REPORT

CLOSURE PLAN ADDENDUM NO. 1

Sandow Steam Electric Station - AX Landfill
Milam County, Texas

Submitted to:

Luminant Generation Company LLC

Submitted by:

WSP GOLDER

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November 2022

PROFESSIONAL CERTIFICATION

This document and all attachments were prepared by WSP Golder under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I hereby certify that Addendum No.1 to the Closure Plan for the AX Landfill at the Sandow Steam Electric Station has been prepared in accordance with the requirements of 40 C.F.R. §257.102(b).

Patrick J. Behling, P.E.
Principal Engineer
WSP Golder
Texas Firm Registration No. 22771

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DOCUMENT REVISION RECORD

Issue No.	Date	Details of Revisions
Revision 0	October 2016	Original Document
Addendum 1	November 2022	Added Slope Stability Model sealed by a Professional Engineer licensed in the State of Texas and confirmation that the Slope Stability Model will be updated using site-specific geotechnical data during final closure

1.0 INTRODUCTION

On behalf of Luminant Generation Company LLC (Luminant), WSP Golder (Golder) has prepared this Addendum No. 1 to the Closure Plan for the AX Landfill (AX LF) located at the Sandow Steam Electric Station (SASES) in Milam County, Texas (hereafter, the “Site”). Luminant formerly operated the SASES and Coal Combustion Residuals (CCR) including fly ash and bed ash generated as part of SASES operation were placed in the AX LF. The AX LF is regulated as an Existing CCR Landfill under 40 C.F.R. § 257, Subpart D (the “CCR Rule”).

The original Closure Plan for the AX LF was prepared in October 2016 in accordance with 40 C.F.R. §257.102(b) and placed in the SASES operating record in accordance with 40 C.F.R. §257.105(h)(10) (PBW, 2016). This Addendum No. 1 updates the Closure Plan to reflect the following:

- Inclusion of a Cap/Cover System Slope Stability Model sealed by a Professional Engineer licensed in the State of Texas; and
- Confirmation that the Cap/Cover System Slope Stability Model will be updated using site-specific geotechnical data during final closure of the AX LF.

2.0 CAP/COVER SYSTEM SLOPE STABILITY MODELING

A final cap/cover system will be constructed over the CCR placed in the AX LF as part of unit closure as described in the 2016 Closure Plan (PBW, 2016). The final cap/cover system for the AX LF described in the 2016 Closure Plan consisted of the following (from bottom to top):

- Minimum 6 inches of select fill on top of CCR to serve as cap subgrade;
- A 40-mil linear low density polyethylene (LLDPE) geomembrane liner;
- A geonet drainage layer to provide lateral drainage of infiltration from the overlying soil layers;
- A 12-inch minimum thickness fill soil layer and a 6-inch minimum thickness vegetative soil layer placed over the geonet drainage layer; and
- Permanent vegetative cover established on the vegetative soil.

The cap/cover system will be constructed using suitable materials, proper material placement, and quality assurance testing to ensure stability of the final cover system.

Slope stability modeling documentation was included as Appendix C to the 2016 Closure Plan to demonstrate that the proposed cap/cover system is stable at the design cap slopes and Cap/Cover System Slope Stability Model documentation sealed by a Professional Engineer licensed in the State of Texas is attached as Appendix A to this Addendum No. 1.

It should be noted that the Cap/Cover System Slope Stability Model in Appendix A to this Addendum No. 1 was completed using generic geotechnical data for the cap/cover system components since closure of the AX LF will occur at a future date and the specific materials selected for the cap will be determined at that time. The AX LF Closure Plan will be updated to include a revised Cap/Cover System Slope Stability Model using site-specific geotechnical data during design of the final cap/closure system for the AX LF.

3.0 REFERENCES

Pastor, Behling & Wheeler, LLC (PBW), 2016. CCR Closure Plan – AX Landfill, Sandow 5 Generating Plant, Rockdale, Texas. October.

APPENDIX A

Cap/Cover System Slope Stability Model Documentation

Bullock, Bennett & Associates, LLC ∗ 165 N. Lampasas Street ∗ Bertram, Texas 78605
Telephone: 512.355.9198 ∗ Fax: 512.355.9197

September 30, 2016

Mr. Pat Behling
Pastor, Behling & Wheeler, LLC
2201 Double Creek Dr., Suite 4004
Round Rock, TX 78664

Re: Evaluation of Landfill Cap Slope Stability – Sandow Unit No. 5 AX Landfill, near Rockdale, Texas

Dear Mr. Behling:

As requested by Pastor, Behling & Wheeler, LLC (PBW), Bullock, Bennett & Associates, LLC (BBA) has completed evaluation of slope-stability of the proposed cap for the AX Landfill at the Sandow Mine located near Rockdale, Texas. This analysis is based on the most recent preliminary design drawings dated August 2016, provided to BBA by PBW. No site specific geotechnical data was provided to BBA for this analysis, therefore, assumptions regarding typical soil properties and interface friction angles are made in this evaluation. It is recommended that site-specific soils and proposed synthetic materials be tested for engineering strength properties, and slope stability analysis using the on-site data and final design criteria be completed prior to construction activities.

<u>Stability Analysis of Synthetic Cap Components</u>

This stability analysis is limited to evaluation of veneer cover soils and synthetics on 4(H):1(V) slopes, assuming the following cap configuration (from bottom to top):

<u>Synthetic Cap System</u>

- Compacted clay subgrade;
- Textured (both sides) flexible membrane liner (FML);
- Double-sided (geotextile on both sides) geonet drainage layer; and,
- 1.5 foot-thick cover soils.

Soil slopes of 4(H):1(V) typically are stable and do not require slope stability analysis; however, when placed as a thin veneer over a barrier such as a synthetic liner/lateral drainage layer, stability can be compromised if resisting forces along the material interfaces are not sufficient to prevent sliding. To evaluate these conditions for the proposed cap systems described above, slope stability analysis was completed using limit equilibrium and a finite slope model. As discussed in the attached analysis, veneer cover soil slope stability is very sensitive to the interface friction angle of materials, while typical variance of soil properties such as unit weight and internal friction angle have considerably less effect on the analysis. Given the sensitivity to interface friction angle, this parameter was varied for analysis, while a generally representative soil unit weight and internal friction angle were used.

A range of interface friction angles from 19 to 27 were used to capture the range associated with proposed cap components, as shown in the attached Appendix Table 1 of the *Geosynthetics Research Institute, Direct Shear Database of Geosynthetic-to Geosynthetic and Geosynthetic-to-Soil Interfaces (Koerner, Narejo, June 14, 2005)*. For conservative analysis, cohesion and adhesion values were assumed to be zero. A unit weight and internal friction angle of 115 pounds per cubic foot (pcf) and 15 degrees, respectively, were used for the soil and are generally representative of commonly available soils in Texas, including a wide range of silty, sandy, and lean to fat clays commonly used as cover soil.

Estimated factors of safety for this analysis range from approximately 1.4 to 2.0 for interface friction angles ranging from 19 to 27, respectively, with assumed cohesion and adhesion values of zero. See *Veneer Cover Soil Analysis of Synthetic Cap System* in Attachment 1 for calculations and further stated assumptions.

Please find attached the landfill cap slope stability analysis and supporting notes, assumptions, and documentation, and please feel free to contact me at (512) 355-9198 if you have any questions about this submittal, or if I can be of any further assistance.

Sincerely,

BBA, LLC

Dan Bullock, P.E.
Principal Engineer

STATE OF TEXAS
DANIEL B. BULLOCK
82596
REGISTERED
PROFESSIONAL ENGINEER
9/30/2016

Attachments

ATTACHMENT 1

Veneer Cover Soil Analysis of Synthetic Cap System

LANDFILL COVER SLOPE STABILITY ANALYSIS
Sandow Unit No. 5 AX Landfill, near Rockdale, Texas

DEFINITION OF TERMS

Wa	Total weight of active wedge
Wp	Total weight of passive wedge
Na	Effective force normal to the failure plane of the active wedge
Np	Effective force normal to the failure plane of the passive wedge
Y	Unit weight of the cover soil
h	Thickness of the cover soil
L	Length of slope measured along the geomembrane
B	Soil slope angle beneath the geomembrane
Phi	Friction angle of the cover soil
Delta	Interface friction angle between cover soil and geomembrane
Ca	Adhesive force between cover soil of the active wedge and the geomembrane
ca	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
Ea	Interwedge force acting on the active wedge from the passive wedge
Ep	Interwedge force acting on the passive wedge from the active wedge, and
FS	Factor of safety against cover soil sliding on the geocomposite

EQUATIONS: (Designing with Geosynthetics (4th Edition), Robert M. Koerner)

Wa = Yh^2(L/h - 1/sinB - tanB/2) (3.14)

Na= WaCosB (3.15)

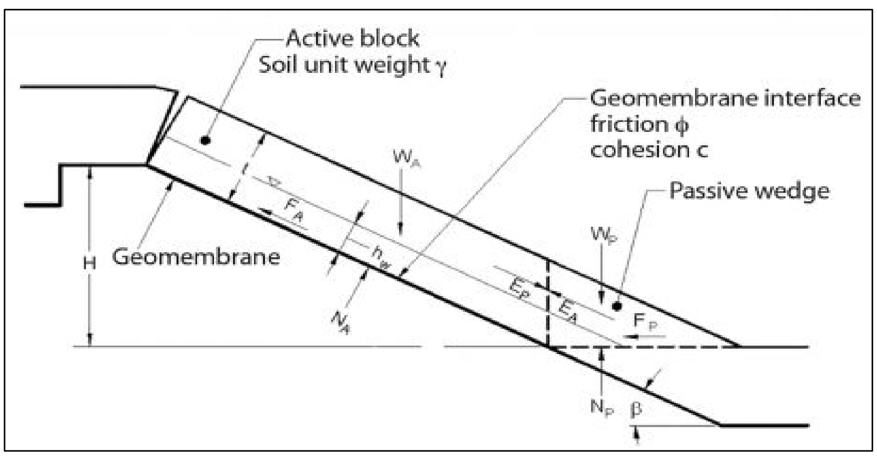
Wp= Yh^2/Sin2B (3.17)

a=(Wa-NaCosB)CosB

b=-[(Wa-NaCosB)sinB*tanPhi+(NaTanDelta+Ca)SinBCosB+sinB(C+WpTanPhi)]

c=(NaTanDelta+Ca)Sin^2BTanPhi

$$FS = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \qquad (3.22)$$



FREE BODY DIAGRAM

LANDFILL COVER SLOPE STABILITY ANALYSIS
Sandow Unit No. 5 AX Landfill, near Rockdale, Texas

INPUT PARAMETERS:

Delta	19	21	23	25	27	degrees
Y	115	115	115	115	115	pcf
Phi	15	15	15	15	15	degrees
h	1.5	1.5	1.5	1.5	1.5	feet
L	3000	3000	3000	3000	3000	feet
B	14.04	14.04	14.04	14.04	14.04	degrees
Ca	0	0	0	0	0	
ca	0	0	0	0	0	
C	0	0	0	0	0	
c	0	0	0	0	0	

CALCULATIONS:

Wa	516,401.07	516,401.07	516,401.07	516,401.07	516,401.07	lb/ft
Wp	549.71	549.71	549.71	549.71	549.71	lb/ft
Na	500,974.42	500,974.42	500,974.42	500,974.42	500,974.42	lb/ft
a	29,515.82	29,515.82	29,515.82	29,515.82	29,515.82	
b	-42,609.43	-47,270.98	-52,059.21	-56,991.52	-62,087.13	
c	2,773.75	3,092.24	3,419.38	3,756.37	4,104.51	
FS	**1.38**	**1.53**	**1.70**	**1.86**	**2.04**	

NOTES/ASSUMPTIONS:

- Assumes cap system includes, from bottom to top: 1 foot compacted clay subgrade, 40 mil textured FML, double-sided geocomposite drainage layer (geotextile on both sides), and 1.5 feet of vegetative cover soil.
- Assumes slopes of 4(h):1(v) (14.04 deg).
- Assumes solid waste is stable (stability of waste not evaluated).
- Dynamic loading associated with construction or operations equipment were not evaluated. Use of construction methods protective of the liner system are assumed.
- Assumes effective lateral drainage layer and drained cover soil conditions prevents excess pore water pressure.
- Assumes no landfill gas migration into cap components.
- Interface friction angles between geotextile and soil, and between FML and geotextile are considered. For conservative evaluation purposes, no contribution of material tensile strengths, adhesion, or cohesion are considered for increased stability.
- Sensitivity analysis indicates very little effect on FS with moderate (plus or minus 10 pcf) change in soil unit weight and soil friction angle (plus or minus 10 degrees) parameters, but is very sensitive to variation in interface friction angles therefore, 5 different interface friction angles (19, 21, 23, 25, and 27) were evaluated. Typical values for interface friction angle are provided in attachments. GRI30 - Appendix Table 1 (Geosynthetics Research Institute, Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces - Koerner, Narejo, June 14, 2005) is attached.
- Assumes cover soil of uniform thickness and constant unit weight. Unit weight of 115 pcf, and friction angle of 15 degrees assumed.
- Due to lack of available on-site soil data, generalized soil engineering properties were assumed. A general range of synthetic material interface friction angles (with soil and other synthetic materials) were also assumed. Use of actual on-site soil materials and proposed synthetic materials for follow up laboratory testing and slope stability analysis is recommended prior to construction. Testing should include interface friction angle (and internal friction angle, as appropriate) measurements for all materials.
- Maximum slope length of less than 3,000 feet measured from preliminary design drawings, 3,000 feet was conservatively used in calculations.

ATTACHMENT 2

GRI30 – Appendix Table 1

Drexel
UNIVERSITY

Geosynthetic Research Institute
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TEL (610) 522-8440
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Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces

by

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GRI Report #30

June 14, 2005

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