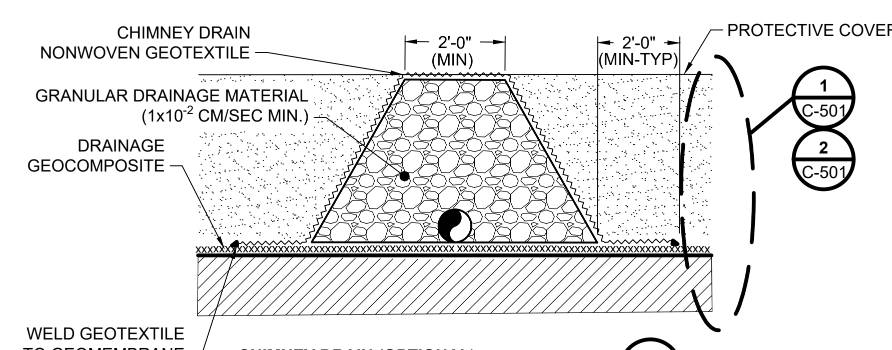
SUMP PUMP SCHEMATIC (5 / C-501)
NOT TO SCALE

ELEVATION TABLE: SOUTHERN EXPANSION AREA (CELLS A1 THROUGH I2)				
WASTE TYPE	EXCAVATION GRADE	TOP OF ENGINEERED SUBGRADE (CLASS 1 ONLY)	TOP OF COMPACTED SOIL LINER	TOP OF PROTECTIVE COVER/BASE OF WASTE PLACEMENT
MSW ONLY	36.5 FT AMSL	N/A	38.5 FT AMSL	43 FT AMSL
CLASS 1	34 FT AMSL	35.5 FT AMSL	38.5 FT AMSL	43 FT AMSL

ELEVATION TABLE: TRENCH 7/8			
WASTE TYPE	EXCAVATION GRADE	TOP OF COMPACTED SOIL LINER	TOP OF PROTECTIVE COVER/BASE OF WASTE PLACEMENT
MSW ONLY	31.1 FT AMSL	33.1 FT AMSL	37.6 FT AMSL



SECTION F (F / C-501)
NOT TO SCALE



CHIMNEY DRAIN (OPTIONAL) (6 / C-501)
NOT TO SCALE

NOTES:

1. NOTE: CHIMNEY DRAINS SHALL BE PLACED AT 200-FT INTERVALS.

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NOTE:

1. CHIMNEY DRAINS (AREAS OF HIGHER HYDRAULIC CONDUCTIVITY) WILL BE EMPLOYED AT A MAXIMUM SPACING OF EVERY 200-FT IF PROTECTIVE COVER PERMEABILITY IS LESS THAN $1x10^{-4}$ CM/SEC (SEE DETAIL 6).

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9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
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designed: T. SCHMIDT
checked: S. MARTIN

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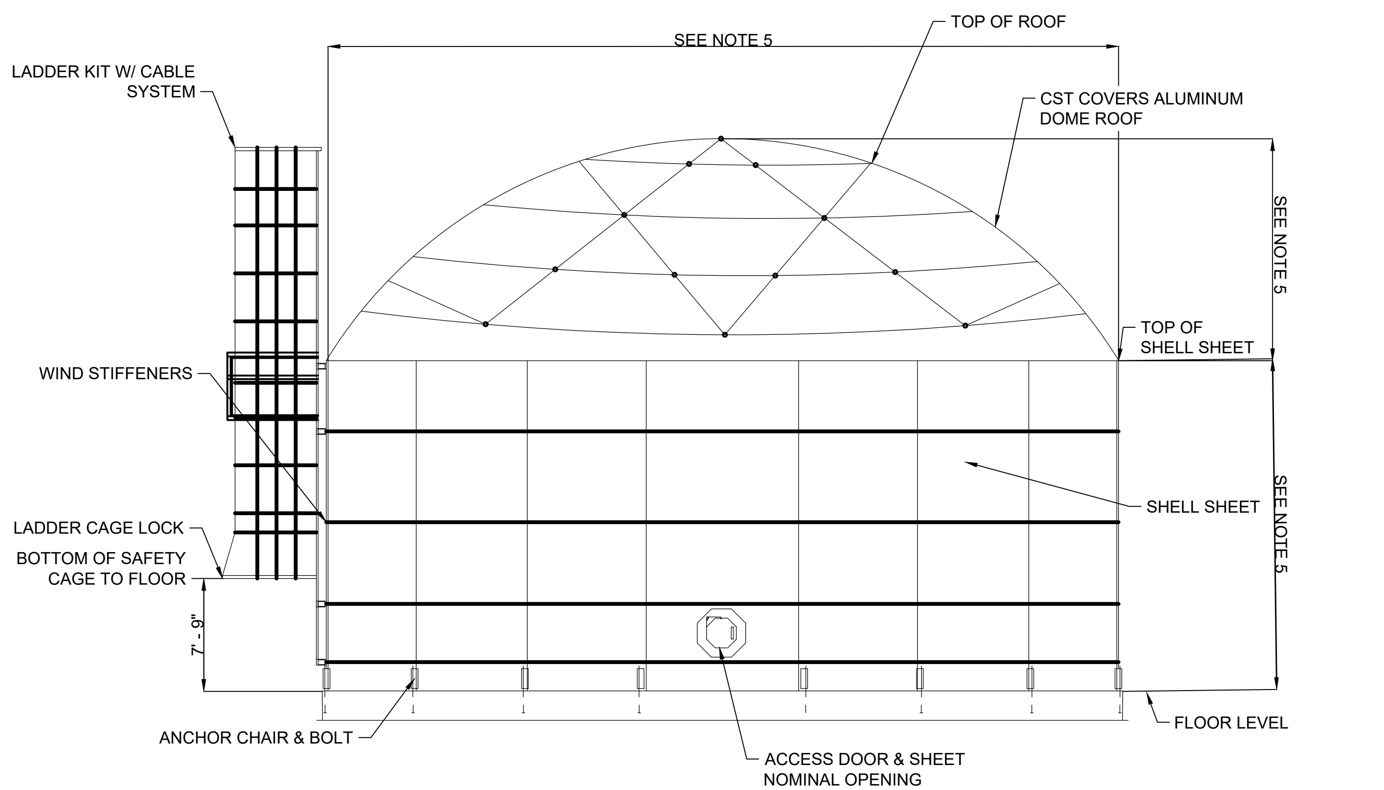
Victoria County, Texas

1522B PERMIT AMENDMENT

DETAIL SHEET 1

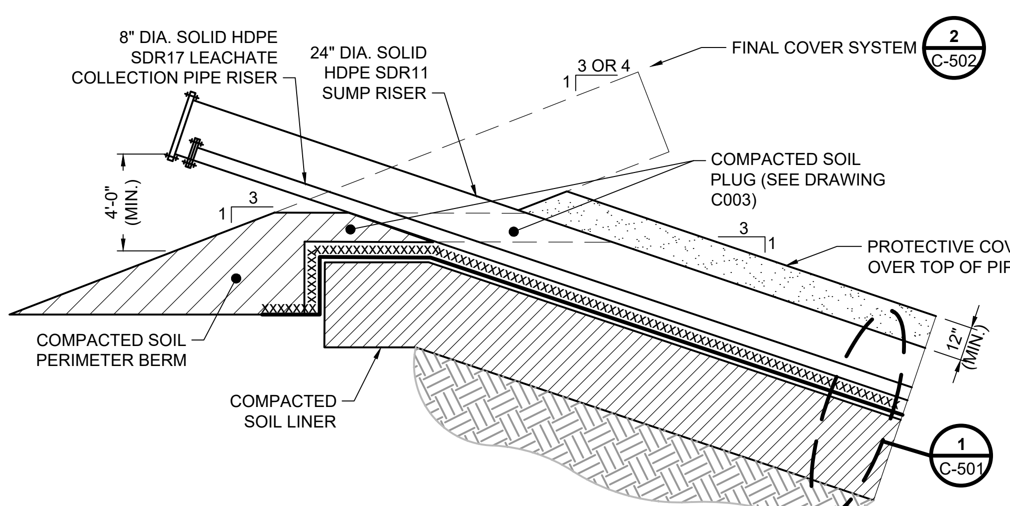
project: 107608
contract: -
drawing: C-501 – rev. A
sheet 17 of 23 sheets
file 107608C501.dwg



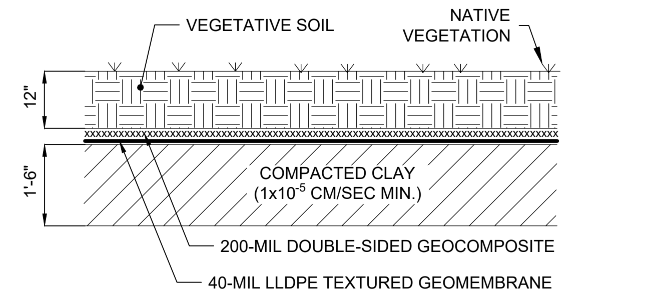
LEACHATE STORAGE TANK (1 / C005)
NOT TO SCALE

NOTES:

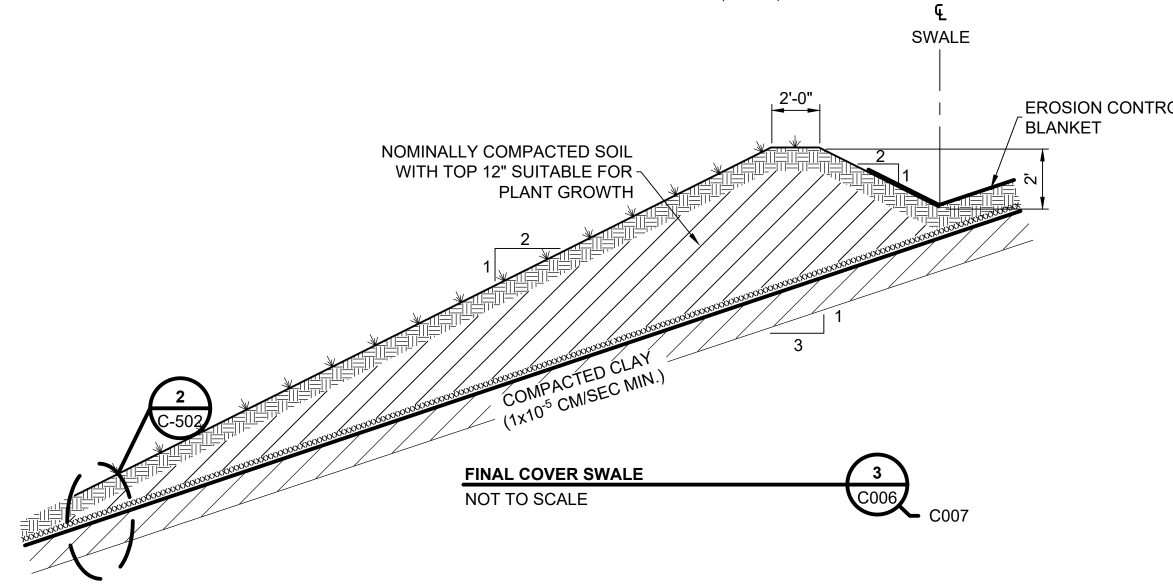
1. PANEL INTERIOR COATING IS WHITE GLASS 97 FUSED GLASS WITH EDGECOAT PROCESS.
2. PANEL EXTERIOR COATING IS FUSED GLASS.
3. FINAL DESIGN DIMENSIONS TO BE PROVIDED TO TCEQ AT DESIGN STAGES.
4. TANKS SHALL BE CAPABLE OF HOLDING 64,000 GALLONS OF LEACHATE.
5. TANK DIMENSIONS SHALL MATCH EXISTING CONSTRUCTED TANK DIMENSIONS, AS SHOWN IN DRAWING 15G-1B (OR EQUIVALENT).
6. THE SECONDARY CONTAINMENT FACILITIES ASSOCIATED WITH THE LEACHATE STORAGE TANKS THAT WILL BE INSTALLED WILL BE DESIGNED TO PREVENT RUN-ON FROM THE 100-YEAR, 24-HOUR STORM EVENT.
7. LEACHATE STORAGE TANK SECONDARY CONTAINMENT WILL BE MAINTAINED AND OPERATED TO MANAGE STORMWATER FROM THE 25-YEAR, 24-HOUR STORM EVENT.



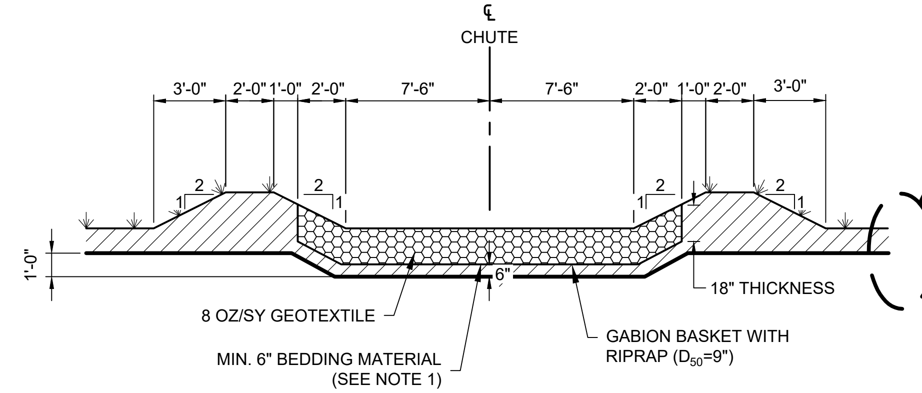
LEACHATE PIPE RISER AND CLEANOUT (5 / C004) C005
NOT TO SCALE



FINAL COVER SYSTEM (2 / C006) C007, C-502, C-503
NOT TO SCALE



FINAL COVER SWALE (3 / C006) C007
NOT TO SCALE



LETDOWN CHUTE (4 / C006) C007

NOTES:

1. BEDDING MATERIAL WILL CONSIST OF CLAYEY SOILS OVERLAIN BY 8 OZ/SY GEOTEXTILE PRIOR TO PLACEMENT OF GABIONS.
2. CHANNEL ARMORING SHALL BE INCISED INTO FINAL COVER. TOP OF ARMORING SHALL MATCH FINAL GRADE ELEVATION AT ALL TERMINATION EDGES. EROSION CONTROL BLANKET IN TERRACE SHALL OVERLAP A MINIMUM OF 1 FOOT AT CONFLUENCE OF TERRACE AND ARMORING.
3. LINER ELEVATIONS SHALL BE LOWERED AS SHOWN TO ACCOUNT FOR 18" GABION BASKET AND BEDDING MATERIAL.
4. GABION KEYWAYS SHALL BE INSTALLED ALONG THE WIDTH OF THE CHUTE AT EVERY TERRACE INTERSECTION. DIMENSIONS SHALL BE 3' THICK X 3' DEEP. FINAL COVER GEOMEMBRANE ELEVATIONS SHALL BE LOWERED IN THESE LOCATIONS TO ACCOUNT FOR ADDITIONAL GABION DEPTH.

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KANSAS CITY, MO 64114
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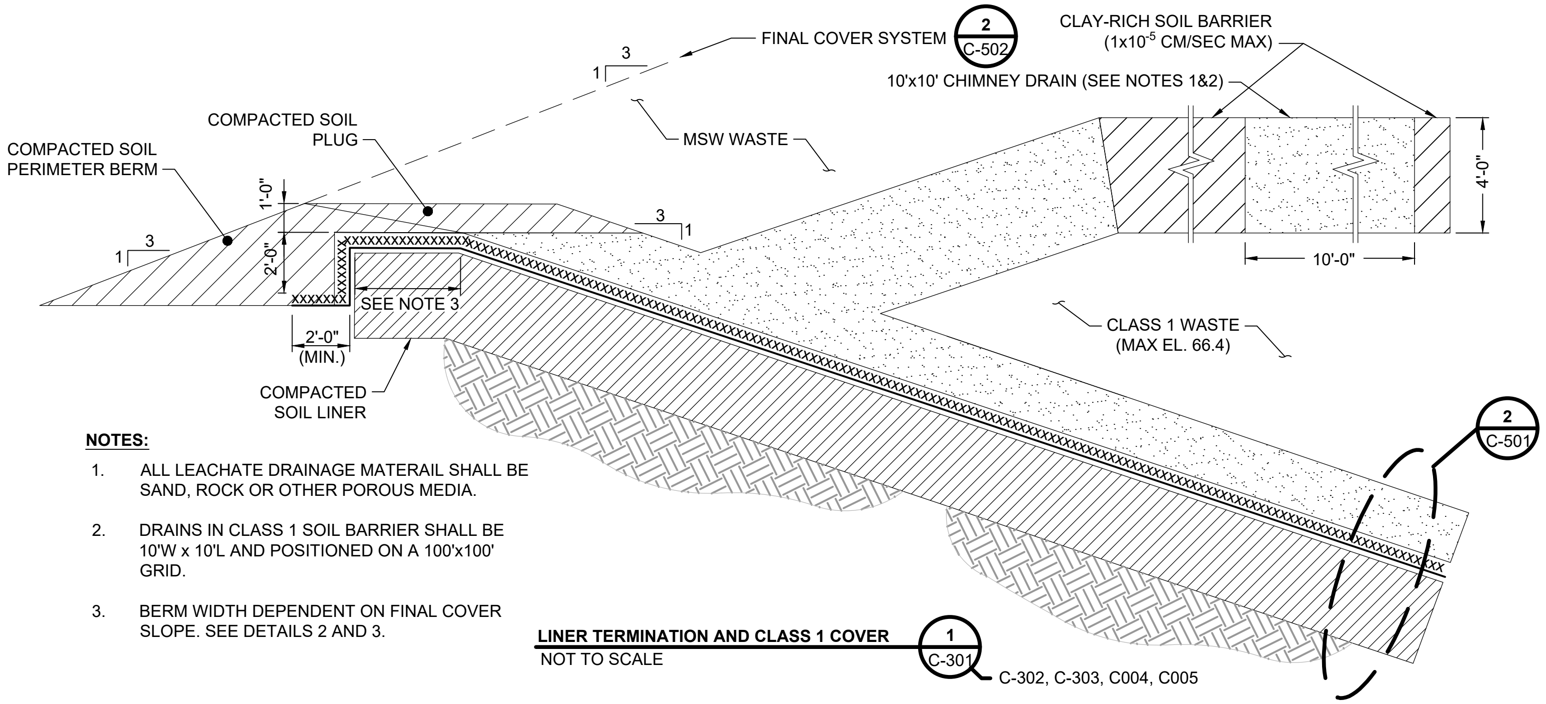
DETAIL SHEET 2

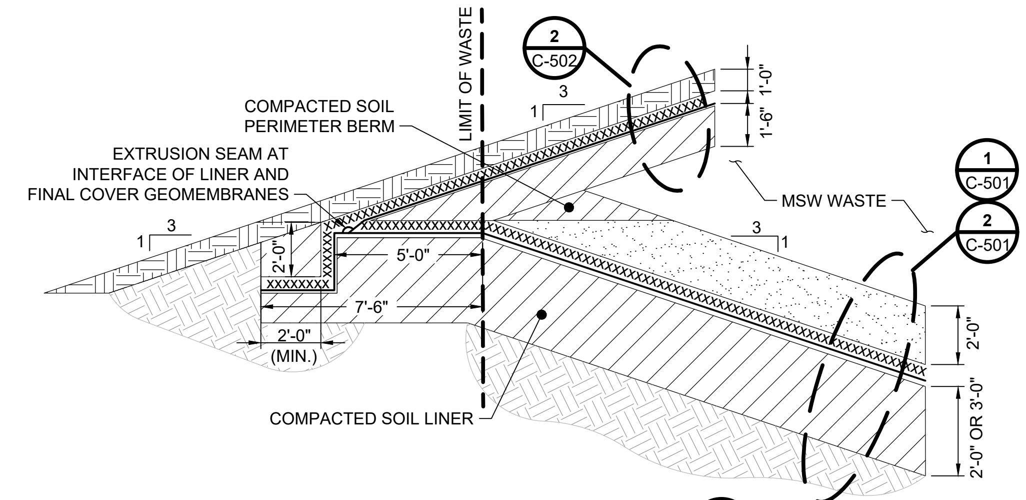
project: 107608 | contract: -
drawing: **C-502** rev. **A**
sheet 18 of 23 sheets
file 107608C502.dwg



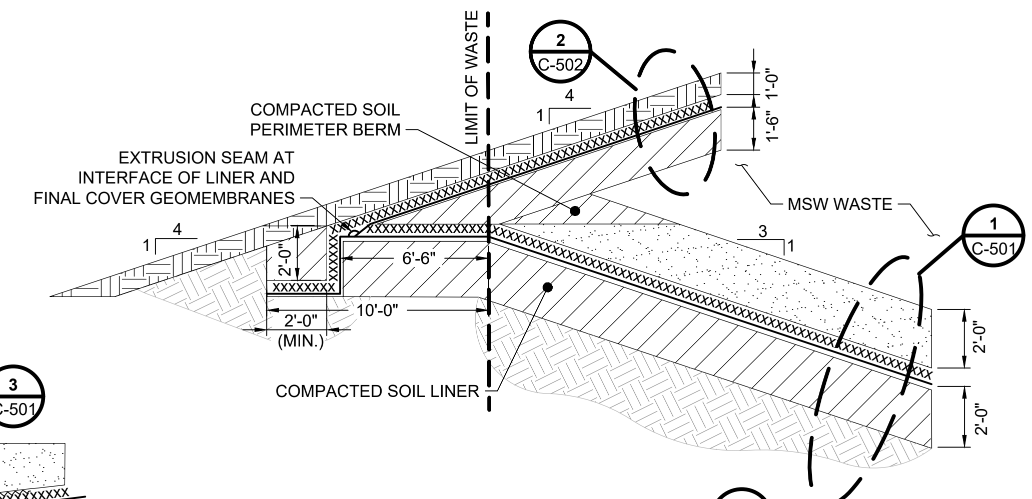
NOTES:

1. ALL LEACHATE DRAINAGE MATERAIL SHALL BE SAND, ROCK OR OTHER POROUS MEDIA.
2. DRAINS IN CLASS 1 SOIL BARRIER SHALL BE 10'W x 10'L AND POSITIONED ON A 100'x100' GRID.
3. BERM WIDTH DEPENDENT ON FINAL COVER SLOPE. SEE DETAILS 2 AND 3.

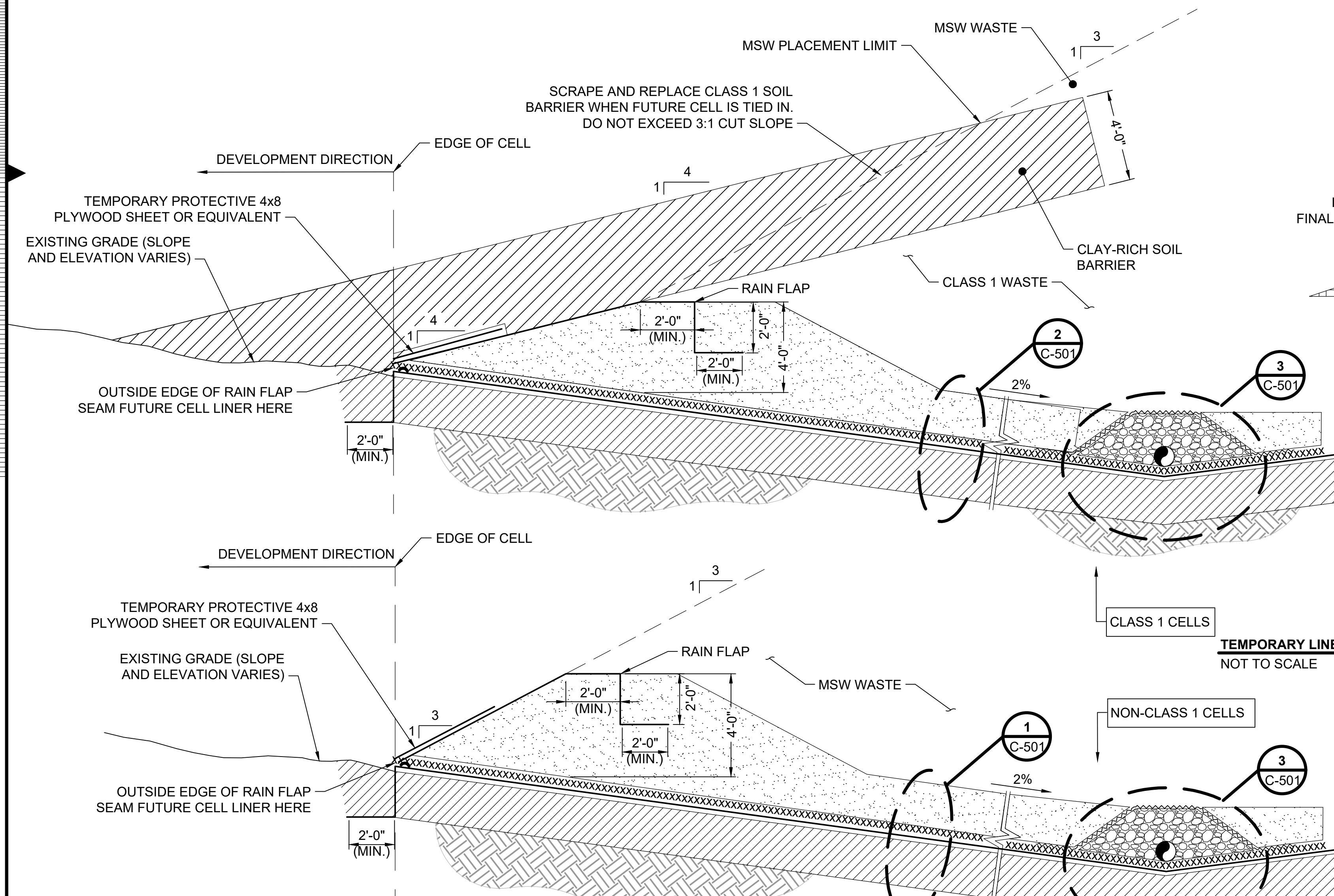
LINER TERMINATION AND CLASS 1 COVER 1 C-301
NOT TO SCALE
C-302, C-303, C004, C005



FINAL COVER TERMINATION AT 3-TO-1 SLOPE 2 C-301
NOT TO SCALE
C-302, C-303, C004, C005



FINAL COVER TERMINATION AT 4-TO-1 SLOPE 3 C-301
NOT TO SCALE
C-302, C-303, C004, C005



TEMPORARY LINER TERMINATION 4 C-301
NOT TO SCALE
C-302, C-303

no.	date	by	ckd	description
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816-333-9400
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Scott Martin
4/5/2022
SCOTT MARTIN P.E.
LICENSE NO. 120819

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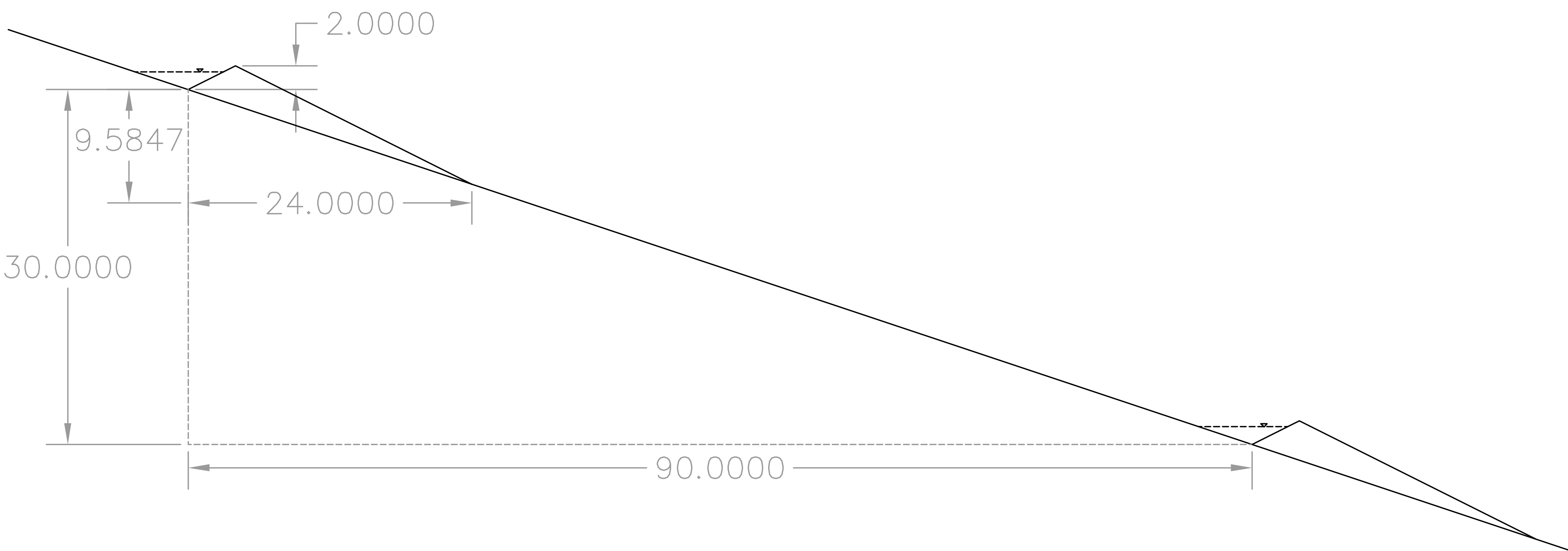
1522B PERMIT AMENDMENT
DETAIL SHEET 3

project: 107608 | contract: -
drawing: C-503 – rev. A
sheet 19 of 23 sheets
file 107608C503.dwg


2.0000
9.5847
24.0000
30.0000
90.0000

Attachment B – GRI Report #30 Excerpt

Appendix Table 1. Summary of interface shear strengths.

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
HDPE-S	Granular Soil	1a	21	0	162	0.93	1b	17	0	128	0.92
HDPE-S	Cohesive Soil										
	Saturated	1c	11	7	79	0.94	1d	11	0	59	0.95
	Unsaturated	1c	22	0	44	0.93	1d	18	0	32	0.93
HDPE-S	NW-NP GT	1e	11	0	149	0.93	1f	9	0	82	0.96
HDPE-S	Geonet	1g	11	0	196	0.90	1h	9	0	118	0.93
HDPE-S	Geocomposite	1i	15	0	36	0.97	1j	12	0	30	0.93
HDPE-T	Granular Soil	2a	34	0	251	0.98	2b	31	0	239	0.96
HDPE-T	Cohesive Soil										
	Saturated	2c	18	10	167	0.93	2d	16	0	150	0.90
	Unsaturated	2c	19	23	62	0.91	2d	22	0	35	0.93
HDPE-T	NW-NP GT	2e	25	8	254	0.96	2f	17	0	217	0.95
HDPE-T	Geonet	2g	13	0	31	0.99	2h	10	0	27	0.99
HDPE-T	Geocomposite	2i	26	0	168	0.95	2j	15	0	164	0.94
LLDPE-S	Granular Soil	3a	27	0	6	1.00	3b	24	0	9	1.00
LLDPE-S	Cohesive Soil	3c	11	12.4	12	0.94	3d	12	3.7	9	0.93
LLDPE-S	NW-NP GT	3e	10	0	23	0.63	3f	9	0	23	0.49
LLDPE-S	Geonet	3g	11	0	9	0.99	3h	10	0	9	1.00
LLDPE-T	Granular Soil	4a	26	7.7	12	0.95	4b	25	5.2	12	0.95
LLDPE-T	Cohesive Soil	4c	21	5.8	12	1.00	4d	13	7.0	9	0.98
LLDPE-T	NW-NP GT	4e	26	8.1	9	1.00	4f	17	9.5	9	0.96
LLDPE-T	Geonet	4g	15	3.6	6	0.97	4h	11	0	6	0.98
PVC-S	Granular Soil	5a	26	0.4	6	0.99	5b	19	0	6	0.99
PVC-S	Cohesive Soil	5c	22	0.9	11	0.88	5d	15	0	9	0.95
PVC-S	NW-NP GT	5e	20	0	89	0.91	5f	16	0	83	0.74
PVC-S	NW-HB GT	5g	18	0	3	1.00	5h	12	0.1	3	1.00
PVC-S	Woven GT	5i	17	0	6	0.54	5j	7	0	6	0.93
PVC-S	Geonet	5k	18	0.1	3	1.00	5l	16	0.6	3	1.00

Appendix Table 1. (continued)

Interface 1*	Interface 2*	Peak Strength					Residual Strength				
		Fig. No.	δ (deg)	Ca (kPa)	Points	R^2	Fig. No.	δ (deg)	Ca (kPa)	Points	R^2
PVC-F	NW-NP GT	6a	27	0.2	26	0.95	6b	23	0	26	0.95
PVC-F	NW-HB GT	6c	30	0	8	0.97	6d	27	0	8	0.90
PVC-F	Woven GT	6e	15	0	6	0.78	6f	10	0	6	0.76
PVC-F	Geonet	6g	25	0	11	1.00	6h	19	0	11	0.99
PVC-F	Geocomposite	6i	27	1.1	5	1.00	6j	22	4.7	6	1.00
CSPE-R	Granular Soil	7a	36	0	3	1.00	7b	16	0	3	1.00
CSPE-R	Cohesive Soil	7c	31	5.7	6	0.71	7d	18	0	6	0.99
CSPE-R	NW-NP GT	7e	14	0	6	0.97	7f	10	0	6	0.98
CSPE-R	NW-HB GT	7g	21	0	3	1.00	7h	10	0	3	1.00
CSPE-R	Woven GT	7i	11	0	6	0.92	7j	11	0	3	1.00
CSPE-R	Geonet	7k	28	0	9	0.87	7l	16	0	9	0.80
NW-NP GT	Granular Soil	8a	33	0	290	0.97	8b	33	0	117	0.96
NW-HB GT	Granular Soil	8c	28	0	6	0.99	8d	16	0	6	0.91
Woven GT	Granular Soil	8e	32	0	81	0.99	8f	29	0	28	0.98
NW-NP GT	Cohesive Soil	9a	30	5	79	0.96	9b	21	0	28	0.79
NW-HB GT	Cohesive Soil	9c	29	0.9	15	0.71	9d	10	0	15	0.83
Woven GT	Cohesive Soil	9e	29	0	34	0.94	9f	19	0	16	0.86
GCL Reinforced (internal)	N/A	10a	16	38	406	0.85	10b	6	12	182	0.91
GCL (NW-NP GT)	HDPE-T	11a	23	8	180	0.95	11b	13	0	157	0.90
GCL (W-SF GT)	HDPE-T	11c	18	11	196	0.96	11d	12	0	153	0.92
Geonet	NW-NP GT	12a	23	0	52	0.97	12b	16	0	32	0.97
Geocomposite (NW-NP GT)	Granular Soil	13a	27	14	14	0.86	13b	21	8	10	0.92

Geosynthetic Research Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces

by

George R. Koerner, Ph.D., P.E.
Geosynthetic Research Institute
Folsom, PA 19033-1208
gkoerner@dca.net

and

Dhani Narejo, Ph.D.
GSE Lining Technology, Inc.
Houston, TX 77073
dnarejo@gseworld.com

GRI Report #30

June 14, 2005

Attachment C – Calculation Spreadsheets

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	284	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	200	Interface cohesion (psf)
Phi (inter)	18	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	20000	Weight of stormwater ditch (lbs)
Wa	53680.4	
Na	50927.2	
Ca	56167.4	
Wp	200.0	
C	0.0	
a	5090.1	
b	-21809.4	
c	0.0	
FS	4.3	

Slope length = 284 feet
Four (4) Stormwater Ditches (20,000 lbs)
Cover Soil-Geocomposite Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	284	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	160	Interface cohesion (psf)
Phi (inter)	26	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	20000	Weight of stormwater ditch (lbs)
Wa	53680.4	
Na	50927.2	
Ca	44933.9	
Wp	200.0	
C	0.0	
a	5090.1	
b	-20927.0	
c	0.0	
FS	4.1	

Slope length = 284 feet
Four (4) Stormwater Ditches (20,000 lbs)
Geocomposite-Geomembrane Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	284	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	220	Interface cohesion (psf)
Phi (inter)	21	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	20000	Weight of stormwater ditch (lbs)
Wa	53680.4	
Na	50927.2	
Ca	61784.1	
Wp	200.0	
C	0.0	
a	5090.1	
b	-24394.4	
c	0.0	
FS	4.8	

Slope length = 284 feet
Four (4) Stormwater Ditches (20,000 lbs)
Geomembrane-Cohesive Soil Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	95	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	200	Interface cohesion (psf)
Phi (inter)	18	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	10000	Weight of stormwater ditch (lbs)
Wa	21000.4	
Na	19923.3	
Ca	18367.4	
Wp	200.0	
C	0.0	
a	1991.3	
b	-7450.5	
c	0.0	
FS	3.7	

Slope length = 95 feet
Two (2) Stormwater Ditches (10,000 lbs)
Cover Soil-Geocomposite Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	95	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	160	Interface cohesion (psf)
Phi (inter)	26	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	10000	Weight of stormwater ditch (lbs)
Wa	21000.4	
Na	19923.3	
Ca	14693.9	
Wp	200.0	
C	0.0	
a	1991.3	
b	-7321.7	
c	0.0	
FS	3.7	

Slope length = 95 feet
Two (2) Stormwater Ditches (10,000 lbs)
Geocomposite-Geomembrane Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	95	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	220	Interface cohesion (psf)
Phi (inter)	21	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	10000	Weight of stormwater ditch (lbs)
Wa	21000.4	
Na	19923.3	
Ca	20204.1	
Wp	200.0	
C	0.0	
a	1991.3	
b	-8353.7	
c	0.0	
FS	4.2	

Slope length = 95 feet
Two (2) Stormwater Ditches (10,000 lbs)
Geomembrane-Cohesive Soil Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	25.3	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	200	Interface cohesion (psf)
Phi (inter)	18	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	5000	Weight of stormwater ditch (lbs)
Wa	7636.4	
Na	7244.8	
Ca	4427.4	
Wp	200.0	
C	0.0	
a	724.1	
b	-2033.9	
c	0.0	
FS	2.8	

Slope length = 25.3 feet
One (1) Stormwater Ditch (5,000 lbs)
Cover Soil-Geocomposite Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	25.3	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	160	Interface cohesion (psf)
Phi (inter)	26	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	5000	Weight of stormwater ditch (lbs)
Wa	7636.4	
Na	7244.8	
Ca	3541.9	
Wp	200.0	
C	0.0	
a	724.1	
b	-2122.1	
c	0.0	
FS	2.9	

Slope length = 25.3 feet
One (1) Stormwater Ditch (5,000 lbs)
Geocomposite-Geomembrane Interface

Gamma	120	Cover soil unit weight (pcf)
h	1	Cover soil thickness (ft)
L	25.3	Length of slope (ft)
Beta	18.43	Slope of cover (degrees)
ca	220	Interface cohesion (psf)
Phi (inter)	21	Interface friction angle (deg)
c	0	Cover soil cohesion (psf)
Phi (soil)	0	Cover soil friction angle (deg)
W ditches	5000	Weight of stormwater ditch (lbs)
Wa	7636.4	
Na	7244.8	
Ca	4870.1	
Wp	200.0	
C	0.0	
a	724.1	
b	-2294.8	
c	0.0	
FS	3.2	

Slope length = 25.3 feet
One (1) Stormwater Ditch (5,000 lbs)
Geomembrane-Cohesive Soil Interface

Attachment D – Example Hand Calculations

BURNS McDONNELL

030215 Form GCO-28

Client: Victoria, TX — Page ____ of ____

Project: 107608 — Date: ~~5/24/21~~ 11/15/21 — Made By: T. [illegible]

Victoria Land Fill — Checked By ____

Cover → Spreadsheet Haul Calc — Preliminary ____ Final ____

Inputs:

Cover Soil Unit Weight = 120 pcf

Cover thickness = ~~0.5'~~ 1.0 (above geosynthetics) → Cover system revised

Slope length = 284'

Slope angle = 18.43°

Interface cohesion = 100 psf

Interface friction angle = 30 deg

Soil cohesion = 0 psf

Soil friction angle = 0 degrees } → ignore passive soil at bottom of slope strength

Weight of dozer = 20,000 lbs

Active Wedge

$$W_A = \gamma h^2 \left[\frac{L}{h} - \frac{1}{\sin\beta} - \frac{\tan\beta}{2} \right] + W_{dozer}$$

$$= (120\ pcf)(~~0.5~~\ 1.0\ ft)^2 \left[\frac{284}{~~0.5~~\ 1.0} - \frac{1}{\sin 18.43} - \frac{\tan 18.43}{2} \right] + 20{,}000$$

$$= ~~30~~\ 120\ pcf \left[~~568~~\ 284 - 3.16 - 0.1666 \right] + 20{,}000$$

$$= ~~36{,}940~~\ 53{,}680\ lbs$$

$$N_A = W_A \cos\beta = (~~36{,}940~~\ 53{,}680\ lb)(\cos 18.43) = ~~35{,}045~~\ 50{,}927\ lbs$$

$$C_a = c_a \left(L - \frac{h}{\sin\beta} \right) = 100 \left(284 - \frac{~~0.5~~\ 1.0}{\sin 18.43} \right) = ~~28{,}242~~\ 28{,}083\ lbs$$

$$W_P = \frac{\gamma h^2}{\sin 2\beta} = \frac{120\ pcf (~~0.5~~\ 1.0)^2}{\sin(2 \cdot 18.43)} = ~~50~~\ 200\ lbs$$

$$C = \frac{c h}{\sin\beta} = \frac{(0)(~~0.5~~\ 1.0)}{\sin 18.43} = 0$$

STATE OF TEXAS
SCOTT MARTIN
120819
LICENSED PROFESSIONAL ENGINEER
Scott Martin 4/5/2022

BURNS & McDONNELL

030215 Form GCO-28

Client: Victoria, TX — Page ____ of ____

Project: 107608 — Date: 5/24/21 — Made By: Texler

Victoria Landfill — Checked By ____

Cover → Spreadsheet Hand Calc — Preliminary ____ Final ____

$a = [W_A - N_A \cos\beta] \cos\beta$

$= [$ ~~31,990~~ 53,680 lbs $-$ (~~35,045~~ 50,927 lbs)(cos 18.43)$]$ cos 18.43

$= [$ ~~3692~~ 5365 lb $]$ cos 18.43 $=$ ~~3,503~~ 5090

$b = -[(W_A - N_A \cos\beta)\sin\beta \tan\phi + (N_A \tan\delta + C_a)\sin\beta\cos\beta + \sin\beta(C + W_p \tan\phi)]$

$= -[($ ~~31,990~~ 53,680 $-$ (~~35,045~~ 50,927)(cos 18.437)) sin 18.43 tan 0 + ((~~35,045~~ 50,927) tan 30 + ~~28,242~~ 28083) sin 18.43 cos 18.43 + sin 18.43 (0 + ~~50~~ 200 tan 0)$]$

$= -[($ ~~3692~~ 5365)(0.316)(0) + (~~20,233~~ 29,403 + ~~28,242~~ 28083)(0.316)(0.949) + (0.316)(0)$]$

$= -$ ~~14,539~~ −17,242

$c = (N_A \tan\delta + C_a)\sin^2\beta \tan\phi = [(35,045) \tan 30 + 28,242] \sin^2 18.43 \tan 0$

$= ($ ~~20,233~~ 29403 + ~~28,242~~ 28083 $)$ (0.099)(0) $= 0$

$FS = \dfrac{-b + \sqrt{b^2 - 4ac}}{2a}$

$= \dfrac{-(\text{~~14,539~~ } -17{,}242) + \sqrt{(\text{~~-14,539~~ } -17{,}242)^2 - 4(\text{~~3,503~~ } 5090)(0)}}{2(\text{~~3,503~~ } 5090)}$

$=$ (~~14,539~~ 17,242 + ~~14,539~~ 17,242) / (~~7006~~ 10,180)

$=$ ~~4.15~~ 3.4 ✓

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Scott Martin
4/5/2022

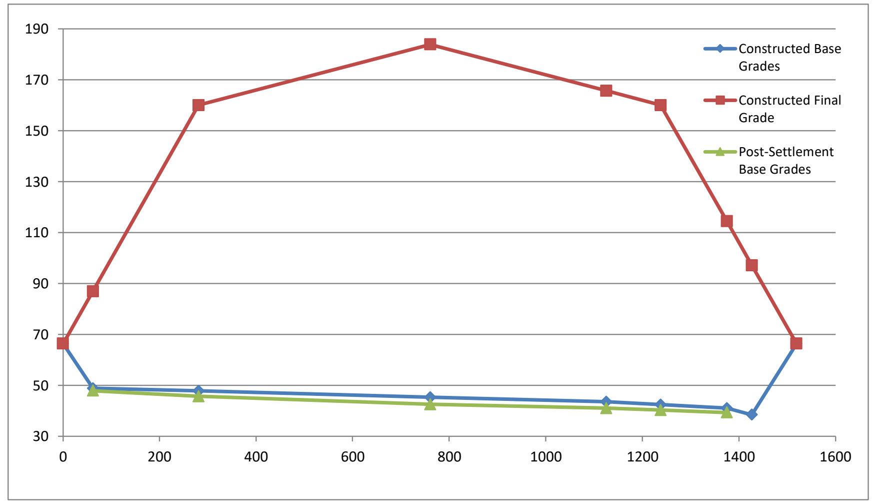
ATTACHMENT A – SETTLEMENT ANALYSIS

Burns & McDonnell

Project Title: Victoria Landfill Permit
Client: City of Victoria
Project Number: 107608

Date: 7/9/2021
Designed By: NT/TS

Design Description: Settlement Analysis - Section B



ASSUMPTIONS:

1. Elevations and stationing from AutoCad Civil3D 2020.
2. Analysis conducted at grade breaks in liner/cover systems to determine settlement in between these defining points.

CROSS SECTION B - Maximum Depth of Fill on Leachate Flowline

Location ID	Delta P (psf)	Total S (inches)	Total S (feet)	Depth of Fill (feet)	Stress Distribution Location
A	2920	12.5	1.04	48.7	Toe of Slope
B	6740	26	2.17	112.3	3:1 to 5% TOFC Grade Break
C	8320	32.7	2.73	138.7	Landfill Peak
D	7330	30.2	2.52	122.2	0.5% to 1.0% Liner Grade Break
E	7060	25	2.08	117.7	5% to 3:1 TOFC Grade Break
F	4410	20	1.67	73.5	1.0% to 10% Sump Grade Break
G	3520	13	1.08	58.7	Sump Grade to Toe of Slope

U/S Node ID	D/S Node ID	Length	Const. Base Grades/Leachate System			Final LF Grades		Depth of Fill		Settlement Depth		Final Leachate System w/ Settlement		
			U/S Invert	D/S Invert	Const. Slope	U/S Invert	D/S Invert	U/S Invert	D/S Invert	U/S Total S	D/S Total S	U/S Invert	D/S Invert	Final Slope
		(feet)	(feet)	(feet)	(%)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(%)
A	B	219	48.79	47.72	0.49	87.02	160.00	38.2	112.3	0.9	2.2	47.93	45.55	1.09
B	C	480	47.72	45.33	0.50	160.00	183.90	112.3	138.6	2.2	2.7	45.55	42.61	0.61
C	D	364	45.33	43.50	0.50	183.90	165.67	138.6	122.2	2.7	2.5	42.61	40.98	0.45
D	E	113	43.50	42.38	0.99	165.67	160.00	122.2	117.6	2.5	2.1	40.98	40.30	0.60
E	F	137	42.38	41.00	1.01	160.00	114.49	117.6	73.5	2.1	1.7	40.30	39.33	0.70
F	G	52	41.00	38.50	4.81	114.49	97.18	73.5	58.7	1.7	1.1	39.33	37.42	3.69

ATTACHMENTS:

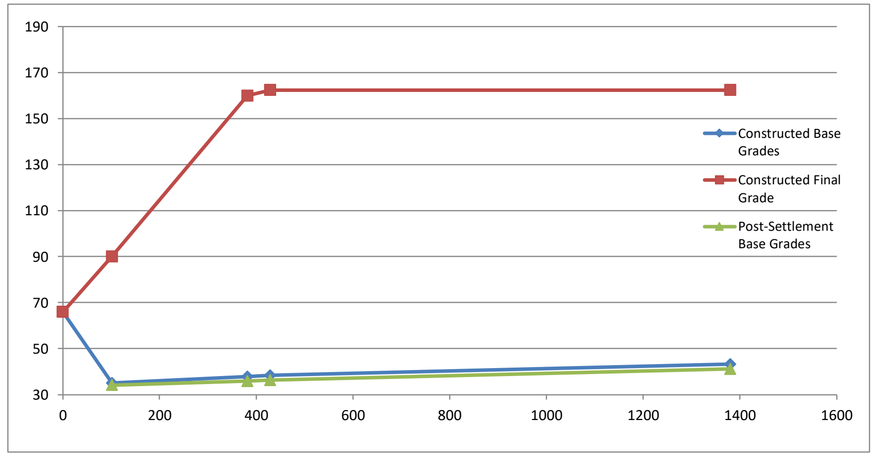
Figure 1-4: Cross Sections

BURNS McDONNELL

Project Title: Victoria Landfill Permit
Client: City of Victoria
Project Number: 107608

Date: 7/9/2021
Designed By: NT/TS

Design Description: Settlement Analysis - Section D



ASSUMPTIONS:

1. Elevations and stationing from AutoCad Civil3D 2020.
2. Analysis conducted at grade breaks in liner/cover systems to determine settlement in between these defining points.

CROSS SECTION D -Leachate Flowline of Revised Trench 7/8 Liner

Location ID	Delta P	Total S	Total S	Depth of Fill	Stress Distribution Location
	(psf)	(inches)	(feet)	(feet)	
A	3300	10.9	0.91	55.0	Toe of Slope
B	7280	24	2.00	121.3	3:1 to 5% TOFC Grade Break
C	7440	24.9	2.08	124.0	1.0% to 0.5% Liner Grade Break
D	7150	24.2	2.02	119.2	0.5% to 3:1 Liner Grade Break

U/S Node ID	D/S Node ID	Length	Const. Base Grades/Leachate System			Final LF Grades		Depth of Fill		Settlement Depth		Final Leachate System w/ Settlement		
			U/S Invert	D/S Invert	Const. Slope	U/S Invert	D/S Invert	U/S Invert	D/S Invert	U/S Total S	D/S Total S	U/S Invert	D/S Invert	Final Slope
		(feet)	(feet)	(feet)	(%)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(feet)	(%)
B	A	280	37.88	35.07	1.00	160.00	90.05	122.1	55.0	2.0	0.9	35.87	34.16	0.61
C	B	47	38.35	37.88	1.00	162.35	160.00	124.0	122.1	2.1	2.0	36.28	35.86	0.89
D	C	951	43.17	38.35	0.51	162.35	162.35	119.2	124.0	2.0	2.1	41.15	36.28	0.51

ATTACHMENTS:

Figure 1-4: Cross Sections

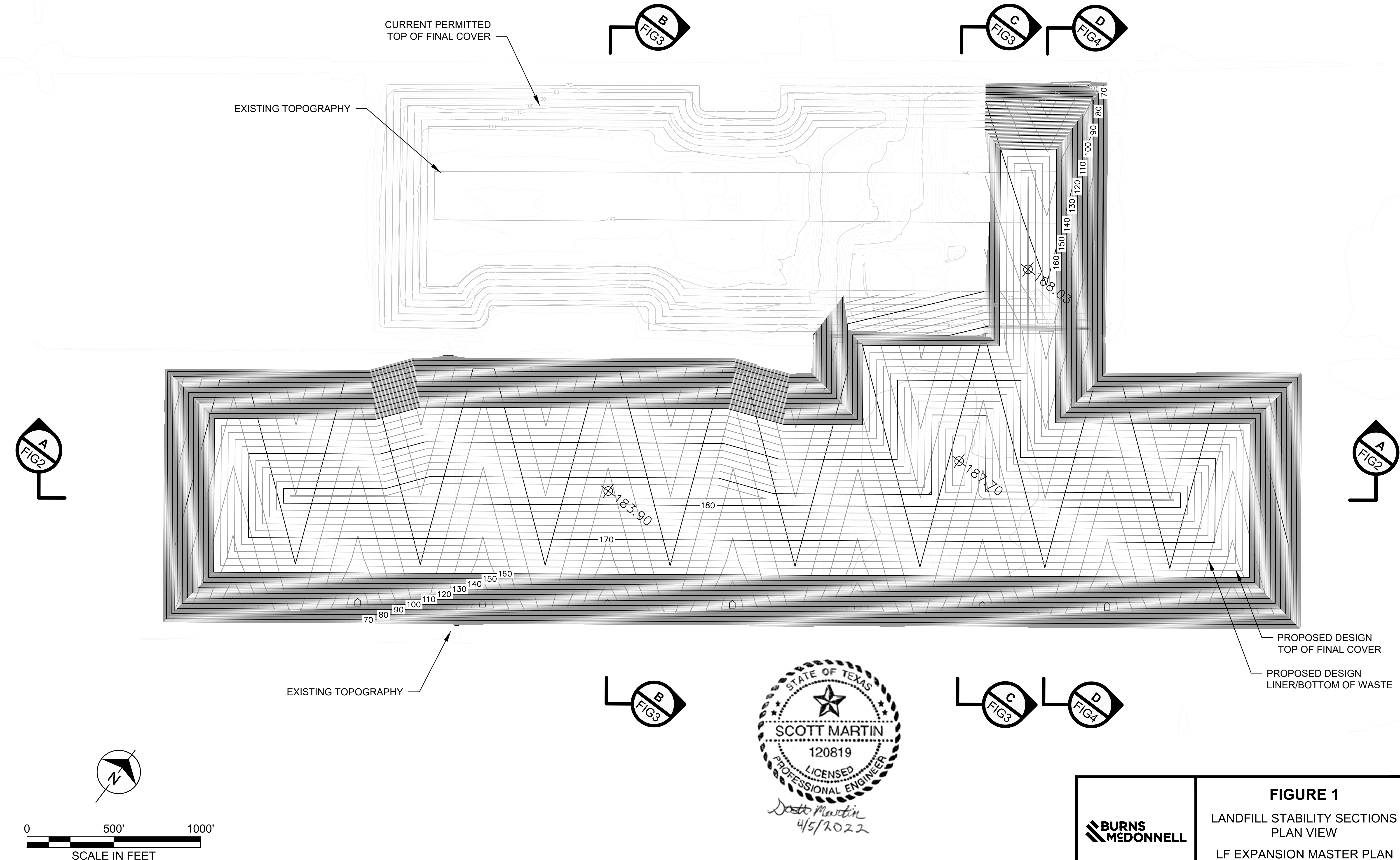


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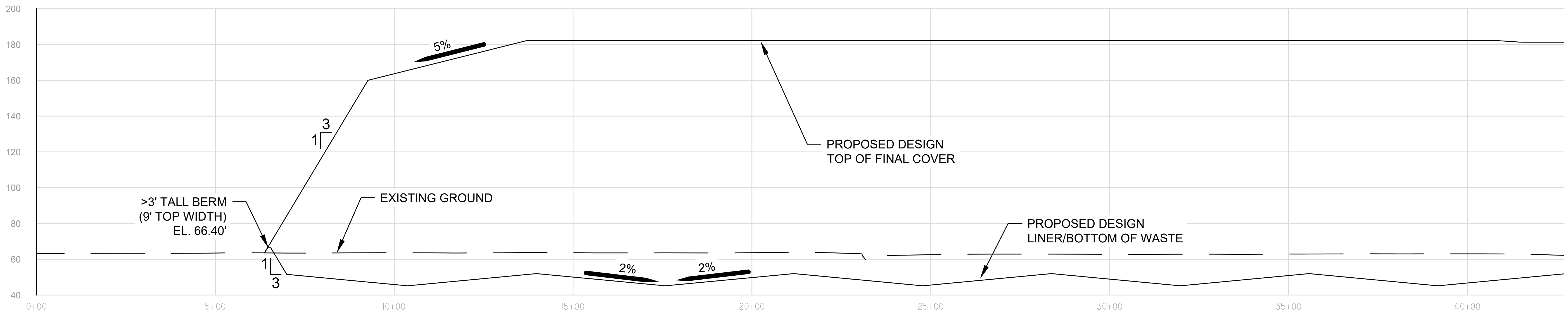
FIGURE 1

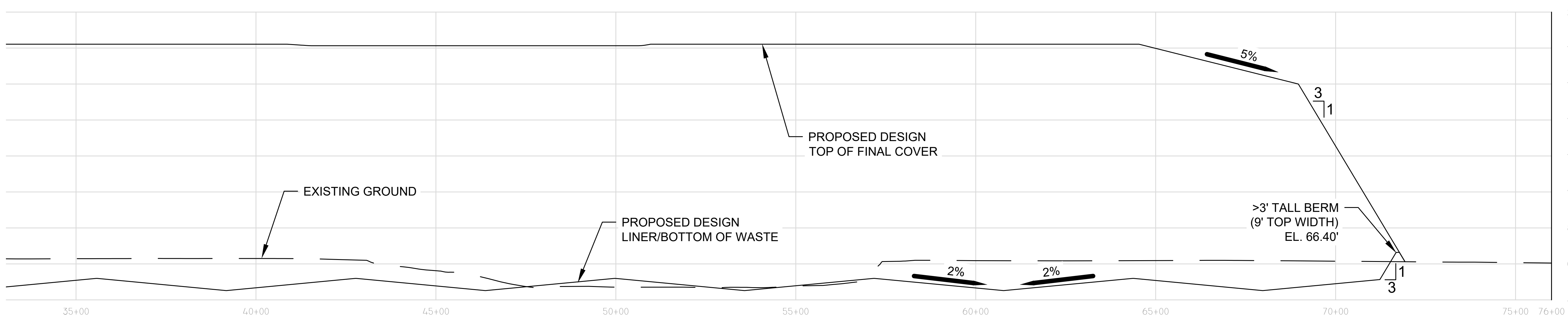
LANDFILL STABILITY SECTIONS
PLAN VIEW

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION A (PART 1)



SECTION A (PART 2)



VERTICAL SCALE: 0 60' 120' SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600' SCALE IN FEET

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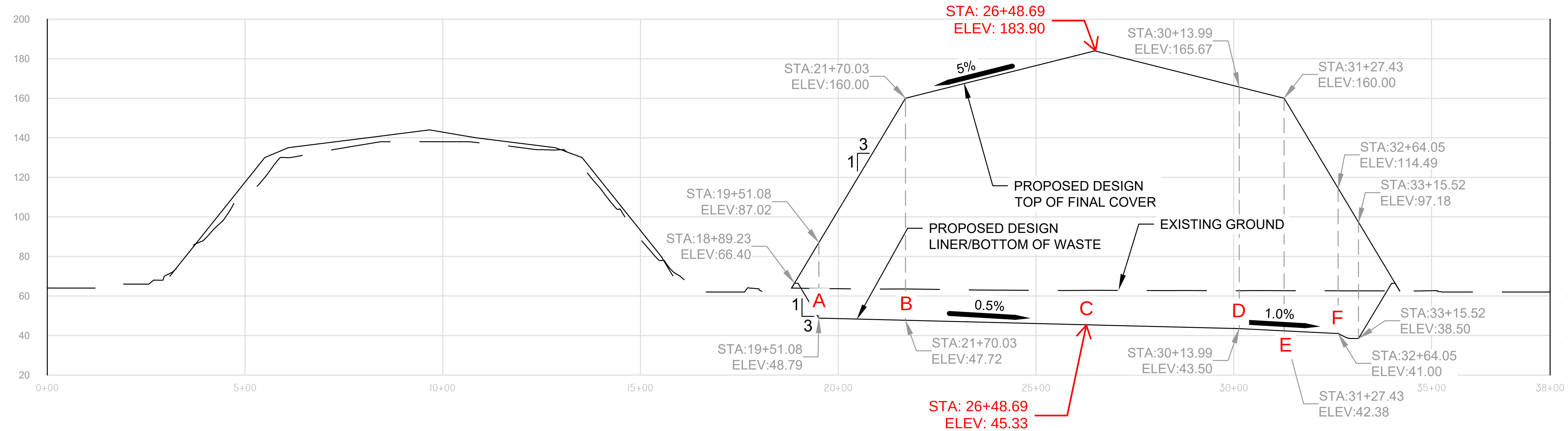
FIGURE 2

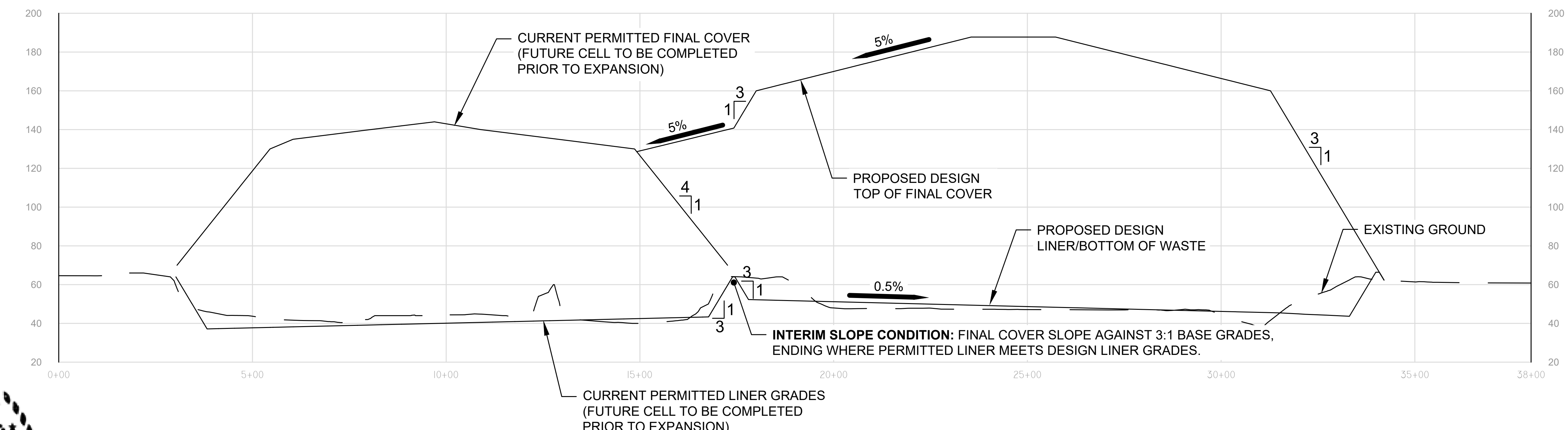
LANDFILL STABILITY SECTIONS
CROSS SECTION A

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION B



SECTION C



VERTICAL SCALE: 0 60' 120'
SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600'
SCALE IN FEET

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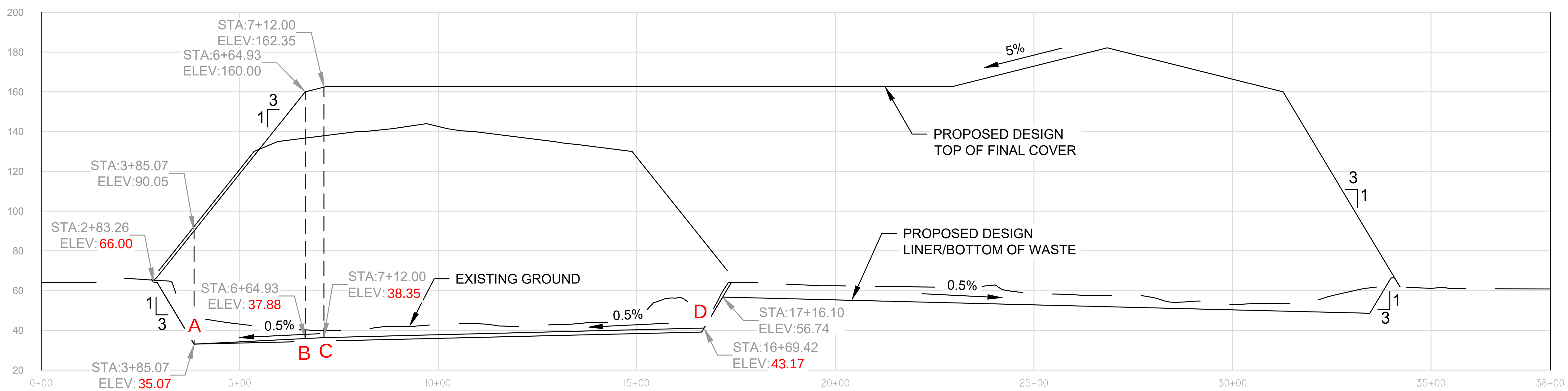
FIGURE 3

LANDFILL STABILITY SECTIONS
CROSS SECTIONS B AND C

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

SECTION D



VERTICAL SCALE: 0 60' 120' SCALE IN FEET

HORIZONTAL SCALE: 0 300' 600' SCALE IN FEET

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FIGURE 4

LANDFILL STABILITY SECTIONS
CROSS SECTIONS D AND E

LF EXPANSION MASTER PLAN
CITY OF VICTORIA, TX

ATTACHMENT 8 – LANDFILL GAS MANAGEMENT PLAN

Part III, Attachment 8 – Landfill Gas Management Plan
TCEQ MSW Permit No. 1522B

City of Victoria, Texas

City of Victoria Landfill Lateral and Vertical Expansion
Project No. 107608

Revision 0, March 28, 2022

Part III, Attachment 8 – Landfill Gas Management Plan
TCEQ MSW Permit No. 1522B

prepared for

City of Victoria, Texas
City of Victoria Landfill Lateral and Vertical Expansion
Victoria County, Texas

Project No. 107608

Revision 0, March 28, 2022
3/28/2022

prepared by

Burns & McDonnell Engineering Company, Inc.
Austin, Texas
Texas Firm Registration No. F-845

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STATE OF TEXAS
SCOTT MARTIN
120819
LICENSED
PROFESSIONAL ENGINEER
Scott Martin
4/5/2022

LIST OF TABLES

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
bgs	Below Ground Surface
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
GCCS	Gas Collection and Control System
EPA	Environmental Protection Agency
k	Decay rate
LEL	Lower Explosive Limit
LFG	Landfill Gas
LO	Ultimate Recovery Rate
MSL	Mean Sea Level
MSW	Municipal Solid Wase
MSWLF	Municipal Solid Waste Landfill
NMOC	Nonmethane Organic Compound
NSPS	New Source Performance Standards
scfm	standard cubic feet per minute
SDP	Site Development Plan
TCEQ	Texas Commission on Environmental Quality
UEL	Upper Explosive Limit

1.0 INTRODUCTION

30 TAC §330.63(g)

1.1 Regulations

This Landfill Gas Management Plan has been prepared pursuant to the State of Texas requirements set forth in 30 TAC §330.159 and §330.371. The Municipal Solid Waste (MSW) Management Regulations Chapter 330 of the Texas Administrative Code, are administered by the Municipal Solid Waste Division of the Texas Commission on Environmental Quality (TCEQ).

Compliance with TCEQ Municipal Solid Waste Landfill (MSWLF) regulations requires landfills to implement a routine monitoring program for methane gas. This plan must demonstrate that the concentration of methane gas generated by the facility does not exceed 25 percent of the lower explosive limit (LEL) (1.25 percent by volume in air) in facility structures (excluding gas control or recovery system components) or 100 percent of the LEL (5 percent by volume in air) at permitted boundary wells, probes, subsurface soils, or other matrices.

TCEQ and Subtitle D regulations define LEL as the lowest percent by volume of a mixture of explosive gases in air that will propagate a flame at 25°C and atmospheric pressure. Methane is flammable when present in the range of 5 to 15 percent by volume in air. The lower (5 percent) threshold is the LEL for methane in air. The upper (15 percent) threshold is the upper explosive limit (UEL) for methane in air. Concentrations of methane less than 5 percent and greater than 15 percent are typically not flammable.

1.2 Background

Landfill gas (LFG) is a product of the anaerobic decomposition of organic waste within the landfill unit and consists primarily of approximately 50% methane and 50% carbon dioxide. Although both gases are colorless, odorless, and tasteless, traces of volatile organic compounds and many other substances usually present in the gas provide the characteristic pungent odor.

As the gas is generated, the pressure within the landfill builds until equilibrium is reached between the quantity of gas being generated and the quantity leaving the landfill unit. Therefore, as landfill liner and cap systems become less permeable, higher internal pressures are expected unless measures are taken to relieve the pressure. The increased pressure within the landfill unit provides the main source of energy for LFG migration through the liner, landfill cap, passive vents, or other high permeability pathways.

LFG can present several problems or hazards. These include the potential for explosion or fire, odor, toxic trace gases, and vegetation stress. Because methane gas is extremely flammable in concentrations between 5 and 15 percent by volume, this is the main hazard associated with LFG.

This LFG Management Plan has been developed to protect lives and property from the hazards associated with LFG. This will be accomplished by providing a monitoring system that will detect LFG concentrations exceeding the LEL at the facility property boundary or 25% LEL within on-site facility buildings and other normally occupiable facility structures. Landfill gas pressures will be controlled by means of the landfill gas extraction system in the landfill to relieve excessive internal pressures that can lead to gas migration.

2.0 METHANE MONITORING

2.1 Landfill Gas Monitoring

Routine methane monitoring, consistent with the requirements of 30 TAC §330.371, will be performed during the active life and post-closure care period to verify methane concentrations do not exceed 1.25% by volume in facility structures and 5% by volume at permitted boundary wells, probes, subsurface soils, or other matrices. At a minimum, methane monitoring will be conducted quarterly. All monitoring probes and on-site structures will be sampled for methane during the monitoring period.

A permanent perimeter gas monitoring system will be constructed, with probes installed at generally 1,000-foot intervals as landfill cells progress (similar to existing spacing) as seen on Attachment 1, Drawing C011. This perimeter network will be installed according to the installation schedule on Drawing C011. The landfill gas management plan will be amended to incorporate additional monitoring infrastructure associated with expansion, and reference applicable requirements from 30 TAC §330.371.

The proposed liner design in the expansion area should provide effective control against landfill gas migration. However, if methane levels exceed acceptable levels, corrective actions will be required by regulation. This includes immediately taking all necessary steps to ensure protection of human health and notifying the Executive Director, local and county officials, emergency officials, and the public. Within seven days of detection, the operating record will include the concentration of methane gas levels detected along with a description of the steps taken to protect human health. Within 60 days of detection, a remediation plan for the methane gas releases will be implemented and a copy of the plan included in the operating record. A copy shall also be provided to the Executive Director, and the Executive Director will be notified that the plan has been implemented. The plan will describe the nature and extent of the problem along with the proposed remedy. The Executive Director may require additional remedial measures. The Executive Director may also establish an alternative schedule for monitoring and exceedance actions.

2.2 Perimeter Monitoring Plan

As of March 2022, 18 permanent LFG monitoring probes of a single tube design are installed around the perimeter of the landfill as shown in Attachment 1, Drawing C001 and are used to detect the presence of migrating LFG. Generally, the probes are at facility property or permit boundary comers, directly between the landfill and offsite structures within a 1,000-foot radius of the waste unit footprint, in backfilled utility trenches, in localized soils of relatively high permeability, and in other high-risk zones. Additional probes are located such that the maximum spacing between the permanent monitoring probes does not exceed 1,000 feet.

Each monitoring probe location is designed to monitor all soil strata above the minimum existing or planned elevation of waste within 1,000 feet of the probe or above bedrock or the permanent low seasonal water table. All monitoring probes located further than 1,000 feet from the existing or planned waste unit footprint will be installed to a minimum depth of 15 feet.

All probe locations have been based on a review of the facilities' geologic, hydrogeologic, and hydraulic conditions. Additionally, the location of on-site and off-site structures, underground utility and pipeline easements, and all other known conditions likely to increase the hazard of migrating LFG have been considered. Each of these criteria are detailed in the following sections.

2.2.1 Geologic Conditions

Geologic conditions are discussed in Attachment 5 – Geology Report.

2.2.2 Surrounding Structures

The only structures within 1,000 feet of the landfill are the landfill office/gatehouse and the landfill equipment maintenance shed (see Attachment 1). The landfill office/gatehouse is equipped with a LFG alarm. The equipment maintenance shed is a roof structure which is open on three sides.

2.2.3 Utility and Pipeline Easements

A 60-foot power line easement occurs along the southeastern property line. Above ground power lines are placed immediately outside of the landfill property boundary. Because all installations are above ground, the presence of this easement will have no impact on potential LFG migration.

2.3 LFG Monitoring Probe Design

Permanent LFG monitoring probes of a single tube design are installed and used to detect the presence of migrating LFG as detailed in Appendix A. The single tube probe design was chosen for the following two reasons. First, it assures that all soils are monitored, preventing the possibility of undetected gas migration through an unscreened zone due to errors in wellbore logging or probe completion. Second, it is extremely difficult to achieve and maintain positive seals for gas between separate monitoring zones within a single wellbore, which increases the chance for misinterpreted results upon gas detection. In the event that landfill gas migration is detected and knowledge of the specific zone of migration is needed for development of the remediation plan, additional probes may be installed next to the original probe and within the suspected zones of migration.

In the event that a perched water table is encountered, separate monitoring probes, located approximately five feet apart, will be installed above and below the saturated zone. As of March 2022, no nested probes have been installed. Similar probe clusters will be installed in the event that specific geologic zones or conditions are encountered that suggest gas movement within a specific zone, or when the use of more than one probe is required to ensure positive LFG monitoring within all soil strata.

2.4 LFG Monitoring Probe Installation

All probes will be constructed of one-inch nominal diameter Schedule 40 threaded PVC pipe in six-inch (minimum) diameter boreholes. To prevent the possibility of incorrect gas measurements, solvent welded (glued) joints will not be allowed. Within the monitoring zone, the pipe will be perforated with 16 evenly spaced 3/16-inch diameter holes per foot. Washed pea gravel backfill will be placed from the bottom of the borehole to approximately one foot above the top perforation. A three-inch layer of bentonite chips will isolate the gravel from the bentonite seal. The top five feet of the probe will be sealed with hydrated bentonite.

Surface completion will consist of a four foot by four foot concrete pad and an eight-inch protective steel casing. A typical LFG probe installation detail is provided in Appendix A.

Existing LFG monitoring probes were generally installed as indicated on the following Table 2-1. Exact depths of probes may be adjusted based on the geologic information obtained while drilling. All boreholes were logged during drilling. Soils were described using visual classification. Rock units were not encountered.

Logs of borings are attached in Appendix D. All LFG monitoring probes were surveyed for horizontal coordinates and elevations and entered into the operating record of the landfill.

Table 2-1: Summary of GMP Information

Probe No.	Approximate Ground Elevation (ft?)	Estimated Bottom of Probe Elevation (ft?)	Minimum Permitted Waste Elevation Within 1,000 ft.	Estimated Bedrock Depth	Estimated Low Seasonal Groundwater Depth (M.S.L.)	Screen Interval (M.S.L.)	
						Upper Limit	Lower Limit
GMP-1	64	34	Approximate El. 43	>250 Feet	29.5	58	34
GM P-2	64	33	Approximate El. 43	>250 Feet	29.5	58	33
GMP-3	63	33	Approximate El. 43	>250 Feet	29.5	57	33
GMP-4 (to be abandoned)	63	23	Approximate El. 43	>250 Feet	29.0	57	23
GMP-5 (to be abandoned)	64	24	Approximate El. 43	>250Feet	28.0	58	24
GMP-5A	80	52		>250 Feet		77.5	52
GMP-6 (abandoned)	63	23	Approximate El. 51	>250 Feet	27.0	57	23
GMP-6A							
GMP-6B							
GMP-7	64	44	Approximate El. 52	>250 Feet	26.5	58	44
GMP-8	64	44	Approximate El. 52	>250 Feet	26.0	58	44
GMP-8A	49	33		>250Feet		NA	NA
GMP-9	64	44	Approximate El. 52	>250 Feet	26.0	58	44
GMP-10	65	45	Approximate El. 52	>250 Feet	25.5	59	45
GMP-11	65	45	Approximate El. 52	>250 Feet	26.0	59	45
GMP-12	65	45	Approximate El. 52	>250 Feet	27.0	59	45
GMP-13	64	34	Approximate El. 52	>250 Feet	27.5	58	34
GMP-14	65	35	Approximate El. 43	>250 Feet	28.0	59	35
GMP-15	64	34	Approximate El. 43	>250 Feet	29.0	58	34

2.5 Monitoring

The landfill manager or his/her designated representative shall be responsible and trained to properly performed all monitoring tests.

2.6 Monitoring of Facility Structures

All on-site buildings and structures designed for normal human occupation will be equipped with continuous gas monitor/alarms that will provide an audible alarm if methane gas concentrations over 25%

LEL are detected. The only building to be monitored is the office/gate house. A gas alarm is located within this building.

Because LFG is often lighter than air (LFG varies from a specific gravity of 0.95 to 1.05), gas monitor/alarms will be located accordingly. Typical alarm placement will be approximately one foot from the top of the lowest enclosed area of the building. For example, the alarm will be placed near the first-floor ceiling of a multistory building or near the ceiling of a building basement or crawl space. Additionally, alarms will be located away from building corners that can act as "dead air" space, which can prevent the rapid detection of combustible gases. Multiple alarms will be installed in larger buildings and where specific routes of migration may exist, such as near underground utility connections.

2.7 Sampling And Monitor/Alarm Equipment

2.7.1 LFG Monitoring Probes

A Landtec GEM 5000 4-gas monitor or equivalent will be used for measuring methane gas concentrations at all LFG monitoring probe locations. An example of a combustible gas indicator calibration record is provided in Appendix B, and a data sheet for the combustible gas indicator is provided in Appendix C. This instrument provides for measurement of both 0-100% LEL and 0-100% gas by volume. Additional benefits of these meters are rugged construction and easy maintenance. Monitor specifications are provided in Appendix C.

When required to be measured, an instrument will be used to measure ambient barometric pressure and ambient temperature.

2.7.2 Continuous Gas Monitor/Alarms

The Macurco, Inc. Model 4S1D, or equivalent will be used to continuously monitor all normally occupiable structures at the facility. These monitors/alarms are inherently explosion-proof and provide an audible alarm when a gas level over 10% LEL is detected. Unless manually overridden, the audible alarm will continue until the gas concentration is reduced to less than 10% LEL. Factory specifications for these monitors/alarms are provided in Appendix C.

2.8 Sampling Procedures

2.8.1 LFG Monitoring Probes

Calibration of the LEL scale of the LFG monitoring probes is to be performed immediately before measuring LFG monitoring probe methane concentrations. The quality control procedures for the Landtec GEM 4-gas monitor is as follows:

1. The unit will be field calibrated in accordance with the Landtec manual.
2. Make note of warnings and messages displayed by the unit. Fix all issues that may affect the device's ability to gather accurate readings.
3. Verify that the meter has been serviced and factory calibrated annually by the manufacturer according to manufacturer guidance.

The following procedure is to be followed for measuring methane concentrations in LFG monitoring probes using the Landtec GEM 4-gas monitor:

1. Calibrate the meter and record results.
2. Remove probe cap and place the meter sampling line into the probe. Seal around meter sampling line and probe. Run the pump until readings stabilize. Record the reading displayed on the meter.
3. Remove the meter sampling line and replace probe cap.
4. Record the results of the monitoring along with any potentially pertinent comments on the appropriate form in the Methane Gas Monitoring Logbook, an example of which is provided in Appendix B.

2.8.2 Continuous Gas Monitor/Alarms

Monitoring for methane gas within facility structures will be continuous and automatic through continuous gas monitor/alarms permanently installed within each structure. Therefore, no specific sampling procedures are required.

Results obtained from each continuous gas monitor/alarm will be recorded on the appropriate form in the Methane Gas Monitoring Logbook, an example of which is provided in Appendix B. If no building alarms have been triggered, this will be stated. If alarms have been triggered, the cause of the alarm will be explained along with the steps taken to protect the health and welfare of employees and other personnel.

2.9 Sampling Frequency

2.9.1 LFG Monitoring Probes

Normally, LFG monitoring probes will only be sampled for methane gas concentration quarterly. However, in the event that methane gas concentrations in excess of 25% LEL are detected in a gas monitoring probe, the monitoring frequency for that probe and the two adjacent probes will be increased to monthly. The increased sampling frequency will continue until three consecutive months of methane gas concentrations of less than 25% LEL are obtained. At that time, monitoring will return to quarterly measurement of methane gas concentration only.

Monitoring for LFG at the facility perimeter will continue for 30 years after final closure of the landfill or until written authorization to reduce the monitoring program is received.

2.9.2 Continuous Gas Monitor/Alarms

Facility buildings and other normally occupiable structures will be equipped with continuous gas monitor/alarms. All monitor/alarms will always remain in the "On" position. Therefore, sampling will occur continuously. Monitoring for LFG within normally occupiable structures will continue for 30 years after final closure of the landfill or until written authorization to reduce the monitoring program is received.

2.10 Record Forms

All LFG related information will be maintained on-site in a Methane Gas Monitoring Logbook. This will include monitoring results, calibration records, equipment test records, official correspondence, etc. Examples of recording and reporting forms can be found in Appendix B. The site may choose to use alternate forms with equivalent information.

2.11 Reporting of Results

The results from sampling the LFG monitoring probes and a summary of the continuous building monitoring results will be submitted to the TCEQ quarterly on a typical form as shown in Appendix B.

2.12 Maintenance Schedule

2.12.1 LFG Monitoring Probes

The LFG monitoring probes, as designed, will not normally require any specific maintenance to remain functional. However, mowing or trimming of nearby grasses will be performed on an "as needed" basis.

2.12.2 Continuous Gas Monitor/Alarms

All continuous gas monitor/alarms are to be tested according to the manufacturers' specifications with a maximum time between tests of 12 months.

2.13 Contingency Plan - Protection of Persons & Property

The following steps will be taken to protect persons and property in the event that methane gas concentrations are detected in the gas monitoring probes:

1. If methane gas concentrations over 25% LEL (lower explosive limit) are detected in the gas probes, monitoring frequency and parameters for the probe and the two adjacent probes will be increased as described in the Sampling Frequency section of this document.
2. If methane gas levels exceed 25% LEL in any facility structure, or 100% LEL in any gas probe, the City or its' operator shall immediately take all necessary steps to ensure protection of human health and notify the executive director, local and county officials, emergency officials, and the public; and within seven days of detection, place in the operating record the methane gas levels detected and a description of the steps taken to protect human health; and within 60 days of detection, implement a remediation plan for the methane gas releases, place a copy of the plan in the operating record and notify the executive director that the plan has been implemented. The plan shall describe the nature and the extent of the problem and proposed remedy.

The following steps, in sequence, provide the actions/activities that are to be taken following a positive response or alarm from a continuous gas detector located in an onsite building or structure. The main concern following any alarm is the safety of personnel in the area. Responding quickly and in an intelligent and calm manner will ensure the safety of and minimize the risk to life and property.

1. Extinguish any possible source of ignition, i.e., cigarettes, welding machines, or any apparatus that can generate an open flame or spark.
2. Evacuate the immediate area of all personnel. Do not turn on/off any electrical switches.
3. Ventilate the area of the alarm by opening windows and doors.
4. Trained personnel will investigate the source of the alarm.

2.14 Contingency Plan – Data Evaluation, Notification & Remediation Procedure

Once appropriate emergency procedures for the protection of persons and property have been taken, verification of the data (probe measurements and/or alarm) will begin. These verification procedures are intended to determine if the measured levels or alarms accurately represent excessive methane gas concentrations resulting from LFG. Possible causes for incorrect measurements or false alarms are equipment malfunction and/or detection and measurement of other non-landfill gasses.

2.14.1 Data Evaluation - Continuous Gas Monitor/Alarms

Verification of excessive levels of flammable gas inside a building or other normally occupiable structure will be accomplished by trained personnel using a calibrated explosimeter or other devices as deemed prudent and/or necessary. The purpose of the verification procedure will be to confirm that excessive levels of flammable gas exist and if so, determine the possible source of flammable gas.

- Proper operation of the continuous gas monitor/alarm(s) will be confirmed by testing using the procedure detailed in the "Maintenance Schedule" section of this plan or replacement of the unit. Removal or installation of monitors is not to occur when a flammable atmosphere is suspected.
- If proper operation of the monitor/alarm(s) is confirmed, the source of the alarm will be investigated. Areas of particular interest will be any possible LFG migration pathway: utility ducts, sewer, and water drains, etc. Other possible sources of methane to be investigated will be furnaces, incinerators, and other appurtenances using a flammable gas as a fuel. Other industrial products or processes (acetylene, Freon, cleaning solvents, vehicle exhaust, etc.) may result in false alarms.

If the verification procedure indicates a false alarm or equipment malfunction, the structure will be returned to normal service. If the verification procedure indicated equipment malfunction, the faulty equipment will be repaired or replaced, and the structure will be returned to normal service. If excessive levels of flammable gas are confirmed to exist, the structure will remain evacuated and ventilated using all precautions necessary to prevent sparks or open flame until the structure is made safe. The results of the investigation/verification procedure will be recorded on the appropriate form in the Methane Gas Monitoring Logbook.

2.14.2 Data Evaluation - LFG Monitoring Probes

Verification of excessive levels of methane gas in monitoring probes will be accomplished by trained personnel using a calibrated explosimeter or other devices as deemed prudent and/or necessary. The purpose of the verification procedure will be to confirm initial measurements. This will be accomplished using the following procedures.

- Recalibrate the explosimeter and immediately recheck the methane concentration in the LFG Monitoring Probe(s).

- Begin daily monitoring of the affected LFG Monitoring Probes(s) for one week.

If excessive methane gas concentrations are not detected in the immediate recheck or any of the daily tests during the following week, daily monitoring will cease, and routine monitoring procedures will resume. If excessive methane gas concentrations are detected in the immediate recheck or any of the daily tests during the following week, notification and remediation procedures will be implemented.

2.15 Emergency Back-Up Plan

In the event that the landfill gas collection and control system (GCCS) becomes inoperative, the Executive Director and the relevant authorities will be notified. Contact information for these parties is provided in Section 4.1. The Executive Director and the relevant authorities will also be contacted upon start up of the GCCS after it is repaired.

Potential remedies for the GCCS being inoperative include bringing in temporary equipment (i.e., blowers or a flare) until existing equipment is operational. Other options include isolating a portion of the GCCS. For example, if there is a landfill fire in one area of the landfill, that portion of the GCCS will be shut off and gas will be extracted where permissible. Both the existing and proposed GCCSs have valves throughout the header that can be used to isolate the wellfield.

In the event that the building monitors/alarms become inoperative, periodic manual monitoring of buildings using a portable meter will be performed until the permanent system is repaired. In the event that portable meters become inoperative, back up rental meters will be brought in and used until the original portable meters are repaired or replaced.

2.16 Landfill Gas (LFG) Control

Landfill gas will be controlled by the landfill GCCS, consisting of extraction wells connected to a network of piping under vacuum. There are no passive final cover gas vents proposed for this site.

2.16.1 Existing LFG Collection and Control System

Currently, the site has an active GCCS as shown in Attachment 1 on Drawings C009 and C010. Construction of the landfill gas extraction system began in April 1996. The system is currently operational. The Victoria Landfill has a design capacity greater than 2.5 million megagrams and 2.5 million cubic meters and is subject to 40 CFR 60, Subpart XXX. Based upon review of historical TCEQ Permit application documents received on May 7, 2020, the Victoria Landfill is not currently subject to the GCCS operational requirements. As such, the existing GCCS was not required to be installed per air quality regulations. However, the existing GCCS has been installed to reduce the internal gas pressures and to prevent LFG migration. In the future should the NMOC emission rate be greater than 34 megagrams per year, the facility will comply with GCCS control requirements specified in 40 CFR Part 60 Subpart XXX, New Source Performance Standards for Municipal Solid Waste Landfills (NSPS) and 40 CFR 63 Subpart AAAA, National Emission Standards for Hazardous Air Pollutants: Municipal Solid Waste Landfills.

The existing GCCS consists of vertical LFG extraction wells, a piping network, condensate management system, and a blower/flare facility. The existing blower provides vacuum to the extraction wells through the LFG collection piping network. The gas collection piping network conveys the extracted LFG from the collection points (i.e., vertical wells) to the flare facility for combustion.

2.16.2 Proposed GCCS Expansions

As the site develops, the NMOC concentration will likely exceed the applicable NMOC emissions standard and the Victoria Landfill will be subject to the GCCS operational requirements discussed in the preceding subsection. A GCCS design plan will be submitted to TCEQ for approval in accordance with the timelines provided in 40 CFR 60 Subpart XXX when the Victoria Landfill becomes subject to the GCCS operational requirements. Should the existing flare capacity need to increase or reach its effective design life, future extraction wells will be tied into the existing flare station or a new flare station. The locations of the anticipated proposed vertical extraction wells and piping are shown in Attachment 1 on Drawings C009 and C010. Existing LFG extraction wells in areas receiving additional waste will be extended and/or replaced with a new well as necessary based on the additional waste fill.

Each extraction well will be equipped with a control valve and monitoring ports as shown in Attachment 1 on Drawing C507. These control valves and monitoring ports, used in conjunction with controls on the blower, will allow the site to regulate vacuum and LFG levels at each individual extraction well. This will allow the site to make adjustments in order to effectively collect LFG.

Each LFG extraction well will consist of a perforated pipe within a gravel backfill. Similarly, horizontal LFG collectors may also be installed using perforated pipe in horizontal trenches if desired by the Victoria Landfill. The LFG extraction wells and/or horizontal collectors will be installed in phases as needed as the landfill develops.

2.16.3 GCCS Operation and Maintenance

To provide effective LFG collection with minimal downtime, monitoring and maintenance of the existing GCCS is, and will continue to be, performed consistent with current industry guidelines and practices. As needed, system adjustments will be made to optimize the extraction of LFG from the Landfill to control

LFG migration and odors. In addition, during monitoring activities the system will be routinely visually inspected for any evidence of needed repairs or other maintenance. The routine monitoring and checks will include the following:

- Each wellhead will be monitored and adjusted as needed to control LFG while reducing oxygen intrusion into the landfill.
- Pressure readings will be taken at various locations along the piping system to evaluate vacuum distribution.
- Condensate sumps will be checked for proper operation.
- Blowers and flares will be inspected for proper operation.

2.17 Considerations for Hydrogen Sulfide Gas

Atmospheric monitoring is of primary concern during activities involving entry into confined spaces. Oxygen deficiency or hydrogen sulfide concentrations may pose a threat to human health and safety. Before any personnel are allowed to enter a confined space, the area must be tested for percentage of oxygen and concentration of hydrogen sulfide. If an oxygen deficient atmosphere is detected, ventilation will be increased using portable blowers until the atmosphere is safe, or a self-contained breathing apparatus will be used. If hydrogen sulfide is detected, a self-contained breathing apparatus will be used. Under no circumstances will any personnel be allowed to enter a confined space without the appropriate equipment and without having received the proper training.

During landfill gas probe and extraction well monitoring activities, personnel will be required to wear a continuously monitoring personal protection device. Typically, a device similar to the BW Clip Single Gas Monitor (H2S) will be used. The instrument provides continuous monitoring of LEL, oxygen, hydrogen sulfide, and carbon dioxide. A data sheet for the BW Clip Single Gas Monitor is provided in Appendix C.

3.0 POST-CLOSURE METHANE MONITORING

Post-Closure landfill gas monitoring will take place on a quarterly basis. Methane monitoring and control will continue for 30 years after certification of final closure consistent with 30 TAC §330.371(e). Gas monitoring will be reduced only with an approved no gas migration demonstration. Information will be submitted to the Executive Director to reduce gas monitoring and control. The information must demonstrate that there is no potential for gas migration beyond the property boundary or into on-site structures. Additional information is located in Attachment 11 – Post-Closure Plan. The gas monitoring and control plan will be revised and maintained as needed in accordance with 30 TAC §330.371. Post-closure land use will not interfere with the gas monitoring system, and all utility trenches crossing the facility will be vented and monitored.

4.0 PROPOSED SYSTEM AND MAINTENANCE PLAN

4.1 Notification Procedures

In the event that confirmed methane gas concentrations over 100% LEL are detected in any of the gas monitoring probes or a confirmed methane gas concentration over 25% LEL is detected in any on-site structure, the following will be immediately notified by telephone.

Executive Director
Texas Natural Resources Conservation Commission
P.O. Box 13087
Austin, Texas 78711-3087
Phone: (512) 239-1000

Victoria Fire Department
Phone: (361) 485-3450

Victoria County Sheriff Dept.
Phone: (361) 575-0651

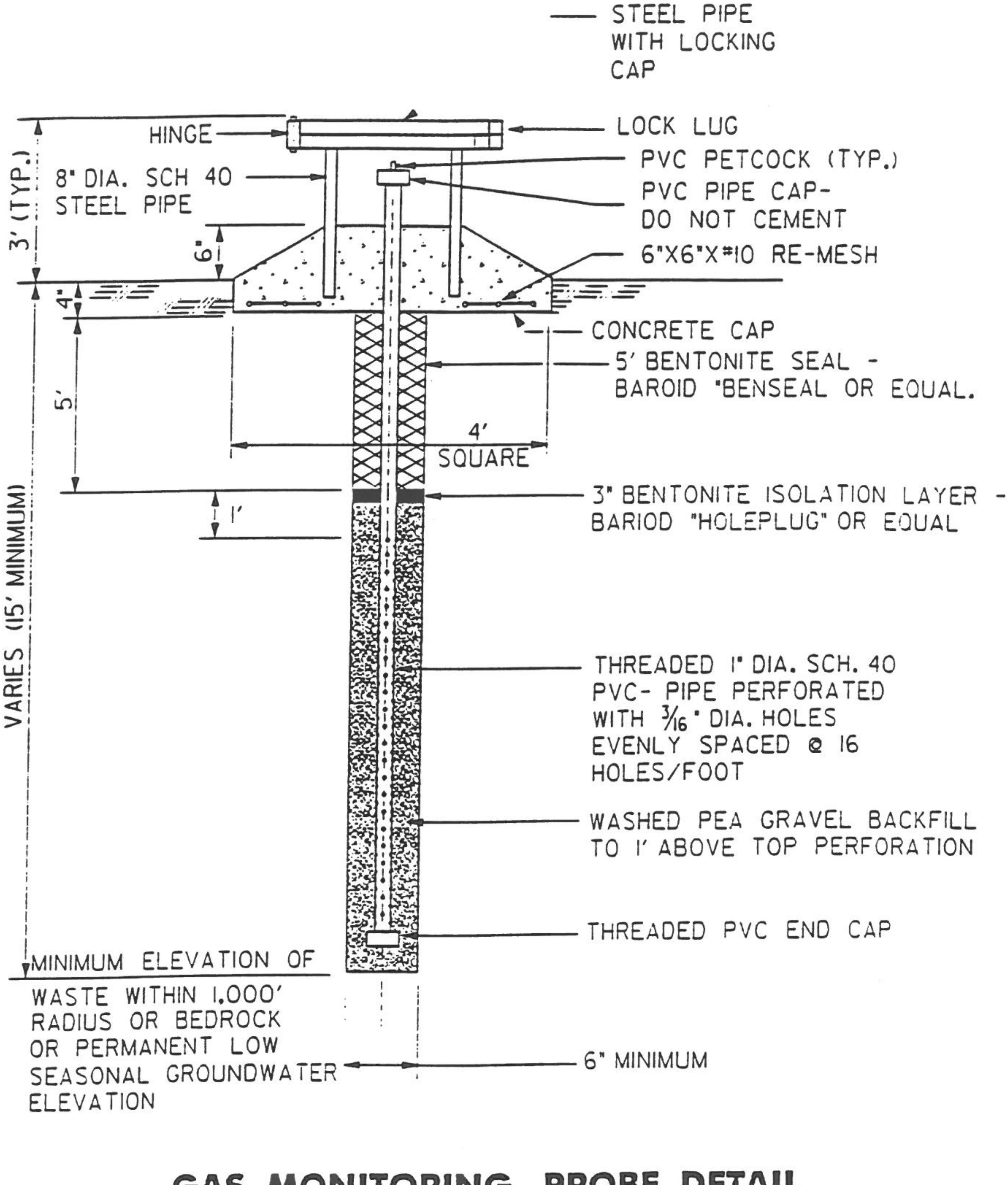
Republic Waste Services of Texas Ltd.
18545 FM 1686 Victoria, TX 77905
Phone: (361) 698-5000

Additionally, in the event that confirmed methane gas concentrations over 100% LEL are detected in any of the gas monitoring probes or a confirmed methane gas concentration over 25% LEL is detected in any on-site structure, the monitoring data will be obtained, and a list of the steps taken to protect persons and property will be placed into the operating record at the landfill.

4.2 Remediation Procedures

Within 60 days of any new detection of confirmed methane gas concentrations over 100% LEL in gas monitoring probe(s) or a confirmed methane gas concentration over 25% LEL is detected in any on-site structure, the site's remediation plan will be implemented, and the executive director of the TCEQ will be notified that the plan has been implemented.

APPENDIX A – GAS MONITORING PROBE DETAIL



GAS MONITORING PROBE DETAIL

NOT TO SCALE

APPENDIX B – GAS MONITORING FORMS

CONTINUOUS GAS MONITOR/ALARM RECORD

METHANE MANAGEMENT PLAN

___________________________ LANDFILL

_____________________, TEXAS

PERMIT NO. ___________

INSTRUMENT DESCRIPTION: ____

INSTRUMENT LOCATION: __________________ MANUFACTURER: ______________

MODEL NUMBER:_________________________ SERIAL NUMBER: ______________

DATE OF ALARM: ________ TIME OF ALARM: ________ INVESTIGATED BY: ________

RESULT OF INVESTIGATION: ____

____

____

SAFETY MEASURES TAKEN: ____

____

____

GENERAL COMENTS: ____

____

INSTRUMENT DESCRIPTION: ____

INSTRUMENT LOCATION: _____________________ MANUFACTURER: ______________

MODEL NUMBER: ____________________________ SERIAL NUMBER: ______________

DATE OF ALARM: ________ TIME OF ALARM: ________ INVESTIGATED BY: ________

RESULT OF INVESTIGATION: ____

____

____

SAFETY MEASURES TAKEN: ____

____

____

GENERAL COMENTS: ____

____

METHANE GAS MONITORING PROBE RECORD

METHANE MANAGEMENT PLAN

____________________________ LANDFILL

______________________, TEXAS

PERMIT NO. ____________

DATE: _____/_____/_____ PERFORMED BY:____

COMBUSTIBLE GAS INDICATOR (MFG. AND MODEL NO.): ______________________________

COMBUSTIBLE GAS INDICATOR SERIAL NUMBER: _____________________________________

AIR DATA INSTRUMENT (MF. AND MODEL NO.): _______________________________________

AIR DATA INSTRUMENT SERIAL NUMBER: ____

AMBIENT BAROMETRIC PRESSURE: ____ IN. HG. AMBIENT TEMPERATURE:____°F

COMMENTS: ____

____

____

PROBE #	**GAS CONCENTRATION**		**PRES. (VACUUM) INCHES W.C.**	**TEMPERATURE °F**	**COMMENTS**
	% METHANE	**% LEL**			

METHANE GAS MONITORING RESULTS (PROBES)

METHANE MANAGEMENT PLAN

___________________________ LANDFILL

_____________________, TEXAS

PERMIT NO. ___________

REPORTING PERIOD: ______/______/______ TO ______/______/______

PROBE #	GAS CONCENTRATION		PRES. (VACUUM) INCHES W.C.	PROBE TEMPERATURE °F	AMBIENT BAROMETRIC PRESSUSE IN. HG.	AMBIENT TEMP (°F)
	% METHANE	% LEL				

CUMULATIVE RAINFALL: _______________ IN.

COMMENTS: ____

____

SUBMITTED BY: ____

(SIGNATURE)

____

(PRINTED/TYPED NAME)

____

(TITLE)

METHANE GAS MONITORING RESULTS

(CONTINUOUS MONITOR/ALARMS)

METHANE MANAGEMENT PLAN

__________________________ LANDFILL

____________________, TEXAS

PERMIT NO. ___________

REPORTING PERIOD: _____/_____/_____ TO _____/_____/_____

MONITOR/ALARM LOCATION: ____

WAS THE ALARM TRIGGERED DURING THE REPORTING PERIOD? _____________________

IF YES:

DATE OF ALARM: ______________ TIME OF ALARM: ____________

CAUSE OF ALARM: ____

____

____

SAFETY MEASURES TAKEN: ____

____

____

MONITOR/ALARM LOCATION: ____

WAS THE ALARM TRIGGERED DURING THE REPORTING PERIOD? _____________________

IF YES:

DATE OF ALARM: ______________ TIME OF ALARM: ____________

CAUSE OF ALARM: ____

____

____

SAFETY MEASURES TAKEN: ____

____

____

COMBUSTIBLE GAS INDICATOR CALIBRATION RECORD

METHANE MANAGEMENT PLAN

___________________________ LANDFILL

_____________________, TEXAS

PERMIT NO. ____________

INSTRUMENT DESCRIPTION: ________________ MANUFACTURER: _______________

MODEL NUMBER: __________________________ SERIAL NUMBER: _______________

DATE: ______/______/______ CHECK GAS (% LEL): _________________________

TIME: ________________________ INITIAL READING (% LEL): ____________________

PERFORMED BY: ______________ FINAL READING (% LEL): _____________________

MAINTENANCE PERFORMED: ____

COMMENTS: ____

____

____

DATE: ______/______/______ CHECK GAS (% LEL): _________________________

TIME: ________________________ INITIAL READING (% LEL): ____________________

PERFORMED BY: ______________ FINAL READING (% LEL): _____________________

MAINTENANCE PERFORMED: ____

COMMENTS: ____

____

____

CONTINUOUS GAS MONITOR/ALARM TEST RECORD

METHANE MANAGEMENT PLANT

___________________________ LANDFILL

_____________________, TEXAS

PERMIT NO. ____________

DATE: ______/______/______ PERFORMED BY: ___________________________________

INSTRUMENT DESCRIPTION: ____

INSTRUMENT LOCATION: ____________________ MANUFACTURER: _______________

MODEL NUMBER: ___________________________ SERIAL NUMBER: _______________

MAINTENANCE PERFORMED: ____

COMMENTS: ____

____

____

DATE: ______/______/______ PERFORMED BY: ___________________________________

INSTRUMENT DESCRIPTION: ____

INSTRUMENT LOCATION: ____________________ MANUFACTURER: _______________

MODEL NUMBER: ___________________________ SERIAL NUMBER: _______________

MAINTENANCE PERFORMED: ____

COMMENTS: ____

____

____

APPENDIX C – LANDFILL GAS MONITORING DATA SHEETS

LANDTEC
QED

GEM™5000

PORTABLEGAS ANALYZER INSTRUMENTATION

PATENT #8,021,612

WWW.LANDTECNA.COM

- SIX TIMES MORE ACCURATE
- ANNUAL RECOMMENDED FACTORY SERVICE
- AVAILABLE WITH GPS AND ADDITIONAL GAS DETECTION

THE NEXT GENERATION OF GEM™ INSTRUMENT

The GEM™5000 is designed specifically for use on landfills to monitor Landfill Gas (LFG) Collection & Control Systems. The GEM™5000 samples and analyzes the methane, carbon dioxide and oxygen content of landfill gas with options for additional analysis.

INFO@QEDENV.COM

800-LANDTEC
909-783-3636

QED ENVIRONMENTAL
2355 Bishop Circle West
Dexter, MI 48130, USA

LANDTEC
QED

GEM™5000

PORTABLEGAS
ANALYZER
INSTRUMENTATION

PATENT #8,021,612

FEATURES

- Measures % CH_4, CO_2 and O_2 Volume, static pressure and differential pressure
- Calculates balance gas, flow (SCFM) and calorific value
- CO and H_2S (on Plus models only)
- High Accuracy and Fast Response Time
- Lighter and More Compact
- Certified intrinsically safe for landfill use
- Annual recommended factory service
- Calibrated to ISO/IEC 17025
- 3 year warranty with optional service plan

APPLICATIONS

- Landfill Gas Collection & Control Systems
- Environmental Compliance
- Landfill Gas to Energy
- Subsurface Migration Probes

KEY BENEFITS

- Designed specifically for use on landfills to monitor landfill gas (LFG) extraction systems, flares, and migration control systems
- No need to take more than one instrument to site
- Can be used for monitoring subsurface migration probes and for measuring gas composition, pressure and flow in gas extraction systems
- The user is able to set up comments and questions to record information at site and at each sample point
- Ensures consistent collection of data for better analysis
- Streamlined user experience reduces operational times

TECHNICAL SPECIFICATION

GAS RANGES

Gases Measured	CH_4	By dual wavelength infrared cell with reference channel		
	CO_2	By dual wavelength infrared cell with reference channel		
	O_2	By internal electrochemical cell		
	CO	By internal electrochemical cell		
	H_2S	By internal electrochemical cell		
Ranges	CH_4	0-100% (vol)		
	CO_2	0-100% (vol)		
	O_2	0-25% (vol)		
	CO	0-2000ppm***		
	H_2S	0-500ppm***		
Gas Accuracy*	CH_4	0-5% ± 0.3% (vol)	0-70% ± 0.5% (vol)	70-100% ± 1.5% FS
	CO_2	0-5% ± 0.3% (vol)	0-60% ± 0.5% (vol)	60-100% ± 1.5% FS
	O_2	0-25% ±1.0% (vol)		
	$CO(H_2)$**	0-2000ppm ± 2.0% FS		
	H_2S	0-500ppm ± 2.0% FS		

* Typical accuracy after calibration as recommended in the operations manual.
**Hydrogen compensated Carbon Monoxide measurement.
***Additional ranges available, contact LANDTEC for more information.

OTHER PARAMETERS

	Unit	Resolution	Comments
Energy	BTU/hr	1000 BTU/hr	Calculated from specific parameters
Static Pressure	in. H_2O	0.01 in. H_2O	Direct Measurement
Differential Pressure	in. H_2O	0.001 in. H_2O	Direct Measurement
Temperature Accuracy	°F	0.1	±1 (Range -58°F to 482°F)

Important Note: The information in this document is correct at the time of generation. We do, however, reserve the right to change the specification without prior notice as a result of continuing development.

PUMP

Flow	Typically 550cc/min
Flow with 80 in. H2O vacuum	Approximately 80cc/min

ENVIRONMENTAL CONDITIONS

Operating Temperature Range	14°F – 122°F (-10°C to +50°C)
Operating Pressure	-100 in. H_2O, +100 in. H_2O (-250mbar, +250mbar)
Relative Humidity	0-95% non condensing
Barometric Pressure	± 14.7 in.Hg (±500mbar) from calibration pressure
Barometric Pressure Accuracy	± 1% typically

POWER SUPPLY

Battery Life	Typical use 8 hours from fully charged
Charge Time	Approximately 4 hours from complete discharge

CERTIFICATION RATING

ATEX	II 2G Ex ib IIA T1 Gb (Ta= -10°C to +50°C)
ISO17025	ISO/IEC17025:2005 Accreditation #66916
CSA	Ex ib IIA T1 (Ta= -10°C to +50°C) (Canada), AEx ib IIA T1 (Ta= -10°C to +50°C) USA

SWANA MEMBER
ISWA International Solid Waste Association

WWW.LANDTECNA.COM

#2387 REV 1 4-17

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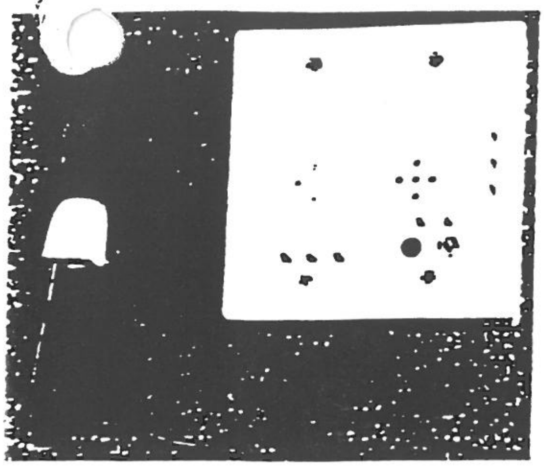
800-LANDTEC
909-783-3636

QED ENVIRONMENTAL
2355 Bishop Circle West
Dexter, MI 48130, USA

GAS DETECTORS

4S1B 4S1C 4S1D



The 4S1B, C, & D are all electronic Gas Detection and Alarm systems. They are inexpensive, self-contained devices that can prevent explosions or asphyxiation due to gas leaks.

In residential use, they complement smoke detectors, which do not detect any gases and can't alarm until a fire occurs. The 4S1B or 4S1C can provide protection from deadly carbon monoxide gas, which is caused by faulty furnaces or exhaust fumes from engines. The 4S1D detects all heating-type gases.

In industrial use, the 4S1B, C, & D can provide an inexpensive alarm to various gases that are hazardous to workers.

FAIL SAFE DESIGN: Sensors and other critical functions are supervised.

EXPLOSION PROOF: Most models are inherently explosion proof.

ELECTRONIC SENSORS: No Maintenance or re-calibration required. Should last 10 years.

DETECT MANY GASES: See list below.

SMALL, COMPACT DESIGN: Takes little space, easy to install.

GAS DETECTION IS FIRE PREVENTION

PECIFICATIONS

Power: 120 VAC, 60Hz, less than 10W
Size: 4½ x 4½ x 2 inches
Shipping Weight: Approx 2 Lbs.
Alarm Sound Level: Approx 88 DB @ 10 Ft.
Circuitry: All solid state
Sensor Maintenance: Not required.
Color: White or Beige

PTIONS

24 VDC operation @ 0.25 Amps
12 VDC operation @ 0.25 Amps
Reed Relay: N.O. closes on alarm
Mounting in electrical box
Special calibrations
220 VAC, 50 HZ.

RESPONSE TO COMMON GASES

The following are normal alarm points of the 4S1B, C, & D to carbon monoxide, natural gas (methane), or the propane/butane/LP gas family. The underlined level is the set calibration point, with the other levels an average, which will vary from unit to unit. LEL is Lower Explosive Limit.

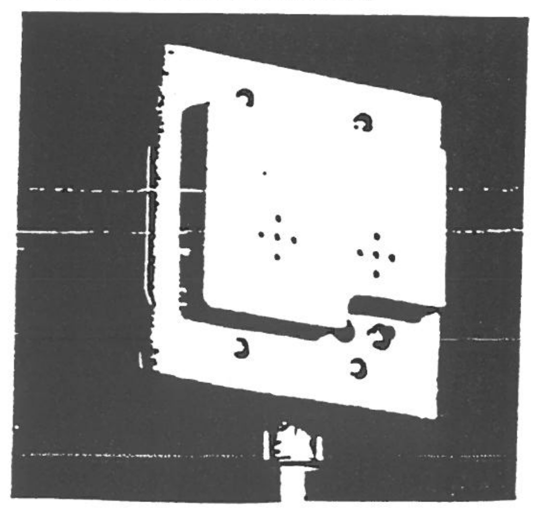
Model	Carbon Monoxide	Natural Gas	Propane
4S1B	300 ppm	60% LEL	2000 ppm
4S1C	600 ppm	30% LEL	1000 ppm
→ 4S1D	Not Applicable	10% LEL	10% LEL

The units can be set to the customers specifications.

NO CASE, MOUNTING IN ELECTRICAL BOX OPTION 4S1B-1, 4S1C-1, 4S1D-1. These units have no case, cord, or plug. They mount in type 4S, 4SL, or 4SD electrical boxes (supplied by the customer). Short pigtail leads connect to the power or relay contacts.

OLLOWING IS A LIST OF GASES THAT ONE OR MORE UNITS CAN DETECT.
ONSULT THE FACTORY FOR EXACT DETAILS OR CALIBRATIONS.

CETONE	ETHYLENE	METHYL CHLORIDE
CETYLENE	ETHYLENE OXIDE	METHYL ETHER
CRYTONITRILE	FORMALDEHYDE	METHYL ETHYL KETONE
COHOL	FREON	METHYL MERCAPTAN
NZENE	GASOLINE FUMES	METHYLENE CHLORIDE
TANE	HEXANE	NATURAL GAS
TANOL	HYDROGEN	PENTANE
RBON MONOXIDE	KEROSENE FUMES	PROPANE
R TRACHLORIDE	LACQUER THINNER	TRICHLOROETHANE
CRIN	L.P. GAS	TRICHLOROETHYLENE
YL AMINE	METHANE GAS	VINYL CHLORIDE
HANE	METHANOL	
HANOL	METHYL ACETATE	



NUFACTURED BY: MACURCO, INC.
3946 S. Mariposa Street
Englewood, Colorado 80110
(303) 781-4062

GAS DETECTION
Macurco inc.

3946 SOUTH MARIPOSA • ENGLEWOOD, COLORADO 80110 • (303) 781-4062
FAX (303) 761-6640

PRICE LIST PROPANE PID-189

MODEL	SUGGESTED LIST PRICE	PRICE TO INSTALLER/DEALERS 1 UNIT	10 OR MORE
4S1 GVC	$200	$150	$135
RPD	294	220	200
RCM	400	306	275
RCM		300	285
→ 4S1C,4S1D	110	76	72
4S1C-1,4S1D-1	100	70	66.50

OPTIONS: 4S1C, 4S1C-1, 4S1D, 4S1D-1; ADD % TO BASE PRICE

RELAY INSTEAD OF BUZZER	10%
RELAY AND BUZZER	20%
12 VDC INSTEAD OF 120 VAC POWER	5%
24 VAC OR 24 VDC POWER	10%
220 VAC, 50 Hz POWER	10%
EXPLOSION PROOF BUZZER	10%
TEMPERATURE COMPENSATION	10%
SPECIAL CALIBRATIONS	CONSULT THE FACTORY

4S1T,4S1TM	137	96	91
MR-1	68.50	48	45.50
[illegible]-1	110	76	72
GD-2	125	86	82

ACCESSORIES FOR RPD

12 VDC BATTERY CHARGER	$10
BELT CLIP	10
CARRYING CASE	5
EARPHONES	5
SENSOR EXTENSION CABLE	25
CARBON MONOXIDE SENSOR	13.50

RCM EXTRA GAS CANISTER 50

NOTES:

1. All prices are F.O.B. Englewood, Colorado, U.S.A. Shipping costs, usually by U.P.S., will be added to the invoice.
2. Terms are cash in advance, C.O.D., or open account--to qualified accounts. Shipping by surface U.P.S., will be paid by Macurco, with cash in advance.
3. Minimum requirements to receive these Installer/dealer prices is: $100 per order.
4. Distributor pricing and requirements available upon request.
5. Any order with special calibration or optional equipment [illegible] non-returnable.

[illegible] A 25% re-stocking fee will be charged on all returned orders.

7. No mixing of several models to obtain a higher quantity break is allowed.

BW Clip

maintenance-free single-gas detector

The most life for the price. Have a two-year detector for H_2S or CO that you're not using? Hibernate it, and get the time back - for up to a year. Spread your detector's 24 months of operation over up to three years instead of the standard two. **Great for turnarounds, short-term projects or employee leave.**

WATER RESISTANT

The most user-friendly, reliable and cost-effective way to ensure safety, compliance and productivity.

The BW Clip single-gas detector is your everyday companion for hazardous environments. It operates up to three years maintenance-free: Just turn on the device and it runs continuously — no need for calibration, sensor replacement, battery replacement or battery charging. That means great reliability and no downtime.

Plus, with the two-year BW Clip for H_2S or CO, you can put the device in a hibernation case when you're not using it for a week or more — and extend its life by that period of time.

Compatible with both the MicroDock II and the IntelliDoX instrument management systems, the BW Clip is engineered to the highest standards of quality and reliability, keeping you safe and compliant.

Easy gas identification with color coded labels and LCD indication:

- **H_2S**
- **CO**
- **O_2**
- **SO_2**

Easy To Wear

Easy to Read

Easy to See

Use our unique advanced technology for safety, compliance and productivity.

- **Surecell™:** unique dual reservoir sensor design dramatically improves instrument performance, response time, and longevity compared to traditional electrochemical sensors and consistently delivers reliable instrument performance under the harshest environmental conditions
- **Reflex Technology™:** advanced automated self-test function routinely checks the operating condition of the sensor to increase safety, up-time, and overall worker confidence
- **IntelliDoX:** instrument management system
  - The quickest bump test in the industry
  - Configuration of alarm set points and more
  - Performing different tests for up to five BW Clip detectors at once — for maximum productivity
  - Easy and accurate record-keeping

BW Technologies
by Honeywell

BW Clip

maintenance-free single-gas detector

BW Clip Standard Features:

- Maintenance-free: no sensor or battery changes necessary
- Compact, lightweight design with one-button operation
- Designed for a range of harsh environments and extreme temperatures
- Hibernation mode with case accessory or IntelliDoX
- Automated self-test of battery, sensor and electronics
- Wide-angle flash, which alerts simultaneously with audible and vibrating alarm
- Automatic logging of the 35 most recent gas events and bump test results
- Compatible with MicroDock II and Fleet Manager II software
- Affordable, with low cost of ownership

Configureable Options:

- Configuration of high and low alarm set points before the device is activated
- Adjustment of alarm set points and other parameters as needed throughout the lifespan
- Option to enable the noncompliance indicator, which flashes red when a bump test is due or a gas event occurs
- Option to display gas reading during alarm
- User settable bump test reminder
- Option to display the Real Time Clock

Options & Accessories

Hibernation Case

Hard Hat Clip

IntelliDoX

For a complete list of kits and accessories, please contact BW Technologies by Honeywell.

Locally available from...

BW Clip Specifications

Size	1.6 x 2.0 x 3.4 in. / 4.1 x 5.0 x 8.7 cm
Weight	3.2 oz. / 92 g
Temperature	H_2S: -40 to +122°F / -40 to +50°C CO: -22 to +122°F / -30 to +50°C O_2: -4 to +122°F / -20 to +50°C SO_2: -22 to +122°F / -30 to +50°C
Humidity	5% - 95% RH (non-condensing)
Alarms	Visual, vibrating, audible (95 dB) • Low, High
Tests	Activated detectors automatically perform one internal diagnostic test every 24 hours.
Typical battery life	Two years (H_2S, CO, O_2 or SO_2) or three years (H_2S or CO)
Event logging	35 most recent events
Ingress Protection	IP 66/67
Certifications and approvals	c UL us: Class I, Div. 1, Gr. A, B, C, D Class I, Zone 0 , Gr. IIC **ATEX:** CE Ex 0539 II 1G Ex ia IIC T4 Ga IP66/67 DEMKO 14 ATEX 1356 **IECEx:** Ex ia IIC T4 Ga IP66/67 IECEx UL 14.0063 CE: European Conformity
Warranty	Two or three years from activation (given normal operation), plus one year shelf life (6 months for O2). Up to three years for two-year H2S and CO detectors when used with the hibernation feature, limited to 24 months of detector operation.

Sensor Specifications

Gas	Measuring Range	Low Alarm Level	High Alarm Level
2 or 3 year detector			
H_2S	0 -100 ppm	10 ppm	15 ppm
CO	0 - 300 ppm	35 ppm	200 ppm
2 year detector only			
O_2	0 - 25.0 % by vol.	19.5 %	23.5 %
SO_2	0 - 100 ppm	5 ppm	10 ppm

Alarm setpoints are user adjustable before and after activating the detector.

Set points shown are default values as shipped from the manufacturer. Additional default values are available.

DUE TO ONGOING RESEARCH AND PRODUCT IMPROVEMENT, SPECIFICATIONS ARE SUBJECT TO CHANGE WITHOUT NOTICE.

BW Technologies by Honeywell

20150108-01-EN

APPENDIX D – GMP LITHOLOGIC LOGS

LITHOLOGIC LOG

DEPTH (FT.)	Description
0–7	CLAY, dark gray (N3), slightly silty, with calcareous nodules to 1/8" dia. firm, plastic, (CH)
7–26	CLAY, yellowish gray (5Y 8/1), silty, with calcareous and ferrous nodules, plastic, (CH)
8–12	Becomes grayish orange (10 YR 7/4) from 8-12 feet.
	Becomes light yellowish gray (5Y 8/1)
	Increase in silt
26–30	SAND, SILTY, very pale orange (10YR 8/2) with rust stains, fine to medium grained, calcareous nodules (SM)
30	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-1

FOOTAGE DRILLED: 30

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1"=

GEOLOGIST: C Beiner

NOTES: 10-28-93

gas readings

HC	00 ppm
O_2	21.3 %
H_2S	00 ppm
CO	01 ppm

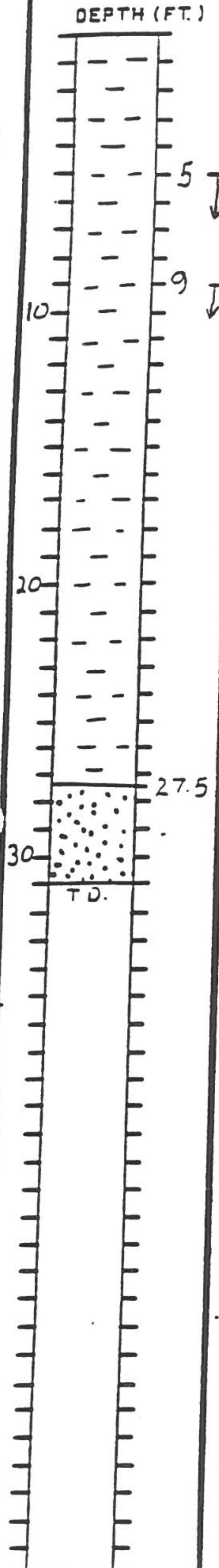
Samples collected from cuttings every 2 feet

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG



CLAY, dark gray (N3) few calcareous white nodules up to 1/8" dia, slightly silty, plastic, (CH)

Becomes grayish orange (10YR 7/4)

Becomes yellowish gray (8YR 8/1)

1/8" dia. ferrous nodules at 12 ft

SAND, very pale orange (10YR 8/2), fine to medium grained, with some clay and silt, (SM)

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-2

FOOTAGE DRILLED: 31

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C Beiner

NOTES: 10-28-93

GAS READINGS

HC	00 ppm
O_2	21.0 %
H_2S	0.5 ppm
CO	00 ppm

Rotery drilled to 30'. Hole caved in to 29 ft. Augered to 31 ft. Hole cave to 30 ft.

No groundwater encountered.

SHEET 1 **OF** 1

MORRISON KNUDSEN

Attachment 8-33

2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U S A

LITHOLOGIC LOG

DEPTH (FT.)

0	CLAY, dark gray (N3), stiff, plastic, with small calcareous nodules common
5 ↓	Becomes yellowish gray (5Y 8/1)
14 ↓	Increase in small ferrous nodules
28	SAND, silty, fine grained, numerous calcareous nodules (cemented w/ $CaCO_3$?) (SM)
30	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-3

FOOTAGE DRILLED: 30

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Bejnar

NOTES: 10-29-93

GAS READINGS

HC	00 ppm
O_2	21.0 %
H_2S	00 ppm
CO	00 ppm

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN

2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS

LITHOLOGIC LOG

PROJECT NAME: BFI VICTORIA
HOLE NUMBER: GMP-4
FOOTAGE DRILLED: 40'
FOOTAGE LOGGED:
COORDINATES:
SEC. ___, ___, ___, ___
COUNTY: Victoria
STATE: Texas
COLLAR ELEVATION:
MAP:
SURVEY:
OTHER:
VERT. SCALE: 1" = 6'
GEOLOGIST: C. Bejnar

DEPTH (FT.)	Description
0	CLAY, dark gray (N3), with small white calcareous nodules and few ferrous nodules
4 ↓	Becomes yellowish gray (5Y 8/1)
12 ↓	Becomes dark yellowish orange (10YR 6/6)
26–28	great number of calcareous nodules 26-28 ft depth
31	SAND, fine grained with calcareous nodules or cement? (SM) or (SW) almost no returns ie. cuttings because sand is staying in suspension in the drilling mud.
40	T.D

NOTES: 10-29-93

GAS READINGS

HC. 00 ppm
O_2 21.0 %
H_2S 00 ppm
CO 01 ppm

No groundwater encountered.

SHEET 1 **OF** 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A

LITHOLOGIC LOG

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-5

FOOTAGE DRILLED: 40

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Beynar

DEPTH (FT.)	Description
0	CLAY, dark gray (N3), slightly silty in places, plastic, with small calcareous and ferrous nodules
5	Becomes yellowish gray (5Y 8/1)
8	Becomes dark yellowish orange (10 YR 6/6)
17	Becomes yellowish gray (5Y 8/1)
30	Becomes light yellowish gray, increase in nodules (white calcareous)
34	SAND, fine grained, sand is staying in suspension in the drilling mud, poor samples. (SM)
40	T.D.

NOTES: 10-30-93

GAS READINGS

HC 00 ppm
O_2 21.0 %
H_2S 00
CO 00 ppm

Hole caved in to 36'-6"

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

STATE OF TEXAS WELL REPORT for Tracking #47492

Owner: **Victoria Landfill**

Owner Well #: **GMP-5A**

Address: **P.O. Box 724**
Bloomington, TX 77951

Grid #: **80-17-6**

Well Location: **18545 FM 1686**
Bloomington, TX 77951

Latitude: **28° 41' 26" N**

Longitude: **096° 54' 15" W**

Well County: **Victoria**

Elevation: **80 ft. above sea level**

Type of Work: **New Well**

Proposed Use: **Monitor**

Drilling Start Date: **9/8/2004** Drilling End Date: **9/8/2004**

Borehole:

Diameter (in.)	*Top Depth (ft.)*	*Bottom Depth (ft.)*
8	**0**	**28**

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Filter Packed**

Filter Pack Intervals:

Top Depth (ft.)	*Bottom Depth (ft.)*	*Filter Material*	*Size*
3	**28**	**Gravel**	**20/40**

Annular Seal Data:

Top Depth (ft.)	*Bottom Depth (ft.)*	*Description (number of sacks & material)*
0	**1**	**1/2 cement bent**

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Surface Slab Installed**

Water Level: **No Data**

Packers: **Bentonite 1' - 3'**

Type of Pump: **No Data**

Well Tests: **No Test Data Specified**

Water Quality:

Strata Depth (ft.)	Water Type
No Data	**No Data**

Chemical Analysis Made: **Unknown**

Did the driller knowingly penetrate any strata which contained injurious constituents?: **Unknown**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Best Drilling Services, Inc.**

P.O. Box
Friendwood, TX 77549

Driller Name: **Lawrence Tobola** License Number: **3026**

Comments: **No Data**

Lithology:
DESCRIPTION & COLOR OF FORMATION MATERIAL

Top (ft.)	Bottom (ft.)	Description
0	**2.5**	**SAND, clayey, silty, yellow brown**
2.5	**28**	**CLAY, slightly silty, drk. gray**

Casing:
BLANK PIPE & WELL SCREEN DATA

Dia. (in.) New/Used Type Setting From/To (ft.)
1 N SCHL 40 PVC RISER 0/5
1 N SCHL 40 PVC SCREEN 5/28 0.010

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

Texas Department of Licensing and Regulation
P.O. Box 12157
Austin, TX 78711
(512) 334-5540

LITHOLOGIC LOG

DEPTH (FT.)

Depth	Description
0	CLAY, dark gray (N3), firm, plastic with tiny calcareous nodules (CH)
4	Becomes yellowish gray (5Y8/1)
8	CLAY, SANDY, yellowish gray (5Y8/1) with numerous large calcareous nodules, not as plastic as above (CL)
10	CLAY, yellowish gray with dark yellowish orange (10YR6/6), small calcareous and ferrous nodules. (CH)
19½	SAND, very fine grained, yellowish gray (5Y8/1), clayey and silty (SM)
20	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-7

FOOTAGE DRILLED: 20

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Bejar

NOTES: 10-31-93

GAS READINGS

HC .00 ppm

O_2 21.0%

H_2S 0.0 ppm

CO 0.0 ppm

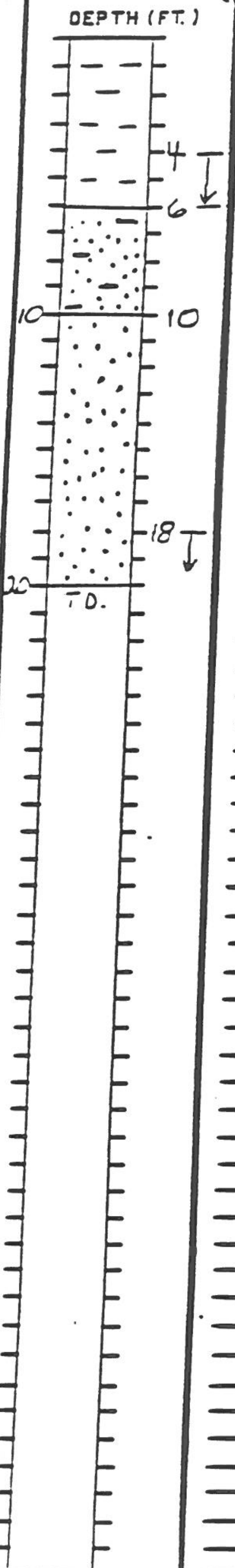
Auger drilled. Samples every 2 feet.

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 U.S.A.

LITHOLOGIC LOG



CLAY, dark gray (N3), firm, plastic, with few small calcareous nodules (CH)

Becomes dark yellowish brown (10YR 4/2)

SAND, CLAYEY, pale yellowish orange (10YR 8/6) with much white calcareous material (SM)

SAND, fine grained, pale yellowish-orange (10YR 8/6), well sorted, clean (SP)

Becomes medium grained, very pale orange (10YR 8/2)

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-8

FOOTAGE DRILLED: 20

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: VICTORIA

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Beinar

NOTES: 10-31-93

GAS READINGS

HC — none recorded
O_2 — Alarm did not sound so all were below allowable limits
H_2S
CO

Auger drilled. Excellent samples every 2 ft.

Hole caved in to 18'-6"

No groundwater encountered

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219

STATE OF TEXAS WELL REPORT for Tracking #47516

Owner:	**Victoria Landfill**	Owner Well #:	**GMP-8A**
Address:	**P.O. Box 724 Bloomington, TX 77951**	Grid #:	**80-17-6**
Well Location:	**18545 FM 1686 Bloomington, TX 77951**	Latitude:	**28° 41' 17" N**
		Longitude:	**096° 54' 37" W**
Well County:	**Victoria**	Elevation:	**49 ft. above sea level**

Type of Work: **New Well**

Proposed Use: **Environmental Soil Boring**

Drilling Start Date: **9/10/2004** Drilling End Date: **9/10/2004**

	Diameter (in.)	*Top Depth (ft.)*	*Bottom Depth (ft.)*
Borehole:	**8**	**0**	**16**

Drilling Method: **Hollow Stem Auger**

Borehole Completion: **Plugged**

	Top Depth (ft.)	*Bottom Depth (ft.)*	*Description (number of sacks & material)*
Annular Seal Data:	**0**	**16**	**1 cement benton**

Seal Method: **Tremie**

Sealed By: **Driller**

Distance to Property Line (ft.): **No Data**

Distance to Septic Field or other concentrated contamination (ft.): **No Data**

Distance to Septic Tank (ft.): **No Data**

Method of Verification: **No Data**

Surface Completion: **Unknown**

Water Level: **No Data**

Packers: **No Data**

Type of Pump: **No Data**

Well Tests: **No Test Data Specified**

Water Quality:	Strata Depth (ft.)	Water Type
	No Data	**No Data**

Chemical Analysis Made: **Unknown**

Did the driller knowingly penetrate any strata which contained injurious constituents?: **Unknown**

Certification Data: The driller certified that the driller drilled this well (or the well was drilled under the driller's direct supervision) and that each and all of the statements herein are true and correct. The driller understood that failure to complete the required items will result in the report(s) being returned for completion and resubmittal.

Company Information: **Best Drilling Services, Inc.**

P.O. Box
Friendwood, TX 77549

Driller Name: **Lawrence Tobola** License Number: **3026**

Comments: **No Data**

Lithology:
DESCRIPTION & COLOR OF FORMATION MATERIAL

Top (ft.)	*Bottom (ft.)*	*Description*
0	**11**	**CLAY, drk. gray**
11	**16**	**SAND, clayey, yellowish gray**

Casing:
BLANK PIPE & WELL SCREEN DATA

Dia. (in.)	*New/Used*	*Type*	*Setting From/To (ft.)*
No Data			

IMPORTANT NOTICE FOR PERSONS HAVING WELLS DRILLED CONCERNING CONFIDENTIALITY

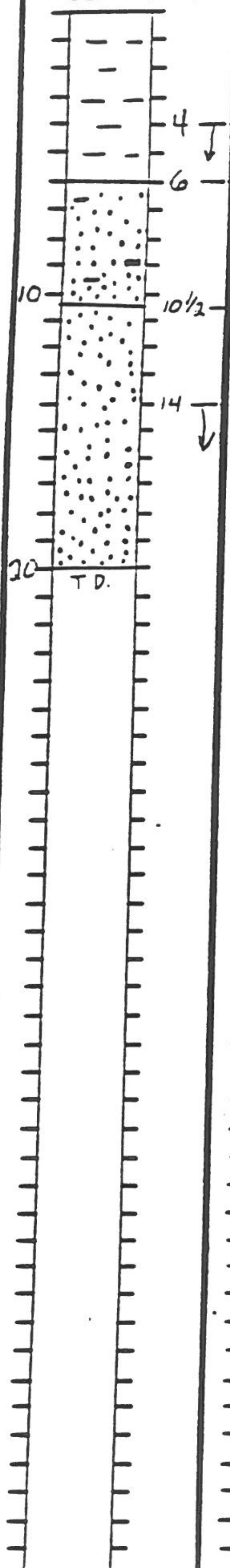
TEX. OCC. CODE Title 12, Chapter 1901.251, authorizes the owner (owner or the person for whom the well was drilled) to keep information in Well Reports confidential. The Department shall hold the contents of the well log confidential and not a matter of public record if it receives, by certified mail, a written request to do so from the owner.

Please include the report's Tracking Number on your written request.

Texas Department of Licensing and Regulation
P.O. Box 12157
Austin, TX 78711
(512) 334-5540

LITHOLOGIC LOG

DEPTH (FT.)



CLAY, dark gray (N3), firm, plastic with small calcareous nodules (CH)

becomes silty, dark yellowish brown (10YR 4/2)

SAND CLAYEY, pale yellowish orange (10YR 8/6) with numerous large calcareous nodules especially 6-8 ft. (SM)

SAND, fine grained, pale yellowish orange (10YR 8/6), well sorted, clean (SP)

Becomes medium grained

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-9

FOOTAGE DRILLED: 20

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Bejnar

NOTES: 10-31-91

GAS READINGS

HC	00 ppm
O_2	21.0 ppm
H_2S	00 ppm
CO	00 ppm

Auger drilled
Excellent samples every 2 feet.

Hole caved in to 19'-6".

No groundwater encountered

SHEET 1 **OF** 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG

DEPTH (FT.)

Depth	Description
0	CLAY, dark gray (N3), with calcareous and ferrous nodules, plastic, (CH)
4	Becomes yellowish orange (10YR 6/6)
12	Becomes pale yellowish gray (5Y 8/1) with trace sand (CH)
17	CLAY SANDY, pale yellowish gray (5Y 8/1) with abundant which calcareous material (CL)
19	SAND, CLAYEY, pale yellowish gray (5Y 8/1) with abundant white calcareous material (SM)
20	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-1C

FOOTAGE DRILLED: 20

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Bejnar

NOTES: 10-31-93

GAS READINGS

HC	00 ppm
O_2	21.0 %
H_2S	00 ppm
CO	.02 ppm

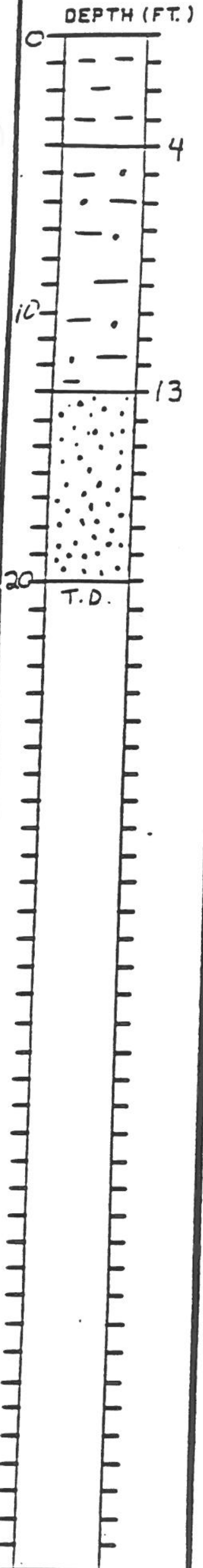
Auger drilled

Excellent samples every 2 ft.

Gas detecter is down wind from engine exhaust

No groundwater encountered

SHEET 1 OF 1



LITHOLOGIC LOG

CLAY, dark gray (N3), with small white calcareous nodules, plastic (CH)

CLAY, SANDY, yellowish gray (5Y8/1) with abundant white caliche and nodules, semi-plastic (CL)

SAND, fine grained, yellowish gray (5Y8/1) well sorted, clean, (SP)

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-11

FOOTAGE DRILLED: 20

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Bejnar

NOTES: 10-31-93

GAS READINGS

HC 00 ppm

O_2 21.0 %

H_2S 00 ppm

CO 00 ppm

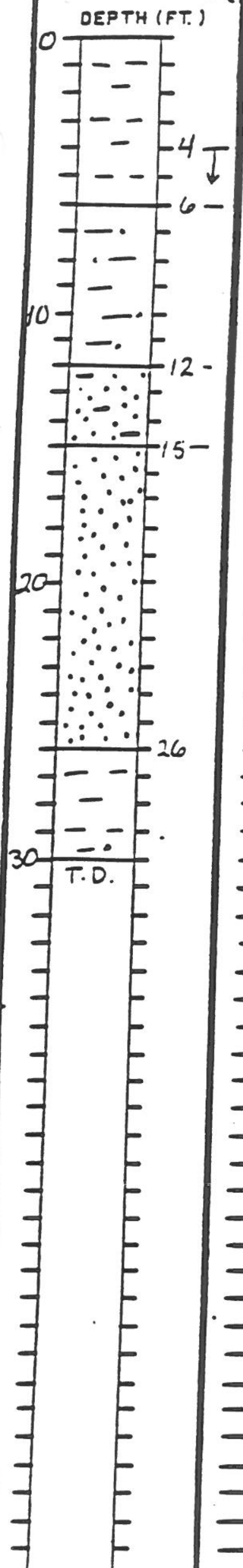
Auger drilled
Excellent samples every 2 ft

No groundwater encountered

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG



CLAY, dark gray (N3), plastic with small white calcareous and dark ferrous nodules. (CH)

Becomes greenish gray (5GY 6/1)

CLAY, yellowish gray (5Y8/1) to dark yellowish orange (10YR 6/6), SANDY with caliche and white nodules, (CL)

SAND, CLAYEY, yellowish gray (5Y8/1) fine grained (SM)

SAND, fine to medium grained, pale yellowish brown (10YR 6/2), well sorted, clean, (SP)

CLAY, dark yellowish orange (10YR 6/6), plastic, trace sand near base

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-12

FOOTAGE DRILLED: 30

FOOTAGE LOGGED:

COORDINATES:

SEC. _____, _____, _____, _____

COUNTY: VICTORIA

STATE: TEXAS

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Beinar

NOTES: 11-1-93

GAS READINGS

HC 00 ppm

O_2 21.0 %

H_2S 00 ppm

CO 00 ppm

hole caved in to 29'-0"

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN

Attachment 8-46

2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG

DEPTH (FT.)	Description
0–4	CLAY, dark gray (N3), plastic, with calcareous and ferrous nodules (CH)
4 ↓	Becomes light yellowish gray (5Y8/1)
10 ↓	Becomes mixed with dark yellowish orange (10YR6/6), and becomes silty with depth
19	SAND, pale yellowish brown (10YR6/2) fine to medium grained with a few thin clay beds. (SP)
28	CLAY, SANDY, light yellowish gray (5Y8/1) (CL)
30	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-13

FOOTAGE DRILLED: 30'

FOOTAGE LOGGED:

COORDINATES:

SEC. ____, ____, ____, ____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Beiner

NOTES: 11-1-93

GAS READINGS

HC. 00 ppm

O_2 21.1%

H_2S .00 ppm

CO 00 ppm

Hole caved in to 25 ft. Set casing to 24½ ft.

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN
2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG

DEPTH (FT.)		
0		CLAY, dark gray (N3), firm becoming hard with depth, plastic, with calcareous and ferrous nodules
5		Becomes light yellow gray (5Y8/1)
9–16	10	Becomes dark yellowish orange (10YR6/6) 9' to 16'
16		Becomes light yellowish gray (5Y8/1)
20	20	CLAY becomes SANDY at 20 ft
21		Calcium carbonate layer (nodules?) at 21 ft
		SAND, fine grained (SM), silty
30	T.D.	

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-14

FOOTAGE DRILLED: 30'

FOOTAGE LOGGED:

COORDINATES:

SEC. _____, _____, _____, _____

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Beimar

NOTES: 10-30-93

GAS READINGS

HC 00 ppm

O_2 21.0 %

H_2S 00 ppm

CO 01 ppm

No groundwater encountered

SHEET 1 OF 1

MORRISON KNUDSEN

2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

LITHOLOGIC LOG

DEPTH (FT.)	Description
0	CLAY, dark gray (N3), plastic with small calcareous and ferrous nodules, (CH)
4½	Becomes yellowish gray (5Y 8/1)
10–16	Becomes dark yellowish orange (10YR 6/6) from 10-16 ft.
16	Becomes yellowish gray (5Y 8/1)
20	Increase in silt and calcareous nodules (CL)
24	SAND, fine grained, with some silt and clay, calcareous nodules present, (SM)
30	T.D.

PROJECT NAME: BFI VICTORIA

HOLE NUMBER: GMP-15

FOOTAGE DRILLED: 30

FOOTAGE LOGGED:

COORDINATES:

SEC. ___, ___, ___, ___

COUNTY: Victoria

STATE: Texas

COLLAR ELEVATION:

MAP:

SURVEY:

OTHER:

VERT. SCALE: 1" = 6'

GEOLOGIST: C. Being

NOTES: 10-30-93

GAS READINGS

HC 00 ppm

O_2 21.0 %

H_2S 00 ppm

CO 00 ppm

High wind.

Hole caved to 29'-6"

No groundwater encountered.

SHEET 1 OF 1

MORRISON KNUDSEN

2446 CEE GEE STREET
P. O. BOX 17219
SAN ANTONIO, TEXAS 78217 / U.S.A.

CREATE AMAZING.

Burns & McDonnell Engineering Company, Inc.
8911 Capital of Texas Highway \ Building 3, Suite 3100
Austin, TX 78759
O 512-872-7130
F 512-872-7127
www.burnsmcd.com

ATTACHMENT 9 – FINAL CLOSURE PLAN

Texas Commission on Environmental Quality

Closure Plan for Municipal Solid Waste Type I Landfill Units and Final Facility Closure

This form is for use by applicants or site operators of Municipal Solid Waste (MSW) Type I landfills to detail the plan for closure of a landfill unit, closure of associated storage or processing units, and final closure of the facility to meet the requirements in 30 TAC Chapter 330, §330.63(h) and 30 TAC Chapter 330 Subchapter K for a MSW Type I facility.

If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: City of Victoria Landfill

MSW Permit No.: 1522B

Site Operator/Permittee Name: City of Victoria/CN600243257

II. Landfill and Other Waste Management Units and Operations Requiring Closure at the Facility

A. Facility Units

Table 1. Description of Landfill Units.

Name or Descriptor of Unit	Operating Status of Unit	Type of Liner System Under Unit	Above Grade Class 1 Disposal Cells in this Unit	Below Grade Class 1 Disposal Cells in this Unit	Other Class 1 Disposal Cells in this Unit (describe)	Size of Unit's Waste Footprint (acres)	Maximum Inventory of Waste Ever in Unit (indicate cubic yards or tons)	Other Necessary Information that Pertains to the Unit
Existing Area	Active	Composite Liner	☐	☐	☐	135.6	15,655,460	* See Below
*The Existing Area includes a Closed, Constructed, and To Be Constructed areas within it. The Closed Area entails 51.6 acres, of which 29.2 acres are permitted as pre-Subtitle D and 22.4 acres are permitted as Subtitle D.								

Name or Descriptor of Unit	Operating Status of Unit	Type of Liner System Under Unit	Above Grade Class 1 Disposal Cells in this Unit	Below Grade Class 1 Disposal Cells in this Unit	Other Class 1 Disposal Cells in this Unit (describe)	Size of Unit's Waste Footprint (acres)	Maximum Inventory of Waste Ever in Unit (indicate cubic yards or tons)	Other Necessary Informatio n that Pertains to the Unit
Expansion Area	To Be Construct ed	Composit e Liner	☐	☒	☐	256.8	35,900,000	** See Below
** The Expansion Area includes a lateral overlap of the Existing Area by 31.3 acres as well as a vertical expansion to an elevation of 187.8 feet								
Totals						361.1	52,555,460	

Table 2. Description of Waste Storage or Processing Units or Operations Associated with this Permit.

Type of Storage or Processing Unit or Operation (individual units may be closed at any time prior to or during the final facility closure as described in this plan)	Operational Status of Unit	Size of the Area Used for the Storage or Processing Unit or Operation (Acres)	Maximum Inventory of Waste Ever in Storage or Processing Unit or Operation (indicate cubic yards or tons)	Other Information (enter other necessary information that pertains to the unit)
Leachate Storage Tanks	Existing	0.057	317 ☒cubic yards ☐tons	Accepts leachate from Existing Area (1 tank)
Leachate Storage Tanks	Future	0.057	317 ☒cubic yards ☐tons	Will accept leachate from Existing Area (1 tank)
Leachate Storage Tanks	Future	0.23	1,268 ☒cubic yards ☐tons	Will accept leachate from Expansion Area (4 tanks)
Totals		0.344	1,902 cy	

B. Waste Inventory Summary

Table 3. Maximum Inventory of Wastes Ever On Site.

Item	Quantity (indicate cubic yards or tons)
Maximum inventory of waste in landfill units (total from Table 1)	51,555,460 ☒cubic yards or ☐tons

Item	Quantity (indicate cubic yards or tons)
Maximum inventory of waste in storage or processing units or operations (total from Table 2)	0 ☒cubic yards or ☐tons
Total Maximum Inventory of Wastes ever on site over the active life of the MSW facility (sum of totals from Tables 1 and 2)	52,555,460 ☒cubic yards or ☐tons

C. Drawings Showing Details of the Waste Management Units at Closure

Table 4. Location of the Drawings showing Details of the Waste Management Units at Closure (outlines, dimensions, maximum elevations of waste and final cover of landfill units, and waste storage or processing units or operations at closure of the facility).

Drawing Location in the SDP	Drawing Figure Number	Drawing Title	Waste Management Units Details Shown
Attachment 9C	A2	Final Cover System Evaluation Report Top of Final Cover Plan	Existing Area: Waste Footprint, outlines of landfill units, top of final cover elevation, and top and side slopes
Attachment 9C	A3	Final Cover System Evaluation Report Final Cover Details	Existing Area: Top and side slopes, cross sections for final cover systems
Attachment 1	C002	Landfill Cell Expansion Plan	Expansion Area: Proposed limits of waste, cell dimensions
Attachment 1	C006	Final Grading Plan - West	Existing Area and Expansion Area: Top of final cover elevation and top and side slopes, stormwater diversion berms
Attachment 1	C007	Final Grading Plan - East	Existing Area and Expansion Area: Top of final cover elevation and top and side slopes, stormwater diversion berms

III. Description of the Final Cover System Design

A. Types and Descriptions of the Final Cover Systems

Table 5. Types and Descriptions of the Final Cover Systems Permitted or Proposed for Closure of the Landfill Units.

Landfill Unit Name or Descriptor	Type of Final Cover System	Final Cover System Components Description	Other Information (Enter other information as applicable)
Existing Area	Pre-Subtitle D prescriptive final cover	6"-thick topsoil erosion layer (earthen material capable of sustaining native plant growth) 18"-thick compacted clay-rich layer (k<1x10^-7 cm/s)	Existing Area – Closed & Existing Area – Constructed: Immediately following the application of the final cover, it will be seeded with Common Bermuda grass, or other similar turf grasses that have with the majority of the root depths of 6 inches or less, in order to minimize erosion
Existing Area	Conventional Composite Final Cover	24"-thick topsoil erosion layer (earthen material) with top 6" capable of sustaining native plant growth 40-mil LLDPE geomembrane (smooth on top deck and textured on side slopes) 18"-thick compacted clay-rich layer (k<1x10^-5 cm/s)	Existing Area – Closed and Existing Area – Trench 11: Immediately following the application of the final cover, it will be seeded with Common Bermuda grass, or other similar turf grasses that have with the majority of the root depths of 6 inches or less, in order to minimize erosion
Existing Area	Alternative Composite Final Cover	12"-thick soil layer capable of sustaining native plant growth 200-mil double-sided drainage geocomposite 40-mil LLDPE geomembrane (textured both sides) 18"-thick compacted clay layer (k<1x10^-5 cm/s)	Existing Area – Constructed and To Be Constructed: Includes Cells 5 – 9. Immediately following the application of the final cover, it will be seeded with Common Bermuda grass, or other similar turf grasses that have with the majority of the root depths of 6

Landfill Unit Name or Descriptor	Type of Final Cover System	Final Cover System Components Description	Other Information (Enter other information as applicable)
			inches or less, in order to minimize erosion
Expansion Area	Alternative Composite Final Cover	12”-thick topsoil layer (capable of sustaining native plant growth). 200-mil double-sided drainage geocomposite (side slopes) and cushion geotextile (top deck) 40-mil LLDPE textured geomembrane 18”-thick compacted clay-layer (k<1x10^-5 cm/s)	Lateral and Vertical: Immediately following the application of the final cover, it will be seeded with Common Bermuda grass, or other similar turf grasses that have with the majority of the root depths of 6 inches or less, in order to minimize erosion

B. Design Details

Table 6. Design Details of the Final Cover Top and Side Slopes for the Landfill Units.

Landfill Unit Name or Descriptor	Maximum Final Elevation of Waste (feet above mean sea level [ft-msl])	Maximum Elevation of Top of Final Cover (ft-msl)	Minimum Grade of the Final Cover Top Slope (%)	Maximum Grade of the Final Cover Side Slope (%)	Other Information (enter other information as applicable, e.g. above-grade Class 1 Cell Dikes)
Existing Area	142'	144'	2.5	25	Pre-Subtitle D
Existing Area	140.5'	144'	2.5	25	Subtitle D/MSW/Trench 11, Trench 9, Parts of Trench 5
Existing Area	165.7'	168.2	5.0	25 (NW slope) 33 (other slopes)	MSW Trenches 7 and 8. Parts of Trenches 5 and 6.
Expansion Area	185.4'	187.9	5.0	33	MSW and Class 1 industrial waste below the exterior berm elevation (66.4’ AMSL) and covered by a 4-foot clay rich soil barrier

C. Final Cover Drainage Features

Storm water drainage and erosion and sediment control features incorporated on the final cover of the landfill units to protect the integrity and effectiveness of the final cover system include *(please list and describe the drainage features to be installed on the final cover at or prior to closure for each landfill unit, or list the drainage features and provide cross references on the location(s) of the descriptive and details (drawing) information in other parts of the SDP)*:

Existing Area (Closed)

Structural controls for the closed and yet to be closed portions have/will consist of letdowns constructed to direct stormwater from the sideslopes and top deck to a perimeter channel and the southern detention pond. Sideslope and top deck swales have will be constructed to intercept and divert stormwater to the letdowns. Letdown locations and constructed berms are shown on Drawings A1 and A2 located in Attachment 9C.

Existing Area (Constructed and To Be Constructed) and Expansion Area

The stormwater system will consist of berms, chimney drains, chutes, stormwater channels, and detention ponds comprising the stormwater control system, shown in Drawings C008, C009, C-501, C-502, and C-503 are located within Part III, Attachment 1. Within the landfill footprint, final cover swales will be used for stormwater conveyance to the letdown channels to maximize waste volume, and gabions are planned to minimize the letdown thickness.

Runoff will generally be segregated for management on the East and West of the landfill. Runoff from the Northeast of the existing landfill (i.e., approximately Trenches #7-#9) and the East portion of the expansion will be conveyed to a new East Detention Pond. Runoff from the Western portion will be conveyed to the new West Detention Pond. The existing detention pond will be used to manage stormwater from the existing closed area and a portion of the expansion area in Cells F1, G2 and G1, not exceeding the area that the pond had originally been designed to manage. The West Detention Pond will discharge from the South into the existing tributary ditch, which will be re-routed to accommodate the landfill expansion.

D. Final Cover Vegetation or Other Ground Cover Material

The final cover will be seeded and/or sodded with native plants immediately following the application of the final cover in order to minimize erosion. Other materials may be incorporated over the final cover soil surface to ensure sufficient coverage of the ground surface to minimize erosion. The estimated percent ground cover to minimize soil loss and maintain long-term erosional stability of the final cover top and side slopes is: **90**%. The minimum material specifications for other ground cover materials are summarized in the table below.

For a landfill with water balance final cover design, the percentage vegetation cover (excluding other ground cover types) will not be less than that assumed in the water balance final cover model.

Table 7. Minimum Specification for Ground Cover Materials Other Than Vegetation, if Applicable.

Other Ground Cover Material	Maximum Particle Size (inches)	Minimum Particle Size (inches)	Material Placement Method	Thickness of Layer (inches)	Percentage Coverage (%)	Other (specify)

E. Final Contour Map

Drawing C006 AND C007, a facility final contour map is attached. The map shows the final contours of the landfill units and the entire facility at closure.

Drawings C-301, C-302 and C-303 showing the cross–sections of the landfill units at closure are also provided.

The facility final contour and cross-section maps/drawings depict the following information:

(1) Final constructed contours of the landfill at closure.

(2) Top slopes and side slopes of the landfill units.

(3) Surface drainage features.

(4) 100-year floodplain, as applicable.

(5) Constructed features providing protection of/from the 100-year floodplain.

(6) Other (specify):

IV. Description of the Final Cover System Installation Procedure

A. Mode of Installation

Table 8. Mode of Final Cover Installation on the Landfill Units.

Landfill Unit Name or Descriptor	Largest Area of Unit Ever Requiring Final Cover (Acres)	Check this Column if Final Cover will be Placed in Installments as Permitted Elevation is Reached	Check this Column if Final Cover will be Placed when Entire Unit Area Reaches Permitted Elevation	Final Cover Installation Status
Expansion Area	55	☒	☐	Yet to be installed
		☐	☐	
		☐	☐	

B. Installation Drawings for Final Cover and Drainage Features

The following attached plan and cross-section drawings show the final cover design details, the largest area requiring final cover, details of the sequence of installation of the final cover system, and all drainage features.

Table 9. List of Attached Installation Drawings for Final Cover and Drainage Features.

Drawing No.	Drawing Title	Description of Information Contained in Drawing
A2	Final Cover System Evaluation Report Top of Final Cover Plan	Existing Area: Outlines, waste footprints, top of final cover, top and side slopes
A3	Final Cover System Evaluation Report Final Cover Details	Existing Area: Outline, top and side slopes, cross sections for final cover systems
C003	Waste Placement Phasing Plan	Expansion Area: Phasing plan for waste placement
C006	Final Grading Plan - West	Expansion Area: Final Cover Plan Drawing
C007	Final Grading Plan - East	Expansion Area: Final Cover Plan Drawing
C008	Largest Open Area	Largest area requiring final cover
C-301	Cross Sections – 1	Expansion Area: Cross section drawing

Drawing No.	Drawing Title	Description of Information Contained in Drawing
C-302	Cross Sections – 2	Expansion Area: Cross section drawing
C-303	Cross Sections – 3	Expansion Area: Cross section drawing
C-501	Detail Sheet 1	Expansion Area: Final cover details
C-502	Detail Sheet 2	Expansion Area: Final cover details and drainage feature details
C-503	Detail Sheet 3	Expansion Area: Final cover details and drainage feature details
C-504	Detail Sheet 4	Expansion Area: Final cover details and drainage feature details
C-505	Detail Sheet 5	Expansion Area: Final cover details and drainage feature details

C. Final Cover Quality Control Plan

A final cover quality control plan (FCQCP), Part III Report, Attachment 10, is attached. The FCQCP describes the final cover system design, construction, and evaluation protocol and processes, including the personnel, materials, methods, sampling and testing standards, procedures, and practices to be used in procuring, handling, installing, and evaluating all elements of the final cover system. It establishes the material requirements; personnel qualifications and roles; installation requirements; quality control and quality assurance monitoring, testing, documentation, and reporting programs to be used during construction of each component of the final cover system to assure and to verify that the final cover system is constructed as designed and in accordance with applicable rules and technical standards.

D. Documentation and Reporting of Final Cover System Construction and Testing

The professional of record will document all aspects and stages of the final cover installation, including materials used, equipment and construction methods, and the type and rate of sampling and quality control testing performed. Following completion of construction of the final cover, the site operator/permittee will submit to the TCEQ executive director, a Final Cover System Evaluation Report (FCSER) for each landfill unit.

V. Closure Activities and Completion Schedules for Each Landfill Unit and for the Final Facility Closure

A. Closure of a Landfill Unit

The following activities will be conducted to satisfy the closure criteria for a landfill unit:

(1) Closure Notification to the TCEQ Executive Director:

The site operator will inform the executive director of the TCEQ, in writing, of the intent to close the unit no later than 45 days prior to the initiation of closure activities and place this notice of intent in the operating record.

(2) Stoppage of Waste Acceptance and Commencement of Other Closure Activities for the Unit:

The site operator will stop accepting waste upon receiving the known final receipt of waste. The site operator will ensure that the permitted top elevations of the in-place waste, as depicted in/derived from the unit's final contour map approved by the TCEQ executive director, are not exceeded at any section or part of the landfill unit. The site operator will begin closure activities for the unit no later than:

- Thirty days after the date on which the unit receives the known final receipt of wastes; or
- One year after the most recent receipt of wastes if the unit has remaining capacity and there is a reasonable likelihood that the unit will receive additional wastes.

(3) Request for Extension Beyond the 1-Year Deadline for Commencing Closure Activities for a Unit:

The site operator may submit a written request to the executive director of the TCEQ for review and approval for an extension beyond the one-year deadline for the initiation of closure. The request will include the following:

(a) All applicable documentation necessary to demonstrate that the unit has the capacity to receive additional waste; and

(b) All documentation necessary to demonstrate that the site operator has taken and will continue to take all steps necessary to prevent threats to human health and the environment from the MSW landfill unit.

(4) Construction of Final Cover:

The site operator will construct the permitted final cover over the waste mass utilizing methods, procedures, and specifications described in the FCQCP. The final constructed contours, elevations, and slopes of the installed final cover will match the permitted final cover contours, elevations, and slopes shown in closure drawings contained in this closure plan.

(5) Construction of Drainage Features:

The site operator will construct the drainage structures shown in drawings referenced or contained in this closure plan or in the facility surface water drainage report.

(6) Completion of Outstanding or Replacement of Damaged Groundwater or Landfill Gas Monitoring Components:

The site operator will complete installation of any outstanding or replacement of any damaged groundwater or landfill gas monitoring system components and landfill gas control systems as needed to maintain current and effective groundwater or landfill gas monitoring and control systems.

(7) Submittal of Final Cover System Evaluation Report (FCSER) to the TCEQ Executive Director:

Following completion of construction of the final cover for the subject landfill unit, the site operator will submit to the TCEQ executive director for review and acceptance, a FCSER for the unit.

(8) Completion of Closure Activities for the Landfill Unit:

The site operator will complete closure activities for the unit within 180 days following the start of closure activities, unless the executive director of the TCEQ grants an extension as described in Item V.A.8(a) below.

(a) Request for Extension of the Completion of Closure Activities for the Landfill Unit:

The site operator may submit a written request for an extension for the completion of closure activities to the TCEQ for review and approval. The extension request will include:

- All applicable documentation necessary to demonstrate that closure will, of necessity, take longer than 180 days; and
- All applicable documentation necessary to document that all steps have been taken and will continue to be taken to prevent threats to human health and the environment from the unclosed MSW landfill unit.

(9) Submittal of Engineer's Certification of Closure to the TCEQ Executive Director and Request of Closure Inspection to TCEQ Regional Office:

Following completion of all closure activities for the landfill unit, the site operator will submit:

(a) Closure Inspection

A written request to the local TCEQ regional office for a closure inspection of the unit.

(b) Closure Certification

A certification, signed by an independent licensed professional engineer, to the executive director of the TCEQ for review and approval verifying that closure has been completed in accordance with this closure plan. The site operator will submit the certification via registered mail, and the submittal will contain all applicable documentation necessary for certification of closure of the unit, including:

- A final cover system evaluation report (FCSER) documenting the installation of the final cover. The FCSER may be submitted as a separate document for review and approval following the completion of the final cover installation. In that case, the certification of closure will be submitted subsequently;
- A final contour map as described under Section III.E that includes the relevant unit; and
- Copy of the letter to the TCEQ regional office requesting a closure inspection of the relevant unit.

(10) TCEQ's Acknowledgement of Termination of Operation and Closure of a Unit:

Upon receipt, the TCEQ executive director will review the closure documents for completeness and accuracy; and following receipt of the closure inspection report from the agency's regional office verifying proper closure of the MSW landfill unit according to this closure plan, the executive director will, in writing, acknowledge the termination of operation and closure of the unit and deem it properly closed. Thereafter, the site operator will comply with the post-closure care requirements described in the post-closure care plan for the unit.

(11) Deed Recordation for Disposed Regulated Asbestos Containing Materials (RACM):

Upon closure of the unit that accepted RACM, the site operator will place a specific notation that the unit accepted RACM in the deed records for the facility with a diagram identifying the RACM disposal areas. Concurrently, the site operator will submit to the TCEQ executive director, a notice of the deed recordation and a copy of the diagram identifying the asbestos disposal areas.

(12) Placement of all Closure Documentation in the Site Operating Record:

Once approved, the closure certification and all other documentation of closure will be placed in the site operating record.

(13) Closure Schedule for the Landfill Unit:

A closure schedule is found in Attachment 9B and discussed below based on the remaining available landfill volume. The schedule shows all the closure activities listed within Section V.A and the timelines for commencing and completing each activity. Also, the schedule shows that closure activities for the landfill unit will be completed within 180 days following the initiation of closure activities as required, unless an extension is granted by the TCEQ executive director.

(14) Other: (enter as applicable).

30 TAC 330.457(e)(3): The total Landfill volume was estimated using AutoCAD by comparing the top of geomembrane to the top of final cover. The total remaining Landfill volume available for waste disposal in the Existing Area is approximately 6.4 million yards of airspace remaining as of the survey

completed in April 2021. The proposed lateral and vertical expansions will add approximately 35.9 million cubic yards of additional airspace, providing which will provide capacity through 2167.

B. Closure of the Waste Storage or Processing Units or Operations

Closure of the waste storage or processing units or operations authorized under this permit will include removal of all waste, waste residues, and any recovered materials. The facility units and operations will either be dismantled and removed off-site or decontaminated. The site operator will dispose at the landfill or evacuate all materials (including feedstock, in process, and processed) to an authorized facility and disinfect all leachate handling units, tipping areas, processing areas, and post-processing areas. If there is evidence of a release from a unit or operation, the site operator will conduct an investigation, as approved by the TCEQ executive director, into the nature and extent of the release and an assessment of measures necessary to correct an impact to groundwater.

C. Final Closure of the Facility

In addition to the closure activities listed in Section V.A above for closing a landfill unit, the site operator will conduct the following activities for the closure of the entire facility:

(1) Publish Final Closure Notice and Place the closure Plan in a Public Place:

No later than 90 days prior to the initiation of the final facility closure, the site operator will:

(a) Publication of Notice:

The site operator will publish notice in the newspaper(s) of largest circulation in the vicinity of the facility to inform the public of the final closure of the facility. This notice will include:

- The name of the facility;
- The address, and physical location of the facility;
- The facility’s permit number; and
- The last date of intended receipt of waste.

(b) Place Copies of the Closure Plan in a Public Place:

The site operator will also make available an adequate number of copies of the approved final closure and post-closure plans for public access and review at the Victoria City Hall, 105 W Juan Linn St., Victoria, TX 77901 (state public place within the area, including address, where the plan will be available for public access and review).

(2) Submit Written Notice of “Intent to Close the Facility” to the TCEQ Executive Director:

The site operator will provide written notification to the TCEQ executive director of the intent to close the facility. This notice will be provided to the executive director no later than 90 days prior to the initiation of the final facility closure, and thereafter be placed in the site operating record.

(3) Post Signs and Install Barriers:

Upon notifying the executive director of the intent to close the facility and no later than 90 days prior to the initiation of final facility closure, the site operator will:

(a) Post Final Closure Signs:

The site operator will post a minimum of one sign at the main entrance and all other frequently used points of access for the facility notifying all persons who may utilize the facility of the date of closing for the entire facility and the prohibition against further receipt of waste materials after the stated date.

(b) Install Barriers:

Also, the site/operator will install suitable barriers at all gates or access points to adequately prevent the unauthorized dumping of solid waste at the closed facility.

(4) Filling of "Affidavit to the Public" and Performance of the Final Deed Recording:

Upon closure of all the landfill units or upon final closure of the facility, the site operator will:

(a) File Affidavit

File with the county deed records an "Affidavit to the Public" in a form provided by the TCEQ executive director that includes an updated metes and bounds description of the extent of the disposal areas at the facility and the restrictions to future use of the land in accordance with applicable provisions under 30 TAC Chapter 330, Subchapter T.

(b) Record a Notation on the Deed

Record a certified notation on the deed to the facility property, or on some other instrument that is normally examined during title search, that will in perpetuity notify any potential purchaser of the property that the land has been used as a landfill facility and use of the land is restricted according to the provisions under 30 TAC Chapter 330, Subchapter T.

(c) Place Documents in the Operating Record

Place a copy of the "Affidavit to the Public" and a copy of the modified deed in the site operating record.

(5) Submittal of a Copy of the "Affidavit to the Public" and the "Modified Deed" to the TCEQ Executive Director:

Within ten days after completion of final closure activities of the facility, the site operator will submit the following to the TCEQ executive director by registered mail:

(a) A certified copy of the "Affidavit to the Public";

(b) A certified copy of the modified deed to the facility property; and

(c) A certification, signed by an independent licensed professional engineer, verifying that final facility closure has been completed in accordance with the approved closure plan. The submittal will contain all applicable documentation necessary for certification of final facility closure, including:

- Final Cover System Evaluation Report (FCSER) documenting the installation of the final cover. The FCSER may be submitted earlier as a separate document for review and approval following the completion of the final cover installation. In that case, the certification of closure will be submitted subsequently;
- A final contour map as described under Item III.G above;
- Copy of a letter to the TCEQ regional office requesting a final closure inspection of the facility; and
- Copies of documents verifying newspaper publication of the notice of the final facility closure.

(6) Other

Additional items relating to the schedule for final facility closure, and additional closure activities specific to the final closure of this facility include:
Cells A1-I2 indicated on Part III, Attachment 1 - Drawing C003 are suitable for disposal of both MSW and Class 1 waste. Class 1 waste shall be disposed of below the exterior berm elevation (66.4' AMSL), and covered by a 4-foot clay rich soil barrier.

(7) TCEQ's Acceptance of Termination of Operation and Closure of a Landfill Facility:

Following the TCEQ executive director's receipt and completion of the review of the professional engineer's certification of the completion of facility closure and the final closure documents, and receipt of the inspection report from the agency's regional office verifying proper closure of the facility according to this closure plan, the executive director will, in writing, accept the termination of operation and closure of the facility and deem it properly closed. Thereafter, the site operator will comply with the post closure care requirements described in the post closure plan for the facility.

(8) Final Closure Schedule for the Facility:

The attached Attachment 9C, Final Closure Schedule, provides the closure schedule for the final facility closure. It incorporates the schedule for closure of a unit as discussed in Section V.A and also shows the commencement and completion timelines for the final closure activities listed within this Section.

VI. Summary of Attachments

A. Drawings and Maps

The following Drawings and Maps are attached as part of this plan.

- Other Drawings/Maps:
  Part III, Attachment 1:
  - Drawing C002, Landfill Cell Expansion Plan
  - Drawing C003, Waste Placement Phasing Plan
  - Drawings C006 to C009, Final Cover and Drainage Features Installation Drawings.
  - Drawings C-301 to C-303 , Cross-Section Drawings of the Landfill Units at Closure.
  - Drawings C-501 to C-505, Final Cover Installation Details and Drainage Feature Details

B. Documents

- Attachment 10, Final Cover Quality Control Plan (FCQCP).
- Attachment 9A , Landfill Unit Closure Schedule Chart.
- Attachment 9B, Final Closure Schedule Chart.
- Other: Attachment

C. Additional Items Attached (enter as applicable)

VII. Professional Engineer's Statement, Seal, and Signature

Name: Scott Martin

Title: Project Engineer

Date: 04/04/2022

Company Name: Burns & McDonnell

Firm Registration Number: F-845

Professional Engineer's Seal

Signature

ATTACHMENT 9A – LANDFILL UNIT CLOSURE SCHEDULE CHART

	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days
Place a copy of closure plan in the operating record by the receipt of waste						
Initiation of unit closure activities						
Written notification of closure to TCEQ						
Time interval for completion of final closure activities						
Note: Schedule is based on anticipated date of receipt of final waste placement for the landfill unit. Heavy vertical line signifies final receipt of waste.						

Victoria Landfill
Unit Closure Schedule Chart

ATTACHMENT 9B – FINAL CLOSURE SCHEDULE CHART

	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days	30 Days
Written notification of closure to TCEQ	—	—								
Public notice of facility closure published in newspaper	—	—	—							
Posting of sign		●								
Initiation of final closure activities					●					
Time interval for completion of final closure activities					—	—	—	—	—	—
Submit engineering certification of final closure to TCEQ										●
Submit certified copies of Affidavit to the Public and modified deed to TCEQ										●
Note: Schedule is based on anticipated date of beginning of final closure activities. Heavy vertical line signifies final receipt of waste.										

Victoria Landfill
Final Closure Schedule Chart

ATTACHMENT 10 – FINAL CLOSURE QUALITY CONTROL PLAN

Part III, Attachment 10 – Final Cover Quality Control Plan
TCEQ MSW Permit No. 1522B

City of Victoria, Texas

City of Victoria Landfill Lateral and Vertical Expansion
Project No. 107608

Revision 0, March 28, 2022

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LIST OF ABBREVIATIONS

AOS	Apparent Opening Size
ASTM	American Society for Testing and Materials
Burns & McDonnell	Burns & McDonnell Engineering Company, Inc.
cm/s	centimeters per second
CQA	Construction Quality Assurance
Existing Area	Previously permitted landfill area including Closed (Pre-Subtitle D and Subtitle D), To Be Constructed (TBC), and Constructed cells.
Expansion Area	Design area south of the previously permitted landfill area that will include a lateral and vertical expansion
FCSER	Final Cover System Evaluation Report
FCQCP	Final Cover Quality Control Plan
FML	Flexible Membrane Liner
FTB	Film Tear Bond
GP	Geotechnical Professional
GRI	Geosynthetic Research Institute
LL	Liquid Limit
LLDPE	Linear Low-Density Polyethylene
mil	millimeter
MSWR	Municipal Solid Waste Regulations
MQA	Manufacturing Quality Assurance
MQC	Manufacturing Quality Control
PE	Professional Engineer
PI	Plasticity Index
PL	Plastic Limit

POR	Professional of Record
psi	pounds per square inch
TBC	To Be Constructed
TCEQ	Texas Commission on the Environment

1.0 INTRODUCTION

1.1 Purpose

This Final Cover Quality Control Plan (FCQCP) has been prepared to provide the Owner, Operator, Design Engineer, Construction Quality Assurance (CQA) Professional of Record (POR), and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Regulations (MSWR). More specifically, the FCQCP addresses the soil and geosynthetic components of the final cover system.

This FCQCP is divided into the following parts:

- Section 1.0 – Introduction
- Section 2.0 – Construction Quality Assurance for Compacted Clay Layer
- Section 3.0 – Construction Quality Assurance for Geosynthetics
- Section 4.0 – Construction Quality Assurance for Erosion Layer
- Section 5.0 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM – American Society for Testing and Materials.

Atterberg Limits – A series of six "limits of consistency" of fine-grained soils defined by Swedish soil scientist Albert Atterberg, two of which are frequently used today to establish a soil's physical boundaries dealing with its plasticity characteristics. These soil boundaries or limits used most frequently in geotechnical engineering are based upon the numerical difference of the Liquid Limit and the Plastic Limit as defined below:

- Liquid Limit (LL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the upper point at which the soil's consistency changes from the plastic to the liquid state.
- Plastic Limit (PL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the lower point at which the soil's consistency changes from the plastic to the semi-solid state.

- Plasticity Index (PI) – The numerical difference between the LL and the PL of a fine-grained soil that denotes the soils plastic range. The larger the PI the greater a soil's plasticity range and the greater its plasticity characteristics.

Compactive Effort – The amount of compaction energy held constant, and usually transferred into a soil sample with a compaction hammer device, used on soil samples in various laboratory test procedures to establish a soil's density at various moisture contents.

CQA – A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design (EPA, 1986). CQA includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. CQA refers to measures taken by the CQA organization to assess if the installer or contractor is compliant with the plans and specifications for a project.

CQA Officers – These are representatives of the POR who work under direct supervision of the POR. The CQA Officer is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA Officer is on site full-time during construction and reports directly to the POR. The CQA Officer performing daily QA/QC observation and testing will be NICET-certified in geotechnical engineering technology at level two or higher for soils and FML testing; a CQA Officer with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA Officer(s) under the direction of the POR. Additional CQA Officers may be used. If working under the direction of a CQA Officer, the second CQA Officer will have a minimum of one year of directly related experience.

CQA POR – The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance and conforming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer (PE) in Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA Officers working under the POR's direction. The POR or his designated representative will be on-site during all final cover system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Contract Documents – These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications – These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor – This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered a contract with the Operator.

Design Engineer – These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork – This is a construction activity involving the use of soil materials as defined in the construction drawings and specifications and Section 2.0.

Film Tear Bond (FTB) – A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Final Cover System Evaluation Report (FCSER) – Upon completion of closure activities, the certification will be in the form of the FCSER which will be signed by the POR and include all the documentation necessary for certification of closure.

Fish Mouth – A semi-conical opening of the seam that is formed by an edge wrinkle in one sheet of the geomembrane.

Flexible Membrane Liner (FML) – This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet.

Geosynthetics Contractor – This individual is also referred to as the "contractor" or "installer" and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or other geosynthetic materials, even if not their primary function.

Independent Testing Laboratory – A laboratory that is independent of ownership or control by the permittee or any party to the construction of the final cover or the manufacturer of the final cover products used.

Manufacturing Quality Assurance (MQA) – A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC) – A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance – This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator – The organization that will operate the disposal unit.

Operator's Representative – This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Panel – This is a unit area of the FML, which will be seamed in the field.

Permeant Fluid – Fluid used in a laboratory coefficient of permeability test and limited to tap water or 0.005 Nominal solution of $CaSO_4$. Distilled water will not be used in these test procedures.

Quality Assurance – This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA Officer.

Quality Control – These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor:

Representative Sample – A representative sample of FML material consists of one or more specimens (commonly referred to as coupons) from the same rectangular portion of FML material, oriented along a seam, that is removed for field or laboratory testing purposes.

Soil Borrow Source – Soils in which the LL and PI do not vary by 10 points. A soil that varies by 10 or more points from the originally established LL or PI is considered as a separate soil source for the purpose of this FCQCP and requires a separate soil test series.

Soil Test Series – Tests performed to determine a soil's physical characteristics and to document its ability to satisfy the MSWR compacted clay layer requirements. These tests include sieve analysis (gradation), Atterberg Limits, moisture/density, and coefficient of permeability.

Specimen – (With respect to FML destructive testing) – A specimen is the individual test strip (sometimes called coupon) from a sample location. A sample location usually consists of many specimens.

1.3 Final Cover Systems

Final cover at the City of Victoria Landfill includes three types of final cover systems. These final cover systems are included under the following unit classifications:

- Pre-Subtitle D: Existing Area – Closed
- Subtitle D: Existing Area – Closed
- Alternative Composite:
    - Existing Area – Constructed or To Be Constructed (TBC)
    - Expansion Area – Lateral or Vertical

These Areas are defined in Part III, Attachment 9 – Final Closure Plan.

The Pre-Subtitle D prescriptive final cover system includes an 18-inch-thick compacted clay-rich soil and a 6-inch thick topsoil erosion layer consisting of earthen material capable of sustaining native plant growth.

The Subtitle D Conventional Composite cover system includes an 18-inch-thick compacted clay layer, 40 mil LLDPE textured geomembrane (textured on both sides), and 24-inch thick erosion layer, of which the top 6 inches can sustain vegetative growth.

Most Existing Areas utilizing Pre-Subtitle D and Subtitle D cover have been closed as of 2015. Final cover for the remaining Pre-Subtitle D open area (Existing Area – Constructed) and Subtitle D open area (Existing Area – Trench 11) will be installed per the previously permitted and approved CQA plan located in Attachment 10C.

The Alternative Composite cover system will include an 18-inch-thick compacted clay layer, 40 mil LLDPE geomembrane (textured both sides), 200-millimeter (mil) double-sided drainage geocomposite, and 12-inch thick soil layer capable of sustaining vegetative growth. The vegetative layer will be seeded with Common Bermuda grass, or other similar turf grasses that have most of the root depths of 6 inches or less.

Alternative Composite cover will be placed on all areas that have yet to receive final cover, including Existing Area – Constructed or TBC and Expansion Areas. This FCQCP covers the CQA requirements for the Alternative Composite cover system.

The final cover systems at the site are designed to minimize the amount of precipitation that infiltrates the deposited waste, thus minimizing the amount of leachate generated. The final cover system is designed to convey stormwater to detention ponds via final cover erosion control structures and perimeter channels.

2.0 CONSTRUCTION QUALITY ASSURANCE FOR COMPACTED CLAY LAYER

This section of the FCQCP addresses the construction of the compacted clay layer component of the final cover system and outlines the FCQCP program to be implemented regarding materials selection and evaluation, laboratory test requirements, field test requirements and treatment of problems.

2.1 Intermediate Cover

The surface of the intermediate cover will be compacted to prepare the working surface for the first lift of compacted clay layer soil. The CQA Officer will visually inspect and approve the prepared intermediate cover prior to the placement of the compacted clay layer or structural fill. Approval will be based on a review of test information, if applicable, and CQA Officer review of the intermediate cover preparation.

Surveying will be performed to verify that the finished intermediate cover is completed consistent with the lines and grades specified in the design.

2.2 Structural Fill

Structural fill material placed below the final cover (e.g., compacted backfill in liner anchor trench) will be placed in uniform lifts which do not exceed 12 inches in loose thickness and are compacted to at least 90 percent of Standard Proctor (ASTM D698) at a moisture content ranging from two percentage points below optimum to three percentage points above optimum (-2 to +3).

2.3 Surface Water Removal

The prepared intermediate cover or compacted clay layer which is under construction may encounter water from storm events. Prior to placement of the compacted clay layer, intermediate cover will be graded to provide positive drainage for the base grades of the compacted clay layer. The compacted clay layer will not be placed in standing water and water will not be allowed to accumulate over constructed compacted clay layer. The construction area will be graded to provide for positive drainage. Temporary diversion berms will be constructed as needed to divert surface flow away from the construction area.

2.4 Compacted Clay Layer

The compacted clay layer will consist of a minimum 18-inch-thick compacted soil barrier (measured perpendicular to the subgrade surface) that will extend along the sideslopes and top slopes of the landfill. Testing and evaluation of the final cover system will be completed in accordance with 30 TAC §330.457. All soils used in compacted clay layers will have the following minimum values verified by testing in a third-party soil laboratory:

- PI equal to or greater than 15.
- LL equal to or greater than 30.
- Percent passing the No. 200 mesh sieve equal to or greater than 30 percent.
- Percent passing the one-inch screen equal to 100 percent.
- Coefficient of permeability should meet the requirements set forth in Section III of Part III, Attachment 9: for the composite Existing Areas (Constructed and TBC) as well as Expansion Area final cover compacted clay layers, coefficient of permeability of less than or equal to $1x10^{-5}$ centimeters per second (cm/s). The 18 inches of compacted compacted clay material will be tested for co-efficient of permeability at a frequency of at least one test per surface acre of final cover. Permeability data shall be submitted to the executive director.

The compacted clay layer material will consist of relatively homogeneous clay, and clayey soils. The soil will be free of debris, rocks greater than one inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Testing will be performed in accordance with Section 2.4.1 (refer to Table 2-1 test methods) for each borrow source. A permeability test will be conducted on samples from each borrow source. The permeability test specimens will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor (ASTM D698) maximum dry density at a moisture content at or above the optimum moisture content. One Proctor moisture-density relationship and remolded permeability test will be required for each different material as determined by a change in the liquid limit or plasticity index of more than 10 points.

The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of previously compacted lift; therefore, the compacted lift thickness will not be greater than the pad or prong length. The material will be compacted to a minimum of 95 percent of the maximum dry density determined by Standard Proctor (ASTM D698) at a moisture content between the Standard Proctor optimum and 5 percentage points above optimum. The CQA Officer, earthwork contractor, and/or operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required.

Because of possible variability of the available clay materials, additional stockpile testing will be performed if different physical properties of the borrow soil (color, texture, etc.) are observed by the CQA Officer, and the materials vary by more than ten points in either liquid limit or plasticity index from previously evaluated materials.

The clay materials to be used for compacted clay layer will require processing to achieve the required moisture content for compaction. The physical characteristics of the clay materials will be evaluated through visual observation before and during construction. To add moisture to the material properly, the clod sizes will first be crushed into manageable sizes of one inch in diameter or less. Rocks within the compacted clay layer should be less than one inch in diameter and will not total more than 10 percent by weight. The prepared compacted clay layer will be observed such that rock content will not be a detriment to the integrity of the overlying geomembrane (geomembrane layer is only applicable to the Subtitle D composite final cover system area).

Clod-size (and shale) reduction, if necessary, may be achieved using a disc harrow or soil pulverizer. To efficiently break down the clods and pieces of shale, multiple passes of the processing equipment in two directions are recommended. Water will be applied as necessary to the material and worked into the material with the processing or compacting equipment. If necessary, to achieve even moisture distribution or break down clod, the material will be watered and processed in the stockpile prior to placing in the compacted clay layer to allow the soil adequate time to hydrate. Water used for the compacted clay layer must be clean and not contaminated by waste or any objectionable material. Collected onsite stormwater may be utilized if it has not come into contact with the solid waste.

The compacted clay layer must be compacted with a pad/tamping-foot or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. The top of intermediate cover will be scarified a minimum of two inches prior to placement of the first lift of compacted clay layer. Use of pad/tamping foot or prong-foot rollers will provide sufficient roughening of compacted clay layer lift's surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds, and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (one direction) of the compactor, not just an axle, over a given area. The recommended minimum of four passes is for a vehicle with front and rear drums. The Caterpillar Series 815 and 825 Compactors are examples of equipment typically used to achieve satisfactory results.

The compacted clay layer will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller.

CQA testing of the compacted clay layer will be performed as the compacted clay layer is being constructed. Testing procedures, frequency, and passing criteria will be in accordance with Section 2.4.1.

Compacted clay layer construction and testing will be conducted in a systematic and timely fashion on each lift. In general, delays will be avoided in compacted clay layer construction (typically no more than 14 days). Reasons for any delays in compacted clay layer construction (greater than 14 days) should be fully explained in the FCSER submittal.

The finished top surface of the compacted clay layer must be rolled with a smooth, steel-wheeled roller to obtain a hard, uniform, and smooth surface. The surface of the compacted clay layer will then be carefully inspected by the CQA Officer for any gravel, rock pieces, and deleterious materials, which might impact the integrity of the overlying geomembrane. All voids created by removing gravel, rock pieces, or other deleterious materials will be backfilled with compacted clay layer material to the density specifications outlined for compacted clay construction and tested at the discretion of the CQA Officer.

Surveying will be performed to document that the finished compacted clay layer has been constructed to a minimum thickness of 18 inches. Thickness verification may be performed by using settlement plates (e.g., plywood sheet or similar material) on a 100-foot grid. The compacted clay layer will be surveyed as indicated in Table 2-1 to verify that a minimum 18-inch-thick soil layer is present at each location. The location of the settlement plates will be established by a Texas registered surveyor on a 100-foot grid. The shaft extending upward from the base will be marked to indicate the minimum required thickness of the compacted clay layer. The compacted clay layer will be constructed to the minimum thickness marked on the shaft of the settlement plate. The POR and CQA Officer will verify that the compacted clay layer is placed uniformly between each settlement plate.

An compacted clay layer thickness drawing at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the final cover system will be called out on the final drawings. The compacted clay layer thickness drawing will be sealed by a Texas registered surveyor. After the construction of the compacted clay layer is complete, the Texas registered surveyor will survey the final elevation of the compacted clay layer. The compacted clay layer certification drawing will be included in the FCSER. In addition, the elevations obtained for the top of the compacted clay layer will be used to verify that the as-built slopes are consistent with the approved landfill completion plan. A statement that confirms that the as-built slopes are consistent with the approved landfill completion plan will be included in the FCSER.

Once the survey is complete, the settlement plate shaft will be removed, and the resulting hole will be backfilled with bentonite or a bentonite/compacted clay layer soil mixture consisting of at least 20 percent bentonite.

Testing and evaluation of the compacted clay layer during construction will be in accordance with this FCQCP. The construction methods and test procedures documented in the FCSER will be consistent with the FCQCP.

The compacted clay layer will be prevented from losing moisture prior to placement of geomembrane. Preserving the moisture content of the installed compacted clay layer will be dependent on the earthwork contractors means and methods and is subject to POR approval.

Sections of the compacted clay layer which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density test results will be incorporated into the FCSER.

Hydraulic conductivity samples will be obtained by pushing a sampler through the constructed compacted clay layer. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/compacted clay layer soil material mixture consisting of at least 20 percent bentonite.

If the integrity of the "A" sample appears to have been compromised. during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the minimum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample, the ASTM D5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned. The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the FCSER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or sample "A" fails in such a way that there is not an option to use the "B" sample), the test interval will be considered unsatisfactory for the area bounded by passing test, locations (but not extending past a satisfactory test location). Additional tests may be taken to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section.

Furthermore, if it is determined that the "B" sample may not be used to replace the " A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed compacted clay layer lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each repair area, given that the reconstructed compacted clay layer area is not larger than one acre. The reconstructed compacted clay layer area will be tied into the currently constructed compacted clay layer with a 5H:1V transition slope. The reconstructed compacted clay layer area is also subject to field density and moisture content testing per Table 2-1 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed).

Reconstruction activities, including additional testing and surveying, will be incorporated into the FCSER.

2.4.1 Construction Testing

CQA Officers will perform field and laboratory tests in accordance with applicable standards specified in this FCQCP. Sampling will be performed by using standard ASTM practices for recovering samples (e.g., ASTM D1587). The sampling holes (e.g., sample for hydraulic conductivity) will be backfilled with liner soil material, bentonite, or bentonite/liner soil mixture.

The test frequencies for the compacted clay layer are listed in Table 2-1. Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Further testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of each final cover area. Section 5.0 describes the documentation requirements.

Table 2-1: Standard Tests on Compacted Clay Layer Soils

<table>
<tr><th>Soil Test Category</th><th>Type of Test</th><th>Standard Test Method</th><th>Frequency of Testing</th></tr>
<tr><td rowspan="5">Quality Control Testing of Source Borrow Materials</td><td>Unified Soil Classification</td><td>ASTM D2487</td><td rowspan="4">Once per soil type</td></tr>
<tr><td>Moisture/Density Relationship</td><td>ASTM D2216 or ASTM D698 or D1557</td></tr>
<tr><td>Grain Size (d)</td><td>ASTM D6913 or ASTM D422 or D1140</td></tr>
<tr><td>Atterberg Limits</td><td>ASTM D4318</td></tr>
<tr><td>Coefficient of Permeability</td><td>ASTM D5084 or CoE EM1110-2-1906 (b)</td><td>1/Moisture/Density Relationship</td></tr>
<tr><td rowspan="5">Constructed Compacted Clay Layer</td><td>Field Density</td><td>ASTM D6938 and D2216A</td><td>1/8,000 ft^2 per 6-inch lift (b)</td></tr>
<tr><td>Grain Size (d)</td><td>ASTM D6913 or ASTM D422 or D1140</td><td rowspan="2">1/100,000 ft^2 per 6-inch lift (a)</td></tr>
<tr><td>Atterberg Limits</td><td>ASTM D4318</td></tr>
<tr><td>Coefficient of Permeability</td><td>ASTM D5084 or CoE EM1110-2-1906</td><td>1/surface acre (evenly distributed through all lifts) (b)</td></tr>
<tr><td>Thickness (c)</td><td>Texas Licensed Surveyor</td><td>1/10,000 ft^2</td></tr>
</table>

(a) This test is not applicable if the field measuring device (i.e., nuclear gauge) also measures moisture.
(b) A minimum of one of each of the designated tests must be conducted for each lift, regardless of cover area.
(c) If the option to use settlement plates to verify the thickness of the final cover layers is utilized, the procedure outlined in Section 2.4 will be followed.
(d) ASTM D422 is specified in §330.339(c)(4)(B) but has been discontinued. ASTM D6913 provides a Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.

2.5 Compacted Clay Layer Tie-In Construction

Newly constructed compacted clay layer will be tied-in with any adjoining existing compacted clay layers. Additionally, terminations will be constructed for future tie-ins along edges where the compacted clay layer will be extended in the future. During the construction of continuous compacted clay layers, the new compacted clay layer segment will not be constructed by "butting" the entire thickness of the new compacted clay layer directly against the edge of the old compacted clay layer. The tie-in will be constructed either by a sloped transition (typically five horizontal to one vertical) or a stair-stepped transition (typically one lift thickness per step). The length of the tie-in should be at least five feet per foot of compacted clay layer thickness. The tie-ins with existing clay compacted clay layer will be constructed utilizing a sloped or stair-stepped transition. In general, terminations for future tie-ins will be constructed by extending the compacted clay layer approximately 7.5 feet past the limits for the final cover area under construction.

3.0 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

This section describes CQA procedures for the installation of geosynthetic components.

The scope of geosynthetic-related construction quality assurance includes the following elements:

- Geomembrane Liner: 40-mil LLDPE – textured on both sides. Minimum required material properties for the geomembrane are listed in Attachment 10B – GRI GM17.
- Drainage Layer: 200-mil drainage geocomposite – minimum required material properties for the drainage layer are found in Attachment 10B – GRI GM17.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements their quality control plan in accordance with this FCQCP, the construction and testing of all elements of the final cover are performed in accordance with this FCQCP and the Part III, Attachment 9 – Final Closure Plan, and that the project is built in accordance with the project construction drawings and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. The FCSER, prepared after project completion, will document that the constructed facility meets design intent and specifications and that all final cover construction and QA/QC testing are performed in accordance with this FCQCP.

3.1 Geosynthetics Quality Assurance

3.1.1 General

A geomembrane and drainage geocomposite are the geosynthetic components of the Alternative Composite final cover system. All testing requirements and minimum required properties are listed in Attachment 10B – GRI GM17. Construction quality control for the geosynthetic installation will be performed by the geosynthetic installation contractor. Construction quality assurance for the geosynthetic installation will be performed by the POR to assure the geosynthetic is constructed as specified in the design. Construction must be conducted in accordance with the project construction drawings, which will be developed in accordance with this FCQCP and the Part III, Attachment 9 – Final Closure Plan at the time of each final cover construction and in accordance with specifications outlined in this FCQCP. Where there is discrepancy, the project construction drawings and specifications shall govern. To monitor compliance, a quality assurance program will include the following:

- Review of Installer's QC submittals
- Material conformance testing
- Construction testing (nondestructive and destructive)
- Construction observation

Conformance testing refers to those activities that can take place prior to material installation. Construction testing includes those activities that occur during and following geosynthetics installation. The manufacturer's quality control submittals will include resin and physical material testing. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this FCQCP, the project construction drawings, and specifications. Field testing will be observed by the CQA Officer. Documentation must meet the requirements of this FCQCP.

The CQA personnel shall be familiar with the design of the landfill, be efficient in coordinating the efforts of all parties involved, have specific technical knowledge of the liner system details, and demonstrate an awareness of construction problems which can have an impact on the constructed facility.

3.2 Geomembrane

3.2.1 Delivery and Handling

The CQA Officer or Owner's Representative shall verify that the following activities are done:

- Equipment used to unload the rolls will not damage the geomembrane
- Care is used to unload the rolls
- Manufacturer's QC documentation for each roll is received and includes the following information:
  - Manufacturer's Name
  - Roll number
  - Date of production
  - Resin identification
  - Roll Dimensions
  - Material Thickness
  - Date(s) of all required conformance testing

At the CQA Officer's discretion, damaged rolls may be rejected. They shall be removed from the site or stored at a location, separate from accepted rolls, designated by the Owner's Representative. All rolls without proper manufacturer's documentation shall be rejected.

A Material Received Log (see **Attachment 10A**) shall be prepared by the CQA Officer for all geosynthetic material delivered to the job site.

3.2.2 Conformance Testing

The geomembrane material shall consist of HDPE. Only textured (both sides) geomembranes shall be utilized.

3.2.2.1 Tests

Unless otherwise specified, prior to delivery, the Geosynthetic Manufacturer shall obtain one geomembrane sample per 50,000 square feet of geomembrane. The samples shall be forwarded to the testing laboratory and tested in accordance with ASTM or other appropriate methods. At a minimum, the following tests shall be performed:

- Density
- Melt Flow Index
- Carbon Black Content
- Carbon Black Dispersion
- Thickness
- Tensile Properties
- Asperity Height
- Tear-Resistance
- Puncture Resistance
- Stress Crack Resistance
- Oxidative Induction Time
- Oven Aging
- UV Resistance
- Interface Friction Angle Testing (one per source)

Test results shall attain minimum industry standards, as appropriate. Where optional procedures are noted in the test method, the destruct specification requirements shall prevail. The CQA Officer shall review all test results and report any nonconformance to the Engineer and the Installer.

3.2.2.2 Sampling Procedures

Samples shall be taken across the entire roll width and shall not include the first three feet. Unless otherwise specified, samples shall be three feet long by the roll width. The Geosynthetics Manufacturer shall mark on the sample the machine direction, manufacturer's roll identification number, and date the sample was obtained.

3.2.3 Geomembrane Installation

All geomembrane installation shall be performed under the daily supervision of a master seamer. All personnel performing seaming operations shall be qualified by sufficient experience or by successfully passing seaming tests. The experience record of each of the Installer’s technicians shall be provided to the CQA Officer prior to the commencement of geomembrane liner installation activities. No seamer shall be allowed to work until their qualifications have been reviewed by the CQA Officer.

3.2.3.1 Surface Preparation and Prepared Subbase

Prior to liner installation, the CQA Officer shall verify that the following conditions exist:

- All lines and grades have been verified by a qualified surveyor
- The subbase has been prepared in accordance with the earthwork specifications
- The surface has been rolled and compacted to be free of surface irregularities and protrusions
- There is minimal desiccation cracking of the prepared soil subbase surface
- There are no excessively soft areas that could result in liner damage
- All construction stakes and hubs have been removed and holes filled with soil placed to the minimum requirements for the adjacent soil
- The certificate of prepared soil subbase acceptance has been completed and signed by the Installer

3.2.3.2 Panel Placement

The Installer shall follow manufacturer’s panel placement recommendations. The Installer shall give each panel a permanent identification number. This number will be used by the CQA Officer, CQC Manager, and all other parties for documentation and record drawings. The CQA Officer shall establish a chart showing correspondence between roll numbers, certification reports, and panel numbers.

The CQC Manager shall maintain a Geomembrane Placement Log and form similar to that shown in **Attachment 10A**.

During panel placement, the CQA Officer shall perform the following activities:

- Observe each panel as it is deployed and record all panel defects and disposition of the defects (panel rejected, patch installed, etc.). Large sections of damaged material shall be cut out and removed from the site. All repairs are to be made in accordance with the procedures given in this manual and the geomembrane specifications.
- Verify that equipment used does not damage the geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that the surface beneath the geomembrane has not deteriorated since acceptance by the Installer.
- Inspect the geomembrane for scratches if it has been pulled across an unprotected surface.
- Record weather conditions including temperature, wind, and humidity. The geomembrane shall not be deployed in the presence of excess moisture (fog, dew, mist, etc.).
- Verify that people working on the geomembrane do not smoke, wear shoes and/or engage in activities that could damage the geomembrane.
- Verify that the method used to deploy the sheet minimizes wrinkles and that the sheets are anchored to prevent movement by wind.

The CQA Officer shall inform both the Installer and Owner's Representative if the above conditions are not met.

3.2.3.3 Field Seaming

The Installer shall provide the Owner's Representative and CQA Officer with a panel layout drawing. This drawing may be modified, with the approval of the CQA Officer, to meet job site conditions. The Installer will maintain record drawings that shall be updated by the Installer on a regular basis.

A seam numbering system shall be agreed to by the CQA Officer and Installer prior to the start of seaming operations. One methodology is to identify the seam by adjacent panels. For example, the seam located between Panel 306 and 401 would be Seam No. 306/401.

Prior to seaming, trial welds for each operator and seaming apparatus (welder) shall be tested in accordance with the geomembrane specification to determine if the equipment and operator are functioning properly. The CQA Officer shall observe welding operations and the testing of the trial welds. Trial weld results shall be recorded by the CQC Manager and on the forms provided by the Installer. All trial welds are to be completed under conditions similar to those existing when the panel shall be seamed. Trial welds shall be completed at the beginning of each morning and afternoon shift, and also at any time the CQA Officer believes that an operator or seaming apparatus is not functioning properly. If there are large changes in temperature, humidity, or wind speed, the test weld is to be repeated.

During seaming operations, the CQA Officer shall verify that the following conditions exist:

- The Installer has the number of welders and spare parts agreed to in the pre-construction meeting
- Equipment used for seaming does not damage the geomembrane
- The extruder is purged prior to beginning a seam until all the heat-degraded extruder is removed (extrusion welding only)
- Seam grinding has been completed less than 30 minutes before seam welding (extrusion welding only)
- Seam edges are beveled and grind marks are perpendicular to the seam (extrusion welding only)
- Grind marks do not extend more than 1/4 inch from edge of weld
- The ambient temperature measured within 6 inches of the geomembrane surface is between 32 degrees and 105 degrees Fahrenheit, unless approved otherwise by the CQA Officer
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only)
- The weld is free of dust, dirt, moisture, or other contaminants
- The seams overlap a minimum of three inches for extrusion welding and four inches for fusion welding, or in accordance with manufacturer’s recommendations
- No solvents or adhesives are present in the seam area
- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing
- The panels are seamed in accordance with the plans and specifications

The CQC Manager shall prepare a Geomembrane Seaming Log for each seam on a form similar to that shown in **Attachment 10A**.

3.2.4 Construction Testing

Two nondestructive testing procedures shall be utilized, depending on the type of welding procedure used. For extrusion welded seams the vacuum box method shall be employed for the full seam length. A vacuum of at least three- pounds per square inch (psi) shall be maintained for at least ten seconds. For the dual wedge (hot shoe) fusion welded seam, the air channel shall be pressurized to a maximum pressure of 30-psi (GRI Test Method GM6). The air channel shall be pressurized for at least five minutes. If the loss of pressure exceeds two psi or pressure does not stabilize after five minutes, the defective area shall be located and repaired.

3.2.4.1 Nondestructive Seam Testing

During nondestructive testing operations, the CQA Officer shall perform the following activities:

- Observe all nondestructive testing.
- Verify that the CQC Manager records the location, date, test number, technician name, and results of all nondestructive testing. These results shall be recorded on a Geomembrane Nondestructive Test Record form similar to that shown in **Attachment 10A**.
- Mark the location of any defects requiring repairs and record on the Geomembrane Repair Log form.
- Mark the failed areas with a waterproof marker compatible with the liner (spray paint should not be used) and inform the CQC Manager of any required repairs.
- Verify that all testing covers the entire length of all field seams and is completed in accordance with the project specifications.
- Verify that all repairs are completed and then tested in accordance with the project specifications
- Tests shall be performed concurrently with seaming operation, not at the completion of all seaming.

3.2.4.2 Destructive Seam Testing

Destructive testing shall be performed concurrently with seaming operations, not at the completion of the installation. The types of destructive testing required during the liner installation are peel and shear tests.

The CQA Officer shall determine test locations as per the ***Sampling Frequency Methodology*** presented below. Locations selected may also be prompted by liner distortion due to overheating, weld contamination, or any potential cause of poor welds. The Installer shall not be informed in advance of the destructive test sample locations.

The CQC Manager shall remove samples at locations identified by the CQA Officer. The CQA Officer shall perform the following activities:

- Observe sample cutting;
- Mark each sample with an identifying number containing the seam number; and

- Record the sample location and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.) on a Geomembrane Destructive Test Record form (an example is provided in **Attachment 10A**).

The destructive sample shall be approximately 42 inches long by 12 inches wide, with the seam centered along the length. This recovered sample shall be divided into three parts: one 12-inch section shall be tested in the field, one 12-inch by 12-inch sample shall be given to the Owner for storage, and one 12-inch by 18-inch sample shall be sent to the Testing Laboratory for testing. Each sample shall be marked with the appropriate identification information. The Contractor or Installer shall ship samples for destructive analysis to the Testing Laboratory on the same day the sample is recovered.

Testing shall include the shear and peel test (ASTM D6392). At least five specimens shall be tested in peel and five specimens in shear. All of the five specimens tested by the Testing Laboratory using each method must meet the minimum test values presented in the Project Documents. The Testing Laboratory shall provide test results within 24 hours in writing or via telephone with the CQA Officer. Certified test results are to be provided within 5 days. The Contractor or Installer shall immediately notify the CQA Officer and Engineer in the event of a failed test. No areas (except as necessary to provide temporary wind protection or to temporarily prevent water from getting under the geomembrane) are to be covered prior to receiving the laboratory test results.

A passing machine-welded seam will be achieved in peel testing when the following two conditions are met:

- Failure is by Separation-in-plane (SIP). SIP is a locus-of-break where the failure surface propagates within one of the seamed sheets during destructive testing (usually in the peel mode).
- The load at failure shall be at least 72 percent of the yield strength of the parent geomembrane material (in pounds per inch width) or greater for hot wedge welds and 62 percent of the yield strength of the parent geomembrane material or greater for extrusion welds.

A passing machine-welded seam shall be achieved in shear when the following conditions are met:

- Failure is by SIP; and
- The load at failure shall be at least 95 percent of the yield strength (in pounds per inch width) of the parent geomembrane material (hot wedge or extrusion weld).

If the laboratory test fails in either peel or shear, the Installer may either reconstruct the entire seam or additional samples may be recovered to identify the deficient area more accurately. If additional samples are to be recovered, samples must be taken on either side of the failed sample for laboratory testing. These samples must be taken at least 10 feet from the location of the failed sample in either direction or at the end of the seam if it is less than 10 feet from the failed sample. Sample size and disposition shall be as described previously.

This process shall be repeated until samples that pass the tests ‘bracket’ the failed seam section on each side. All failed seams will be bounded by locations where samples passing laboratory tests have been taken. In cases involving more than 50 feet of reconstructed or cap stripped seam, the reconstructed or cap stripped seam must also be tested. Laboratory testing governs seam acceptance (for destructive testing). In no case shall destructive field testing of installed seams be used for final acceptance.

The testing locations shall be documented and included as part of the as-built panel placement drawing.

The CQA Officer shall select locations where seam samples will be cut for laboratory testing. These locations shall be established in the following manner:

Sampling Frequency Methodology

Method 1: For all landfill construction projects consisting of 50,000 linear feet of geomembrane seaming or less, a minimum of one test per 500 feet of seam length will be taken. This is a minimum frequency for the entire installation; individual samples may be taken at shorter intervals as determined by the CQA Officer. A testing frequency shall be agreed to by the CQC Manager, CQA Officer, and Owner’s Representative at the pre-construction meeting. However, if the number of failed samples exceeds 3 percent of the tested samples, this frequency may be increased at the discretion of the CQA Officer. Samples taken as the result of failed tests do not count toward the total number of tests.

Method 2: For all landfill construction projects consisting of more than 50,000 linear feet of geomembrane seaming the prescriptive methodology contained within the Geosynthetics Institute publication GRI GM17, which is included as **Attachment 10B**, will be utilized:

- The failure rate shall be laboratory failure rate. The provisions for corrective actions required to address failures is provided above.

- If at any time, the failure rate equals or exceeds 3%, the sampling frequency shall be increased to a minimum of 1 sample per 420 linear feet of seam length for the next 39 tests. This frequency may be increased at the discretion of the CQA Officer.
- If at any time, the failure rate is between 2% and 3%, the sampling frequency shall remain constant as established by the criteria below.
- If at any time, the failure rate is less than 2%, the sampling frequency shall be able to be reduced by the factors identified below. The maximum sampling interval shall be 1 destructive test per 1,000 linear feet.
- Minimum Allowable Batch Size shall be no less than 20 samples, due to lead time associated with receipt of laboratory destruct results. This approach increases the number of required tests when compared to the GRI GM17 Method's standard "Batch Size" reduction at each stage (it will require more testing for an installer to demonstrate "Good" Quality).

A stepwise example is included below for illustrative purposes assuming 90,000 linear feet of seam (initial number of 180 samples at the one test per 500 feet of seam length).

- Initial destructive seam sampling frequency shall be set at 1 sample per 500 linear feet of seam length for first 32 destructive tests (Table 2b, **Attachment 10B**);
- If a minimum of 32 of the first 32 destructive tests pass, then sampling frequency shall be decreased to 1 sample per 600 linear feet for the next 28 destructive tests (total of 60 destructive tests). If more than 1 seam fails in the first 32 destructive laboratory tests, then the sampling frequency shall increase to 1 sample per 420 linear feet of seam length for the next 39 tests (frequency will return to 500 linear feet if cumulative failure rate is less than 3%);
- If a minimum of 59 of the first 60 destructive tests pass, then the sampling frequency shall be decreased to 1 sample per 720 linear feet for the next 23 destructive tests (total of 83 destructive tests). If more than 2 seams fail in the first 60 destructive laboratory tests, then the sampling frequency shall increase to 1 sample per 420 linear feet of seam length for the next 39 tests;
- If a minimum of 81 of the first 83 destructive tests pass, then the sampling frequency shall be decreased to 1 sample per 850 linear feet for the next 20 destructive tests (total of 103 destructive tests). If more than 2 seams fail in the first 83 destructive laboratory tests, then the sampling frequency shall increase to 1 sample per 420 linear feet of seam length for the next 39 tests;
- If a minimum of 101 of the first 103 destructive tests pass, then the sampling frequency shall be decreased to 1 sample per sample per 1,000 linear feet for the next 17 destructive tests (total of 120 destructive tests). If more than 3 seams fail in the first 103 destructive laboratory tests, then

the sampling frequency shall increase to 1 sample per 420 linear feet of seam length for the next 39 tests.

3.2.5 Repairs

Portions of the geomembrane with flaws or that fail a nondestructive or destructive test shall be repaired in accordance with the specifications and manufacturer's recommendations. The CQA Officer shall locate and describe all repairs on the Geomembrane Repair Log form (see **Attachment 10A**).

- Patching is used to repair large holes, tears, large panel defects, and destructive testing sample locations.
- Extrusion is used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8 inch in the largest dimension.
- Capping is used to repair failed welds or to cover seams where welds cannot be nondestructively tested.
- Removal is used to replace areas with large defects where the preceding methods are not appropriate. Removal is also used to remove excess material (wrinkles) from the installed geomembrane.

3.2.6 Wrinkles

Placing soil cover or drainage materials over the geomembrane, temperature changes, or creep may cause wrinkles to develop in the geomembrane. Any wrinkles that can fold over shall be repaired either by cutting out excess material or, if possible, allowing the liner to contract due to temperature reduction. In no case shall material be placed over the geomembrane that could result in the geomembrane folding.

3.2.7 Bridging

Unless approved by the CQA Officer, bridging must be removed and repaired at no cost to Owner.

3.2.8 Folded Material

All folded HDPE geomembrane shall be removed and repaired at no cost to Owner.

3.2.9 Geomembrane Acceptance

The Installer shall retain all ownership and responsibility for the geomembrane until acceptance by the Owner. In the event the Installer is responsible for placing a protective cover over the geomembrane, the Installer shall retain ownership and responsibility for the geomembrane until the protective cover is placed.

The CQA Officer shall accept the geomembrane when the following activities have occurred:

- The installation is finished
- All seams have been inspected and approved
- All required laboratory tests have been completed and approved
- Signed QC certificates for each roll of geomembrane have been supplied by the Installer and approved by the CQA Officer. Certificates shall include resin identification, roll number, date of production, and test results for density, melt index, and tensile strength (ASTM D638)
- All record drawings have been completed and approved
- All documentation required by the specification has been received

3.3 Geocomposite

3.3.1 Delivery and Handling

The CQA Officer shall verify that the following activities are completed:

- Equipment used to unload the rolls shall not damage the geocomposite
- Care is used to unload the rolls
- The label containing product identification, roll number, and roll dimensions has been supplied by the Installer and been approved by the CQA Officer
- The geocomposite is covered to minimize contact with dirt and other contaminants
- Geocomposite rolls are not dragged across ground surface
- Heavy construction equipment is not operated directly on the geocomposite

At the CQA Officer's discretion, damaged rolls may be rejected and removed from the site or stored at a location, separate from accepted rolls, designated by the Owner's Representative. All rolls without proper manufacturer's documentation shall be rejected.

3.3.2 Conformance Testing

3.3.2.1 Tests

Before delivery, the Geosynthetics Manufacturer shall obtain one geocomposite sample per 50,000 square feet of geocomposite. The samples shall be forwarded to the Testing laboratory for the following tests:

- Carbon Black
- Transmissivity

- Thickness
- Tensile Properties
- Density
- Adhesion of Geotextile to Geonet

Where optional procedures are noted in the test method, the specification requirements shall prevail. The CQA Officer shall review all test results and report any nonconformance to the Owner's Representative and the Installer.

3.3.2.2 Sampling Procedure

Samples shall be taken across the entire roll width and shall not include the first three feet unless otherwise specified, samples shall be three feet long by the roll width. The CQA Officer or authorized representative shall tag the sample with the manufacturer's roll identification number and the date sampled.

3.3.3 Geocomposite Installation

Prior to geocomposite installation, the CQA Officer shall verify that the following conditions exist:

- The geocomposite installation, including all required documentation, has been completed
- The geocomposite surface is clean

During panel placement, the CQA Officer shall perform the following activities:

- Observe the geocomposite as it is deployed and record all defects and disposition of the defects (panel rejected, patch installed, etc.). All repairs are to be made in accordance with the specifications
- Verify that equipment used does not damage the geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or other means
- Verify that people working on the geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying geomembrane
- Verify that the geocomposite is anchored to prevent movement by the wind (the Installer is responsible for any damage resulting to or from windblown geocomposite)
- Verify that the geocomposite remains free of contaminants such as soil, grease, fuel, etc.

The CQA Officer shall inform the Installer and Owner's Representative if the above conditions are not met.

During geocomposite placement, the CQA Officer shall verify that the following conditions exist:

- Adjacent edges along the length of the geocomposite roll shall be overlapped a minimum of four inches, or as recommended by the Manufacturer.
- The overlapped edges shall be joined in accordance with the plans and specifications.
- Adjoining rolls across the roll width should be shingled down in the direction of the slope and joined together in accordance with the plans and specifications.
- Repair procedures include the following activities:
    - Patching is used to repair holes, breaks, tears, and defects
    - Removal is used to replace areas with large defects where patching is not appropriate.

3.4 Equipment on Geosynthetic Materials

Construction equipment on the composite final cover system will be minimized to reduce the potential for geosynthetic material puncture. The CQA Officer will verify that small equipment such as generators are placed on scrap geomembrane material (rub sheets) above geosynthetic materials in the final cover system. The erosion layer will be placed using low ground pressure equipment. The CQA Officer will verify that the geosynthetics are not displaced while the soil layers (e.g., erosion layer) are being placed.

Unless otherwise specified by the POR, lifts of soil material placed over geosynthetics will conform to the guidelines in Table 3-1.

Table 3-1: Equipment and Soil Material Guidelines

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in.)
<5.0	12 and under
5.1 - 8.0	18
8.1 - 16.0	24
>16.0	36

No equipment will be left running and unattended over the constructed geosynthetics.

3.5 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of the constructed final cover system. Section 5.0 describes the documentation requirements.

4.0 CONSTRUCTION QUALITY ASSURANCE FOR EROSION LAYER

The erosion layer for the Alternative Composite final cover areas will consist of a minimum of 12 inches of earthen material and a 200-mil double-sided drainage geocomposite. The top six inches of erosion layer will be capable of sustaining native and introduced vegetative growth and must be seeded immediately after completion of the final cover. Temporary or permanent erosion control materials may be used to minimize erosion and aid establishment of vegetation. The physical characteristics of the erosion layer will be evaluated through visual observation (and laboratory testing if deemed necessary by the POR) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the POR.

The erosion layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics. Equipment used to install the erosion layer must meet the requirement of Section 3.4.

The thickness of the erosion layer will be verified with surveying procedures at a minimum of one survey point per 10,000 square feet of constructed area by a licensed Texas surveyor with a minimum of one reference point. The survey results for the erosion layer will be included in the FCSER.

During construction, the CQA Officer will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Monitor haul-road thickness over installed geosynthetics and verify that equipment hauling, and material placement meet equipment specifications (see Section 3.4).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the erosion layer materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey. Thickness surveying to determine minimum erosion layer thickness will be performed similar to the compacted clay layer thickness verification shown in Table 2-1.

5.0 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA Officer will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports, progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the FCSER. Standard report forms will be provided by the POR prior to construction.

5.1 Preparation of FCSER

The POR, on behalf of the Operator, will submit to the TCEQ a FCSER for approval of each portion of final cover system constructed.

Testing, evaluation, and submission of the FCSER for the final cover system during construction will be in accordance with this FCQCP. The construction methods and test procedures documented in the FCSER will be consistent with this FCQCP.

At a minimum, the FCSER will contain:

- A summary of all construction activities.
- All laboratory and field test results.
- Third party conformance test results for geocomposite transmissivity.
- Manufacturer's certifications for all geosynthetics.
- Documentation of thickness of the compacted clay and erosion layers by a Texas registered Surveyor.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings, including all previous FCSER submittals and dates of TCEQ approval.
- A statement of compliance with the permit FCQCP and construction plans.
- The reports will be signed and sealed by a professional engineer(s) licensed in the State of Texas.

The as-built record drawings will accurately site the constructed location of work items, including the anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the FCSER.

5.2 Reporting Requirements

The FCSER will be signed and sealed by the POR, signed by the site operator, and submitted to the MSW Permits Section of the Waste Permits Division of the TCEQ for approval.

ATTACHMENT 10A – EXAMPLE CQA FORMS

City of Victoria MSW Landfill

GEOMEMBRANE MATERIAL RECEIVED LOG

Sheet of

Project Number:

Landfill Phase:

Supplier:

Material Type:

Recorder:

Date Received	Roll No.	Lot/ Batch	Roll Size			Date QC Docs Rcvd	Panel Number(s)	Remarks
			W (ft)	L (ft)	Sq. Ft.			

City of Victoria MSW Landfill

GEOCOMPOSITE MATERIAL RECEIVED LOG

Project Number: **Sheet of**

Landfill Phase:

Supplier:

Material Type:

Recorder:

Date Received	Roll Number	Lot / Batch	Roll Size			Date QC Docs Received
			W (ft)	L (ft)	Sq. Ft.	

City of Victoria MSW Landfill

GEOMEMBRANE PLACEMENT LOG

Project Number: **Sheet of**
Landfill Phase:
Recorder:

Panel #	Roll #	Date Placed	Panel		Panel Area (sf)	Material Type	Remarks
			L (ft)	W (ft)			

City of Victoria MSW Landfill

GEOMEMBRANE SEAMING LOG

Project Number: **Sheet of**
Landfill Phase:
Recorder:

Date	Seam No.	Time	Seam Length (ft)	Machine Type and Number	Name of Operator	Machine Settings	
						Temperature	Machine Speed

City of Victoria MSW Landfill

GEOMEMBRANE NONDESTRUCTIVE TEST RECORD (Air Pressure Testing)

Project Number: **Sheet of**

Landfill Phase:

Recorder:

Seam No.	Date	Start Test Time/Pressure (psi)	End Test Time/Pressure (psi)	Pass/ Fail	Tester Name	Remarks

City of Victoria MSW Landfill

FIELD GEOMEMBRANE DESTRUCTIVE TEST RECORD

Project Number: **Sheet of**

Landfill Phase:

Recorder:

Sample Number	Seam Number	Location	Date Seamed	Date Sampled	Oper.	Machine Number and Oper.	Field Peel (ppi)	Field Shear (ppi)	Laboratory Peel (ppi)	Laboratory Shear (ppi)	% Peel	Failure Type	Pass/ Fail	Pass/ Fail

City of Victoria MSW Landfill

GEOMEMBRANE REPAIR LOG

Project Location:

Project Number:

Recorder:

Repair Number	Date of Repair	Location	Description	Vacuum Test OK by:

ATTACHMENT 10B – GRI GM17

Geosynthetic Institute

475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

Revision 14: March 17, 2021
Revision schedule on pg. 12

GRI - GM17 Standard Specification*

Standard Specification for

"Test Methods, Test Properties and Testing Frequency for
Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes" SM

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

1. Scope

1.1 This specification covers linear low density polyethylene (LLDPE) geomembranes with a formulated sheet density of 0.939 g/ml, or lower, in the thickness range of 0.50 mm (20 mils) to 3.0 mm (120 mils). Both smooth and textured geomembrane surfaces are included.

1.2 This specification sets forth a set of minimum, maximum, or range of physical, mechanical and endurance properties that must be met, or exceeded by the geomembrane being manufactured.

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

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

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

1.4 This standard specification is intended to ensure good uniform quality LLDPE geomembranes for use in general applications.

Note 2: Additional tests, or more restrictive values for the tests indicated, may be necessary under conditions of a particular application. In this situation, interactions with the manufacturers are required.

Note 3: For information on installation techniques, users of this standard are referred to the geosynthetics literature, which is abundant on the subject.

2. Referenced Documents

2.1 ASTM Standards

D 792 Specific Gravity (Relative Density) and Density of Plastics by Displacement
D 1004 Test Method for Initial Tear Resistance of Plastics Film and Sheeting
D 1238 Test Method for Flow Rates of Thermoplastics by Extrusion Plastometer
D 1505 Test Method for Density of Plastics by the Density-Gradient Technique
D 1603 Test Method for Carbon Black in Olefin Plastics
D 4218 Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
D 4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
D 5199 Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
D 5323 Practice for Determination of 2% Secant Modulus for Polyethylene Geomembranes
D 5596 Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics
D 5617 Test Method for Multi-Axial Tension Test for Geosynthetics
D 5721 Practice for Air-Oven Aging of Polyolefin Geomembranes
D 5885 Test method for Oxidative Induction Time of Polyolefin Geosynthetics by High Pressure Differential Scanning Calorimetry
D 5994 Test Method for Measuring the Core Thickness of Textured Geomembranes
D 6370 Standard Test Method for Rubber-Compositional Analysis by Thermogravimetry (TGA)
D 6693 Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes
D 7238 Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent Condensation Device
D 7466 Test Method for Measuring the Asperity Height of Textured Geomembranes

D 8117 Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by Differential Scanning Calorimetry

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

3. Definitions

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

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

Linear Low Density Polyethylene (LLDPE), n – A ethylene/α-olefin copolymer having a linear molecular structure. The comonomers used to produce the resin can include 1-butene, 1-hexene, 1-octene or 4-methyl-1-pentene. LLDPE resins have a natural density in the range of 0.915 to 0.926 g/ml (ref. Pate, T. J. Chapter 29 in Handbook of Plastic Materials and Technology, I.I. Rubin Ed., Wiley, 1990).

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

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

4. Material Classification and Formulation

4.1 This specification covers linear low density polyethylene geomembranes with a formulated sheet density of 0.939 g/ml, or lower. Density can be measured by ASTM D1505 or ASTM D792. If the latter, Method B is recommended.

4.2 The polyethylene resin from which the geomembrane is made will generally be in the density range of 0.926 g/ml or lower, and have a melt index value per ASTM D1238 of less than 1.0 g/10 min. This refers to the natural, i.e., nonformulated, resin.

4.3 The resin shall be virgin material with no more than 10% rework. If rework is used, it must be of the same formulation (or other approved formulation) as the parent material.

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

5. Physical, Mechanical and Chemical Property Requirements

5.1 The geomembrane shall conform to the test property requirements prescribed in Tables 1 and 2. Table 1 is for smooth LLDPE geomembranes and Table 2 is for single and double sided textured LLDPE geomembranes. Each of the tables are given in English and SI (metric) units. The conversion from English to SI (metric) is "soft". It is to be understood that the tables refer to the latest revision of the referenced test methods and practices.

Note 4: The tensile strength properties in this specification were originally based on ASTM D 638 which uses a laboratory testing temperature of 23°C ± 2°C. Since ASTM Committee D35 on Geosynthetics adopted ASTM D 6693 (in place of D 638), this GRI Specification followed accordingly. The difference is that D 6693 uses a testing temperature of 21°C ± 2°C. The numeric values of strength and elongation were not changed in this specification. If a dispute arises in this regard, the original temperature of 23°C ± 2°C should be utilized for testing purposes.

Note 5: There are several tests sometimes included in other LLDPE geomembrane specifications which are omitted from this standard because they are outdated, irrelevant or generate information that is not necessary to evaluate on a routine MQC basis. The following tests have been purposely omitted:

- Volatile Loss
- Dimensional Stability
- Coeff. of Linear Expansion
- Resistance to Soil Burial
- Low Temperature Impact
- ESCR Test (D 1693 and D 5397)
- Wide Width Tensile
- Water Vapor Transmission
- Solvent Vapor Transmission
- Water Absorption
- Ozone Resistance
- Hydrostatic Resistance
- Tensile Impact
- Small Scale Burst
- Various Toxicity Tests
- Field Seam Strength

Note 6: There are several tests which are included in this standard (that are not customarily required in other LLDPE geomembrane specifications) because they are relevant and important in the context of current manufacturing processes. The following tests have been purposely added:

- Oxidative Induction Time
- Oven Aging
- Ultraviolet Resistance
- Asperity Height of Textured Sheet

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

- Thickness of Textured Sheet
- Tensile Properties, incl. 2% Secant Modulus
- Puncture Resistance
- Axi-Symmetric Break Resistance Strain
- Carbon Black Dispersion (In the viewing and subsequent quantitative interpretation of ASTM D 5596 only near spherical agglomerates shall be included in the assessment).

Note 8: The minimum average value of asperity height does not represent an expected value of interface shear strength. Shear strength associated with geomembranes is both site-specific and product-specific and should be determined by direct shear testing using ASTM D5321/ASTM D6243 as prescribed. This testing should be included in the particular site's CQA conformance testing protocol for the geosynthetic materials involved, or formally waived by the Design Engineer, with concurrence from the Owner prior to the deployment of the geosynthetic materials.

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

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

Note 9: This specification is focused on manufacturing quality control (MQC). Conformance testing and manufacturing quality assurance (MQA) testing are at the discretion of the purchaser and/or quality assurance engineer, respectively. Communication and interaction with the manufacturer is strongly suggested.

6. Workmanship and Appearance

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

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

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

7. MQC Sampling

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

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

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

8. MQC Retest and Rejection

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

9. Packaging and Marketing

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

9.2 Marking of the geomembrane rolls shall be done in accordance with the manufacturers accepted procedure as set forth in their quality manual.

10. Certification

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

English Units

Table 1(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane (SMOOTH)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness - (min. ave.) - mils • lowest individual of 10 values - %	D5199	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	per roll
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,00 lb
Tensile Properties *(1)* (min. ave.) • break strength - lb/in. • break elongation - %	D 6693 Type IV	76 800	114 800	152 800	190 800	228 800	304 800	380 800	456 800	20,000 lb
2% Modulus (max.) - lb/in.	D 5323	1200	1800	2400	3000	3600	4800	6000	7200	per formulation
Tear Resistance (min. ave.) - lb	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance (min. ave.) - lb	D 4833	28	42	56	70	84	112	140	168	45,000 lb
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 *(2)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(4)* (a) Standard OIT - min. — or — (b) High Pressure OIT - min.	 D 8117 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	200,000 lb
Oven Aging at 85°C *(5)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(6)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 7238 D 8117 D 5885	 N. R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	per formulation

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

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

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

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

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

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

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

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

SI (Metric) Units

Table 1(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane (SMOOTH)

Properties	Test Method	Test Value 0.50 mm	0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	Testing Frequency (minimum)
Thickness - (min. ave.) - mm • lowest individual of 10 values - %	D5199	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	nom. -10	per roll
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties *(1)* (min. ave.) • break strength - N/mm • break elongation - %	D 6693 Type IV	 13 800	 20 800	 27 800	 33 800	 40 800	 53 800	 66 800	 80 800	9,000 kg
2% Modulus (max.) - N/mm	D 5323	210	315	420	520	630	840	1050	1260	per formulation
Tear Resistance (min. ave.) - N	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance (min. ave.) - N	D 4833	120	190	250	310	370	500	620	750	20,000 kg
Axi-Symmetric Break Resistance Strain - % (min.)	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	note *(3)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(4)* (c) Standard OIT - min. — or — (d) High Pressure OIT - min.	 D 8117 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	90,000 kg
Oven Aging at 85°C *(5)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(6)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(8)*	D 7238 D 8117 D 5885	 N. R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	 N.R. *(7)* 35	per formulation

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

(2) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(3) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(4) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(5) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(6) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(7) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(8) UV resistance is based on percent retained value regardless of the original HP-OIT value.

English Units

Table 2(a) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		20 mils	30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils	
Thickness (min. ave.) - mils • lowest individual for 8 out of 10 values - % • lowest individual for any of the 10 values - %	D 5994	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	per roll
Asperity Height (min. ave.) - mils	D 7466	16	16	16	16	16	16	16	16	Every 2nd roll *(1)*
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	200,000 lb
Tensile Properties *(2)* (min. ave.) • break strength - lb/in. • break elongation - %	D 6693 Type IV	 30 250	 45 250	 60 250	 75 250	 90 250	 120 250	 150 250	 180 250	20,000 lb
2% Modulus – lb/in. (max.)	D 5323	1200	1800	2400	3000	3600	4800	6000	7200	per formulation
Tear Resistance (min. ave.) - lb	D 1004	11	16	22	27	33	44	55	66	45,000 lb
Puncture Resistance (min. ave.) - lb	D 4833	22	33	44	55	66	88	110	132	45,000 lb
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	45,000 lb
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	45,000 lb
Oxidative Induction Time (OIT) (min. ave.) *(5)* (e) Standard OIT - min. — or — (f) High Pressure OIT - min.	 D 8117 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	200,000 lb
Oven Aging at 85°C *(6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 8117 D 5885	 N. R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	per formulation

(1) Alternate the measurement side for double sided textured sheet
(2) Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction.
- Break elongation is calculated using a gage length of 2.0 in. at 2.0 in./min.

(3) Other methods such as D 1603 (tube furnace) or D 6370 (TGA) are acceptable if an appropriate correlation to D 4218 (muffle furnace) can be established.
(4) Carbon black dispersion (only near spherical agglomerates) for 10 different views:
- 9 in Categories 1 or 2 and 1 in Category 3

(5) The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
(6) It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.
(7) The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(8) Not recommended since the high temperature of the Std-OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.
(9) UV resistance is based on percent retained value regardless of the original HP-OIT value.

SI (Metric) Units

Table 2(b) – Linear Low Density Polyethylene (LLDPE) Geomembrane (TEXTURED)

Properties	Test Method	Test Value								Testing Frequency (minimum)
		0.50 mm	0.75 mm	1.00 mm	1.25 mm	1.50 mm	2.00 mm	2.50 mm	3.00 mm	
Thickness (min. ave.) - mm • lowest individual for 8 out of 10 values • lowest individual for any of the 10 values	D 5994	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. (5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	nom. -5% -10 -15	per roll
Asperity Height mm (min. ave.)	D 7466	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	Every 2nd roll *(1)*
Formulated Density (max.) - g/cc	D 1505/D 792	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939	90,000 kg
Tensile Properties *(2)* (min. ave.) • break strength - N/mm • break elongation - %	D 6693 Type IV	 5 250	 9 250	 11 250	 13 250	 16 250	 21 250	 26 250	 31 250	9,000 kg
2% Modulus (max.) - N/mm	D 5323	210	315	420	520	630	840	1050	1260	per formulation
Tear Resistance (min. ave.) - N	D 1004	50	70	100	120	150	200	250	300	20,000 kg
Puncture Resistance – (min. ave.) - N	D 4833	100	150	200	250	300	400	500	600	20,000 kg
Axi-Symmetric Break Resistance Strain (min.) - %	D 5617	30	30	30	30	30	30	30	30	per formulation
Carbon Black Content (range) - %	D 4218 *(3)*	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	20,000 kg
Carbon Black Dispersion	D 5596	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	note *(4)*	20,000 kg
Oxidative Induction Time (OIT) (min. ave.) *(5)* (g) Standard OIT - min. — or — (h) High Pressure OIT - min.	 D 8117 D 5885	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	 100 400	90,000 kg
Oven Aging at 85°C *(6)* (a) Standard OIT (min. ave.) - % retained after 90 days — or — (b) High Pressure OIT (min. ave.) - % retained after 90 days	D 5721 D 8117 D 5885	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	 35 60	per formulation
UV Resistance *(7)* (a) Standard OIT (min. ave.) — or — (b) High Pressure OIT (min. ave.) - % retained after 1600 hrs *(9)*	D 7238 D 8117 D 5885	 N. R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	 N.R. *(8)* 35	per formulation

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

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

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

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

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

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

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

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

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

Adoption and Revision Schedule
for
GRI Test Method GM17

"Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes"

Adopted:	April 3, 2000
Revision 1:	June 28, 2000: added a new Section 5.2 that the numeric tables values are neither MARV nor MaxARV. They are to be interpreted per the designated test method. Also, corrected typographical error of textured sheet thickness test method designation from D5199 to D5994.
Revision 2:	December 13, 2000: added one Category 3 is allowed for carbon black dispersion. Also, unified terminology to "strength" and "elongation".
Revision 3:	June 23, 2003: Adopted ASTM D 6693, in place of ASTM D 638, for tensile strength testing. Also, added Note 4.
Revision 4:	February 20, 2006: Added Note 9 on Asperity Height clarification with respect to shear strength.
Revision 5:	Removed recommended warranty from specification.
Revision 6:	June 1, 2009: Replaced GRI-GM12 test method for asperity height of textured geomembranes with ASTM D 7466.
Revision 7:	April 11, 2011: Added alternative carbon black test methods.
Revision 8:	October 3, 2011: Expanded types of comonomers in the definition of LLDPE.
Revision 9:	December 14, 2012: Replaced GRI-GM12 with the equivalent ASTM D7238.
Revision 10:	November 14, 2014: Increased asperity height of textured sheet from 10 to 16 mils (0.25 to 0.40 mm).
Revision 11:	April 13, 2015: Unit conversion error was corrected for 0.75 mm (30 mil) thickness for the property of 2% modulus. The test value was changed from 370 N/mm to 315 N/mm in the SI (Metric) units tables to agree with the English units tables.
Revision 12:	November 4, 2015: Removed Footnote (1) on asperity height from tables.
Revision 13:	September 9, 2019: Editorial update to harmonize tables.
Revision 14:	March 17, 2021: Updated Standard OIT Test from ASTM D3895 to D8117.

ATTACHMENT 10C – 2014 CQA Plan

CITY OF VICTORIA LANDFILL
VICTORIA COUNTY, TEXAS
TCEQ PERMIT NO. MSW-1522A

SITE DEVELOPMENT PLAN
ATTACHMENT 12J
FINAL COVER SYSTEM QUALITY CONTROL PLAN

Prepared for

City of Victoria

May 2014

STATE OF TEXAS
KYLE D. GOULD
106018
LICENSED
PROFESSIONAL ENGINEER
5.7.14

Prepared by

Weaver Boos Consultants, LLC–Southwest
TBPE Registration No. F-3727
6420 Southwest Boulevard, Suite 206
Fort Worth, TX 76109
817-735-9770

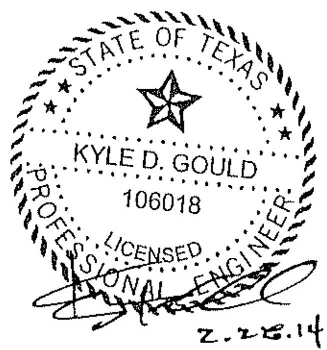
WBC Project No. 5084-351-11-00-01

This document is intended for permitting purposes only.

CONTENTS

STATE OF TEXAS
KYLE D. GOULD
106018
LICENSED PROFESSIONAL ENGINEER
5.7.14

CONTENTS (Continued)



LIST OF TABLES

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LIST OF ACRONYMS

AOS – apparent opening size

ASTM – American Society for Testing and Materials

CQA – construction quality assurance

FCSER – final cover system evaluation report

FCSQCP – final cover system quality control plan

FTB – film tear bond

GM – geomembrane liner

GP – Geotechnical Professional

GRI – Geosynthetics Research Institute

HDPE – high density polyethylene

LL – liquid limit

LLDPE – linear low density polyethylene

MQA – manufacturing quality assurance

MQC - manufacturing quality control

MSW – municipal solid waste

MSWR – Municipal Solid Waste Regulations

NICET - National Institute for Certification in Engineering Technologies

OIT – oxidative induction time

PI – plasticity index

PL – plastic limit

POR – Professional of Record

QA/QL – quality assurance/quality control

TCEQ – Texas Commission on Environmental Quality

UV – ultraviolet

1 INTRODUCTION

1.1 Purpose

This Final Cover System Quality Control Plan (FCSQCP) has been prepared to provide the Owner, Operator, Design Engineer, Construction Quality Assurance Professional of Record, and the Contractor the means to govern the construction quality and to satisfy the environmental protection requirements under current Texas Commission on Environmental Quality (TCEQ) Municipal Solid Waste Regulations (MSWR). More specifically, the FCSQCP addresses the soil and geosynthetic components of the final cover system.

This FCSQCP is divided into the following parts:

- Section 1 – Introduction
- Section 2 – Construction Quality Assurance for Soil Infiltration Layer
- Section 3 – Construction Quality Assurance for Geosynthetics
- Section 4 – Construction Quality Assurance for Erosion Layer
- Section 5 – Documentation

1.2 Definitions

Whenever the terms listed below are used, the intent and meaning will be interpreted as indicated.

ASTM

American Society for Testing and Materials.

Atterberg Limits

A series of six "limits of consistency" of fine-grained soils defined by Swedish soil scientist Albert Atterberg, two of which are frequently used today to establish a soil's physical boundaries dealing with its plasticity characteristics. These soil boundaries or limits used most frequently in geotechnical engineering are based upon the numerical difference of the Liquid Limit and the Plastic Limit as defined below:

- Liquid Limit (LL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the upper point at which the soil's consistency changes from the plastic to the liquid state.
- Plastic Limit (PL) – The percentage of moisture in a soil, subjected to a prescribed test, that defines the lower point at which the soil's consistency changes from the plastic to the semi-solid state.
- Plasticity Index (PI) – The numerical difference between the LL and the PL of a fine-grained soil that denotes the soils plastic range. The larger the PI the greater a soil's plasticity range and the greater it's plasticity characteristics.

Compactive Effort

The amount of compaction energy held constant, and usually transferred into a soil sample with a compaction hammer device, used on soil samples in various laboratory test procedures to establish a soil's density at various moisture contents.

Construction Quality Assurance (CQA)

A planned system of activities that provides the Operator and permitting agency assurance that the facility was constructed as specified in the design (EPA, 1986). Construction quality assurance includes observations and evaluations of materials, and workmanship necessary to determine and document the quality of the constructed facility. Construction quality assurance (CQA) refers to measures taken by the CQA organization to assess if the installer or contractor is in compliance with the plans and specifications for a project.

Construction Quality Assurance (CQA) Monitors

These are representatives of the POR who work under direct supervision of the POR. The CQA monitor is responsible for quality assurance monitoring and performing onsite tests and observations. The CQA monitor is on site full-time during construction and reports directly to the POR. The CQA monitor performing daily QA/QC observation and testing will be NICET-certified in geotechnical engineering technology at level two or higher for soils and FML testing; a CQA monitor with a minimum of four years of directly related experience; or a graduate engineer or geologist with one year of directly related experience. Field observations, testing, or other activities associated with CQA may be performed by the CQA monitor(s) under the direction of the POR. Additional CQA monitors may be used. If working under the direction of a CQA monitor, the second CQA monitor will have a minimum of one year of directly related experience.

Construction Quality Assurance Professional of Record (POR)

The POR is an authorized representative of the Operator and has overall responsibility for construction quality assurance and confirming that the facility was constructed in general accordance with plans and specifications approved by the permitting agency. The POR must be licensed as a Professional Engineer in Texas and experienced in geotechnical testing and its interpretations. Experience and education should include geotechnical engineering, engineering geology, soil mechanics, geotechnical laboratory testing, construction quality assurance, and quality control testing, and hydrogeology. The POR must show competency and experience in certifying like installations, and be approved by the permitting agency, and be presently employed by or practicing as a geotechnical engineer in a recognized geotechnical/environmental engineering organization. The credentials of the POR must meet or exceed the minimum requirements of the permitting agency. Any references to monitoring, testing, or observations to be performed by the POR should be interpreted to mean the POR or CQA monitors working under the POR's direction. The POR or his designated representative will be on-site during all final cover system construction.

The POR may also be known in applicable regulations and guidelines as the CQA Engineer, Resident Project Representative, or the Geotechnical Professional (GP).

Contract Documents

These are the official set of documents issued by the Operator. The documents include bidding requirements, contract forms, contract conditions, specifications, contract drawings, addenda, and contract modifications.

Contract Specifications

These are the qualitative requirements for products, materials, and workmanship upon which the contract is based.

Contractor

This is the person or persons, firm, partnership, corporation, or any combination, private or public, who, as an independent contractor, has entered into a contract with the Operator and who is referred to throughout the contract documents by singular number and masculine gender.

Design Engineer

These individuals or firms are responsible for the design and preparation of the project construction drawings and specifications. Also referred to as "designer" or "engineer."

Earthwork

This is a construction activity involving the use of soil materials as defined in the construction drawings and specifications and Section 2 of this plan.

Film Tear Bond (FTB)

A failure in the geomembrane sheet material on either side of the seam and not within the seam itself.

Final Cover System Evaluation Report (FCSER)

Upon completion of closure activities, the certification will be in the form of the FCSER which will be signed by the POR and include all the documentation necessary for certification of closure.

Fish Mouth

A semi-conical opening of the seam that is formed by an edge wrinkle in one sheet of the geomembrane.

Geomembrane Liner (GM)

This is a synthetic lining material, also referred to as geomembrane, membrane liner, or sheet. The term Flexible Membrane Liner (FML) is also used for GM.

Geosynthetics Contractor

This individual is also referred to as the "contractor" or “installer”, and is the person or firm responsible for geosynthetic construction. This definition applies to any person installing FML or other geosynthetic materials, even if not his primary function.

Independent Testing Laboratory

A laboratory that is independent of ownership or control by the permittee or any party to the construction of the final cover or the manufacturer of the final cover products used.

Manufacturing Quality Assurance (MQA)

A planned system of activities that provides assurance that the raw materials were constructed (manufactured) as specified.

Manufacturing Quality Control (MQC)

A planned system of inspection that is used to directly monitor and control the manufacture of a material.

Nonconformance

This is a deficiency in characteristic, documentation, or procedure that renders the quality of an item or activity unacceptable or indeterminate. Examples of non-conformances include, but are not limited to, physical defects, test failures, and inadequate documentation.

Operator

The organization that will operate the disposal unit.

Operator's Representative

This is the person that is an official representative of the operator responsible for planning, organizing, and controlling the design and construction activities.

Panel

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

Permeant Fluid

Fluid used in a laboratory coefficient of permeability test and limited to tap water or 0.005 Normal solution of $CaSO_4$. Distilled water will not be used in these test procedures.

Quality Assurance

This is a planned and systematic pattern of procedures and documentation to ensure that items of work or services meet the requirements of the contract documents. Quality assurance includes quality control. Quality assurance will be performed by the POR and CQA monitor.

Quality Control

These actions provide a means to measure and regulate the characteristics of an item or service to comply with the requirements of the contract documents. Quality control will be performed by the contractor:

Representative Sample

A representative sample of FML material consists of 1 or more specimens (commonly referred to as coupons) from the same rectangular portion of FML material, oriented along a seam, that is removed for field or laboratory testing purposes.

Soil Borrow Source

Soils in which the Liquid Limit (LL) and Plasticity Index (PI) do not vary by 10 points. A soil that varies by 10 or more points from the originally established LL or PI is considered as a separate soil source for the purpose of this FCSQCP and requires a separate soils test series.

Soil Test Series

Tests performed to determine a soil's physical characteristics and to document its ability to satisfy the MSWR soil infiltration layer requirements. These tests include sieve analysis (gradation), Atterberg Limits, moisture/density, and coefficient of permeability.

Specimen

(With respect to FML destructive testing) – A specimen is the individual test strip (sometimes called coupon) from a sample location. A sample location usually consists of many specimens.

2 CONSTRUCTION QUALITY ASSURANCE FOR SOIL INFILTRATION LAYER

2.1 Introduction

This section of the FCSQCP addresses the construction of the soil infiltration layer component of the final cover system and outlines the FCSQCP program to be implemented with regard to materials selection and evaluation, laboratory test requirements, field test requirements and treatment of problems.

The scope of soil infiltration layer related construction quality assurance includes the following elements:

- Subgrade preparation
- Soil infiltration layer stockpile
- Soil infiltration layer placement
- General fill

2.2 Final Cover

Final cover at the City of Victoria Landfill includes two types of final cover systems (pre-Subtitle D and Subtitle D) as defined in Section III of the Final Closure Plan (Attachment 12). The pre-Subtitle D cover system includes an 18-inch-thick compacted clay infiltration layer and 6-inch-thick erosion layer capable of sustaining vegetative growth. The Subtitle D cover system includes an 18-inch-thick compacted clay infiltration layer, geomembrane, drainage geocomposite (sideslopes only), and 24-inch-thick erosion layer, of which the top 6 inches is capable of sustaining vegetative growth.

Note that drainage geocomposite is not required for topslopes for the Subtitle D area, as discussed in Attachment 12 and demonstrated in Attachment 12H. However, the design engineer or POR may opt to use a cushion geotextile between the geomembrane and erosion layer to protect the geomembrane, as discussed in Section 3.

The final cover system for both the Subtitle D area and the pre-Subtitle D area is designed to minimize the amount of precipitation that infiltrates the deposited waste, thus minimizing the amount of leachate generated. The final cover system is designed to convey stormwater to detention ponds via final cover erosion control structures and perimeter channels.

2.3 Soil Infiltration Layer Construction

Sections 2.3.1 and 2.3.2 describe general construction procedures to be used for the soil infiltration layer and the preparation of the intermediate cover layer.

2.3.1 Intermediate Cover

The surface of the intermediate cover will be compacted to prepare the working surface for the first lift of infiltration layer soil. The CQA monitor will visually inspect and approve the prepared intermediate cover prior to the placement of the soil infiltration layer or structural fill. Approval will be based on a review of test information, if applicable, and CQA monitoring of the intermediate cover preparation.

Surveying will be performed to verify that the finished intermediate cover is completed consistent with the lines and grades specified in the design.

2.3.2 Soil Infiltration Layer

The soil infiltration layer will consist of a minimum 18-inch-thick compacted soil barrier (measured perpendicular to the subgrade surface) that will extend along the sideslopes and topslopes of the landfill. All soils used in soil infiltration layers will have the following minimum values verified by testing in a third party soil laboratory:

- Plasticity Index equal to or greater than 15.
- Liquid Limit equal to or greater than 30.
- Percent passing the No. 200 mesh sieve equal to or greater than 30 percent.
- Percent passing the 1-inch screen equal to 100 percent.
- Coefficient of permeability should meet the requirements set forth in Section III of Attachment 12: (1) for the composite Subtitle D final cover infiltration layer, coefficient of permeability of less than or equal to 1×10^{-5} cm/s; and (2) for the pre-Subtitle D final cover infiltration layer, coefficient of permeability of less than or equal to 1×10^{-7} cm/s will be used.

The soil infiltration layer material will consist of relatively homogeneous clay, and clayey soils. The soil will be free of debris, rock greater than 1 inch in diameter, vegetative matter, frozen materials, foreign objects, and organics. Testing will be performed in accordance with Section 2.4 (refer to Table 2-1 for test methods) for each borrow source. A permeability test will be conducted on samples from each borrow source. The permeability test specimens will be prepared by laboratory compaction to a dry density of approximately 95 percent of the Standard Proctor (ASTM D 698) maximum dry density at a moisture content at or above the optimum moisture content. One Proctor moisture-density relationship and remolded permeability test will be required for each different material as determined by a change in the liquid limit or plasticity index of more than 10 points.

The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of previously compacted lift; therefore, the compacted lift thickness will not be greater than the pad or prong length. The material will be compacted to a minimum of 95 percent of the maximum dry density determined by Standard Proctor (ASTM D 698) at a moisture content between the Standard Proctor optimum and 5 percentage points above optimum. The CQA monitor, earthwork contractor, and/or Operator will identify the clay material during excavation, and the clay material will be stockpiled separately, if stockpiling is required.

Because of possible variability of the available clay materials, additional stockpile testing will be performed if different physical properties of the borrow soil (color, texture, etc.) are observed by the CQA monitor, and the materials vary by more than ten points in either liquid limit or plasticity index from previously evaluated materials.

The clay materials to be used for infiltration layer will require processing to achieve the required moisture content for compaction. The physical characteristics of the clay materials will be evaluated through visual observation before and during construction. To add moisture to the material properly, the clod sizes will first be crushed into manageable sizes of 1 inch in diameter or less. Rocks within the infiltration layer should be less than 1 inch in diameter and will not total more than 10 percent by weight. The prepared infiltration layer will be observed such that rock content will not be a detriment to the integrity of the overlying geomembrane (geomembrane layer is only applicable to the Subtitle D composite final cover system area).

Clod-size (and shale) reduction, if necessary, may be achieved using a disc harrow or soil pulverizer. In order to efficiently break down the clods and pieces of shale, multiple passes of the processing equipment in two directions are recommended. Water will be applied as necessary to the material and worked into the material with the processing or compacting equipment. If necessary to achieve even moisture distribution or break down clod, the material will be watered and processed in the stockpile prior to placing in the infiltration layer to allow the soil adequate time to hydrate. Water used for the soil infiltration layer must be clean and not contaminated by waste or any objectionable material. Collected onsite stormwater may be utilized if it has not come into contact with the solid waste.

The soil infiltration layer must be compacted with a pad/tamping-foot or prong-foot (sheepsfoot) roller. The lift thickness will be controlled so that there is total penetration through the loose lift under compaction into the top of the previously compacted lift; therefore, the lift thickness must not be greater than the pad or prong length. The top of intermediate cover will be scarified a minimum of two inches prior to placement of the first lift of soil infiltration layer. Use of pad/tamping foot or prong-foot rollers will provide sufficient roughening of soil infiltration layer lift's surface for bonding between lifts. These procedures are necessary to achieve adequate bonding between lifts and reduce seepage pathways. Adequate cleaning devices must be in place and maintained on the compaction roller so that the prongs or pad feet do not become clogged with clay soils to the point that they cannot achieve full penetration during initial compaction. The footed roller is necessary to achieve this bonding and to reduce the individual clods and achieve a blending of the soil matrix through its kneading action. In addition to the kneading action, weight of the compaction equipment is important. The minimum weight of the compactor should be 40,000 pounds, and a minimum of four passes are recommended for the compaction process. A pass is defined as one pass (1 direction) of the compactor, not just an axle, over a given area. The recommended minimum of four passes is for a vehicle with front and rear drums. The Caterpillar 815B and 825C are examples of equipment typically used to achieve satisfactory results.

The soil infiltration layer will not be compacted with a bulldozer or any track-mobilized equipment unless it is used to pull a pad-footed roller.

CQA testing of the soil infiltration layer will be performed as the infiltration layer is being constructed. Testing procedures, frequency, and passing criteria will be in accordance with Section 2.4.

Soil infiltration layer construction and testing will be conducted in a systematic and timely fashion on each lift. In general, delays will be avoided in infiltration layer construction (typically no more than 14 days). Reasons for any delays in infiltration layer construction (greater than 14 days) should be fully explained in the FCSER submittal.

The finished top surface of the soil infiltration layer must be rolled with a smooth, steel-wheeled roller to obtain a hard, uniform, and smooth surface. The surface of the soil infiltration layer will then be carefully inspected by the CQA monitor for any gravel, rock pieces, and deleterious materials, which might impact the integrity of the geomembrane to be placed upon it. All voids created by removing gravel, rock pieces, or other deleterious materials will be backfilled with infiltration layer material to the density specifications outlined for soil infiltration construction and tested at the discretion of the CQA monitor.

Surveying will be performed to document that the finished soil infiltration layer has been constructed to a minimum thickness of 18 inches. Thickness verification may be performed by using settlement plates (e.g., plywood sheet or similar material) on a 100-foot grid. The infiltration layer will be surveyed as indicated in Table 2-1 to verify that a minimum 18-inch-thick soil layer is present at each location.

The location of the settlement plates will be established by a Texas registered surveyor on a 100-foot grid. The shaft extending upward from the base will be marked to indicate the minimum required thickness of the infiltration layer. The infiltration layer will be constructed to the minimum thickness marked on the shaft of the settlement plate. The

POR and CQA monitor will verify that the infiltration layer is placed uniformly between each settlement plate.

An infiltration layer thickness drawing at each of the survey measurement grid points will be provided. Coordinates defining the perimeter of the final cover system will be called out on the final drawings. The infiltration layer thickness drawing will be sealed by a Texas registered surveyor. After the construction of the infiltration layer is complete, the Texas registered surveyor will survey the final elevation of the infiltration layer. The infiltration layer certification drawing will be included in the FCSER. In addition, the elevations obtained for the top of the infiltration layer will be used to verify that the as-built slopes are consistent with the approved landfill completion plan. A statement that confirms that the as-built slopes are consistent with the approved landfill completion plan will be included in the FCSER.

Once the survey is complete, the settlement plate shaft will be removed and the resulting hole will be backfilled with bentonite or a bentonite/infiltration layer soil mixture consisting of at least 20 percent bentonite.

Testing and evaluation of the soil infiltration layer during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with the FCSQCP.

The soil infiltration layer will be prevented from losing moisture prior to placement of geomembrane. Preserving the moisture content of the installed soil infiltration layer will be dependent on the earthwork contractors means and methods and is subject to POR approval.

Sections of the soil infiltration layer which do not pass both the density and moisture requirements will be reworked with additional passes of the compactor until the section in question passes. All field density test results will be incorporated into the FCSER.

Hydraulic conductivity samples will be obtained by pushing a sampler through the constructed infiltration layer. The sample from each test location will be sealed and transported to the laboratory. Two samples may be collected at each sample location and labeled the "A" and "B" sample. The sampling holes (e.g., samples for hydraulic conductivity) will be backfilled with bentonite or a bentonite/infiltration layer soil material mixture consisting of at least 20 percent bentonite.

If the integrity of the "A" sample appears to have been compromised during the transportation of the sample prior to testing, the "B" sample may be tested. In addition, if an "A" sample hydraulic conductivity test does not comply with the minimum allowable value, the "B" sample collected at the same location may be tested to determine compliance with the hydraulic conductivity requirements if during testing of the "A" sample, the ASTM D 5084 or EM 1110-2-1906 procedure was not followed or the permeameter malfunctioned.

The POR will provide a detailed justification of the use of the "B" sample, if applicable, in the FCSER.

If the "B" sample passes, the area will be considered in compliance. If the "B" sample fails (or sample "A" fails in such a way that there is not an option to use the "B" sample), the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location). Additional tests may be taken to further define the unsatisfactory area. The area defined unsatisfactory will be reworked and retested in accordance with this section.

Furthermore, if it is determined that the "B" sample may not be used to replace the "A" sample result, then the test interval will be considered unsatisfactory for the area bounded by passing test locations (but not extending past a satisfactory test location).

Once the exact area is determined, the constructed soil infiltration layer lifts will be removed to the bottom of the lift that did not pass the hydraulic conductivity test, and reconstructed until all the samples obtained from the failed area meet the hydraulic conductivity requirements. At a minimum, one hydraulic conductivity test will be performed for each repair area, given that the reconstructed soil infiltration layer area is not larger than one acre. The reconstructed soil infiltration layer area will be tied into the currently constructed soil infiltration layer with a 5H:1V transition slope. The reconstructed soil infiltration layer area is also subject to field density and moisture content testing per Table 2-1 (at least one field density and one moisture content test is required for each lift regardless of the size of the area that is reconstructed).

Reconstruction activities, including additional testing and surveying, will be incorporated into the FCSER.

2.3.3 Structural Fill

Structural fill material placed below the final cover (e.g., compacted backfill in liner anchor trench) will be placed in uniform lifts which do not exceed 12 inches in loose thickness and are compacted to at least 90 percent of Standard Proctor (ASTM D 698) at a moisture content ranging from 2 percentage points below optimum to 3 percentage points above optimum (-2 to +3).

2.3.4 Surface Water Removal

The prepared intermediate cover or infiltration layer which is under construction may encounter water from storm events. Prior to placement of the soil infiltration layer, intermediate cover will be graded to provide positive drainage for the base grades of the soil infiltration layer. The soil infiltration layer will not be placed in standing water and water will not be allowed to accumulate over constructed infiltration layer. The construction area will be graded to provide for positive drainage. Temporary diversion berms will be constructed as needed to divert surface flow away from the construction area.

2.3.5 Infiltration Layer Tie-In Construction

Newly constructed infiltration layer will be tied-in with any adjoining existing infiltration layers. Additionally, terminations will be constructed for future tie-ins along edges where the infiltration layer will be extended in the future. During the construction of continuous infiltration layers, the new infiltration layer segment will not be constructed by "butting" the entire thickness of the new infiltration layer directly against the edge of the old infiltration layer. The tie-in will be constructed either by a sloped transition (typically 5 horizontal to 1 vertical) or a stair-stepped transition (typically 1 lift thickness per step). The length of the tie-in should be at least 5 feet per foot of infiltration layer thickness. The tie-ins with existing clay infiltration layer will be constructed utilizing a sloped or stair-stepped transition. In general, terminations for future tie-ins will be constructed by extending the infiltration layer approximately 7.5 feet past the limits for the final cover area under construction.

2.4 Construction Testing

2.4.1 Standard Operating Procedures

CQA monitors will perform field and laboratory tests in accordance with applicable standards specified in this FCQCP. Sampling will be performed by using standard ASTM practices for recovering samples (e.g., ASTM D 1587). The sampling holes (e.g., sample for hydraulic conductivity) will be backfilled with liner soil material, bentonite or bentonite/liner soil mixture.

2.4.2 Test Frequencies

The test frequencies for the infiltration layer are listed in Table 2-1. Additional testing must be conducted whenever work or materials are suspect, marginal, or of poor quality. Further testing may also be performed to provide additional data for engineering evaluation. The minimum number of tests is interpreted to mean minimum number of passing tests, and any tests that do not meet the requirements will not contribute to the total number of tests performed to satisfy the minimum test frequency.

2.5 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of each final cover area. Section 5 describes the documentation requirements.

Table 2-1
Standard Tests on Infiltration Layer Soils

Soil Test Category	Type of Test	Standard Test Method	Frequency of Testing
Quality Control Testing of Source Borrow Materials	Unified Soil Classification[D]	ASTM D 2487	Once per soil type
	Moisture/Density Relationship	ASTM D 698 or D 1557	
	Grain Size	ASTM D 422 or D 1140	
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE Em1110-2-1906[B]	1/Moisture/Density Relationship
Constructed Soil Infiltration Layer	Field Density	ASTM D 6938 and D 2216[A]	1/8,000 ft^2 per 6-inch lift[B]
	Grain Size	ASTM D 422 or D 1140	1/100,000 ft^2 per 6-inch lift[A]
	Atterberg Limits	ASTM D 4318	
	Coefficient of Permeability	ASTM D 5084 or CoE EM1110-2-1906	1/surface acre (evenly distributed through all lifts)[B]
	Thickness[C]	Texas Licensed Surveyor	1/10,000 ft^2

[A] This test is not applicable if the field measuring device (i.e., nuclear gauge) also measures moisture.
[B] A minimum of 1 of each of the designated tests must be conducted for each lift, regardless of cover area.
[C] If the option to use settlement plates to verify the thickness of the final cover layers is utilized, the procedure outlined in Section 2.3.2 will be followed.
[D] Soil texture classification also must be determined for soil-only pre-Subtitle D final cover.

3 CONSTRUCTION QUALITY ASSURANCE FOR GEOSYNTHETICS

3.1 Introduction

This section describes CQA procedures for the installation of geosynthetic components (applicable to Subtitle D areas only).

The scope of geosynthetic-related construction quality assurance includes the following elements:

- Geomembrane Liner
  - 40-mil LLDPE – smooth on the top slopes and textured on both sides for sideslopes. Minimum required material properties for the geomembrane are listed in Table 3-2.
- Drainage Layer
  - Drainage geocomposite – double-sided on side slopes (and not required on topslopes). Minimum required material properties for the drainage layer are listed in Table 3-3.
- Cushion Layer (Optional)
  - Geotextile – the design engineer or POR may opt to use a cushion geotextile between the geomembrane and erosion layer on topslopes to protect the geomembrane. Minimum required material properties for the cushion geotextile are listed in Table 3-3.

The overall goal of the geosynthetics quality assurance program is to assure that proper construction techniques and procedures are used, the geosynthetic contractor implements his quality control plan in accordance with this FCSQCP, the construction and testing of all elements of the final cover are performed in accordance with this FCSQCP and the Final Closure Plan (Attachment 12), and that the project is built in accordance with the project construction drawings and technical specifications. The quality assurance program is intended to identify and define problems that may occur during construction and to observe that these problems are avoided and/or corrected before construction is complete. The FCSER, prepared after project completion, will document that the constructed facility meets design intent and specifications and that all final cover construction and QA/QC testing are performed in accordance with this FCSQCP.

3.2 Geosynthetics Quality Assurance

3.2.1 General

A geomembrane and a drainage geocomposite (and cushion geotextile, if used) are the geosynthetic components of the composite final cover system. All testing requirements and minimum required properties are listed in Tables 3-1, 3-2, and 3-3. Construction quality control for the geosynthetic installation will be performed by the geosynthetic installation contractor. Construction quality assurance for the geosynthetic installation will be performed by the POR to assure the geosynthetic is constructed as specified in the design. Construction must be conducted in accordance with the project construction drawings, which will be developed in accordance with this FCSQCP and the Final Closure Plan (Attachment 12) at the time of each final cover construction and in accordance with specifications outlined in this FCSQCP. To monitor compliance, a quality assurance program will include the following:

- A review of the manufacturer's quality control submittals;
- Material conformance testing;
- Field and construction testing; and
- Construction monitoring.

The manufacturer's quality control submittals will include resin and physical material testing. Conformance testing refers to verification tests conducted by an independent third party laboratory to confirm the material meets the required specification prior to acceptance of the geosynthetic from the manufacturer. Field and construction testing includes testing that occurs during geosynthetics installation.

Quality assurance testing will be conducted in accordance with this FCSQCP, the project construction drawings, and specifications. Field testing will be observed by the CQA monitor. Documentation must meet the requirements of this FCSQCP.

3.3 Geomembrane

3.3.1 General

This section describes material types, handling, installation, and testing of geomembrane. Smooth geomembrane will be used on topslopes (slopes less than 6 percent) and textured geomembrane will be used on sideslopes (e.g., 25 percent slopes).

3.3.2 Delivery

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

- The geomembrane is delivered in rolls and is not folded. Folded geomembrane is not acceptable because the highly crystalline structure of the geomembrane will be damaged if it is folded. Any evidence of folding (other than from the manufacturing process) or other shipping damage is cause for rejection of the material.
- Equipment used to unload and store the rolls or pallets does not damage the geomembrane.
- The geomembrane is stored in an acceptable location in accordance with the specifications and stacked not more than five rolls high. The geomembrane is protected from puncture, dirt, grease, water, moisture, mud, mechanical abrasions, excessive heat, or other damage.
- Manufacturing documentation required by the specifications has been received and reviewed for compliance with the specifications. This documentation will be included in the FCSER.
- The geosynthetics receipt log form has been completed for materials received.

Damaged geomembrane may be rejected and removed from the site or stored at a location separate from accepted geomembrane. Geomembrane that does not have proper manufacturer's documentation must be stored at a separate location until documentation has been received, reviewed, and accepted.

3.3.3 Conformance Testing

Tests. One geomembrane sample will be obtained for every resin lot of material supplied and for each 100,000 square feet of geomembrane installed. The material will be sampled at the site by the CQA monitor. The samples will be forwarded to the third-party laboratory for the following conformance tests:

- Specific gravity/Density (ASTM D 1505 or alternate ASTM D 792, Method A if approved by the POR)
- Carbon black content (ASTM D 1603)
- Carbon black dispersion (ASTM D 5596)
- Thickness (ASTM D 5199 for smooth geomembrane and ASTM D 5994 for textured geomembrane)
- Tensile properties (ASTM D 638/Type IV Specimen)

The density of the geomembrane must be less than 0.939 g/cc; the carbon black content must be between 2 percent and 3 percent; and recycled or reclaimed material must not be used in the manufacturing process.

The design engineer may require additional test procedures and will inform the third party laboratory in writing. The POR must review all test results and report any nonconformance to the design engineer prior to product installation. In addition to the conformance thickness tests shown above, field thickness measurements must be taken at maximum 5-foot intervals along the leading edge of each geomembrane panel. No single measurement may be less than 10 percent below the required nominal thickness for the panel to be accepted (i.e., for 40 mil geomembrane a minimum thickness of 36 mils is required), and the average must be at least 40 mils.

Sampling Procedure. Samples will be taken across the entire roll width. Unless otherwise specified, samples should be approximately 15 inches long by the roll width. The CQA monitor must mark the machine direction and the manufacturer's roll identification number on the sample. The CQA monitor must also assign a conformance test number to the sample and mark the sample with that number.

Table 3-1
Required Testing for Geomembranes[1]

Responsible Party	Type of Test		Standard Test Method	Frequency of Testing
Resin Manufacturer	Resin	Density	ASTM D 1505/D792	Per 100,000 ft² and every resin lot
		Melt Flow Index	ASTM D 1238 (Condition E)	
	Resin/Compound Evaluation		Per manufacturer's quality control specifications	Per manufacturer's quality control specifications
Geomembrane Manufacturer	Manufacturer's Quality Control		Testing per GRI Standard, GRI Test Method GM17 for 40 mil LLDPE[1]	
Conformance Testing by Third Party Independent Laboratory	Thickness[2]		ASTM D 5199 (smooth LLDPE), or D 5994 (textured LLDPE)	Per 100,000 ft² and every resin lot
	Specific Gravity/Density		ASTM D 1505/D 792	
	Carbon Black Content		ASTM D 1603	
	Carbon Black Dispersion		ASTM D 5596	
	Tensile Properties		ASTM D 6693 (Type IV)	
Third Party CQA	Destructive Seam Field Testing[3]	Shear & Peel	ASTM D 6392	Various for field, lab, and archive
Third Party CQA	Non-Destructive Seam Field Testing	Air Pressure	ASTM D 5820	All dual-track fusion weld seams
		Vacuum	ASTM D 5641	All non-air pressure tested seams when possible
		Other		Concurrence of TCEQ

[1] UV Resistance testing not required for geomembrane, which is to be immediately covered.

[2] Field thickness measurements for each panel must be conducted. Use ASTM D 374/D 5994 and perform 1 series of measurements among the leading edge of each panel, with individual measurements no greater than 5 feet apart. No single measurement will be less than 10% below the required nominal thickness in order for the panel to be acceptable.

[3] Passing criteria for seams are listed in Table 3-2.

Table 3-2
Minimum Required Properties of 40-mil-thick Smooth and Textured (Both Sides) LLDPE Geomembrane

Property	Test Method	Minimum Required Property[6]	
		Smooth	Textured
Thickness, mils Minimum average Lowest individual reading Lowest individual of 8 of 10 readings	ASTM D 5199 (smooth) ASTM D 5994 (textured)	40 36 NA	38 34 36
Density, g/cc (maximum)	ASTM D 1505/ D 792	0.939	0.939
Asperity Height, mils	GRI GM12	NA	10
Tensile Properties[1] Break Strength, lb/in Break Elongation, %	ASTM D 6693, Type IV	152 800	60 250
Tear Resistance, lb	ASTM D 1004	22	22
Puncture Resistance, lb	ASTM D 4833	56	44
Break Resistance Strain, % (min)	ASTM D 5617	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0-3.0	2.0 – 3.0
Carbon Black Dispersion[3], Category	ASTM D 5596	1 or 2 and 3	1 or 2 and 3
Oxidative Induction Time (OIT), minimum average Standard OIT, minutes, or High Pressure OIT, minutes	ASTM D 3895 ASTM D 5885	100 400	100 400
Oven Aging at 85°C, minimum average Standard OIT – % retained after 90 days or High Pressure OIT – % retained after 90 days	ASTM D 5721 ASTM D 3895 ASTM D 5885	35 60	35 60
UV Resistance[4], minimum average High Pressure OIT[5] – % retained after 1600 hrs	GRI GM 11 ASTM D 5885	35	35
Seam Properties Shear Strength, lb/in Peel Strength, lb/in	ASTM D 6392	60 50 (44, Extrusion Weld)	60 50 (44, Extrusion Weld)

[1] Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
[2] Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
[3] Carbon black dispersion for 10 different views; 9 in Categories 1 or 2 and 1 in Category 3.
[4] The condition of the test should be 20 hr UV cycle at 75°C followed by 4 hr. condensation at 60°C.
[5] UV resistance is based on percent retained value regardless of the original HP-OIT value.
[6] Minimum required property values are based on GRI GM17, except for seam properties, which are based on GRI GM19.

3.3.4 Anchor Trench Backfill

General fill material placed in anchor trenches will be placed in uniform lifts, which do not exceed 12 inches in loose thickness and are compacted. In-place moisture/density tests may be taken at the discretion of the CQA monitor to evaluate the quality of the backfill. The test results will not be required as part of the FCSER. Slightly rounded corners will be provided in anchor trenches where the geomembrane enters the trench so as to avoid sharp bends in the geomembrane. No loose soil (e.g., excessive water content) will be allowed to underlie the anchored components of final cover system.

3.3.5 Geomembrane Installation

Surface Preparation. Prior to any geomembrane installation, the subgrade (e.g., soil infiltration layer) should be inspected by the CQA and geosynthetics contractor. The POR or CQA monitor must observe the following:

- Lines and grades for the infiltration layer have been verified by the contractor and surveying of top of soil infiltration grades has been completed in accordance with Section 2.
- Soil infiltration layer construction has been completed in areas with no ponded water.
- The infiltration layer has been placed in accordance with the specification.
- No signs of desiccation exist, and the moisture content of the infiltration layer surface was controlled. A smooth drum roller will be used, as necessary, to minimize desiccation.
- The infiltration layer is free of surface irregularities and protrusions.
- The infiltration layer surface does not contain stones or other objects that could damage the geomembrane and underlain infiltration layer. The surface will be smooth and free of foreign and organic material, sharp objects, stones greater than 3/8 inches, or other deleterious material.
- The anchor trench dimensions have been checked, and the trenches are free of sharp objects and stones.
- The geomembrane will not be placed during inclement weather such as rain or high winds.
- Construction stakes and hubs have been removed and the resultant holes have been backfilled. There are no rocks, debris, or any other objects on the infiltration layer surface.
- The geosynthetics contractor, POR or his representative, and the permittee or his representative have certified in writing that the surface on which the geomembrane will be installed is acceptable.

Panel Placement. Prior to the installation of the geomembrane, the contractor must submit drawings showing the panel layout, indicating panel identification number, both fabricated (if applicable) and field seams, as well as details not conforming to the drawings. The POR must review field conditions and approve revised panel layout plan if the field conditions vary from the original plan layout.

The CQA monitor must maintain an up-to-date panel layout drawing showing panel numbers that are keyed to roll numbers on the placement log. The panel layout drawing will also include seam numbers and destructive test locations.

During panel placement, the POR or CQA monitor must:

- Observe that the geomembrane is placed in direct and uniform contact with underlying soil infiltration layer.
- Record roll numbers, panel numbers, and dimensions on the panel or seam logs. Measure and record thickness of leading edge of each panel at 5-foot maximum intervals. No single thickness measurement can be less than 10 percent below the required nominal thickness.
- Observe the sheet surface as it is deployed and record panel defects and repair of the defects (panel rejected, patch installed, extradite placed over the defect, etc.) on the repair sheet. Repairs must be made in accordance with the specifications and located on a repair drawing.
- Observe that support equipment is not allowed on the geomembrane during handling (see Section 3.5 also).
- Observe that the surface beneath the geomembrane has not deteriorated since previous acceptance.
- Observe that there are no stones, construction debris, or other items beneath the geomembrane that could cause damage to the geomembrane.
- Observe that the geomembrane is not dragged across a surface that could damage the material. If the geomembrane is dragged across an unprotected surface, the geomembrane must be inspected for scratches and repaired or rejected, as necessary.
- Record weather conditions including temperature, wind, and humidity. The geomembrane must not be deployed in the presence of excess moisture (fog, dew, mist, etc.) or during inclement weather. In addition, geomembrane seaming operation should not be performed when the air temperature is less than 41°F or greater than 104°F, or when standing water or frost is on the ground, unless these requirements are waived by the design engineer. Excessive wind is that which can lift and move the geomembrane panels.
- Observe that people working on the geomembrane do not smoke, wear shoes that could damage the liner, or engage in activities that could damage the liner.
- Observe that the method used to deploy the sheet minimizes wrinkles but does not cause bridging and that the sheets are anchored to prevent movement by the wind (the contractor is responsible for any damage to or from windblown

geomembrane). Excessive wrinkles should be walked-out or removed at the discretion of the CQA monitor.

- Observe that no more panels are deployed than can be seamed on the same day.
- Observe that seams are oriented parallel to the slip direction, and the textured material extends a minimum of approximately 5 feet out past the sideslope.

The CQA monitor must inform both the contractor and the POR of the above conditions.

Field Seaming. The contractor must provide the POR with a seam and panel layout drawing and update this drawing daily as the job proceeds. No panels should be seamed until the panel layout drawing has been accepted by the POR. A seam numbering system must provide a unique number for each seam and be agreed to by the POR and contractor prior to the start of seaming operations. One procedure is to identify the seam by adjacent panels. For example, the seam located between Panels 306 and 401 would be Seam No. 306/401.

Prior to geomembrane welding, each welder and welding apparatus (both wedge and extrusion welder) must be tested, at a minimum, at daily start-up and immediately after any break, and/or anytime the machine is turned off for more than 30 minutes in accordance with the specifications to determine if the equipment is functioning properly. The FCSER should include the names for each seamer and the time and the temperatures for each seaming apparatus used each day. One trial weld will be taken prior to the start of work and when the type of geomembrane seam (e.g., smooth to smooth, smooth to textured, etc.) is changed. In addition, a trial weld will also be obtained prior to seaming the tie-in. The trial weld sample must be 3 feet long and 12 inches wide, with the seam centered lengthwise. The minimum number of specimens per trial weld test must be two coupons for shear and two coupons for peel. Both the inner and outer welds of dual track fusion welds must be tested for each peel test coupon (or additional coupons will be required). Trial weld samples must comply with "Passing Criteria for Welds" included in Section 3.3.6 – Construction Testing. The CQA monitor must observe welding operations, quantitative testing of each trial weld for peel and shear, and recording of the results on the trial weld form. The trial weld will be completed under conditions similar to those under which the panels will be welded. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in ASTM D 6392:

Hot Wedge: AD and AD-Brk>25%

Extrusion Fillet: AD1, AD2, AD-WLD (unless strength is achieved)

Additionally, there should be no apparent weld separation (i.e., greater than 1/8 inch). The third party strength tests must meet the manufacturer's specifications for the sample sheets, or percentage of the manufacturer's parent sheet strength as determined by the manufacturer. For dual-track fusion welds, both sides (the inner and outer weld) must meet the minimum requirements for a satisfactory peel test. If, at any time, the CQA monitor believes that an operator or welding apparatus is not functioning properly, a weld test must be performed. If there are wide changes in temperature (±30° Fahrenheit), humidity, or wind speed, the test weld should be repeated. The test weld must be allowed to cool to ambient temperature before testing. If a weld test fails the shear or peel test, the length of the non-passing weld will be identified at a 10-foot interval, and the failed area will be patched. Patching will be performed by placing additional geomembrane material over the failed area or removing the failed geomembrane weld and patching it with additional geomembrane per POR's direction. The welding for patches must comply with the welding passing criteria requirements outlined in this section.

Construction quality assurance documentation of trial seam procedures will include, at a minimum, the following:

- Documentation that trial seams are performed by each welder and welding apparatus prior to commencement of welding and prior to commencement of the second half of the workday.
- The welder, the welding apparatus number, time, date, ambient air temperature, and welding machine temperatures.

During geomembrane welding operations, the CQA monitor must observe the following:

- The contractor has the number of welding apparatuses and spare parts necessary to perform the work.
- Equipment used for welding will not damage the geomembrane.
- The extrusion welder is purged prior to beginning a weld until the heat-degraded extradite is removed (extrusion welding only).
- Seam grinding has been completed less than one hour before seam welding, and the upper sheet is beveled (extrusion welding only).
- The ambient temperature, measured 6 inches above the geomembrane surface, is between 41°F and 104°F, or manufacturer's recommended temperature limits if they are more stringent.
- The end of old welds, more than five minutes old, are ground to expose new material before restarting a weld (extrusion welding only).
- The contact surfaces of the sheets are clean, free of dust, grease, dirt, debris, and moisture prior to welding.
- The weld is free of dust, rocks, and other debris.
- The seams are overlapped a minimum of 3 inches for extrusion and hot-wedge welding, or in accordance with manufacturer's recommendations, whichever is more stringent. Panels should be overlapped (shingled) in the downgrade direction.
- No solvents or adhesives are present in the seam area.

- The procedure used to temporarily hold the panels together does not damage the panels and does not preclude CQA testing.
- The panels are being welded in accordance with the plans and specification. Seams should be oriented parallel to the line of maximum slope with no horizontal seams on sideslopes or topslopes. In corners and odd-shaped geometric locations, the number of field seams should be minimized.
- There is no free moisture in the weld area.
- Measure surface sheet temperature every two hours.
- Observe that at the end of each day or installation segment, unseamed edges are anchored with sandbags or other approved device. Penetration anchors will not be used to secure the geomembrane.

3.3.6 Construction Testing

Nondestructive Seam Testing. The purpose of nondestructive testing is to detect discontinuities or holes in the seam. It also indicates whether a seam is continuous and non-leaking. Nondestructive tests for geomembrane include vacuum testing for extrusion welds and air pressure testing for dual-track fusion welds. Nondestructive testing must be performed over the entire length of the seam.

Nondestructive testing is performed entirely by the contractor. The CQA monitor's responsibility is to observe and document that testing performance is in compliance with the specifications and document any seam defects and their repairs.

Nondestructive testing procedures are described below.

- For welds tested by vacuum method, the weld is placed under suction utilizing a vacuum box made of rigid housing with a transparent viewing window, a soft neoprene rubber gasket attached to the open bottom perimeter, a vacuum gauge on the inside, and a valve assembly attached to the vacuum hose connection. The box is placed over a seam section that has been thoroughly saturated with a soapy water solution (1 oz. soap to 1 gallon water). The rubber gasket on the bottom perimeter of the box must fit snugly against the soaped seam section of the liner, to ensure a leak-tight seal. The vacuum pump is energized, and the vacuum box pressure is reduced to approximately 3 to 5 psi gauge. Any pinholes, porosity, or non-bonded areas are detected by the appearance of soap bubbles in the vicinity of the defect. Dwell time must not be less than ten seconds.
- Air pressure testing is used to test double seams with an enclosed air space. Both ends of the air channel should be sealed. The pressure feed device, usually a needle equipped with a pressure gauge, is inserted into the channel. Air is then pumped into the channel to a minimum pressure of 30 psi. The air chamber must sustain the pressure for five minutes without losing more than 4 psi. Following a passed pressure test, the opposite end of the tested seam must be punctured to

release the air. The pressure gauge must return to zero; if not, a blockage is most likely present in the seam channel. Locate the blockage and test the seam on both sides of the blockage. The penetration holes must be sealed after testing.

During nondestructive testing, the CQA monitor must perform the following work:

- Review technical specifications regarding test procedures.
- Observe that equipment operators are fully trained and qualified to perform their work.
- Observe that test equipment meets project specifications.
- Observe that the entire length of each seam is tested in accordance with the specifications.
- Observe all continuity testing and record results on the appropriate log.
- Observe that testing is completed in accordance with the project specifications.
- Identify the failed areas by marking the area with a waterproof marker compatible with the geomembrane and inform the contractor of any required repairs, then record the repair area on the repair log.
- Observe that repairs are completed and tested in accordance with the project specifications.
- Record completed and tested repairs on the repair log and the repair drawing.

Destructive Seam Testing. Destructive seam tests for geomembrane seams will be performed at a frequency of at least one test for each 500 linear feet of seam length. At a minimum, a destructive test will be completed for each welding machine used for seaming. A destructive test will also be completed for individual repairs (or additional seaming for the failed welds) of more than 10 feet of seam length. The CQA monitor must perform additional tests if he suspects a seam does not meet specification requirements. Reasons for performing additional tests may include, but are not limited to the following:

- Wrinkling in seam area
- Non-uniform weld
- Excess crystallinity
- Suspect seaming equipment or techniques
- Weld contamination
- Insufficient overlap
- Adverse weather conditions
- Possibility of moisture, dust, dirt, debris, and other foreign material in the seam

- Failing tests

There are two types of destructive testing required for the geomembrane installation: peel adhesion (peel) and bonded seam strength (shear) in accordance with ASTM D 6392. The purpose of peel and shear tests is to evaluate seam strength and to evaluate long-term performance. Shear strength measures the continuity of tensile strength through the seam and into the parent material. Peel strength determines weld quality. Test welds must be allowed to cool naturally to ambient temperature prior to testing.

The CQA monitor selects locations where seam samples will be cut for laboratory testing. Select these locations as follows:

- A minimum of one stratified location for every 500 feet of field seam length or major fraction thereof.
- Sample locations should not be disclosed to the contractor prior to completion of the seam.
- A maximum frequency must be agreed to by the contractor, POR, and the Operator at the preconstruction meeting. However, if the number of failed samples exceeds 5 percent of the tested samples, this frequency may be increased at the discretion of the POR. Samples taken as the result of failed tests do not count toward the total number of required tests.

Sampling Procedures. The contractor will remove samples at locations identified by the CQA monitor. The CQA monitor must:

- Observe sample cutting.
- Mark each sample with an identifying number that contains the seam number and destructive test number.
- Record sample location on the panel layout drawing and destructive seam log.
- Record the sample location, weather conditions, and reason sample was taken (e.g., random sample, visual appearance, result of a previous failure, etc.).

For each destructive test obtain one sample approximately 45 inches long by 12 inches wide, with the weld centered along the length. Cut two 1-inch-wide coupons from each end of the sample (a total of 4 coupons). The contractor must test two of these coupons in shear and two in peel (one shear and one peel from each end) using a tensiometer capable of quantitatively measuring the seam strengths. For double wedge welding, both sides of the air channel will be tested in peel. The CQA monitor must observe the tests and record the results on the destructive seam test log. A geomembrane seam sample passes the field testing when the break is a film tear bond (FTB) and the seam strength meets the required strength values for peel and shear given previously in Table 3-2 and below in the subsection "Passing Criteria for Welds" for both field testing and third party laboratory testing. As previously discussed, both welds have to pass for dual-track welds. Also, it is recommended that additional samples be obtained as discussed in the following paragraph if there is apparent separation of the weld (i.e., greater than 1/8 inch) during peel testing.

If one or both of the 1-inch specimens fail in either peel or shear, the contractor can, at his discretion: (1) reconstruct the entire seam between passed test locations, or (2) take two additional test samples 10 feet or more in either direction from the point of the failed test and repeat this procedure. For tracking purposes the additional samples should be identified by assigning an identifying letter to the initial destructive test sample number (e.g., DS-6A and B). Only satisfactory tests count toward the required minimum number, and additional tests (i.e., A and B) count as one test, if passing. If the second set of tests pass, the contractor can reconstruct or cap-strip the seam between the two passed test locations. If subsequent tests fail, the sampling and testing procedure is repeated until the length of the poor quality seam is established. Repeated failures indicate that either the seaming equipment or operator is not performing properly, and appropriate corrective action must be taken immediately.

If the field test coupons are satisfactory, divide the remaining sample into three parts: one 12-inch by 12-inch section for the contractor, one 12-inch by 16-inch section for the third party laboratory for testing, and one 12-inch by 12-inch section for the Operator to archive. The laboratory sample will be shipped to the third party laboratory for delivery and subsequent testing.

If the laboratory test fails in either peel or shear, the contractor must either reconstruct the entire seam between passing test locations or recover additional samples at least 10 feet on either side of the failed sample for retesting. Sample size and disposition must be as described in the preceding paragraph. This process is repeated until passed tests bracket the failed seam section. Seams must be bounded by locations from which passing laboratory tests have been taken. Laboratory testing governs seam acceptance. In no case can field testing of repaired seams be used for final acceptance.

Third Party Laboratory Testing. Destructive samples must be shipped to the third party laboratory for seam testing. Testing for each sample will include five bonded seam shear strength tests and five peel adhesion tests (ten for dual-track welds). For dual-track welds each peel test specimen (coupon) will be tested on both sides of the air channel (i.e., the inner and outer welds). At least four of the five specimens tested in peel and shear will meet the minimum strength requirements. The minimum peel strength and the minimum shear strength values must meet the manufacturer's specifications. Additionally, 4 of 5 of the peel test coupons must have no greater than 25 percent seam separation. For dual-track welds if either weld exhibits greater than 25 percent separation or does not meet the required strength, that coupon is considered out of compliance and two out of compliance coupons cause the weld to fail. The third party laboratory must provide test results in timely manner, in writing or via telephone, to the POR. Certified test results are to be provided within five days. The CQA monitor must immediately notify the POR in the event of a calibration discrepancy or failed test results.

Passing Criteria for Welds. Passing criteria are established by Geosynthetic Institute GRI Test Method GM-19 for geomembrane seams. A passing extrusion or fusion welded seam will be achieved when the following values are tested. The following values listed for shear and peel strengths are for 4 out of 5 test specimens (the 5th specimen can be as low as 80 percent of the listed values) for 40-mil smooth and textured LLDPE. Elongation measurements should be omitted for field testing.

- Shear strength (lb/in) 60
- Shear elongation at break (%) 50
- Peel strength (lb/in) 44
- Peel separation (%) 25

3.3.7 Repairs

Any portion of the geomembrane with a detected flaw, or which fails a nondestructive or destructive test, or where destructive tests were cut, or where nondestructive tests left cuts or holes, must be repaired in accordance with the specifications developed for each phase of final cover construction and consistent with application parts (e.g., material requirements, installation, testing, etc.) of Section 3 of this FCSQCP. The CQA monitor must locate and record all repairs on the repair sheet and panel layout drawing. Repair techniques include the following:

- Patching – used to repair large holes, tears, large panel defects, undispersed raw materials, contamination by foreign matter, and destructive sample locations.
- Extrusion – used to repair small defects in the panels and seams. In general, this procedure should be used for defects less than 3/8-inch in the largest dimension.
- Capping – used to repair failed welds or to cover seams where welds or bonded sections cannot be nondestructively tested.
- Removal – used to replace areas with large defects where the preceding methods are not appropriate. Also used to remove excess material (wrinkles, fishmouths, intersections, etc.) from the installed geomembrane. Areas of removal will be patched or capped.

Repair procedures include the following:

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

- Perform testing on repair seams consistent with Section 3.3.6 – Construction Testing.

3.3.8 Wrinkles

Wrinkles must be walked-out or removed as much as possible prior to field seaming. Any wrinkles which can fold over must be repaired either by cutting out excess material or, if possible, by allowing the liner to contract by temperature reduction. In no case can material be placed over the geomembrane which could result in the geomembrane folding. The CQA monitor must monitor geomembrane for wrinkles and notify the contractor if wrinkles are being covered by soil. The CQA monitor is then responsible for documenting corrective action to remove the wrinkles.

3.3.9 Folded Material

Folded geomembrane must be removed. Remnant folds evident after deployment of the roll that are due to manufacturing process are acceptable.

3.3.10 Geomembrane Anchor Trench

The geomembrane anchor trench will be left open until seaming is completed. Expansion and contraction of the geomembrane should be accounted for in the geomembrane placement. Prior to backfilling, the depth of penetration of the geomembrane into the anchor trench must be verified by the CQA monitor at a minimum of 100-foot spacing along the anchor trench. The anchor trench should be filled in the morning when temperatures are coolest to reduce bridging of the geomembrane.

3.3.11 Geomembrane Acceptance

The contractor retains all ownership and responsibility for the geomembrane until acceptance by the Operator. In the event the contractor is responsible for placing cover over the geomembrane, the contractor retains all ownership and responsibility for the geomembrane until all required documentation is complete, and the cover material is placed. After panels are placed, seamed, tested successfully, and any repairs are made, the completed installation will be walked by the Operator's and contractor's representatives. Any damage or defect found during this inspection will be repaired properly by the installer. The installation will not be accepted until it meets the requirements of both representatives. In addition, the geomembrane will be accepted by the POR only when the following has been completed:

- The installation is finished.
- Seams have been inspected and verified to be acceptable.
- Required laboratory and field tests have been completed and reviewed.

- Required contractor-supplied documentation has been received and reviewed.
- As-built record drawings have been completed and verified by the POR. The as-built drawings show the true panel dimensions, the location of seams, trenches, pipes, appurtenances, and repairs.
- Acceptance of the FCSER by TCEQ.

3.3.12 Bridging

Bridging must be removed.

3.4 Drainage Geocomposite – Geonet and Geotextile

3.4.1 General

The drainage layer consists of a drainage geocomposite overlying the geomembrane and infiltration layer on the Subtitle D area sideslopes. The CQA monitor will provide on-site observation of drainage layer installation. The POR will make sufficient site visits during the drainage layer installation to document the installation in the FCSER.

Double-sided drainage geocomposite (non-woven geotextile bonded to the top and bottom of HDPE drainage net) will be installed on the sideslopes. The design engineer or POR may opt to use perforated drainage pipes to convey flow from the drainage geocomposite to either the final cover drainage letdowns or the perimeter drainage system.

As demonstrated in Attachment 12H, a drainage layer is not required on the Subtitle D area topslopes. However, the design engineer or POR may opt to use a cushion geotextile between the geomembrane and erosion layer to protect the geomembrane on the Subtitle D area topslopes. The installation procedure for the cushion geotextile is provided in Section 3.4.4. The drainage geocomposite (and cushion geotextile if used) will have the minimum properties listed in Table 3-3.

Manufacturer quality control testing procedures and frequencies for drainage geocomposite are discussed in Section 3.4.3 and Table 3-3.

3.4.2 Delivery

Upon delivery the CQA monitor must observe the following:

- The drainage geocomposite is wrapped in rolls with protective covering.
- The rolls are not damaged during unloading.
- Protect the drainage geocomposite from mud, soil, dirt, dust, debris, cutting, or impact forces.

- Each roll must be marked or tagged with proper identification.

Any damaged rolls will be rejected and removed from the site or stored at a location separate from accepted rolls, designated by the Operator. Rolls that do not have proper manufacturer's documentation will also be stored at a separate location until documentation has been received and approved. The references herein to drainage geocomposite also apply to geonet and geotextile (and cushion geotextile if used) as applicable.

3.4.3 Testing

The drainage geocomposite manufacturer (or supplier) will conduct quality control testing and certify that materials delivered to the site comply with project specifications for each phase of final cover construction. The minimum testing frequency will be one test sample per 100,000 square feet of drainage geocomposite (or geonet/geotextile). The material certifications will be reviewed by the POR to verify that the drainage geocomposite meets the values given in the FCSQCP or specifications. Third party laboratory testing will be required for drainage layer geocomposite transmissivity.

Geonet will be tested by the manufacturer for thickness, tensile strength, and carbon black content. Geotextile will be tested for mass per unit area, grab tensile strength, and Apparent Opening Size (AOS). The finished drainage geocomposite will be tested for peel adhesion and transmissivity. The cushion geotextile (if used) will be tested for mass per unit area. Table 3-3 summarizes testing requirements for drainage geocomposite and geotextile (and cushion geotextile if used).

Where optional procedures are noted in the test method, the specification requirements will prevail. The CQA monitor will review test results and will report any nonconformance to the POR and to the contractor.

3.4.4 Installation

Surface Preparation. Prior to drainage geocomposite installation, the CQA monitor must observe the following:

- Lines and grades have been verified by the surveyor (where required).
- The subgrade has been prepared in accordance with the specifications and the geomembrane has been installed as outlined in Section 3.3.5.
- The geomembrane installation, including required documentation, has been completed.
- The supporting surface (i.e., the geomembrane) does not contain stones that could damage the drainage geocomposite or the geomembrane.

Drainage Geocomposite Placement. During placement, the CQA monitor must:

- Ensure that double-sided geocomposite is placed on sideslopes (4H:1V) and cushion geotextile (if used) is placed on topslopes.

Table 3-3
Geotextile and Drainage Geocomposite Required Testing and Properties[1]

Responsible Party	Material	Test	Standard	Required Property
Manufacturer	Cushion[2] Geotextile (optional)	Unit Weight	ASTM D 5261	10 oz/sy
		Grab Strength	ASTM D 4632	230 lbs
		Grab Elongation	ASTM D 4632	50%
		Tear Strength	ASTM D 4533	95 lbs
		Puncture Strength	ASTM D 4833	120 lbs
Manufacturer	Double-sided Drainage Geocomposite	<u>HDPE Geonet</u>		
		Specific Gravity	ASTM D 1505	0.939 g/cm^3
		Thickness	ASTM D 5199	0.20 inch
		Carbon Black	ASTM D 1603	2%
		Tensile Strength	ASTM D 7179	45 lb/in (Peak)
		<u>Geotextile</u>		
		Unit Weight	ASTM D 5261	6 oz/sy
		Apparent Opening Size	ASTM D 4751	80 sieve
		Grab Strength	ASTM D 4632	157 lbs
		Tear Strength	ASTM D 4533	56 lbs
		Puncture Strength	ASTM D 4833	56 lbs
		Permeability	ASTM D 4491	0.2 cm/s
Manufacturer	Double-sided Drainage Geocomposite	Peel Adhesion	ASTM D 7005	1.0 lb/in
Third Party Laboratory		Transmissivity[3]	ASTM D 4716	$1.7x10^{-4}$ m^2/s

[1] The minimum testing frequency will be one test sample per 100,000 square feet.

[2] Required material properties for cushion geotextile provided by Geosynthetic Research Institute (GRI) Test Method GT 12(a), Standard Specification for "Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials", Revised December 18, 2012.

[3] Minimum transmissivity is calculated in Attachment 12H. The transmissivity of the double-sided geocomposite will be measured at a gradient of 1.0 under a minimum normal pressure of 240 psf, boundary conditions consisting of soil/geocomposite/geomembrane with minimum seating time of 100 hours.

- Observe the drainage geocomposite as it is deployed and record defects and disposition of the defects (panel rejected, patch installed, etc.). Repairs are to be made in accordance with the specifications.

- Verify that equipment used does not damage the drainage geocomposite or underlying geomembrane by handling, trafficking, leakage of hydrocarbons, or by other means.
- Verify that people working on the drainage geocomposite do not smoke, wear shoes that could damage the geocomposite, or engage in activities that could damage the geocomposite or underlying geomembrane.
- Verify that the drainage geocomposite is anchored to prevent movement by the wind (the contractor is responsible for any damage resulting to or from wind blown geocomposite).
- Verify that the drainage geocomposite remains free of contaminants such as soil, grease, fuel, etc.
- Observe that the drainage geocomposite is laid smooth and free of tension, stress, folds, wrinkles, or creases.
- Observe that on slopes the drainage geocomposite is secured with sand bag anchoring at the top of the slope and then rolled down the slope.
- Observe that adjacent rolls of drainage geocomposite are overlapped, tied, and seamed in accordance with the specifications and manufacturer's recommendations.
- Observe that tying is with plastic fasteners in accordance with the manufactures recommendations. In the absence of other specifications the geonet panels will be tied approximately every 5 feet along the roll length (edges) and every 1 foot along the roll width (ends).
- Observe that geotextile component is overlapped and either heat bonded or sewn together.
- The design engineer or POR may opt to use a cushion geotextile between the geomembrane and erosion layer on Subtitle D topslopes. If the cushion geotextile is used, the sideslope double-sided geocomposite will extend a minimum of 50 feet along the topslope beyond the sideslope/topslope transition. The cushion geotextile will be placed over the drainage geocomposite with a minimum 1-foot overlap.

3.4.5 Repairs

Repair procedures include:

- Holes or tears in the drainage geocomposite will be repaired by placing a patch extending 2 feet beyond the edges of the hole or tear.
- Secure patch to the originally installed drainage geocomposite by tying every 6 inches.

- Where the hole or tear width across the roll is more than 50 percent of the roll width, the damaged area will be cut out across the entire roll, and the two portions of the drainage geocomposite will be jointed.
- Patches will be installed in accordance with "Drainage Geocomposite Placement" under Section 3.4.4.

3.5 Equipment on Geosynthetic Materials

Construction equipment on the composite final cover system will be minimized to reduce the potential for geosynthetic material puncture. The CQA monitor will verify that small equipment such as generators are placed on scrap geomembrane material (rub sheets) above geosynthetic materials in the final cover system. The erosion layer will be placed using low ground pressure equipment. The CQA monitor will verify that the geosynthetics are not displaced while the soil layers (e.g., erosion layer) are being placed.

Unless otherwise specified by the POR, lifts of soil material placed over geosynthetics will conform to the following guidelines:

Equipment Ground Pressure (psi)	Minimum Lift Thickness (in.)
< 5.0	12 and under
5.1 - 8.0	18
8.1 - 16.0	24
>16.0	36

No equipment will be left running and unattended over the constructed geosynthetics.

3.6 Reporting

The POR on behalf of the Operator will submit to the TCEQ a FCSER for approval of the constructed final cover system. Section 5 describes the documentation requirements.

4 CONSTRUCTION QUALITY ASSURANCE FOR EROSION LAYER

The erosion layer for the Subtitle D final cover area will consist of a minimum of 24 inches of earthen material, and the pre-Subtitle D final cover erosion layer will have a minimum of 6 inches of thickness. The top 6 inches of erosion layer (all areas) will be capable of sustaining native and introduced vegetative growth and must be seeded immediately after completion of the final cover. Temporary or permanent erosion control materials may be used to minimize erosion and aid establishment of vegetation. The physical characteristics of the erosion layer will be evaluated through visual observation (and laboratory testing if deemed necessary by the POR) before construction and visual observation during construction. Additional testing during construction will be at the discretion of the POR.

The erosion layer may be placed using any appropriate equipment capable of completing the work and should only receive minimal compaction required for stability. Under no circumstances will the construction equipment come in direct contact with the installed geosynthetics. Equipment used to install the erosion layer must meet the requirement of Section 3.5.

The thickness of the erosion layer will be verified with surveying procedures at a minimum of one survey point per 10,000 square feet of constructed area by a licensed Texas surveyor with a minimum of one reference point. The survey results for the erosion layer will be included in the FCSER.

During construction the CQA monitor will:

- Verify that grade control is performed prior to work.
- Verify that underlying geosynthetic installations are not damaged during placement operations or by survey grade controls. Mark damaged geosynthetics and verify that damage is repaired.
- Monitor haul-road thickness over installed geosynthetics and verify that equipment hauling and material placement meet equipment specifications. (See Section 3.5).
- The POR will coordinate with the project surveyor to perform a thickness verification survey of the erosion layer materials upon completion of placement operations. Verify corrective action measures as determined by the verification survey. Thickness surveying to determine minimum erosion layer thickness will be performed similar to the infiltration layer thickness verification shown in Table 2-1.

5 DOCUMENTATION

The quality assurance plan depends on thorough monitoring and documentation of construction activities. Therefore, the POR and CQA monitor will document that quality assurance requirements have been addressed and satisfied. Documentation will consist of daily recordkeeping, testing and installation reports, nonconformance reports, progress reports, photographic records, and design and specification revisions. The appropriate documentation will be included in the FCSER. Standard report forms will be provided by the POR prior to construction.

5.1 Preparation of FCSER

The POR, on behalf of the Operator, will submit to the TCEQ a FCSER for approval of each portion of final cover system constructed.

Testing, evaluation, and submission of the FCSER for the final cover system during construction will be in accordance with this FCSQCP. The construction methods and test procedures documented in the FCSER will be consistent with this FCSQCP.

At a minimum, the FCSER will contain:

- A summary of all construction activities.
- All laboratory and field test results.
- Third party conformance test results for geocomposite transmissivity.
- Manufacturer's certifications for all geosynthetics.
- Documentation of thickness of the infiltration and erosion layers by a Texas registered Surveyor.
- Sampling and testing location drawings.
- A description of significant construction problems and the resolution of these problems.
- As-built record drawings, including all previous FCSER submittals and dates of TCEQ approval.
- A statement of compliance with the permit FCSQCP and construction plans.
- The reports will be signed and sealed by a professional engineer(s) licensed in the State of Texas.

The as-built record drawings will accurately site the constructed location of work items, including the anchor trenches. The POR will review and verify that as-built drawings are correct. As-built drawings will be included in the FCSER.

5.2 Reporting Requirements

The FCSER will be signed and sealed by the POR, signed by the site operator, and submitted to the MSW Permits Section of the Waste Permits Division of the TCEQ for approval.

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ATTACHMENT 11 – POST-CLOSURE PLAN

Texas Commission on Environmental Quality

Post-Closure Care Plan for Municipal Solid Waste Type I Landfill Units and Facilities

This form is for use by applicants or site operators of Municipal Solid Waste (MSW) Type I landfills to provide landfill unit or final facility post-closure care closure plans to meet the requirements in 30 TAC Chapter 330, §330.63(h) and as set out under 30 TAC Chapter 330 Subchapter K for a MSW Type I facility.

If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: City of Victoria Landfill

MSW Permit No.: 1522B

Site Operator/Permittee Name: City of Victoria/CN600243257

II. Party Responsible for Overseeing and Conducting Post Closure Care Activities

Name (Person or Office Responsible):

Position or Title: Browning-Ferris, Inc. Closure Group

Mailing Address: P.O. Box 3151

City: Houston

State: Texas

Zip Code: 77253

Telephone Number: 281-870-7632

III. Post-Closure Care Status of Landfill Units at the Facility

Check the applicable box for the post-closure care status of the units at the facility and complete the applicable tables as indicated:

A. ☐ No landfill unit is in post-closure care in this facility at the time this application is submitted (skip Table 1 and complete Table 2 below if you check this item)

B. ☒ This facility includes landfill units currently in post-closure care and landfill units that are not yet in post-closure care (complete Tables 1 and 2 below if you check this item).

C. ☐ This facility contains only landfill units currently in post-closure care (complete Table 1 below if you check this item; do not complete Table 2).

Table 1: Landfill Units Currently in Post-Closure Care

Landfill Unit Name	Drawing Number Showing the Landfill Unit	Date TCEQ Acknowledged Closure of Unit	Date Post-Closure Care Commenced	Projected Date of End of Post-Closure Care
Existing Area	A2, C006	September 29, 2015	September 29, 2015	September 29, 2045

Table 2: Landfill Units Not yet in Post-Closure Care

Category of Landfill Unit (Regarding Status of Waste Receipt)	Landfill Unit Names or Descriptors	Site Development Plan Drawing Titles and Numbers Showing the Units
Stopped Receiving Waste Prior to October 9, 1993	**Existing Area**	A2, C006
Received Waste on or after October 9, 1993	**Existing Area**	A2, C006, C007
Proposed to be Constructed	**Expansion Area**	C006, C007
Other (enter as applicable)		

IV. Post-Closure Care Maintenance Requirements and Activities to be Conducted

A. Categories of Landfill Units and Applicable Post-Closure Care Maintenance Requirements and Activities

Check the appropriate boxes to indicate the categories of landfill units at the facility and complete the applicable section of the post-closure care maintenance requirements and activities below.

This facility includes landfill units that:

☒ Stopped receiving waste prior to October 9, 1993

If you check this item, complete the post-closure care maintenance requirements and activities specified in Subsection IV.B below. Skip Subsection IV.B if this item does not apply to your facility.

☒ Received waste on or after October 9, 1993

If you check this item, complete the post-closure care maintenance requirements and activities specified in Subsection IV.C below. Skip Subsection IV.C if this item does not apply to your facility.

☒ Are proposed to be constructed

If you check this item, complete the post-closure care maintenance requirements and activities specified in Subsection IV.C below. Skip Subsection IV.B, unless your facility also contains units that stopped receiving waste prior to October 9, 1993.

B. Post-Closure Care Maintenance Requirements and Activities for the Landfill Units that Stopped Receiving Waste Prior to October 9, 1993

The site operator will commence and conduct post-closure care maintenance of the units that stopped receiving waste prior to October 9, 1993 for a minimum of the first **five years** following commencement of post-closure care as specified below and in accordance with applicable rules under 30 TAC §330.463(a). Post-closure care maintenance will start on the date the professional engineer's certification of the completion of closure is accepted in writing by the TCEQ executive director and the site operator will carry out the following activities and operations during the period.

1. Maintenance of Right of Entry and Rights of Way

The site operator will retain the right of entry to and maintain all rights-of-way of the closed units in order to conduct periodic inspections of the units throughout the post-closure care period. TCEQ staff will have access to the site to conduct inspection or investigation that may be necessary during the period.

2. Inspection Activities and Correction of Problems

The site operator will conduct inspection of the closed landfill units at the frequencies indicated in Table 3 below, utilizing the inspection protocol maintained in the site operating record, and will correct all identified problems as needed.

Table 3: Inspection Activities Schedule

Post-Closure Care Inspection Item	Frequency of Inspection	Types of Deficiency Conditions to be looked for during Inspection
Final Cover Condition	Annual	Damage to integrity and effectiveness - cracks, exposed liner, obvious wear or damage, significant erosion, exposed liner, no clogging or draining
Vegetation	Annual	Less than 90 percent vegetative cover is present, significant erosion, areas of dead vegetation indicating methane migration
Leachate Management Systems	Annual	Per Attachment 3 - Leachate and Contaminated Water Plan
Landfill Gas Monitoring and Control Systems	Per Attachment 8 - LFG Management Plan - no more than one year between inspections	Damage to components, rusting, reduced functionality
Groundwater Monitoring Systems	Annually	Damaged well pro tops and casings, rusting, missing components
Drainage Structures	Annual, Following a 25-yr, 24-hr storm event	During wet weather conditions when flow is expected, the pipe outlets will be inspected to verify that flow is occurring. If there is no

Post-Closure Care Inspection Item	Frequency of Inspection	Types of Deficiency Conditions to be looked for during Inspection
		flow, the pipe will be checked for clogging and flushed or replaced as necessary
Ponding of Water	Annual, Following a 25-yr, 24-hr storm event	Look for ponding on and around cap during/following significant wet weather events.
Other:		

3. Continuation of Monitoring Programs during Post-Closure Care Period

The site operator will continue the monitoring programs listed in Table 4 during the post-closure care period. The monitoring programs will be conducted as specified in the applicable section of the facility's Site Development Plan and applicable rules.

Table 4: Monitoring and Reporting Schedule

Monitoring Program	Frequency of Monitoring	Frequency of Reporting of Results
Groundwater monitoring	Semi-Annually	60 days after each monitoring event.
Landfill gas monitoring	Quarterly	60 days after each monitoring event
Other: Surface Water Monitoring	Quarterly	60 days after each monitoring event

4. Detection of a Release, Nature and Extent Investigation, and Corrective Action to Address Release from the MSW Unit

Upon detection of any evidence of a release from the landfill or other associated waste management units at the facility, the site operator will:

- Notify the executive director of the TCEQ of the condition detected;

- Investigate, if so directed by the executive director of the TCEQ, whether a release from the landfill or other associated waste management units at the facility has occurred;
- Investigate the nature and extent of the release, if a release is confirmed;
- Assess measures necessary to correct any impact to groundwater;
- Submit a corrective action plan via a permit modification for TCEQ executive director's review and approval; and
- Conduct corrective action as approved by the TCEQ executive director.

5. Extension of Post-Closure Care Period

If any of the problems listed in Table 3 occurs, or corrective action as indicated in Subsection IV.B.4 above continues, after the end of the five-year post-closure care period or persists for longer than the first five years of post-closure care, the site operator will be responsible for their correction and will continue to conduct post-closure care maintenance until the TCEQ executive director determines that all problems have been adequately resolved.

6. Reduction of Post-Closure Care Period

The site operator may request in writing for the TCEQ executive director to reduce the post-closure care period for the units if all wastes and waste residues have been removed during closure and any new or on-going corrective action to address confirmed releases from the landfill have been completed as acknowledged in writing by the executive director.

C. Post-Closure Care Requirements and Activities for Municipal Solid Waste Landfill Units that Receive Waste on or after October 9, 1993 and for New Units

The site operator will commence and conduct post-closure care maintenance of the units that receive waste on or after October 9, 1993 and new units constructed under this permit as follows and in accordance with applicable rules under 30 TAC §330.463.

1. Commencement of Post-Closure Care

Post-closure care maintenance will start on the date the professional engineer's certification of the completion of closure is accepted in writing by the TCEQ executive director and the site operator will carry out the following activities and operations during the period.

2. Period of Post-Closure Care

The site operator will conduct post-closure care for the landfill units for a period of **30 years**, unless this time period is increased or reduced by the executive director as discussed in Subsection IV.C.11.

3. Maintenance of Right of Entry and Rights of Way

The site operator will retain the right of entry to the closed units and the facility and will maintain all rights-of-way of the closed units in order to conduct periodic inspection and maintenance of the closed units until the end of the post-closure care period.

4. Inspection Activities

The site operator will conduct periodic inspection of the closed units to identify and document deficiency conditions and conduct maintenance and corrective action to maintain compliance. Sections IV.C. 8.(a)-(c) provide information on the inspection items and deficiency conditions that the site operator will look for during inspection of the major components of the landfill and the site during the post-closure care period. Other inspection and maintenance provisions that apply during the post-closure care period as specified in the facility's site operating plan, site development plan, or applicable rules will remain in effect.

5. Documentation of Inspection

The site operator will document and maintain records of the post-closure care inspections in the site operating record. The records will include:

- The date of inspection;
- Components and items inspected;
- Problems detected or observed; and
- The name of the personnel who conducted the inspection.

6. Corrective Actions

Based on the results of the inspection activities, the site operator will conduct needed restoration and remediation actions on the closed unit no later than the next scheduled inspection event. Also, the site operator will conduct maintenance action on regular periodic schedule in order to:

- Maintain the integrity and effectiveness of all final cover, facility vegetation, and drainage control systems;
- Correct any effects of settlement, subsidence, ponded water, erosion, or other events or failures detrimental to the integrity of the closed unit; and
- Prevent any surface run-on and run-off from eroding or otherwise damaging the final cover system during the post-closure care period.

7. Documentation of Corrective Actions

The site operator will document and maintain, in the facility's site operating record, records of the restoration, remediation, and maintenance activities performed, including the date of completion of the activities.

8. Inspection Activities Schedules

(a) Final Cover Inspection

Inspection Frequency: Annually

Other Inspection Occasions/Events: Following significant wet weather events

Table 5: Final Cover Inspection Items

Inspection Item	Types of Deficiency Conditions to be looked for during Inspection
Vegetation and other Ground Cover Materials	Erosion, Less than 90 percent established vegetative cover
Settlement	Concave appearance of cap, signficant cracking/damage to soil/geomembrane, ponding after precipitation
Subsidence	Concave appearance of cap, signficant cracking/damage to soil/geomembrane, ponding after precipitation
Ponded Water	Ponding water where not designed following 25-yr, 24-hr storm events

Inspection Item	Types of Deficiency Conditions to be looked for during Inspection
Erosion	Significant erosion, lack of vegetation
Other (enter other events or failures detrimental to the integrity and effectiveness of the final cover):	

(b) *Drainage Control System Inspection*

Inspection Frequency: Annually

Other Inspection Occasions/Events: Following/during wet weather events

Table 6: Drainage Control System Inspection Items

Inspection Item	Types of Deficiency Conditions to be looked for during Inspection
Vegetation within Drainage Control Structures	Lack of established vegetation
Component Failures	During wet weather conditions when flow is expected, the pipe outlets will be inspected to verify that flow is occurring. If there is no flow, the pipe will be checked for clogging and flushed or replaced as necessary
Wash Outs	Significant washout of vegetation or riprap directly downgradient of the outlet pipe or around entrance of inlet pipe
Sediment Build Up	Sediment buildup inside pipe or up/downgradient of pipe inlet/outlet
Other (enter other events or failures detrimental to the integrity and effectiveness of drainage structures):	

(c) *Access and Rights-of-Way*

Inspection Frequency: Annually

Other Inspection Occasions/Events:

Table 7: Access and Rights of Way Inspection Items

Inspection Item	Types of Deficiency Conditions to be looked for During Inspection
Gates, Gate Locks and Barriers	Damaged locks, gates, barriers; rusting; mechanized pieces that are functioning at less than optimal condition
Fence and other Access Control Barriers	Damage to fence what would allow entry outside of gates, significant ruts in roads or erosion/washout of the roads
Vegetation Control in Areas of the Facility other than the Final Cover	Erosion, lack of established vegetation
Other (enter other access control and rights-of-way inspection items):	

9. Continuation of Operation and Maintenance of the Leachate Collection and Removal Systems (LCRS)

The site operator will continue the operation and maintenance of the LCRS and disposal of leachate during the post-closure care period in accordance with the facility's leachate management plan found in Attachment 3.0 - Leachate and Contaminated Water Plan of the Site Development Plan and consistent with applicable provisions under 30 TAC Sections 330.331 and 330.333.

(a) Performance Monitoring and Inspection of the LCRS

During the post-closure care period, the site operator will monitor the performance of the LCRS on an annual basis to assure continuous compliance with the design criteria and inspect the LCRS components on an annual basis, at a minimum, to determine the need for repair or maintenance. Inspection and monitoring will follow the procedure described in the facility's leachate management plan found in Attachment 3.0 - Leachate and Contaminated Water Plan of the Site Development Plan or in the written inspection protocol maintained in the facility's site operating record. Results of the monitoring and inspection activities will be documented in the site operating record. The items and components of the leachate collection and removal system to be inspected will include but are not limited to the items in Table 8 below.

Table 8: Leachate Collection and Removal System Inspection

Inspection Item/Component	Types of Deficiency Conditions to be looked for during Inspection
Sump Levels	Leachate collection sump levels will be measured on an annual basis. Site personnel will verify that leachate level is maintained within the sump as discussed in Part III, Attachment 3. The leachate collection system will be operated consistent with Part III, Attachment 3, which includes procedures for the operation of the leachate collection sump, storage tanks, and disposal of leachate. If there is a significant increase in leachate generation, inspection frequency will be increased to ensure compliance.

(b) LCR Maintenance and Repairs

During the post-closure care period, the site operator will perform routine and needed maintenance or repairs of the LCRS items and components based on the monitoring and inspection results. Maintenance and repair will be completed prior to the next scheduled monitoring event and documented within the site operating record.

(c) Discontinuation of Leachate Management

The site operator may submit data and information from the closed units to the TCEQ executive director to demonstrate that leachate no longer poses a threat to human health and the environment. Upon the executive director's approval of the demonstration, the site operator will be allowed to stop managing leachate at the closed unit.

10. Continuation of Monitoring Systems Operation and Maintenance:

The site operator will continue to conduct monitoring systems operation and maintenance activities to ensure the integrity of the containment system and to promptly detect and control releases to the environment during the post-closure care period as follows.

(a) Groundwater Monitoring System

The site operator will continue groundwater monitoring activities (including sampling, analysis, reporting, etc.) in accordance with the approved site-specific Groundwater Sampling and Analysis Plan (GWSAP) found in Part III, Attachment 6.0 - Groundwater and Sampling Analysis Plan of the Site Development Plan, the Groundwater Monitoring System Design found in Part III, Attachment 1 - Drawing C011 - Final Environmental Monitoring Plan of the Site Development Plan and consistent with the provisions under 30 TAC Chapter 330 Subchapter J. Groundwater monitoring will be conducted semiannually or as otherwise approved by the TCEQ executive director during the post-closure care period.

i. Inspection of the Groundwater Monitoring System

During each groundwater monitoring event, the site operator will perform inspection of all the groundwater monitoring wells that are part of the groundwater monitoring system and other items discussed in the GWSAP or the Groundwater Monitoring System Design. The items and components of the groundwater monitoring system to be inspected are included in Table 9:

Table 9: Groundwater Monitoring Systems Inspection

Inspection Item/Component	Types of Deficiency Conditions to be looked for during Inspection
Monitoring Wells	Damage to components, rusting, reduced functionality

ii. Maintenance and Repair of the Groundwater Monitoring System

The site operator will perform needed maintenance and/or repairs of the groundwater monitoring system items and components based on the inspection results. Maintenance and/or repairs will be performed no later than the next scheduled monitoring event.

iii. Documentation of Inspection, Maintenance, and Repairs

The site operator will document and discuss the results of the groundwater monitoring system inspection, maintenance, and repair activities in the groundwater monitoring report submitted to the TCEQ executive director, and maintain the documents in the site operating record.

(b) Landfill Gas Management System

During the post-closure care, the site operator will continue landfill gas monitoring operations and activities, documentation, and reporting in accordance with the facility's landfill gas management plan and consistent with the requirements under 30 TAC Chapter 330, Subchapter I.

i. LFG Monitoring and Monitoring System Inspection

All structures and perimeter gas monitoring probes will be sampled quarterly or more frequently as approved by the TCEQ executive director. The site operator will conduct routine inspections of the landfill gas management system components as provided in the landfill gas management plan during the post-closure care period. The items and components to be inspected are included in Table 10.

Table 10: Landfill Gas Management System Inspection

Inspection Item/Component	Types of Deficiency Conditions to be looked for during Inspection
Continuous Gas Monitor/Alarms	Alarm placed anywhere other than approximately one foot from the top of the lowest enclosed area of the building. Additionally that all alarms have been checked for operationality on a regular basis.
Monitoring Probes	Damage to components, rusting, reduced functionality
Active Gas Collection System	System operating incorrectly

ii. LFG Management System Maintenance

The site operator will perform routine and needed maintenance of the landfill gas management system including calibration of the monitoring equipment. Needed maintenance and/or repair work will be performed based on the inspection and monitoring results no later than the next scheduled monitoring event.

(c) Continuation of Earth Electrical Resistivity Survey

The site operator will, if applicable, continue earth electrical resistivity surveys as applicable at the frequency stated in the approved site development plan or as otherwise approved by the TCEQ executive director.

11. Detection of a Release, Nature and Extent Investigation, and Corrective Action to Address Release from the MSW Unit

If there is evidence of a release from the landfill or other associated waste management units at the facility, the site operator will:

- Notify the executive director of the TCEQ of the condition detected;
- Investigate, if so directed by the executive director of the TCEQ, whether a release from the landfill or other associated waste management units at the facility has occurred;
- Investigate the nature and extent of the release, if a release is confirmed;
- Assess measures necessary to correct any impact to groundwater;
- Submit a corrective action plan via a permit modification for TCEQ executive director's review and approval; and
- Conduct corrective action as approved by the TCEQ executive director.

12. Revision of the Length of Post-Closure Care Period

(a) The Post-Closure Care Period May Be Decreased

The length of the post-closure care period may be decreased by the TCEQ executive director if the site operator submits a documented certification signed by a licensed professional engineer and including all applicable supporting documentation that demonstrates that the reduced period is sufficient to protect human health and the environment, and the executive director approves the decrease in writing after review.

(b) The Post-Closure Care Period May be Increased

The length of the post-closure care period may be increased by the TCEQ executive director if it is determined that the longer period is necessary to protect human health and the environment.

V. Recordkeeping

The site operator will place a copy of this post-closure plan in the facility's site operating record by the initial receipt of waste at the units proposed at the time of this application. Also, the site operator will document and maintain records of all inspection, monitoring, maintenance, repair, or remediation activities, and detail the results of any inspection and schedules of any other actions to be taken to maintain compliance, in the site operating record.

VI. Planned Use of the Land during and after the Post-Closure Care Period

Post-closure use of the property will not disturb the final cover, liners, or other containment or monitoring systems unless such disturbance is necessary for the proposed use or to protect human health and the environment and is authorized by the TCEQ executive director consistent with provisions under 30 TAC Chapter 330 Subchapter T.

The subsequent use of the City's Landfill is currently agricultural or open rangeland with grass cover for control of erosion.

VII. Post-Closure Care and Corrective Action Cost Estimates

A detailed written cost estimate in current dollars for conducting post closure care is provided in *(enter location of the post-closure care cost estimate in the application/permit document)*:

Attachment 13

The cost estimate for corrective action will be provided as needed, via a permit modification, during the life and/or post-closure care period of the unit or facility.

VIII. Certification of Completion of Post-Closure Care

Upon completion of the post-closure care maintenance period for each municipal solid waste landfill unit, the site operator will submit to the TCEQ executive director for review and approval a certification, signed by an independent licensed professional engineer, verifying that post-closure care has been completed in accordance with the approved post-closure plan. The submittal to the executive director shall include all applicable documentation necessary for the certification of completion of post-closure care. These will include information relating to the condition and status of:

- The final cover integrity and stability, including the condition of the soil, vegetation, drainage structures, etc.
- Groundwater quality at the site, as determined from on-going groundwater detection or assessment monitoring or corrective measures data during the period.
- Landfill gas (methane) migration, as determined from on-going landfill gas monitoring and remediation data during the period.
- Leachate generation rate and quantity as determined from on-going leachate management data over the period.
- The surface water management system.
- Access control structures.

The engineer's certification of post-closure will show that, based on a summary of monitoring and inspection results, the final cover system continues to maintain its integrity, stability, and function; groundwater remains uncontaminated and monitoring is no longer required; landfill gas is not migrating beyond the facility boundary or accumulating in structures at action levels and monitoring is no longer required; leachate generation rate and quantity will not result in greater than 12 inches of head above the liner, no breakouts have occurred, and all slopes remain as approved and leachate management is no longer required; the surface water management system continues to function as designed; and the access control structures remain intact.

Documentation supporting the professional engineer's certification will be furnished to the TCEQ executive director upon request and will be maintained in the site operating record until the executive director acknowledges termination of post-closure in writing.

IX. Voluntary Revocation Request

Upon completion of the post-closure care period for the final unit at the facility, the site operator will submit to the executive director a request for voluntary revocation of the facility permit.

X. Attachments

The following figures and documents are attached as part of this post-closure care plan:

Located in **Part III – Attachment 11A:**

Drawing A1 – Final Cover System Evaluation Report Top of Final Cover Plan

Drawing A2 – Final Cover System Evaluation Report Top of Final Cover Plan

Located in **Part III – Attachment 1:**

C006 – Final Grading Plan - West

C007 – Final Grading Plan – East

C011 – Final Environmental Monitoring Plan

XI. Engineer's Seal and Signature

Name: Scott Martin Title: Project Engineer

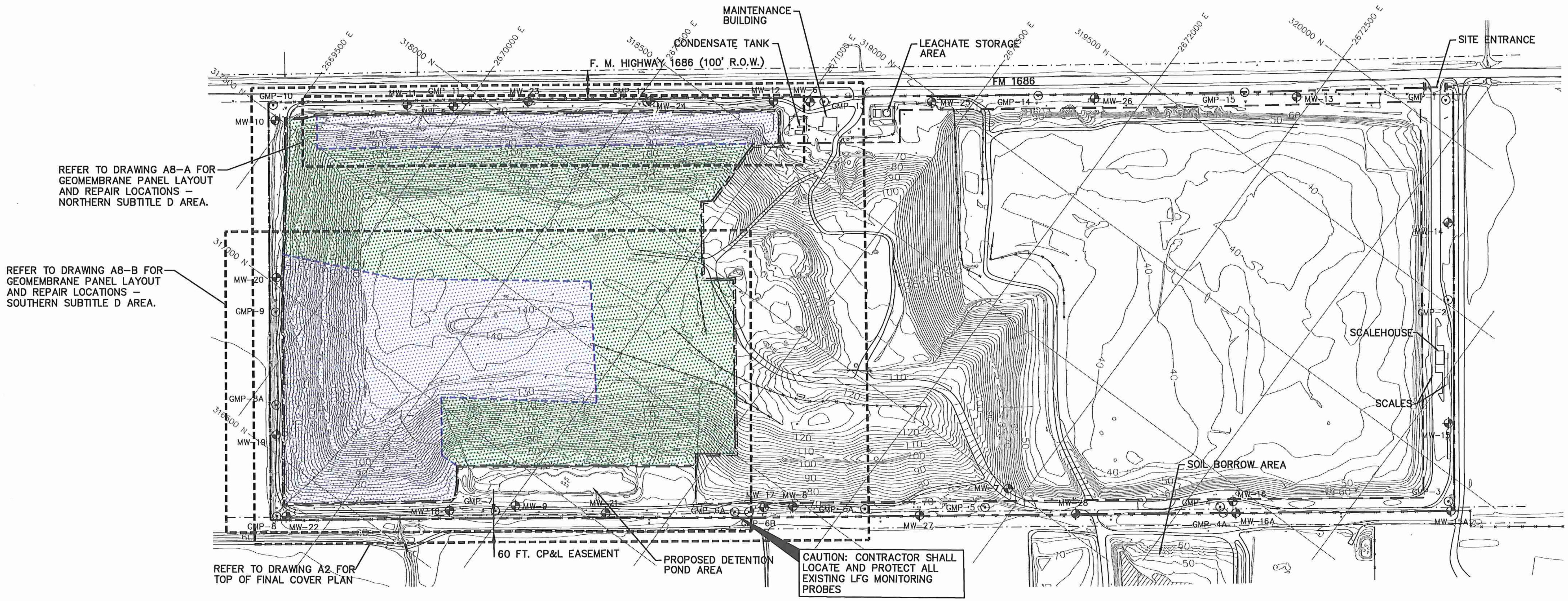
Date: 04/04/2022

Company Name: Burns & McDonnell Firm Registration Number: F-845

Professional Engineer's Seal

Signature

ATTACHMENT 11A - Historical Drawings

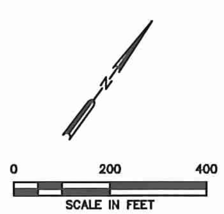


LEGEND

— - - —	PERMIT BOUNDARY
— — — —	LIMIT OF WASTE
- - - - -	PRE–SUBTITLE D/SUBTITLE D FINAL COVER LIMIT
——90——	EXISTING CONTOUR
318000 N	STATE PLANE COORDINATE SYSTEM
— · — · —	EASEMENT
	TIE–IN ZONE
⊙GMP–6	LANDFILL GAS MONITORING PROBE
MW–17	GROUNDWATER MONITORING WELL
⊕SV–44	SOIL VAPOR WELL
	PRE–SUBTITLE D AREA (29.2 ACRES)
	SUBTITLE D AREA (22.4 ACRES)

NOTE:

1. THE EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO., FROM AERIAL PHOTOGRAPHY FLOWN FEBRUARY 6, 2014.



STATE OF TEXAS
KYLE D. GOULD
106018
LICENSED PROFESSIONAL ENGINEER
8.11.15

☐ DRAFT	
☒ FOR INFORMATIONAL PURPOSES ONLY	
☐ ISSUED FOR CONSTRUCTION	
DATE: 08/2015	DRAWN BY: JDW
FILE: 0120–558–11	DESIGN BY: GWT
CAD: A1–SITE PLAN.DWG	REVIEWED BY: KDG

Weaver Consultants Group
TBPE REGISTRATION NO. F–3727

PREPARED FOR
CITY OF VICTORIA AND REPUBLIC SERVICES

REVISIONS

NO.	DATE	DESCRIPTION

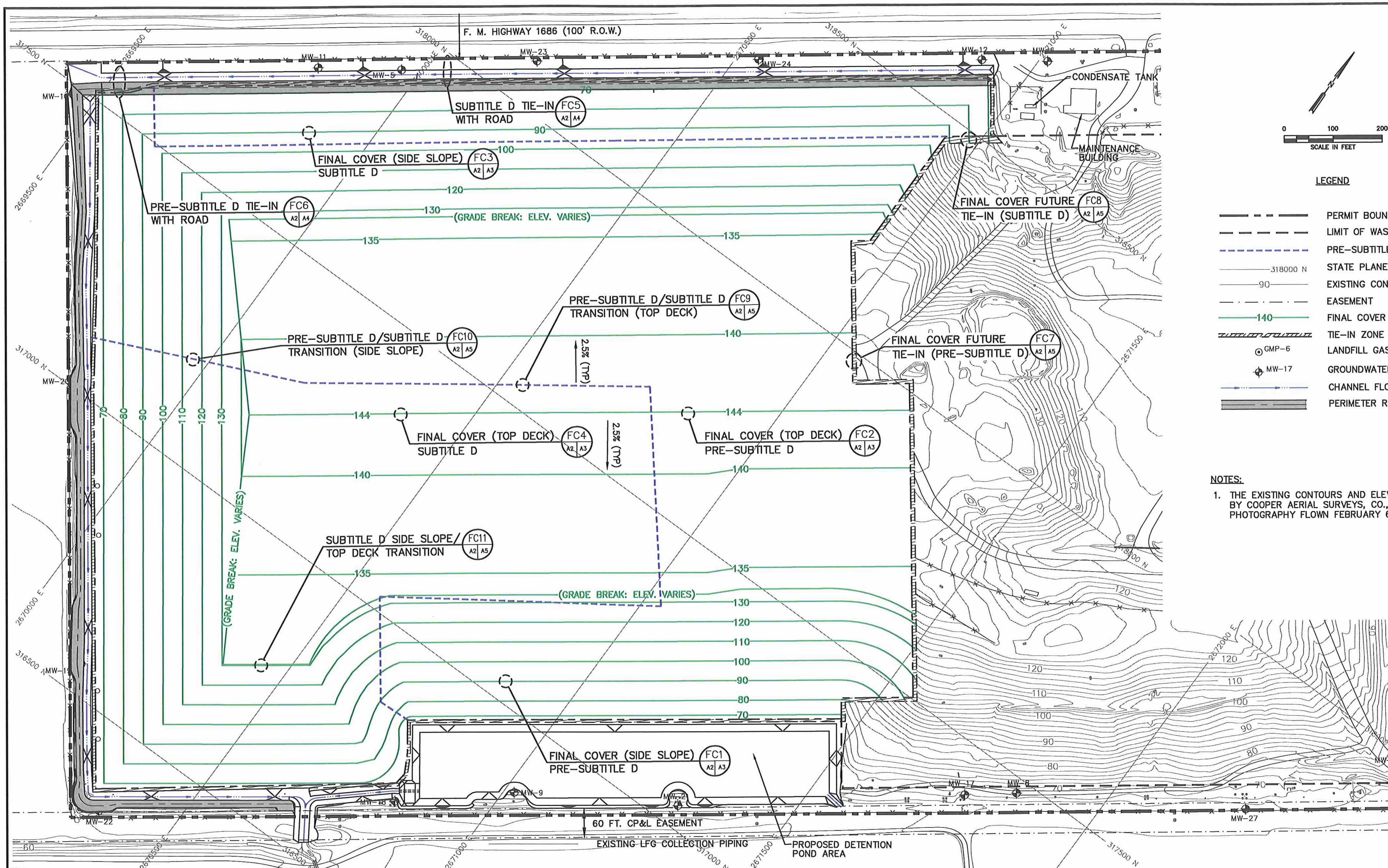
FINAL COVER SYSTEM EVALUATION REPORT
SITE PLAN

CITY OF VICTORIA LANDFILL
VICTORIA COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING A1

O:\0120\74\FCSER 2015\A1-SITE PLAN.dwg, jwilson, 1:2



0 100 200
SCALE IN FEET

LEGEND

- PERMIT BOUNDARY
- LIMIT OF WASTE
- PRE-SUBTITLE D/SUBTITLE D FINAL COVER LIMIT
- 318000 N — STATE PLANE COORDINATE SYSTEM
- 90 — EXISTING CONTOUR
- EASEMENT
- 140 — FINAL COVER CONTOUR
- TIE-IN ZONE
- GMP-6 — LANDFILL GAS MONITORING PROBE
- MW-17 — GROUNDWATER MONITORING WELL
- CHANNEL FLOWLINE
- PERIMETER ROAD

NOTES:

1. THE EXISTING CONTOURS AND ELEVATIONS PROVIDED BY COOPER AERIAL SURVEYS, CO., FROM AERIAL PHOTOGRAPHY FLOWN FEBRUARY 6, 2014.

STATE OF TEXAS
KYLE D. GOULD
106018
LICENSED PROFESSIONAL ENGINEER
8.11.15

O:\0120\74\FCSER 2015\A2-TOP OF FINAL COVER PLAN.dwg, jwilson, 1:2

☐ DRAFT
☒ FOR INFORMATIONAL PURPOSES ONLY
☐ ISSUED FOR CONSTRUCTION

DATE: 08/2015
FILE: 0120-558-11
CAD: A2-SITE PLAN.DWG

DRAWN BY: JDW
DESIGN BY: GWT
REVIEWED BY: KDG

Weaver Consultants Group
TBPE REGISTRATION NO. F-3727

PREPARED FOR
CITY OF VICTORIA AND REPUBLIC SERVICES

REVISIONS

NO.	DATE	DESCRIPTION

FINAL COVER SYSTEM EVALUATION REPORT
TOP OF FINAL COVER PLAN

CITY OF VICTORIA LANDFILL
VICTORIA COUNTY, TEXAS

WWW.WCGRP.COM

DRAWING A2

ATTACHMENT 12 – CLOSURE COST ESTIMATE

Texas Commission on Environmental Quality

Closure Cost Estimate Form for Municipal Solid Waste Type I Landfills

This form is for use by applicants or site operators to provide cost estimates for closure of MSW Type I landfills to meet the requirements in 30 Texas Administrative Code (TAC) Chapter 330, Section 330.63(j) and 30 TAC Chapter 330 Subchapter L. The costs to be provided herein are cost estimates for hiring a third party to close the largest waste fill area that could potentially be open in the year to follow and those areas that have not received final cover. If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

Facility Name: City of Victoria Landfill

MSW Permit No.: 1522B

Site Operator/Permittee Name and Mailing Address: City of Victoria, 700 Main Street, Victoria, TX 77902

Total Closure Cost Estimate (2021 Dollar Amount): 7,334,503

I. Professional Engineer's Statement, Seal, and Signature

I am a licensed professional engineer in the State of Texas. To the best of my knowledge, this Closure Cost Estimate has been completed in substantial conformance with the facility Closure Plan and, in my professional opinion, is in compliance with Title 30 of the Texas Administrative Code, Chapter 330.

Name: Scott Martin

Title: Project Engineer

Date: 04/04/2022

Company Name: Burns & McDonnell

Firm Registration Number: F-845

Professional Engineer's Seal

Professional Engineer's Signature

II. Annual Review of Permit Conditions, Cost Estimates, Inflation Factor, and Financial Assurance

The permittee/site operator acknowledges that he/she will:

(1) Review the facility's permit conditions on an annual basis and verify that the current active and inactive waste fill areas of the landfill match the areas on which closure cost estimates are based.

(2) Request in writing via a permit modification application for an increase in the closure cost estimate and the amount of financial assurance provided if changes to the closure plan or the landfill conditions increase the maximum cost of closure at any time during the remaining active life of the landfill.

(3) Request in writing via a permit modification application for a reduction in the cost estimate and the amount of financial assurance provided if the cost estimate exceeds the maximum cost of closure at any time during the remaining active life of the landfill. The permit modification application will include a description of the situation and a detailed justification for the reduction of the closure cost estimate and the amount of financial assurance.

(4) Establish financial assurance for closure of the unit in an amount no less than the current closure cost estimate in accordance with 30 TAC Chapter 37, Subchapter R.

(5) Adjust the current cost estimate for inflation within 60 days prior to the anniversary date of the first establishment of the financial assurance mechanism.

(6) Provide annual inflation adjustments to the closure costs and financial assurance during the active life of the facility, until the facility is officially placed under the post closure care period and all requirements of the final closure plan have been approved in writing by the TCEQ executive director. The adjustment will be made using an inflation factor derived from the most recent annual Implicit Price Deflator for Gross National Product published by the United States Department of Commerce in its Survey of Current Business, as specified in paragraphs (1) and (2) of 30 TAC §37.131. The inflation factor is the result of dividing the latest published annual Deflator by the Deflator for the previous year.

(7) Provide continuous financial assurance coverage for closure until the facility is officially placed under the post-closure care period.

III. Description of the Closure Cost Estimates Worksheet

The following descriptions of the items on the closure cost estimates worksheet provide guidance for identifying the minimum work or cost elements and estimating the unit or lump sum cost of each item as applicable. Enter additional detail for each item in the field following the item as necessary and as site-specific condition warrants. The cost items are grouped under closure costs for engineering, construction, and storage and processing units. Include attachments to detail any additional work and associated costs necessary to close the site that is not already included as a line item on the worksheet. Reference the attachments and list the work or cost items in the fields under "Additional Engineering Cost Items Not Listed on the Worksheet," "Additional Construction Cost Items Not Listed on the Worksheet," or "Additional Storage and Processing Units Items Not Listed on the Worksheet" as applicable. Provide the total cost of the additional work or cost items in each cost category on the worksheet line that precedes the cost subtotal for each cost group.

1. Engineering Costs

The engineering tasks have been subdivided into seven items and are described below. Other related costs may be added as site-specific issues warrant.

1.1. Topographic Survey

A topographic survey will be required to verify the existing elevation and slopes of the landfill to ensure conformance with the final cover system, drainage system, and final grading designs.

Enter additional topographic survey work or cost element details as site-specific conditions warrant:

1.2. Boundary Survey

The metes and bounds description is required for filing of the affidavit of closure and deed recording of any area of the site which has received waste. Other activities to be included here are publication of the public notice of closing activities.

Enter additional boundary survey work or cost element details as site-specific conditions warrant:

1.3. Site Evaluation

The evaluation includes a site inspection to identify waste disposal areas, analyze drainage and erosion protection needs, and to determine other site operational features that are not in compliance with the permit. The site evaluation also includes verifying the need for new or relocation of existing groundwater monitoring wells and landfill gas monitoring probes, analysis of groundwater samples, and review of site operating record. The third party consultant who performed the site evaluation will prepare and submit an engineering report to the executive director to document the status of the site.

The report will identify all areas of work and the associated implementation costs necessary to safely close the landfill operations with recommendations on how to fulfill these needs.

Enter additional site evaluation work or cost element details as site-specific conditions warrant:

1.4. Development of Plans

The final closure, plan the final cover system design and specifications, grading and drainage plans, specification for revegetation, design of any other improvements to bring the site into compliance with the permit, the closure schedule, and coordination with the TCEQ and provision of closure notice to the public.

Enter additional development of plans work or cost element details as site-specific conditions warrant:

1.5. Contract Administration (bidding and award)

The third-party consultant will advertise the project, receive the bids, evaluate the bids, award the closure construction contract and administer the contract during construction.

Enter additional contract administration work or cost element details as site-specific conditions warrant:

1.6. Closure Inspection and Testing

The professional of record will observe closure construction, perform cover thickness and permeability verification, and prepare an evaluation report upon completion of closure.

Enter additional closure inspection or testing work or cost element details as site-specific conditions warrant:

1.7. TPDES and other Permits

The third-party consultant will prepare plans, specifications, and other documents necessary for compliance with applicable federal and state laws and requirements, including the Clean Water Act, for the proper closure of the site.

Enter additional TPES or other permits work or cost element details as site-specific conditions warrant:

1.8. Additional Engineering Cost Items Not Listed on the Worksheet

List the Attachment(s) detailing any additional engineering cost items necessary to close the site that is not already included as a line item on the worksheet:

Also, reference these Attachments in the “Units” column on this line of the worksheet. Provide the total cost of all additional engineering cost items in the "Cost" column.

1.9. Engineering Costs Subtotal

1.9.1. Enter the sum of engineering costs in Items 1.1 through 1.8.

2. Construction Costs

Closure construction costs include those for construction of the final cover system, site grading, and drainage improvements. Other costs may be added as site-specific issues warrant.

2.1. Mobilization

2.1.1. Mobilization of Personnel and Equipment

The cost of mobilizing personnel and construction heavy equipment must be included as part of the construction costs.

Enter additional work or cost element details for mobilization of personnel and equipment as site-specific conditions warrant:

2.2. Final Cover System

The owner or operator must install a final cover system that is designed to minimize infiltration and erosion. The final cover system is subdivided into the sideslope cover and cap cover with their associated components to facilitate cost calculations. If an alternative final cover is proposed, the closure cost estimate will still be based on a design that utilizes the conventional composite cover system.

Enter additional final cover system work or cost element details as site-specific conditions warrant:

2.2.1. Side Slope Cover

Enter information for Items 2.2.1a through 2.2.1h.

2.2.2. Top Slope Cover

Enter information for Items 2.2.2a through 2.2.2h.

2.2.3. Cells for Class 1 Nonhazardous Industrial Waste

2.3. Site Grading

Site grading includes the final grading of the site, including the landfill cap and sideslopes.

Enter additional site grading work or cost element details as site-specific conditions warrant:

2.4. Site Fencing and Security

Site fencing and security must be included for the area which has received waste and have no existing approved fencing.

Enter additional site fencing and security work or cost element details as site-specific conditions warrant:

2.5. Landfill Gas Monitoring and Control Systems

Enter information for Items 2.5.1 through 2.5.6.

Final installation of the landfill gas monitoring and control systems must include the installation costs of pipes and appurtenances. In the event of a forced closure, the systems may not have been completed, thus, the estimated costs to complete the landfill gas monitoring and control system must be provided.

Enter additional landfill gas monitoring and control systems work or cost element details as site-specific conditions warrant:

2.6. Groundwater Monitoring System

2.6.1. Monitor Well Installation

Upon closure of the site, it may be necessary to relocate the compliance boundary. This requires the installation of new monitor wells.

Enter additional groundwater monitoring system work or cost element details as site-specific conditions warrant:

2.6.2. Piezometer and Monitor Well Plugging and Abandonment

Piezometer or monitor well abandonment is the cost of abandoning (plugging) piezometers or monitor wells that are no longer needed. Determine the number of piezometers or monitor wells to be abandoned and include the total cost.

Enter additional plugging and abandonment work or cost element details as site-specific conditions warrant:

2.7. Leachate Management

2.7.1. Completion of Existing Leachate Collection System

In the event of a forced closure, there may be circumstances where the leachate collection system has not been completed. In this event, the leachate collection system must be closed with a permanent outfalls and permanent cleanouts installed.

Enter additional leachate management work or cost element details as site-specific conditions warrant:

2.8. Stormwater Management

2.8.1. Stormwater Drainage Management System

To reduce the potential long-term impacts of the landfill on surface water quality, drainage features must be incorporated into the final cover design to direct runoff, minimize erosion, control sediments, and avoid ponding of stormwater. The drainage system construction costs must be included.

Enter additional stormwater drainage management work or cost element details as site-specific conditions warrant:

2.9. Additional Construction Cost Items Not Listed on Worksheet

List the Attachments detailing any additional construction cost items necessary to close the site that is not already included as a line item on the worksheet:
Also, reference these Attachments in the "Units" column on this line of the worksheet. Provide the total cost of all additional construction cost items in the "Cost" column.

2.10. Construction Costs Subtotal

2.10.1. Enter the sum of construction costs in Items 2.1 through 2.9.

3. Storage and Processing Unit Closure Costs

For landfills that incorporate storage and/or processing operations that are not separately authorized, all waste and processed and unprocessed materials associated with storage and/or processing units must be removed during the closure process.

3.1. Waste Disposal

The cost of disposal of waste at an authorized facility. *Enter additional waste disposal work or cost element information as necessary.*

3.2. Material Removal and Disinfection

The cost of removal, including transportation, of any remaining processed and unprocessed materials to an authorized off-site location. *Enter additional material removal and disinfection work or cost element information as necessary.*

3.3. Demolition and Disposal

The cost of dismantling and/or disinfection of storage and/or processing units and disposal, as applicable. *Enter additional demolition and disposal work or cost element information as necessary.*

3.4. Additional Storage and Processing Unit Closure Cost Items Not Listed in Worksheet

List the Attachments detailing any additional storage and processing unit closure cost items necessary to close the site that is not already included as a line item on the worksheet. Also, reference these Attachments in the "Units" column on this line of the worksheet. Provide the total cost of all additional storage and processing unit closure cost items in the "Cost" column.

3.5. Storage and Processing Unit Closure Costs Subtotal

4. Sum of Cost Subtotals

4.1. Enter the sum of engineering, construction, and storage and processing unit closure cost subtotals from lines 1.9.1, 2.10.1, and 3.5.1.

5. Contingency

5.1. Add an amount equal to at least 10 percent of the sum of cost subtotals to cover unanticipated events during implementation of closure activities.

6. Contract Performance Bond

6.1. Add an amount equal to at least 2 percent of the sum of cost subtotals for purchase of a surety bond to guarantee satisfactory completion of the closure activities.

7. Third Party Administration and Project Management Costs

7.1. Add an amount equal to at least 2.5 percent of the sum of cost subtotals to cover the cost for a third party hired by TCEQ to administer the closure activities.

8. Total Closure Cost

8.1. Enter the sum of the amounts on lines 4.1, 5.1, 6.1, and 7.1.

IV. Closure Cost Estimates Worksheet

A. Landfill Data

Total Permitted Waste Disposal Area: 361.1 acres

Largest Area Requiring Final Cover in the year to follow: 55 acres

Total Filled Area with Constructed Final Cover: 51.6 acres

Total Area Certified Closed: 51.6 acres

Number of Monitor Wells to be Installed for Closure: 0 (already constructed)

Number of Gas Probes to be Installed for Closure: 0 (already constructed)

Total Acreage Needing LFG Collection and Control System: 361.1 acres

The unit or lump sum cost for each item is based on the work items and cost elements described in Section III of this Closure Cost Estimate document:

Yes ☒ No ☐ Partially ☐

(*if "No" or "Partially" is checked, please include attachments describing the additional work items and detailing the unit, quantities, and costs for the additional items*)

B. Facility Drawings and Financial Assurance Documentation

- Facility drawings
  - Attach facility drawings showing the closure areas to which the closure cost estimates apply.
- Financial assurance documentation
  - For an existing facility, attach a copy of the documentation required to demonstrate financial assurance as specified in 30 TAC Chapter 37, Subchapter R.
  - For a new facility, a copy of the required documentation shall be submitted 60 days prior to the initial receipt of waste.

C. Attachments

- Additional Engineering, Construction, and Storage and Processing Units Cost Items Details

D. Closure Cost Estimates Worksheet

If any item listed in this worksheet is not applicable to the subject facility, enter "NA" (Not Applicable) in the affected field.

Table 1. Closure Cost Estimates Worksheet.

Item No.	Item Description	Units[1]	Quantity	Unit Cost	Cost	Source of Unit Cost Estimate[2]
1. Engineering Costs						
1.1	Topographic Survey	Acres	55	160	8,800	04/04/21 Victoria CPC Permit Mod
1.2	Boundary Survey	LS	1	9,000	9,000	Industry standard cost
1.3	Site Evaluation	Acres	55	560	30,800	04/05/21 Victoria CPC Permit Mod
1.4	Development of Plans	Lump Sum	NA	NA	30,000	04/05/21 Victoria CPC Permit Mod
1.5	Contract Administration (bidding and award)	Lump Sum	NA	NA	(included above)	NA
1.6	Closure Inspection and Testing	Acres	55	1,600	88,000	04/05/21 Victoria CPC Permit Mod
1.7	TPDES and other Permits	Lump Sum	NA	NA	5,000	Industry standard cost
1.8	Additional Engineering Cost Items (describe in attachments)	NA	NA	NA	NA	NA
1.9 Engineering Costs Subtotal						
1.9.1	Engineering Costs Subtotal	NA	NA	NA	171,600	NA
2. Construction Costs						
2.1 Mobilization						

Closure Cost Estimate for MSW Type I Landfill

Facility Name: City of Victoria Landfill — Revision No.: 0

Permit No: 1522B — Date: 03/28/22

Item No.	Item Description	Units[1]	Quantity	Unit Cost	Cost	Source of Unit Cost Estimate[2]
2.1.1	Mobilization of Personnel and Equipment	Lump Sum	NA	NA	249,000	5% of construction costs
2.2 Final Cover System						
2.2.1 Side Slope and Top Slope Cover						
2.2.1a	Infiltration Layer – Compacted Clay	Cubic Yards	133,100	4.74	630,894	04/05/21 Victoria CPC Permit Mod
2.2.1b	Infiltration Layer – Geosynthetic Clay Liner	Square Feet	NA	NA	NA	NA
2.2.1c	Flexible Membrane Cover – HDPE	Square Feet	NA	NA	NA	NA
2.2.1d	Flexible Membrane Cover – LLDPE	Square Feet	2,395,800	0.58	1,389,564	Industry standard cost
2.2.1e	Drainage Layer – Aggregate	Cubic Yards	NA	NA	NA	NA
2.2.1f	Drainage Layer – Drainage Geocomposite Material	Square Feet	2,395,800	0.76	1,820,808	04/05/21 Victoria CPC Permit Mod
2.2.1g	Erosion Layer	Cubic Yards	88,733	3.70	328,313	04/05/21 Victoria CPC Permit Mod
2.2.1h	Vegetation	Acres	55	1,260	69,300	04/05/21 Victoria CPC Permit Mod
2.2.2 Top Slope Cover – NA, Included in the Above						
2.2.2a	Infiltration Layer – Compacted Clay	Cubic Yards	NA	NA	NA	NA
2.2.2b	Infiltration Layer – Geosynthetic Clay Liner	Square Feet	NA	NA	NA	NA
2.2.2c	Flexible Membrane Cover – HDPE	Square Feet	NA	NA	NA	NA
2.2.2d	Flexible Membrane Cover – LLDPE	Square Feet	NA	NA	NA	NA
2.2.2e	Drainage Layer – Aggregate	Cubic Yards	NA	NA	NA	NA
2.2.2f	Drainage Layer – Drainage Geocomposite Material	Square Feet	NA	NA	NA	NA

Closure Cost Estimate for MSW Type I Landfill

Facility Name: City of Victoria Landfill | Revision No.: 0

Permit No: 1522B | Date: 03/28/22

Item No.	Item Description	Units[1]	Quantity	Unit Cost	Cost	Source of Unit Cost Estimate[2]
2.2.2g	Erosion Layer	Cubic Yards	NA	NA	NA	NA
2.2.2h	Vegetation	Acres	NA	NA	NA	NA
2.2.3 Cells for Class 1 Nonhazardous Industrial Waste						
2.2.3a	Dike Construction	specify	NA	NA	NA	NA
2.3 Site Grading						
2.3.1	Site Grading	Acres	55	1,200	66,000	Industry standard cost
2.4 Site Fencing and Security						
2.4.1	Site Fencing and Security	LF	NA	NA	NA	Already constructed prior to closing
2.5 Landfill Gas Monitoring and Control System						
2.5.1	Gas Control Wells	linear ft	4,160	120	499,200	Industry standard cost
2.5.2	Gas Header Piping (24”)	linear ft	2800	120	336,000	Industry standard cost
2.5.2	Jumper Pipe (12”)	linear ft	2250	80	180,000	Industry standard cost
2.5.3	Gas Lateral Piping (6”)	linear ft	8000	40	320,000	Industry standard cost
2.5.4	Air Lines (2”)	linear ft	1500	5	7,500	Industry standard cost
2.5.5	Force Main (2”)	linear ft	1500	5	7,500	Industry standard cost
2.5.4	Flare Station	Lump Sum			NA	NA
2.5.5	Condensate Sumps	Each	1	20,000	20,000	Industry Standard Cost

Closure Cost Estimate for MSW Type I Landfill

Facility Name: City of Victoria Landfill — Revision No.: 0

Permit No: 1522B — Date: 03/28/22

Item No.	Item Description	Units[1]	Quantity	Unit Cost	Cost	Source of Unit Cost Estimate[2]
2.5.6	Completion of LFG Monitoring System	Acres	NA	NA	NA	Already Installed
2.6 Groundwater Monitoring System						
2.6.1	Groundwater Monitoring Well Installation	Each	NA	NA	NA	Completed prior to closure
2.6.2	Piezometer and Monitor Well Plugging and Abandonment	Each	NA	NA	NA	Completed prior to closure
2.7 Leachate Management						
2.7.1	Completion of Leachate Management System	NA	NA	NA	NA	Completed prior to closure
2.8 Stormwater Management						
2.8.1	Stormwater Drainage Management System	AC	55	6,000	330,000	Industry standard cost
2.9 Other Cost Items						
2.9.1	Additional Construction Cost Items (describe in attachments)	NA	NA	NA	NA	NA
2.10 Construction Costs Subtotal						
2.10.1	Construction Costs Subtotal	NA	NA	NA	6,254,079	NA
3. Storage and Processing Unit Closure Costs						
3.1	Waste Disposal	☐ Tons ☐ Cubic Yards	NA	NA	NA	NA
3.2	Material Removal and Disinfection	NA	NA	NA	NA	NA
3.3	Demolition and Disposal Units	NA	NA	NA	NA	NA
3.4	Additional Storage and Processing Unit Closure Cost Items (describe in attachments)	NA	NA	NA	NA	NA
3.5 Storage and Processing Unit Closure Costs Subtotal						
3.5.1	Storage and Processing Unit Closure Costs Subtotal	NA	NA	NA	NA	NA

Closure Cost Estimate for MSW Type I Landfill

Facility Name: City of Victoria Landfill — Revision No.: 0

Permit No: 1522B — Date: 03/28/22

Item No.	Item Description	Units[1]	Quantity	Unit Cost	Cost	Source of Unit Cost Estimate[2]
4. Sum of Engineering, Construction, and Storage and Processing Unit Closure Costs						
4.1	Sum of Engineering, Construction, and Storage and Processing Unit Closure Cost Subtotals	NA	NA	NA	6,425,679	NA
5. Contingency						
5.1	Contingency (10% of Sum of Engineering, Construction, and Storage and Processing Unit Closure Cost Subtotals)	NA	NA	NA	642,568	NA
6. Contract Performance Bond						
6.1	Contract Performance Bond (2% of Sum of Engineering, Construction, and Storage and Processing Unit Closure Cost Subtotals)	NA	NA	NA	128,514	NA
7. Third Party Administration and Project Management Costs						
7.1	Third Party Administration and Project Management Costs (2.5% of Sum of Engineering, Construction, and Storage and Processing Unit Closure Cost Subtotals)	NA	NA	NA	160,642	NA
8. Total Closure Costs						
8.1	Total Closure Costs (sum of amounts in Sections 4, 5, 6, and 7)	NA	NA	NA	7,357,403	NA

[1] For items marked "specify," the responsible professional engineer will enter appropriate unit of measurement

[2] Sources of Unit Costs for Cost Estimates table may include:
(1) Published Cost Estimator Manuals (e.g., RS Means);
(2) Third Party Quotes (e.g., Environmental Field Services Contractors);
(3) Verifiable Data based on Actual Operations; or
(4) Other sources of cost acceptable to the executive director of the TCEQ.

ATTACHMENT 13 – POST-CLOSURE COST ESTIMATE

Texas Commission on Environmental Quality

Post-Closure Care Cost Estimate Form for Municipal Solid Waste Type I Landfills

This form is for use by applicants or site operators to provide post-closure care cost estimates for post-closure care of MSW Type I landfills to meet the requirements in 30 Texas Administrative Code (TAC) Chapter 330, Section 330.63(j) and 30 TAC Chapter 330 Subchapter L. The costs to be provided herein are cost estimates for hiring a third party to conduct post-closure care of the largest waste fill area that has been certified closed in writing by the TCEQ executive director.

If you need assistance in completing this form, please contact the MSW Permits Section in the Waste Permits Division at (512) 239-2335.

I. General Information

Facility Name: City of Victoria Landfill

MSW Permit No.: 1522B

Date: 03/28/22

Revision Number: 0

Site Operator/Permittee Name and Mailing Address: City of Victoria, 700 Main Street, Victoria, TX 77902

Total Post-Closure Care Cost Estimate (2021 Dollar Amount): 11,139,083

II. Professional Engineer's Statement, Seal, and Signature

I am a licensed professional engineer in the State of Texas. To the best of my knowledge, this Post- Closure Care Cost Estimate has been completed in substantial conformance with the facility Post-Closure Care Plan and, in my professional opinion, is in compliance with Title 30 of the Texas Administrative Code, Chapter 330.

Name: Scott Martin Title: Professional Engineer

Date: 04/04/2022

Company Name: Burns & McDonnell Firm Registration Number: F-845

Professional Engineer's Seal

STATE OF TEXAS
SCOTT MARTIN
120819
LICENSED
PROFESSIONAL ENGINEER

Scott Martin
4/5/2022

Signature

III. Annual Review of Permit Conditions, Cost Estimates, Adjustments for Inflation, and Financial Assurance

The site operator/permittee acknowledges that he/she will:

1. Revise and increase the post-closure care cost estimate and the amount of financial assurance provided whenever changes in the post-closure care plan or the landfill conditions increase the maximum cost of post-closure care at any time during the remaining active life of the landfill and until the facility is officially released from the post-closure care period in writing by the executive director.
2. Request a reduction in the post-closure care cost estimate and the amount of financial assurance as a permit modification whenever the post-closure care cost estimate exceeds the maximum cost of post-closure care remaining over the post-closure period. The permit modification will include a detailed justification for the reduction of the post-closure care cost estimate and the amount of financial assurance.
3. Establish financial assurance for post-closure care of the unit in an amount no less than the current post-closure care cost estimate in accordance with 30 TAC Chapter 37
4. Adjust the current post-closure care cost estimate for inflation within 60 days prior to the anniversary date of the first establishment of the financial assurance mechanism.
5. Provide annual inflation adjustments to the post-closure care costs and financial assurance during the active life of the facility and during the post closure care period. The adjustment will be made using an inflation factor derived from the most recent annual Implicit Price Deflator for Gross National Product published by the United States Department of Commerce in its Survey of Current Business, as specified in 30 TAC Chapter 37. The inflation factor is the result of dividing the latest published annual Deflator by the Deflator for the previous year.
6. Provide continuous financial assurance coverage for post-closure care until the facility is officially released in writing by the executive director from the post-closure care period in accordance with all requirements of the post-closure care plan.

IV. Description of Worksheet Items of the Post-Closure Care Cost Estimates

The following descriptions of the worksheet items provide guidance for identifying the minimum work or cost elements for estimating the unit or lump sum cost of each item as applicable. Enter additional detail for each item in the field following the item as necessary and as site-specific conditions warrant. The cost items are grouped under post-closure care costs for engineering, construction, and leachate management. Include attachments to detail any additional work and associated costs necessary for the post-closure care of the unit or facility that is not already included as a line item on the worksheet. Reference the attachments and list the work or cost items in the fields under "Additional Engineering Cost Items Not Listed on the Worksheet," "Additional Construction Cost Items Not Listed on the Worksheet," or Additional Leachate Management Costs Not Listed on the Worksheet" as applicable. Provide the total cost of additional work or cost items in each cost category on the worksheet line that precedes the cost subtotal for each cost group.

1. Engineering Costs

1.1. Site Inspection and Recordkeeping

Regularly scheduled and event-driven site inspection must be performed to identify areas experiencing settlement, subsidence, erosion, or other drainage related problems, and note the conditions of the environmental control and monitoring systems, including leachate collection, groundwater monitoring, and landfill gas monitoring systems*. Enter additional site inspection and recordkeeping work or cost element detail as site-specific conditions warrant.*

1.2. Correctional Plans and Specifications

The cost for an engineering consultant to prepare corrective measure construction plans and specifications to correct problems identified during site inspections. *Enter additional work or cost element details for correctional plans and specifications as site-specific conditions warrant.*

1.3. Site Monitoring

The cost of performing semiannual groundwater (including costs for sampling and analyzing parameters, and assessment and reporting) and quarterly landfill gas monitoring (including costs for sampling and reporting) and the monitoring of other site-specific systems at the landfill during the post-closure period. *Enter additional site monitoring work or cost element details as site-specific conditions warrant.*

1.4. Additional Engineering Cost Items Not Listed on the Worksheet

List the Attachments detailing additional post-closure care engineering cost items not already included as a line item on the worksheet. (Also, reference these Attachments in the "Units" column of this line of the worksheet. Provide the total cost of all additional engineering cost items in the "Cost" column).

2. Construction Costs

2.1. Cap and Sideslopes Repairs and Revegetation

The cost of repair of the cap and cap drainage control structures due to erosion or structural integrity failures and maintaining final cover vegetation to minimize erosion. *Enter additional cap and sideslopes repair and revegetation work or cost element details as site-specific conditions warrant.*

2.2. Mowing and Vegetation Control

The cost of controlling vegetation growth on the final cover and other areas of the landfill. *Enter additional mowing and vegetation control work or cost element details as site-specific conditions warrant.*

2.3. Groundwater Monitoring System Maintenance

The cost of repairs/replacement and routine maintenance. *Enter additional groundwater monitoring system maintenance work or cost element details as site-specific conditions warrant.*

2.4. LFG Monitoring Probes Maintenance

The cost of repairs/replacement and routine maintenance. Enter additional LFG monitoring probes maintenance work or cost element details as site-specific conditions warrant.

2.5. LFG Collection System Maintenance

The cost of repairs and routine maintenance. *Enter additional LFG collection system maintenance work or cost element details as site-specific conditions warrant.*

2.6. Perimeter Fence and Gates Maintenance

The cost of maintaining perimeter fence and gates to restrict unauthorized access to the closed landfill. *Enter additional perimeter fence and gates maintenance work or cost element details as site-specific conditions warrant.*

2.7. Access and Rights of Way Maintenance

The cost of maintaining the access roads and other rights of way to the closed landfill to conduct inspections, environmental sampling, routing maintenance and other post-closure activities. *Enter additional access and rights of way maintenance work or cost element details as site-specific conditions warrant.*

2.8. Drainage System Cleanout and Repairs

The cost to include costs for maintaining and repairing ditches, conveyance structures, and ponds/basins. *Enter additional drainage system cleanout and repairs work or cost element details as site-specific conditions warrant.*

2.9. Additional Construction and Maintenance Cost Items Not Listed on the Worksheet

List the Attachments detailing any additional construction and maintenance cost items necessary for post-closure care that are not already covered on the worksheet. (Also, reference these Attachments in the "Units" column on this line of the worksheet. Provide the total cost of all additional construction and maintenance cost items in the "Cost" column.)

3. Leachate Management Costs

3.1. Leachate Collection and Removal System Operation and Maintenance

The cost of operation, routine maintenance and repairs. *Enter additional work or cost element details for leachate collection and removal system operation and maintenance as site-specific conditions warrant.*

3.2. Leachate Disposal

The cost of leachate disposal off-site. *Enter additional work or cost element details for leachate disposal as site-specific conditions warrant*.

3.3. Additional leachate management cost items not listed on the worksheet.

List the Attachments detailing any additional leachate management cost items necessary for post-closure care that are not already covered on the worksheet. (Also, reference these Attachments in the "Units" column on this line of the worksheet. Provide the total cost of all additional leachate management cost items in the "Cost" column.)

4. Sum of Cost Subtotals

Enter the sum of engineering, construction, and storage and leachate management post-closure care cost subtotals from lines 1.5.1, 2.10.1, and 3.5.1.

5. Contingency

The cost added to cover unanticipated events during implementation of post-closure activities. (Enter additional work or cost element information as necessary)

6. Third Party Administration and Project Management Costs

The cost for the third party hired by TCEQ to administer the post-closure activities. (Enter additional work or cost element information as necessary)

V. Post-Closure Care Cost Estimates Worksheet

Post-Closure Care Period – 30 years

Total Permitted Acreage: 361.1 acres

Total Permitted Waste Footprint: 361.1 acres

Number of Groundwater Monitoring Wells: 41

Number of GW Monitoring Events: 2 /year

Number of Gas Probes: 29

Number of LFG Monitoring Events: 4 /year

The unit or lump sum cost for each item is based on the work items and cost elements described in Section III of this Post-Closure Cost Estimate document:

Yes ☒ No ☐ Partially ☐

If “No” or “Partially” is checked, please attach a written description of work items and cost elements which form the bases of unit or lump sum cost for the affected items.

(NOTE: If any item listed in this worksheet is not applicable to the subject facility, enter Not Applicable (N/A) in the affected fields)

Attachments

Additional Engineering, Construction, and Leachate Management Cost Items Details.

Table 1: Post-Closure Care Cost Estimates

Item No.	Item Description	Units	Annual Qty.	Unit Cost	Annual Cost	Source of Unit Cost Estimate[i]
1.0 Engineering Costs						
1.1	Site Inspection and Recordkeeping[ii]	AC	361.1	32	11,555	04/05/21 Victoria CPC Permit Mod
1.2	Correctional Plans and Specifications	AC	361.1	47	16,972	04/05/21 Victoria CPC Permit Mod
1.3 Site Monitoring						
1.3.1 Groundwater Monitoring System						
1.3.1(a)	Sampling and Analysis of GW Monitoring Wells (Quantity = 2 x Number of wells)	Wells	82	950	77,900	04/05/21 Victoria CPC Permit Mod
1.3.1(b)	Piezometers/Well Abandonment	Each	NA	NA	NA	NA
1.3.2 LFG Monitoring System						
1.3.2(a)	LFG Quarterly Monitoring (Quarterly)	Each	4	1,500	6,000	04/05/21 Victoria CPC Permit Mod
1.3.2(b)	GCCS Operations	LS	1	93,000	93,000	Industry Standard Cost
1.3.2(b)	LFG Probe Plugging and Abandonment	Each	NA	NA	NA	NA
1.3.3 Surface Water Monitoring System						
1.3.3(a)	Surface Water Quarterly Monitoring	Each	4	1,700	6,800	04/05/21 Victoria CPC Permit Mod
1.4 Additional Engineering Cost Items (Detail in Attachments)						
1.4.1	Additional Engineering Cost Items (describe in attachments)	Identify attach ments	NA	NA		NA

Item No.	Item Description	Units	Annual Qty.	Unit Cost	Annual Cost	Source of Unit Cost Estimate[i]
1.5 Engineering Costs Subtotal						
1.5.1	Engineering Costs Subtotal	NA	NA	NA	212,227	NA
2.0 Construction and Maintenance Costs						
2.1	Cap and Sideslopes Repairs and Revegetation	LS	1	21,900	21,900	2015 Victoria Cost Estimate
2.2	Mowing and Vegetation Management	LS	1	3,200	3,200	2015 Victoria Cost Estimate
2.3	Groundwater Monitoring System Maintenance	LS	1	2,200	2,200	2015 Victoria Cost Estimate
2.4	LFG Monitoring Probes Maintenance	LS	1	2,800	2,800	2015 Victoria Cost Estimate
2.5	LFG Collection System Maintenance	LS	1	6,400	6,400	2015 Victoria Cost Estimate
2.6	Perimeter Fence and Gates Maintenance	LS	1	1,700	1,700	2015 Victoria Cost Estimate
2.7	Access Roads Maintenance	LS	1	2,800	2,800	2015 Victoria Cost Estimate
2.9 Additional Construction and Maintenance Cost Items (Details in Attachments)						
2.9.1	Additional Construction and Maintenance Cost Items (details in attachments)	Identify attach ments	NA	NA		NA
2.10 Construction and Maintenance Costs Subtotal						
2.10.1	Construction and Maintenance Costs Subtotal	NA	NA	NA	41,000	NA
3.0 Leachate Management						
3.1	Leachate Management System Operation and Maintenance	LS	1	4,600	4,600	2015 Victoria Cost Estimate
3.2	Leachate Disposal	AC	361.1	200	72,220	04/05/21 Victoria CPC Permit Mod

Item No.	Item Description	Units	Annual Qty.	Unit Cost	Annual Cost	Source of Unit Cost Estimate[i]
3.3 Additional Leachate Management Cost Items (Details in Attachments)						
3.4	Additional Leachate Management Cost Items (details in attachments)	Identify attach ments	NA	NA		
3.5 Leachate Management Costs Subtotal						
3.5.1	Leachate Management Costs Subtotal	NA	NA	NA	76,820	NA
4.0 Sum of Engineering, Construction, and Leachate Management Costs						
4.1	Sum of Engineering, Construction, and Leachate Management Cost Subtotals	NA	NA	NA	330,047	NA
5.0 Contingency						
5.1	Contingency (10% of Sum of Engineering, Construction, and Leachate Management Cost Subtotals)	NA	NA	NA	33,005	NA
6.0 Third Party Administration and Project Management Costs						
6.1	Third Party Administration and Project Management Costs (2.5% of Sum of Engineering, Construction, and Leachate Management Cost Subtotals)	NA	NA	NA	8,251	NA
7. Total Post-Closure Cost						
7.1	Total Annual Post-Closure Cost (Sum of amounts in Sections 4, 5, and 6)	NA	NA	NA	371,303	NA
7.2	30 Year Post-Closure Costs (Total Annual Post-Closure Cost x 30)	NA	NA	NA	11,139,083	NA

---

[i] Sources of Unit Cost Estimates may include:

(1) Published Cost Estimator Manuals (e.g., RS Means);
(2) Third Party Quotes (e.g., Environmental Field Services Contractors); or
(3) Verifiable Data based on Actual Operations

[ii] Example Description for Item No. 1.1 – "Includes costs for site inspection performed at least annually for identification of areas experiencing settlement or subsidence, erosion or other drainage-related problems, inspection of the leachate collection system, gas monitoring system and LFG monitoring system."

ATTACHMENT 14 – RUSLE2 REPORT

RUSLE2 Report – Intermediate Phase

Detailed printout of RUSLE2 calculation for multiple fields, one or more management alternatives per field

I. Client/Tract ID & Summary

Client/Owner name: City of Victoria
Location: USA\Texas\Victoria County

Printout date: December 22, 2021
Prepared by (name): Rebecca Warnken
USDA Service Center/Location:

Narrative description of plan, fields, and/or management alternatives being compared:
Two separate landfill section slopes were compared as separated by Scenarios 1A – 1F and Scenarios 2A – 2E. Each section of the slope is bounded on the downward gradient end by a diversion berm or the perimeter channel running along the bottom.

Soil Type was identified using the NRCS Web Soil Survey. This is included in Attachment 14A.

The slopes identified for analysis in each Scenario are shown on Part III, Attachment 1 – Drawings C006 and C007.

Summary of RUSLE2 output for each field & management alternative:

Field name	*Description*	*Cons. plan. soil loss, t/ac/yr*	*Soil conditioning index (SCI)*	*STIR value*
1	**Scenario 1A**	**23**	**-1.7**	**0.15**
1	**Scenario 1B**	**20**	**-1.6**	**0.15**
1	**Scenario 1C**	**48**	**-5.7**	**47**
1	**Scenario 1D**	**56**	**-6.6**	**47**
1	**Scenario 1E**	**56**	**-6.6**	**47**
1	**Scenario 1F**	**20**	**-2.2**	**0.15**
2	**Scenario 2A**	**20**	**-1.6**	**0.15**
2	**Scenario 2B**	**47**	**-5.4**	**47**
2	**Scenario 2C**	**54**	**-5.8**	**47**
2	**Scenario 2D**	**54**	**-5.8**	**47**
2	**Scenario 2E**	**18**	**-2.0**	**0.15**

II. RUSLE2 Plan Inputs

1. CLIMATE (R FACTOR)

Climate Location: USA\Texas\Victoria County (R Factor: 350 US)

2 & 3. SOIL & TOPOGRAPHY (K and LS FACTORS)

Field name	*Soil*	*Slope T Value, t/ac/yr*	*Slope length, ft*	*Slope steepness, %*
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	250	5.0
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	180	5.0
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	60	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	80	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	80	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	61	8.0
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	180	5.0
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	97	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	110	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	110	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	66	7.0

4A. CROP MANAGEMENT (C FACTOR) SUMMARY – ALL FIELDS/ALTERNATIVES

RUSLE2 crop management file name for each field & management alternative:

Field name	*Description*	*Management*
1	Scenario 1A	managements\CMZ 58\d.Construction Site Templates\default
1	Scenario 1B	managements\CMZ 58\d.Construction Site Templates\default
1	Scenario 1C	managements\CMZ 58\d.Construction Site Templates\Construction site
1	Scenario 1D	managements\CMZ 58\d.Construction Site Templates\Construction site
1	Scenario 1E	managements\CMZ 58\d.Construction Site Templates\Construction site
1	Scenario 1F	managements\CMZ 58\d.Construction Site Templates\default
2	Scenario 2A	managements\CMZ 58\d.Construction Site Templates\default
2	Scenario 2B	managements\CMZ 58\d.Construction Site Templates\Construction site
2	Scenario 2C	managements\CMZ 58\d.Construction Site Templates\Construction site
2	Scenario 2D	managements\CMZ 58\d.Construction Site Templates\Construction site
2	Scenario 2E	managements\CMZ 58\d.Construction Site Templates\default

5. SUPPORT PRACTICES (P FACTOR) SUMMARY

Summary of support practices selected for each field & management alternative:

Field name	*Description*	*Contouring system*	*Support practices*	*Terrace/diversion system*
1	Scenario 1A	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1B	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1C	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1D	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1E	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1F	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2A	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2B	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2C	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope

2	Scenario 2D	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2E	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope

6. RUSLE2 SOFTWARE DETAILS

- Program version: Nov 7 2018
- Database name: BASE_NRCS_MOSES_03302016
- Plan file name: plans\Victoria Comparison_Bare Ground

III. RUSLE2 Plan Outputs & Definitions

1. SOIL LOSS ESTIMATES & SOIL QUALITY SCORES – ALL FIELDS & ALTERNATIVES:

Field name	*Description*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*	*Soil conditioning index (SCI)*	*STIR value*
1	Scenario 1A	23	6	-1.7	0.15
1	Scenario 1B	20	6	-1.6	0.15
1	Scenario 1C	48	17	-5.7	47
1	Scenario 1D	56	19	-6.6	47
1	Scenario 1E	56	19	-6.6	47
1	Scenario 1F	20	6	-2.2	0.15
2	Scenario 2A	20	6	-1.6	0.15
2	Scenario 2B	47	18	-5.4	47
2	Scenario 2C	54	20	-5.8	47
2	Scenario 2D	54	20	-5.8	47
2	Scenario 2E	18	6	-2.0	0.15

Cons. Plan. Soil Loss, t/ac/yr = Soil loss for conservation planning in tons/acre/year
Estimate of average annual rainfall-induced soil loss (detachment of soil particles & transport downhill) over the length of the modeled slope. It is critical to understand that this value represents a long-term (20- to 30-year) average, not a prediction of actual soil loss in any single year. This is the number to use for conservation planning and to compare with the field's "T" soil loss tolerance value. This number is a measure of the likelihood of degradation by erosion of the soil resource in upslope (steeper) areas of the field. Very little credit is given for any sediment deposition that may occur towards the bottom of the modeled slope (for example, due to an end-of-slope filter strip), because upslope areas are still being degraded.

Sed. Delivery, t/ac/yr = Sediment delivery, tons/acre/year

Estimate of the amount of sediment delivered by runoff to the end of the modeled slope. This is RUSLE2's best estimate of long-term average "edge of field" soil loss. Full credit is given for any sediment deposition that occurs anywhere on the modeled slope due to reductions in slope grade, filter strips, terraces, etc. This number is not used for conservation planning, but may be used for other environmental applications (e.g., P-Index). In many cases, RUSLE2 users will model slopes as uniform with no structural practices, vegetative features (filter strips), or breaks in topography that result in sediment deposition. In this typical situation, results for sediment delivery and soil loss for conservation planning will be identical.

Soil conditioning index (SCI)
Soil organic matter (SOM) or soil carbon (C) trend score. If SCI is negative (less than zero), SOM and soil C and soil quality are predicted to decline over time on the modeled slope under the modeled management system. If SCI is positive (greater than zero), SOM and soil C and soil quality are predicted to stay the same or to increase over time. SCI scores usually range from -1 to +1 in typical VA situations, although more extreme values are possible. SCI is an index score (no units) designed solely for comparing the relative impact of different management alternatives on long-term soil quality trends. When calculating SCI, RUSLE2 considers three key factors: (1) amount of surface and subsurface biomass returned to the soil; (2) tillage-induced oxidation of soil carbon; and (3) predicted sheet & rill erosion. Climate and soil type inputs are also considered due to the influence of these factors on soil C oxidation trends.

STIR = Soil Tillage Intensity Rating (average annual value for the overall crop rotation)
Measure of intensity of tillage or soil disturbance. STIR is an index (no units) designed solely for comparing the relative impact of different management alternatives on soil disturbance. STIR increases with increasing tillage and can range from 0 to 200+. Average annual STIR values (shown in this printout) reflect the total amount of soil disturbance that occurs during the overall rotation, averaged across the number of years in the rotation. STIR values can also be calculated for individual crops (shown only in the VA Profile Printout w/ Details). The STIR for an individual crop represents the sum of all soil disturbance associated with establishing and harvesting that crop. STIR values in the 5 to 20 range are typical of no-till crops and/or continuous no-till or low soil disturbance cropping systems. In long rotations with a mix of tilled and no-till and/or perennial crops, the average annual STIR for the overall rotation may be relatively low even if significant tillage occurs in individual years and STIR values for one or more crops in the rotation are relatively high.

Vegetated Phase

Detailed printout of RUSLE2 calculation for multiple fields, one or more management alternatives per field

I. Client/Tract ID & Summary

Client/Owner name: City of Victoria
Tract #:
Location: USA\Texas\Victoria County

Printout date: December 22, 2021
Prepared by (name): Rebecca Warnken
USDA Service Center/Location:

Narrative description of plan, fields, and/or management alternatives being compared:
Two separate landfill section slopes were compared as separated by Scenarios 1A – 1F and Scenarios 2A – 2E. Each section of the slope is bounded on the downward gradient end by a diversion berm or the perimeter channel running along the bottom.

Soil Type was identified using the NRCS Web Soil Survey. This is included in Attachment 14A.

The slopes identified for analysis in each Scenario are shown on Part III, Attachment 1 – Drawings C006 and C007.

Summary of RUSLE2 output for each field & management alternative:

Field name	*Description*	*Cons. plan. soil loss, t/ac/yr*	*Soil conditioning index (SCI)*	*STIR value*
1	**Scenario 1A**	**1**	**0.72**	**0**
1	**Scenario 1B**	**1**	**0.72**	**0**
1	**Scenario 1C**	**3**	**0.54**	**0**
1	**Scenario 1D**	**3**	**0.54**	**0**
1	**Scenario 1E**	**3**	**0.54**	**0**
1	**Scenario 1F**	**1**	**0.71**	**0**
2	**Scenario 2A**	**1**	**0.72**	**0**
2	**Scenario 2B**	**2**	**0.58**	**0**
2	**Scenario 2C**	**2**	**0.58**	**0**
2	**Scenario 2D**	**2**	**0.58**	**0**
2	**Scenario 2E**	**1**	**0.72**	**0**

II. RUSLE2 Plan Inputs

1. CLIMATE (R FACTOR)

Climate Location: USA\Texas\Victoria County (R Factor: 350 US)

2 & 3. SOIL & TOPOGRAPHY (K and LS FACTORS)

Field name	*Soil*	*Slope T Value, t/ac/yr*	*Slope length, ft*	*Slope steepness, %*
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	250	5.0
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	180	5.0
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	60	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	80	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	80	33
1	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	61	8.0
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	180	5.0
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	100	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	110	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	110	25
2	soils\SSURGO\Victoria County, Texas\LaA Laewest clay, 0 to 1 percent slopes\Laewest Clay 90%	5	66	7.0

4A. CROP MANAGEMENT (C FACTOR) SUMMARY – ALL FIELDS/ALTERNATIVES

RUSLE2 crop management file name for each field & management alternative:

Field name	*Description*	*Management*
1	Scenario 1A	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
1	Scenario 1B	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
1	Scenario 1C	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
1	Scenario 1D	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
1	Scenario 1E	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
1	Scenario 1F	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
2	Scenario 2A	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
2	Scenario 2B	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
2	Scenario 2C	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
2	Scenario 2D	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested
2	Scenario 2E	managements\Strip/Barrier Managements\Common Bermudagrass; not harvested

5. SUPPORT PRACTICES (P FACTOR) SUMMARY

Summary of support practices selected for each field & management alternative:

Field name	*Description*	*Contouring system*	*Support practices*	*Terrace/diversion system*
1	Scenario 1A	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1B	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1C	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1D	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
1	Scenario 1E	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope

1	Scenario 1F	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2A	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2B	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2C	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2D	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope
2	Scenario 2E	contour-systems\c. perfect contouring no row grade	-- none --	hydraulic-element-systems\1 Diversion 1.0% grade at bottom of RUSLE slope

6. RUSLE2 SOFTWARE DETAILS

- Program version: Nov 7 2018
- Database name: BASE_NRCS_MOSES_03302016
- Plan file name: plans\Victoria Comparison

III. RUSLE2 Plan Outputs & Definitions

1. SOIL LOSS ESTIMATES & SOIL QUALITY SCORES – ALL FIELDS & ALTERNATIVES:

Field name	*Description*	*Cons. plan. soil loss, t/ac/yr*	*Sed. delivery, t/ac/yr*	*Soil conditioning index (SCI)*
1	Scenario 1A	1	1	0.72
1	Scenario 1B	1	1	0.72
1	Scenario 1C	3	3	0.54
1	Scenario 1D	3	3	0.54
1	Scenario 1E	3	3	0.54
1	Scenario 1F	1	1	0.71
2	Scenario 2A	1	1	0.72
2	Scenario 2B	2	2	0.58
2	Scenario 2C	2	2	0.58
2	Scenario 2D	2	2	0.58
2	Scenario 2E	1	1	0.72

Cons. Plan. Soil Loss, t/ac/yr = Soil loss for conservation planning in tons/acre/year

Estimate of average annual rainfall-induced soil loss (detachment of soil particles & transport downhill) over the length of the modeled slope. It is critical to understand that this value represents a long-term (20- to 30-year) average, not a prediction of actual soil loss in any single year. This is the number to use for conservation planning and to compare with the field's "T" soil loss tolerance value. This number is a measure of the likelihood of degradation by erosion of the soil resource in upslope (steeper) areas of the field. Very little credit is given for any sediment deposition that may occur towards the bottom of the modeled slope (for example, due to an end-of-slope filter strip), because upslope areas are still being degraded.

Sed. Delivery, t/ac/yr = Sediment delivery, tons/acre/year
Estimate of the amount of sediment delivered by runoff to the end of the modeled slope. This is RUSLE2's best estimate of long-term average "edge of field" soil loss. Full credit is given for any sediment deposition that occurs anywhere on the modeled slope due to reductions in slope grade, filter strips, terraces, etc. This number is not used for conservation planning, but may be used for other environmental applications (e.g., P-Index). In many cases, RUSLE2 users will model slopes as uniform with no structural practices, vegetative features (filter strips), or breaks in topography that result in sediment deposition. In this typical situation, results for sediment delivery and soil loss for conservation planning will be identical.

Soil conditioning index (SCI)
Soil organic matter (SOM) or soil carbon (C) trend score. If SCI is negative (less than zero), SOM and soil C and soil quality are predicted to decline over time on the modeled slope under the modeled management system. If SCI is positive (greater than zero), SOM and soil C and soil quality are predicted to stay the same or to increase over time. SCI scores usually range from -1 to +1 in typical VA situations, although more extreme values are possible. SCI is an index score (no units) designed solely for comparing the relative impact of different management alternatives on long-term soil quality trends. When calculating SCI, RUSLE2 considers three key factors: (1) amount of surface and subsurface biomass returned to the soil; (2) tillage-induced oxidation of soil carbon; and (3) predicted sheet & rill erosion. Climate and soil type inputs are also considered due to the influence of these factors on soil C oxidation trends.

STIR = Soil Tillage Intensity Rating (average annual value for the overall crop rotation)
Measure of intensity of tillage or soil disturbance. STIR is an index (no units) designed solely for comparing the relative impact of different management alternatives on soil disturbance. STIR increases with increasing tillage and can range from 0 to 200+. Average annual STIR values (shown in this printout) reflect the total amount of soil disturbance that occurs during the overall rotation, averaged across the number of years in the rotation. STIR values can also be calculated for individual crops (shown only in the VA Profile Printout w/ Details). The STIR for an individual crop represents the sum of all soil disturbance associated with establishing and harvesting that crop. STIR values in the 5 to 20 range are typical of no-till crops and/or continuous no-till or low soil disturbance cropping systems. In long rotations with a mix of tilled and no-till and/or perennial crops, the average annual STIR for the overall rotation may be relatively low even if significant tillage occurs in individual years and STIR values for one or more crops in the rotation are relatively high.

ATTACHMENT 14A – SOIL MAP

Hydrologic Soil Group—Victoria County, Texas

Map Scale: 1:14,900 if printed on A landscape (11" x 8.5") sheet.

Meters: 0, 200, 400, 800, 1200

Feet: 0, 500, 1000, 2000, 3000

N

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 14N WGS84

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Victoria County, Texas
Survey Area Data: Version 19, Sep 10, 2021

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Apr 23, 2020—Apr 25, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
DnA	Dacosta-Contee complex , 0 to 1 percent slopes	D	10.2	3.4%
LaA	Laewest clay, 0 to 1 percent slopes	D	293.1	96.6%
Totals for Area of Interest			**303.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

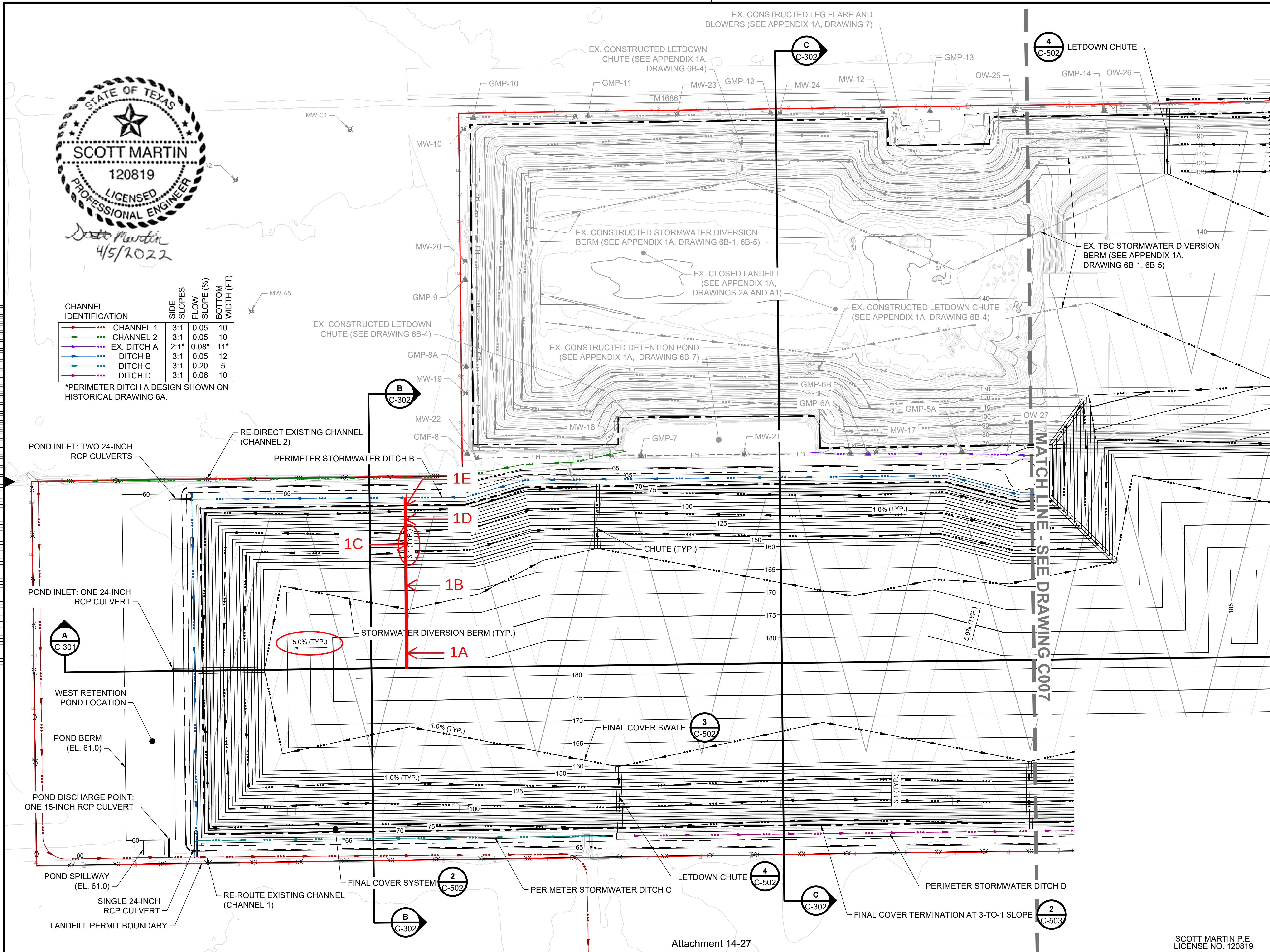
Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher

ATTACHMENT 14B – CALCULATION LOCATION DRAWINGS



CHANNEL IDENTIFICATION	SIDE SLOPES	FLOW SLOPE (%)	BOTTOM WIDTH (FT)
CHANNEL 1	3:1	0.05	10
CHANNEL 2	3:1	0.05	10
EX. DITCH A	2:1*	0.08*	11*
DITCH B	3:1	0.05	12
DITCH C	3:1	0.20	5
DITCH D	3:1	0.06	10

*PERIMETER DITCH A DESIGN SHOWN ON HISTORICAL DRAWING 6A.

no.	date	by	ckd	description
A	3/28/22	TJS	SAM	INITIAL SUBMITTAL

NOTES:

1. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER. DESIGN CONTOUR INTERVAL IS 5-FEET. BACKGROUND CONTOURS REPRESENT TOP OF SOIL LINER AND EXISTING GROUND (OUTSIDE OF TRENCHES 6-9, EASTERN PORTION OF TRENCH 5 AND CELLS A1-I2). BACKGROUND CONTOUR INTERVAL IS 2-FEET.

PRELIMINARY - NOT FOR CONSTRUCTION

BURNS & McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MARCH 2022
detailed: T. CAMMACK
designed: T. SCHMIDT
checked: S. MARTIN

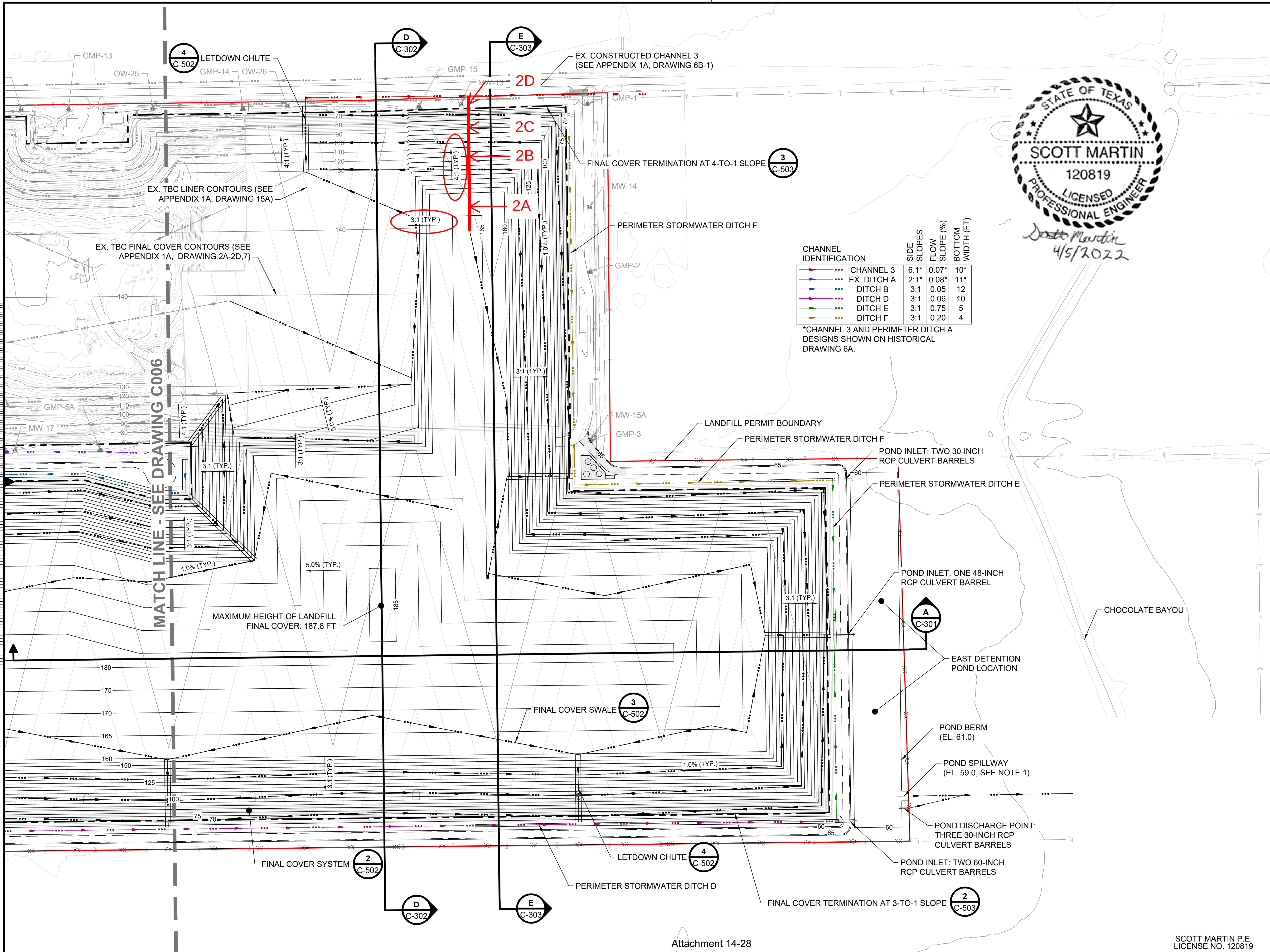
THE CITY OF VICTORIA TEXAS
Victoria County, Texas

1522B PERMIT AMENDMENT

FINAL GRADING PLAN - WEST

project: 107608
contract: -
drawing: C006 — rev. A
sheet 8 of 23 sheets
file 107608C006.dwg

SCOTT MARTIN P.E.
LICENSE NO. 120819



CHANNEL IDENTIFICATION	SIDE SLOPES	FLOW SLOPE (%)	BOTTOM WIDTH (FT)
CHANNEL 3	6:1*	0.07*	10*
EX. DITCH A	2:1*	0.08*	11*
DITCH B	3:1	0.05	12
DITCH D	3:1	0.06	10
DITCH E	3:1	0.75	5
DITCH F	3:1	0.20	4

*CHANNEL 3 AND PERIMETER DITCH A DESIGNS SHOWN ON HISTORICAL DRAWING 6A.

STATE OF TEXAS — SCOTT MARTIN — 120819 — LICENSED PROFESSIONAL ENGINEER
Scott Martin 4/5/2022

no.	date	by	ckd	description
A	3/28/22	TJS	SAM	INITIAL SUBMITTAL

NOTES:

1. THE EAST POND DISCHARGES INTO AN EXISTING DITCH NOT SHOWN IN THE EXISTING TOPOGRAPHY.
2. DESIGN CONTOURS REPRESENT TOP OF FINAL COVER. DESIGN CONTOUR INTERVAL IS 5-FEET. BACKGROUND CONTOURS REPRESENT TOP OF SOIL LINER AND EXISTING GROUND (OUTSIDE OF TRENCHES 6-9, EASTERN PORTION OF TRENCH 5 AND CELLS A1-I2). BACKGROUND CONTOUR INTERVAL IS 2-FEET.

PRELIMINARY - NOT FOR CONSTRUCTION

BURNS McDONNELL
9400 WARD PARKWAY
KANSAS CITY, MO 64114
816-333-9400
Burns & McDonnell Engineering Co, Inc.
FIRM REG. NO. F-845

date: MARCH 2022 — detailed: T. CAMMACK
designed: T. SCHMIDT — checked: S. MARTIN

THE CITY OF VICTORIA TEXAS
Victoria County, Texas

1522B PERMIT AMENDMENT
FINAL GRADING PLAN - EAST

project: 107608 — contract: -
drawing: C007 — rev. A
sheet 9 of 23 sheets
file 107608C007.dwg

SCOTT MARTIN P.E.
LICENSE NO. 120819

BURNS & McDONNELL

CREATE AMAZING.

Burns & McDonnell Engineering Company, Inc.
8911 Capital of Texas Highway \ Building 3, Suite 3100
Austin, TX 78759
O 512-872-7130
F 512-872-7127
www.burnsmcd.com