CLOSURE PLAN

Chesterfield Power Station FFCP Management Facility
Solid Waste Permit 609
Chesterfield County, Virginia

Prepared for:

Dominion Energy

Dominion Energy Virginia
120 Tredegar Street
Richmond, Virginia 23219

COMMONWEALTH OF VIRGINIA
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09/29/2023
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ATTACHMENTS

CERTIFICATION

This Closure Plan for the Chesterfield Power Station Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) was prepared by Schnabel Engineering (Schnabel). The document and Certification/Statement of Professional Opinion are based on and limited to information that Schnabel has relied on from Dominion Energy and others, but not independently verified.

On the basis of and subject to the foregoing, it is my professional opinion as a Professional Engineer licensed in the Commonwealth of Virginia that this document has been prepared in accordance with good and accepted engineering practices as exercised by other engineers practicing in the same discipline(s), under similar circumstances, at the same time, and in the same locale. It is my professional opinion that the document was prepared consistent with the requirements in the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (CCR Rule, 40 CFR §257 Subpart D) as well as the Virginia Department of Environmental Quality's Virginia Solid Waste Management Regulations (VSWMR, 9VAC20-81).

The use of the word "certification" and/or "certify" in this document shall be interpreted and construed as a Statement of Professional Opinion and is not and shall not be interpreted or construed as a guarantee, warranty, or legal opinion.

James R. DiFrancesco, P.E.

Name

Principal / Practice Leader Solid Waste

Title

Signature

September 29, 2023

Date

1.0 PURPOSE

This Closure Plan (Plan) has been prepared for the Chesterfield Power Station (Station) Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) located in North Chesterfield, Virginia. The Facility accepts coal combustion residuals (CCR) previously and currently generated at the Station and operates as a captive industrial landfill (CCR Unit) under the Virginia Department of Environmental Quality (DEQ) Solid Waste Permit (SWP) 609.

The contents of this Closure Plan were previously prepared by Golder Associates Inc., dated July 2012, as part of SWP 609 and last approved by DEQ February 2017. Schnabel Engineering (Schnabel), on behalf of the Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy), has revised this plan to reflect updated site conditions and regulatory requirements.

The Facility is subject to the closure requirements in the United States Environmental Protection Agency's "Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments" (CCR Rule, 40 CFR §257 Subpart D) as well as the DEQ's Virginia Solid Waste Management Regulations (VSWMR, 9VAC20-81).

1.1 Closure Plan Implementation

The final cover system is designed in accordance with the requirements of both the VSWMR and the CCR Rule to lessen the need for maintenance after closure through adequate implementation of stormwater run-off controls which prevent sloughing and reduce the potential for erosion; prevent the impoundment of water and minimize hydraulic head on the liner system; and prevent exposure of the final cover components and underlying CCR wastes.

The CCR Unit will be developed per Attachment III of the Part B Permit (Design Plans). The total capped area of the CCR Unit will be approximately 66 acres and features infiltration, barrier, and drainage components to prevent water percolation into the CCR Unit and the saturation of cover soils. The maximum CCR Unit sideslope grade is 3H:1V (horizontal to vertical), with stormwater benches and tack-on berms that are designed to intercept sheet flow from the final cover before it can concentrate into an erosive flow. Vegetation will be established and maintained on the protective cover soil layer for all capped areas of the CCR Unit.

2.0 CLOSURE ACTIVITIES

2.1 Closure Plan Timeframe

Virginia Code §10.1-1402.03 requires the Chesterfield Lower and Upper Ash Ponds be closed by removal or beneficiation of impounded CCR by 2034. The Facility will be used to dispose of CCR generated from the pond closures and any authorized Station wastes. Dates for the final receipt of CCR and final closure may vary from the table below depending on facility fill rates, remaining capacity, and regulatory changes. Currently, it is anticipated the Facility will cease accepting CCR by 2036 and complete closure by 2038. Progressive closure construction is expected to be in accordance with timeframes outlined in the table below. The final closure date may vary depending on the ash generation and beneficial use rate. Construction of the final closure cap of the facility will take place in three interim stages:

Closure Stage	Approximate Area, Ac.	Approximate Closure Year
1	21	2025

2	14	2028
3	32	2038
Final		2038

Selection of the interim closure stage is based on the CCR Unit fill sequence and when an area of approximately 15 to 20 acres is at final grades and can be closed. Exhibit B shows the approximate closure areas for each closure stage. Supporting calculations for the approximate closure year are included in Appendix A.

2.2 Inventory Removal and Disposal

Facility equipment and temporary structures used during normal operations will be removed after their usefulness ends. Lubricants, fuel, waste oil, and other residues used or generated as part of Facility operations will be managed and disposed of appropriately. Operational equipment should not require decontamination, and routine equipment maintenance will be performed to minimize the risk of contamination from lubricants or fuel oil used at the Facility.

2.3 Closure of Surface Impoundments

The two sediment basins serving the Facility will have accumulated sediment removed and the basins will be transitioned into permanent stormwater management ponds. The ponds will be left in place to manage stormwater flow from the site.

The lined contact stormwater basin, which handles stormwater that has come into contact with CCR, will have any remaining accumulated sediments removed and disposed of at a permitted, Dominion Energy-approved, off-site disposal facility as part of final closure activities. The pond liner will be removed and the subgrade inspected for contamination. If contaminated soil is found, it will be excavated and disposed of off-site as part of final closure activities. The principal spillway intake structure will be removed and the outlet pipe permanently closed. The auxiliary spillway will be deepened to allow flow into the adjacent unlined stormwater pond. The inside sideslopes and other disturbed areas of the pond will then be seeded to establish vegetation above the normal pool level.

3.0 FINAL COVER DESIGN

Final closure will be performed progressively as significant portions (approximately 15- to 20- acre areas) of the Facility are filled to design grades. The Final Cover Design is a pre-approved alternate as described in 9VAC20-81-160.D.2.e. Final closure will be conducted to fulfill requirements of the permit and the construction plan as described below:

- The closure side slopes are designed for a maximum 3H:1V (Horizontal to Vertical) slope, and the crown is designed with a minimum seven percent slope.
- The final cover design consists of (from the bottom up):
  - 12-inch compacted subgrade (soil or CCR);
  - 40-mil textured high-density polyethylene (HDPE) geomembrane;
  - 250-mil double-sided geocomposite;
  - A minimum 18-inch infiltration layer of compacted soil; and,
  - A minimum 6-inch layer of vegetative support soil that is subsequently seeded.

- The final closure grading is sloped so that runoff will be directed to the sedimentation basin located at the east end of the facility.

The final cover system is designed in accordance with 40 CFR §257.102(d)(3)(i), including the use of a geomembrane liner to minimize the infiltration of liquids into the FFCP. The final cover system is designed to prevent the future impoundment of water, and includes measures to prevent sloughing, minimize erosion, and prevent excessive hydraulic head build-up. The final cover system is designed to minimize the need for maintenance after closure. The largest area requiring a final cover is estimated at approximately 66 acres.

Construction quality assurance procedures for the geosynthetic and soil components of the final closure system are, included in Attachment VII of the Part B Permit (Construction Quality Assurance (CQA) Plan and Technical Specifications). Final closure material descriptions and construction methods are included in the Technical Specifications.

3.1 Components of the Final Cover System

The final cover system consists of the following described components, which shall conform to the requirements presented in the CQA Plan and Technical Specifications. The proposed Final Cover for the Chesterfield FFCP Facility is considered a pre-approved alternate as described in 9VAC20-81-160.D.2.e, and an alternate under 4040 CFR §257.102(d)(3).

3.1.1 Liner Subgrade

The subgrade for the barrier layer geomembrane will consist of compacted soil or CCR material that meets the liner subgrade requirements as specified in the Technical Specifications. The liner subgrade shall not contain particles larger than 3/8" and will be rolled with a smooth-drum roller to flatten out wheel ruts and protrusions that may damage the overlying geosynthetics.

3.1.2 Barrier / Infiltration Layer

The proposed barrier layer for the facility is 40 mil High Density Polyethylene (HDPE) geomembrane liner meeting the requirements of the Technical Specifications. HDPE was selected due to its combination of being a physically "tough" barrier composed of a highly chemically resistant material. Long term settlement of the in-place CCR is anticipated to be negligible due to the rapid consolidation properties of the material, so liner strain is not expected to occur. A demonstration showing the adequacy of the geomembrane component for the proposed final cover system is included in Attachment XVI of the Part B Permit (Alternate Final Cover Demonstration).

3.1.3 Cover Drainage Layer

A drainage layer, consisting of 250-mil double-sided geocomposite, will be installed on top of the barrier layer to provide drainage for the protective cover soils. The geocomposite will prevent the cover soils from becoming saturated, which will help prevent slope failure. Collected drainage from within the geocomposite will drain to the perimeter drainage system at the toe of the slope. This collected water will not be exposed to CCR and will be treated as ordinary stormwater. A demonstration showing the adequacy of the proposed drainage layers is included in the Alternate Final Cover Demonstration.

3.1.4 Erosion Control / Protective Cover Layer

The 18-inch protective cover layer will be constructed of on-site soils. The protective cover layer will be placed and compacted to at least 90% of its Standard Proctor Density, in accordance with the Technical Specifications.

3.1.5 Vegetative Support Layer

The top six inches of the Final Cover System will be the vegetative support layer soil. This soil will be placed, but not compacted, and then seeded in accordance with the Technical Specifications or with a site-specific mixture based on recommendations from a soils report. In either case, the seed mixture will consist mainly of turf-type grasses and nurse crops that will lend themselves to quickly establishing a healthy stand of grass. Woody vegetation is not allowed on the Final Cover System. Established vegetation will be maintained by mowing and application of fertilizer as required to maintain a healthy stand of vegetation.

3.1.6 Cover System Performance

The combined 24-inch-thick final cover soil is sufficiently thick to protect the underlying geosynthetics from freezing. The maximum anticipated depth of frost penetration for central Virginia is approximately 20 inches (0.5 meters).

The cover system soils will consist of on-site soils that are fine-grained loamy soils that generally exhibit some degree of plasticity and are classified as low to moderately erodible by wind and water. The calculated soil loss by the Revised Universal Soil Loss Equation (RUSLE) is 1.79 tons per acre per year for the CCR Unit. Calculations for the RUSLE are included in Attachment 2.

3.1.7 Erosion and Sediment Control

Erosion and Sediment Control will be performed in accordance with the current edition of the Virginia Erosion and Sediment Control Handbook (VESCH). Typically, this will involve the construction and maintenance of stormwater diversions, temporary and permanent seeding, and stone outlet protection, as shown in the Design Plans.

Vegetation will be established in accordance with the Technical Specifications to provide protection from direct raindrop erosion. Prior to seeding, the vegetative support layer will be roughened by tracking a bulldozer along the slopes providing a surface of small depressions that will aid in establishing vegetative cover and reducing run-off velocity. Until vegetation is established, mulch or temporary erosion matting,as appropriate and necessary, will be installed over the seeded surface.

Calculations for the stormwater diversion and collection system are included in Attachment 4. Erosion and sediment control details are included in the Design Plans.

3.2 Final Slopes

The proposed final slopes for the Facility are a maximum of 3:1 on the sideslopes and 7% on the top deck. To protect from erosion, diversion berms will be constructed at a maximum vertical spacing of 30 feet to collect surface runoff into a protected channel before it has time to concentrate into small rivulets and cause erosion. The diversion berms are protected with appropriate lining to minimize erosion.

The global and veneer stability of the Facility was previously analyzed by Golder Associates as part of the initial permitting of the CCR Unit. As a result of seismic impact zone mapping updates, the Facility is now located in a seismic impact zone as defined by the EPA. The maximum horizontal ground acceleration (2% probability of occurrence in 50 years based on USGS mapping) is 0.11g. Schnabel has amended the global stability analysis, included in the Design Report, and the veneer stability analysis, to include seismic conditions. The materials and slopes of the final cover system layers are such that a factor of safety of at least 1.5 is calculated for each interface during static conditions, and a factor of safety of 1.3 is achieved for seismic conditions based on the maximum horizontal acceleration of lithified earth material. Slope stability calculations are included in Attachment 3.

3.3 Runoff Controls

The features described in the ESC Plan are designed to manage the peak flow for the 25-year, 24-hour storm event. The stormwater system is designed as a series of diversion berms, slope drain pipes, engineered stormwater channels and stormwater basins. The system is designed to adequately convey to 25-year, 24-hour storm event. The system was also checked for overtopping during the 100-year storm event. Runoff from a typical non-contact area of the CCR Unit would be as follows: sheet flow to a sideslope diversion berm, channel flow to a slope drain pipe, slope drain pipe to perimeter channel, perimeter channel to stormwater basin. Calculations for the stormwater system are included in Attachment VI of the Part B Permit (Design Report).

3.3.1 Drainage Structure Maintenance

Maintenance of the Facility’s drainage structures will include routine inspections as per the Operations Plan to identify areas of erosion, undercutting or other maintenance needs. Additional inspections may be required after large storm events to check for damage. Specific items to be inspected include:

- Culvert inlets for accumulated sediment or debris;
- Diversion berms for erosion and establishment of vegetation;
- Slope drain pipes for proper anchorage, leaking joints, undercutting;
- Vegetation in other areas for proper establishment, need of mowing;
- Perimeter channels for erosion and establishment of vegetation;
- Energy dissipation and drop inlet structures for integrity and accumulated sediment; and,
- Other temporary controls (e.g. silt fence) for proper function and sediment control.

Activities to correct or repair identified deficiencies will be initiated as soon as practicable by site operations. Additional time may be required to correct larger deficiencies or if additional drainage structure construction is required. Sediment removed from the sediment basins during maintenance or repair activities will be dewatered and used as cover soil on the CCR Unit. The level of accumulated sediment will be monitored on a regular basis through visual inspection, and the removal of accumulated sediment will be performed as necessary.

3.4 Settlement, Subsidence, and Displacement

Settlement associated with the consolidation of CCR wastes is expected to be minimal given the inorganic nature of compacted CCR. Non-uniform settlement may warrant occasional regrading and/or repair to the soil layer above the cap to maintain drainage. The overall effectiveness of the geomembrane liner at minimizing liquid infiltration will not be jeopardized by non-uniform differential settlement. Further discussion of settlement is included in the Design Report.

The proposed exterior sideslopes of the CCR Unit are to be 3H:1V. The stability of the final cover system was evaluated under static conditions by examining potential rotational failure through the exterior slopes and veneer failure of the sideslopes. The analyses indicate that the final cover system will be stable under design static conditions. Certain minimum physical properties were assumed, including interface friction angles and soil properties (i.e., internal friction angles and cohesion). Laboratory testing of materials proposed for use in final closure construction will be completed prior to use to verify that the material provides equivalent performance.

4.0 SCHEDULE FOR CLOSURE

The Facility's disposal units will be developed in a staged manner and final closure construction will be conducted as Facility areas of approximately 15- to 20-acres reach final closure grades. The final closure schedule is dependent on the beneficial use market demand for CCRs. Beneficial use of the CCRs may extend the life of the Facility until the closure of the Station; the Facility is anticipated to close in approximately 2038. Final closure activities will begin within the regulatory 30 days of the CCR Unit receiving its final load of CCR, or, if the Facility has remaining capacity and there is a reasonable likelihood that the Facility will receive additional CCR, no later than one year after the most recent receipt of CCR. The DEQ may approve a longer closure period if it is demonstrated that the required or planned closure activities will take longer than the regulatory 180 days to complete and that steps have been taken to eliminate any significant threat to human health and the environment. A 24-month closure period is requested under this plan.

Progressive closure phases may be initiated once an approximately 15- to 20-acre are reaches final permitted grades, as determined by either an annual aerial or field survey. The progressive closure construction activity for each cycle of closure is anticipated to take approximately 9 to 12 months to complete, based on construction experience of similarly size closure projects. Minimizing the exposure of CCR during closure cap construction to prevent erosion from rain and wind will be accomplished by methods such as:

- Installing stormwater runoff and run-on controls such as temporary diversion berms, silt fencing, slope drains, and sediment trapping measures as required by the specific construction activity;
- Sequencing the stripping of cover soil and fine grading for cap construction such that it occurs during periods of favorable weather; and,
- Limiting exposed areas to those that can covered with geosynthetics in a short amount of time.

5.0 CLOSURE IMPLEMENTATION

5.1 Closure Posting

One sign will be posted at the site entrance to the Facility notifying all persons of the final closure of the Facility and prohibition against further receipt of CCRs. Unauthorized access to the Facility will be controlled by fencing and lockable gates across the access roads.

5.2 Notification

Chesterfield County, Virginia will be notified upon the completion of closure of the Facility. The survey plat will be prepared showing the final closure grades, as well as the locations of the groundwater monitoring wells. The survey plat and deed will have the following notification language:

> **This property has been used for the management and disposal of CCR wastes. Any future use of the site shall not disturb the integrity of the final cover, liners, or any other components of the containment systems, or the function of the monitoring system unless necessary to comply with the Virginia Solid Waste Management Regulations or approved by the Department of Environmental Quality.**

Within 30 days of recording a notation on the deed to the property, a notification of the notation being recorded will be sent to DEQ, posted on Dominion Energy's publicly accessible internet site, and placed in the Facility's operating record.

5.3 Certification

Within 30 days of the completion of closure construction, a Professional Engineer licensed in the Commonwealth of Virginia and representing the Facility will provide the DEQ with certification of closure in accordance with this Plan, along with the results of the CQA Plan. The certification statement should generally read as follows: **I certify that closure has been completed in accordance with the Closure Plan dated [DATE] for permit number 609 issued to Dominion, with the exception of the following discrepancies:**

In addition, a sign(s) was(were) posted on [DATE] at the landfill entrance notifying all persons of the closing [and state other notification procedures if applicable] and barriers [indicate type] were installed at [location] to prevent new waste from being deposited.

A survey plat prepared by [NAME] was submitted to the County of Chesterfield, Virginia on [DATE]. A copy of the survey plat is included with this certification.

A notation was recorded on the deed to the landfill property on [DATE]. A copy of the revised deed is attached to this certification.

[Signature, date and stamp of Professional Engineer]

The certification will be posted on Dominion Energy's publicly accessible internet site and placed in the Facility's operating record.

6.0 CLOSURE COST ESTIMATE

The estimated cost for closure of the CCR Unit is $20,289,112. A construction contractor will be hired to provide closure construction services. Calculations for the closure cost estimate are included in Attachment 4.

ATTACHMENT 1

SITE LIFE AND PHASE CAPACITY CALCULATION

(Prepared by Golder Associates and amended by Dominion Energy 2023)

Chesterfield FFCP Management Facility - Permit #609

Calculations for Site Life - Closure Plan Attachment 1

Phase volume and life

Phase	Area, Ac	Gross Volume, CY	LCS Volume, CY	IC and Final Cover Volume, CY	Net Disposal Volume, CY	Site Life, yr
1	13.9	1,137,772	35,320	92,392	1,010,060	2.10
2	15.4	1,963,701	39,131	102,363	1,822,207	2.96
3	15.7	2,619,269	39,894	104,357	2,475,018	4.02
4	21.4	4,250,670	54,377	142,244	4,054,048	6.58
Total	66.4	9,971,412	168,72Z	441,356	9,361,333	15.66

Where: Phase 1

Disposal Rate =	600,000	ton/yr
In-Place Density =	1.25	ton/cy
Volume/yr =	480,000	cy/yr

Where: Phase 2,3,4

Disposal Rate =	770,000	ton/yr
In-Place Density =	1.25	ton/cy
Volume/yr =	616,000	cy/yr

Revised by Will Culbertson 7/7/2023

Interim closure schedule of the Chesterfield FFCP Facility
Based on airspace consumption of an average of
616,000 CY per year

Year	Event	Net Volume, CY	Volume Consumed, CY	Remaining Capacity, CY
2018	Build Phase 1 / begin operations	1,010,060	89,867	920,193
2019	Fill Phase 1		41,425	878,768
2020	Fill Phase 1		88,047	790,721
2021	Fill Phase 1		45,496	745,225
2022	Fill Phase 1 / Build Phase 2		489,479	255,746
2023	Fill Phase 1 / Fill Phase 2 / Build Phase 3	1,822,207	600,000	1,477,953
2024	Fill Phase 2 / Build Phase 3	2,475,018	531,364	3,421,607
2025	Fill Phase 3 / Close Stage 1 (21 Ac.) / Build Phase 4		931,364	2,490,243
2026	Fill Phase 3 / Build Phase 4	4,054,048	931,364	5,612,927
2027	Fill Phase 3		931,364	4,681,563
2028	Fill Phase 3 / Fill Phase 4 / Close Stage 2 (14 Ac.)		931,364	3,750,199
2029	Fill Phase 4		931,364	2,818,835
2030	Fill Phase 4		431,364	2,387,471
2031	Fill Phase 4		431,364	1,956,107
2032	Fill Phase 4		431,364	1,524,743
2033	Fill Phase 4		206,364	1,318,379
2034	Fill Phase 4		439,460	878,919
2035	Fill Phase 4		439,460	439,459
2036	Fill Phase 4		439,459	0
2037	Begin Final Closure (32 Ac.)		0	0
2038	Final Closure (32 Ac.)		0	0

Revised by Will Culbertson 7/7/2023

ATTACHMENT 2

RUSLE DEMONSTRATION

(Prepared by Golder Associates and last approved by DEQ February 2017)

Golder Associates
Richmond, Virginia

Subject: RUSLE Calculation		
Job No. 073-660711	Made By: DPM	Date: 1/12/12
	Checked: JDA 5-17-12	
Ref:	Reviewed: JRD 5-17-12	Sheet 1 of 1

OBJECTIVE

To compute the expected amount of soil to be lost from the site after closure, by using the Revised Universal Soil Loss Equation (RUSLE).

METHOD

RUSLE is an empirically derived formula based on several decades of field research by the National Resource Conservation Service (NRCS). It is based on several site-specific factors involving precipitation, soil type, slope, and cover/conservation practices employed.

REFERENCES

1. Predicting Soil erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE) USDA Handbook Number 703 (AH-703), July 1996.

CALCULATIONS

The RUSLE equation is as follows:

A=R*K*LS*C*P

Variable	Description	Value Used
A	soil loss in tons/yr/acre	-
R	Rainfall-Runoff erosivity factor	200 (for Chesterfield, VA)
K	Soil Erodibility factor	0.37 (Tetotum loam)
LS	Slope Length/Steepness factor	4.83 (33% slope, 75' long)
C	Cover management factor	.005 (good stand of dense grass)
P	Support Practice Factor	1.0 (no specific measures)

Values for each of the above variables were chosen based on guidance presented in AH-703 and from the NRCS Soil Database for the Tetotum loam, one of the prevalent soil types on the site.

RESULTS

A=200*0.37*4.83*.005*1.0=1.79 tons/acre/year

CONCLUSIONS

The landfill final cover as designed meets the criteria of less than two tons of soil loss per acre per year.

ATTACHMENT 3

SLOPE STABILITY CALCULATIONS

(Prepared by Golder Associates and amended by Schnabel Engineering 2023)

Golder Associates

CALCULATIONS

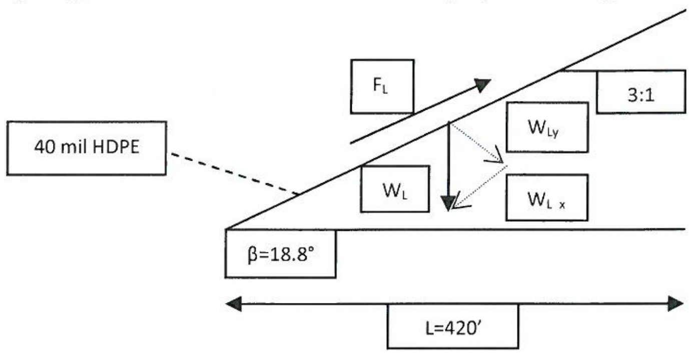
Date:	March 16, 2012	**Made by:**	FKW
Project No.:	073-660711	**Checked by:**	DPM 4/19/12
Subject:	Liner Self Weight Final Grades	**Reviewed by:**	JRD 4/19/12
Project Short Title:	Chesterfield FFCPMF; Chesterfield County, VA		

1.0 OBJECTIVE

To calculate the factor of safety of the ability of the 40 mil HDPE textured geomembrane to support its own weight at the design slopes during construction.

2.0 METHOD

Use free-body diagram to calculate factor of safety by balancing forces.



Equations

$$W_L = \gamma_L t_L L cos\beta$$

Where W_L= Weight of the Liner
γ_L= Unit Weight of Liner
t_L= Thickness of Liner
L= Length of Slope Base

$$W_{Lx} = W_L sin\beta$$

Where W_{Lx}= Weight of Liner along Plane X

$$W_{Ly} = W_L cos\beta$$

Where W_{Ly}= Weight of Liner along Plane Y

$$F_L = W_{Ly} tan\delta$$

Where F_L= Force along Liner
δ= Geomembrane to Subgrade Interface Friction Angle
β= Angle of Slope

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3.0 ASSUMPTIONS

1. A 40 mil HDPE textured is used as the geomembrane.
2. The interface friction angle of the geomembrane to intermediate cover is 30.0 degrees.

4.0 CALCULATIONS

Where;

$\gamma_L=$	unit weight of liner	=	0.94	g/cm^3
		=	58.68	lb/ft^3
$t_L=$	thickness of liner	=	40	mil
		=	0.04	"
$\delta=$	interface friction angle	=	30	°
$\beta=$	side slope angle	=	18.4	°
L=	length of slope base	=	420	ft

Then;

$W_L=$	$\gamma_L t_L(L/\cos\beta)$	=	86.58	lb/ft
$W_{Lx}=$	$W_L \sin\beta$	=	27.33	lb/ft
$W_{Ly}=$	$W_L \cos\beta$	=	82.16	lb/ft
$F_L=$	$W_{ly} \tan\delta$	=	47.43	lb/ft
T=	$W_{Lx}-F_L$	=	-20.10	lb/ft
FS=	F_L/W_{Lx}	=	1.74	

Since the frictional resistance force along the line (F_L) is greater than the weight of the liner in the x-plane (W_{Lx}) then no tension is present in the liner. This creates a factor of safety greater than one which demonstrates that no tension is present in the liner due to self weight.

5.0 ATTACHMENTS

Geomembrane properties for 40 mil HDPE textured

6.0 CONCLUSIONS

The minimum factor of safety for the ability of geomembrane liner to support its own weight is 1.74. Therefore, the 40 mil HDPE textured is sufficient for design of the closure cap system.

7.0 REFERENCES

1) Koerner, Robert M. *Designing with Geosynthetics, Fifth Edition*. Upper Saddle River, New Jersey: Pearson Prentice Hall, 2005. Print.

High Density Polyethylene
Micro Spike® Liner

Product Data

Property	Test Method	Values				
Thickness, nominal (mm)		30 (.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min. ave.), mil (mm)	ASTM D5994*	29 (.71)	38 (.95)	57 (1.43)	76 (1.90)	95 (2.38)
Thickness (lowest indiv. for 8 of 10 spec.), mil (mm)	ASTM D5994*	27 (.68)	36 (.90)	54 (1.35)	72 (1.80)	90 (2.25)
Thickness (lowest indiv. for 1 of 10 spec.), mil (mm)	ASTM D5994*	26 (.64)	34 (.85)	51 (1.28)	68 (1.70)	85 (2.13)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Asperity Height (min. ave.), mil (mm)	GRI GM12/ASTM D7466	16 (.41)	16 (.41)	16 (.41)	16 (.41)	16 (.41)
Density, g/cc, minimum	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Tensile Properties (ave. both directions)	ASTM D6693, Type IV					
Strength @ Yield (min. ave.), lb/in width (N/mm)	2 in/minute	66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Yield (min. ave.), % (GL=1.3in)	5 specimens in each direction	13	13	13	13	13
Strength @ Break (min. ave.), lb/in width (N/mm)		66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Break (min. ave.), % (GL=2.0in)		350	350	350	350	350
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	60 (267)	90 (400)	120 (534)	150 (667)	180 (801)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3				
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	300	300	300	300	300
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥100	≥100	≥100	≥100	≥100
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging with HP OIT, (% retained after 90 days)	ASTM D5721 ASTM D5885, 150°C, 500psi O_2	80	80	80	80	80
UV Resistance	GRI GM11	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C				
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	50	50	50	50	50

These product specifications meet or exceed GRI's GM13

Supply Information (Standard Roll Dimensions)

Thickness		Width		Length		Area (approx.)		Weight (average)*	
mil	mm	ft	m	ft	m	ft^2	m^2	lbs	kg
30	.75	23	7	930	283.117	21,390	1,984	3,900	1,770
40	1.0	23	7	710	216.41	16,330	1,514.87	3,900	1,770
60	1.5	23	7	505	153.53	11,615	1,078	3,900	1,770
80	2.0	23	7	385	117.35	8,855	821	3,900	1,770
100	2.5	23	7	310	94.49	7,130	661	3,900	1,770

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special lengths are available on request. All roll lengths and widths have a tolerance of ±1%
**The weight values may change due to project specifications (i.e. absolute minimum thickness or special roll lengths) or shipping requirements (i.e. international containerized shipments).*

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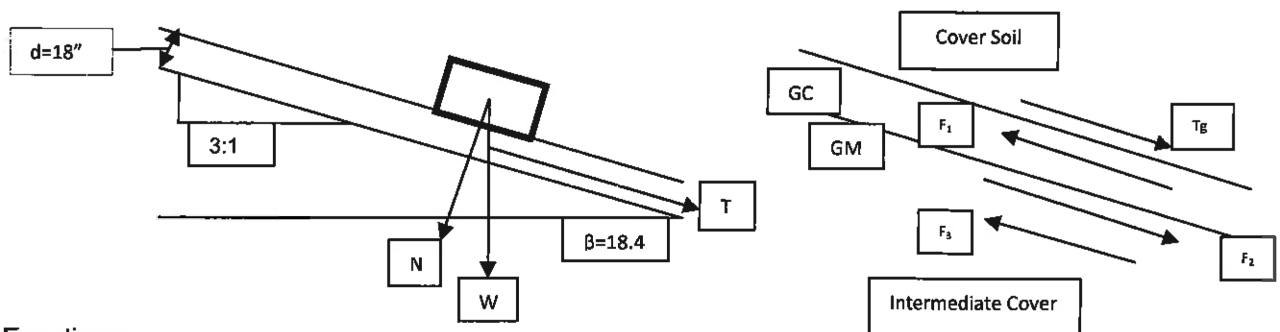
Date:	March 16, 2012	**Made by:**	FKW
Project No.:	073-660711	**Checked by:**	DPM 4/19/12
Subject:	Stress on Liner during Construction Final Grades	**Reviewed by:**	JRD 4/19/12
Project Short Title:	Chesterfield FFCPMF; Chesterfield County, VA		

1.0 OBJECTIVE

To determine the minimum factor of safety of stress on the liner during construction. A D6LGP dozer on 18" cover soil layer will be used in calculation.

2.0 METHOD



<u>Equations</u>

$P_c = W/nT_wT_l$ Where P_c = Contact Pressure; W= Weight of Equipment; T_w= Track Width; T_l= Track Length; n= Number of Tracks

$N = P_c cos\beta$ Where N= Normal Force; P_c = Contact Pressure; β= Slope Angle

$T = P_c sin\beta$ Where T= Tension Force in Geocomposite (GC)

$N_g = N + \gamma_{soil} d cos\beta$ Where N_g= Normal Force on Geocomposite (GC); γ_{soil}= Unit Weight of Cover Soil; d= Depth of Cover Soil

$T_g = T + \gamma_{soil} d sin\beta$ Where T_g= Sliding Force on Geocomposite (GC)

$F_1 = N_g tan\delta_1$ Where F_1= Sliding Resistance on Geocomposite (GC); δ_1= Geocomposite/Drainge Soil Interface Friction Angle

$F_2 = T_g$ Where F_2= Sliding Resistance in Geomembrane/Geocomposite (GM)

$F_3 = N_g tan\delta_3$ Where F_3= Sliding Resistance on Geomembrane (GM); δ_3= Geomembrane/Intermediate Cover Interface Friction Angle

$FS = F_{1,3}/T_g$ Where FS= Factor of Safety

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3.0 ASSUMPTIONS

1. A D6LGP dozer is used or equipment of less than or equal weight.
2. A 40 mil HDPE textured is used as the geomembrane.
3. The interface friction angle of the geocomposite to cover soil is 35 degrees.
4. The interface friction angle of the geomembrane to intermediate cover is 30.0 degrees.

4.0 CALCULATIONS

Where;

$W=$	weight of equipment	=	44,804	lb
$T_w=$	track width	=	3	ft
$T_l=$	track length	=	10.67	ft
$n=$	number of tracks	=	2	
$\beta=$	slope angle	=	18.4	°
$d=$	depth of soil cover	=	1.5	ft
$\gamma_{soil}=$	unit weight of cover soil	=	120	lb/ft^3
$\delta_1=$	interface friction angle, GC/soil	=	35	°
$\delta_3=$	interface friction angle, GM/subgrade	=	30	°

Then;

$P_c=$	$W/(nT_wT_l)$	=	4.86	psi
$N=$	$P_c\cos\beta$	=	4.61	psi
$T=$	$P_c\sin\beta$	=	1.53	psi
$N_g=$	$N+\gamma_{soil}d\cos\beta$	=	21.61	psi
$T_g=$	$T+\gamma_{soil}d\sin\beta$	=	7.19	psi
$F_1=$	$N_g\tan\delta_1$	=	15.13	psi
$F_2=$	T_g	=	7.19	psi
$F_3=$	$N_g\tan\delta_3$	=	12.48	psi
$FS=$	F_1/T_g	=	2.10	
	F_3/T_g	=	1.74	

Since $F_1>T_g$ only a force equal to will be transferred to geomembrane liner. Therefore F_2 is equal to T_g ($F_2= T_g= 1.86$ psi). This force is then transferred to the geomembrane/subgrade interface, F_3, which produces a factor of safety=1.74 for the system.

The construction factor of safety of 1.74 was deemed satisfactory being that it was above 1.3. This factor of safety must also be considered conservative since the load distribution along the depth of the soil layer was not included in the calculation along with using a conservative friction angle for the interface with an assumed value of zero for the adhesion between the geomembrane and the ash.

5.0 ATTACHMENTS

Caterpillar D6 Track-Type Tractor Specifications

6.0 CONCLUSION

The minimum factor of safety for the closure cap geosynthetics during construction is 1.74. Therefore, the 40 mil HDPE textured is sufficient for design of the closure cap system.

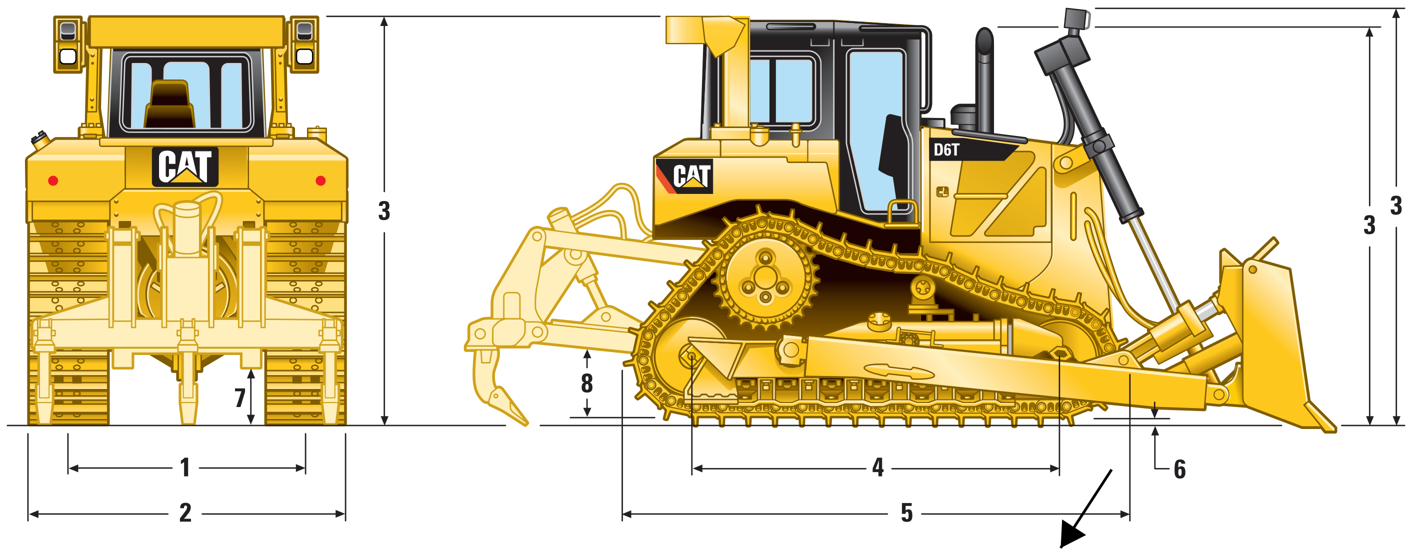
7.0 REFERENCES

Koerner, Robert M. *Designing with Geosynthetics, Fifth Edition*. Upper Saddle River, New Jersey: Pearson Prentice Hall, 2005. Print.

D6T Specifications

Dimensions

All dimensions are approximate.



	XW		XW VPAT		LGP		LGP VPAT	
1 Track gauge	2032 mm	6 ft 8 in	2286 mm	7 ft 6 in	2286 mm	7 ft 6 in	2286 mm	7 ft 6 in
2 Width of tractor								
Over trunnions	2950 mm	9 ft 8 in	—		3480 mm	11 ft 5 in	—	
Without trunnions (std. track)	2794 mm	9 ft 2 in	2997 mm	9 ft 10 in	3193 mm	10 ft 6 in	3150 mm	10 ft 4 in
3 Machine height from tip of grouser:								
Stack	3126 mm	10 ft 3 in	3126 mm	10 ft 3 in	3176 mm	10 ft 5 in	3176 mm	10 ft 5 in
ROPS	3169 mm	10 ft 5 in	3169 mm	10 ft 5 in	3219 mm	10 ft 7 in	3219 mm	10 ft 7 in
Premium Light Package	3310 mm	10 ft 10 in	3310 mm	10 ft 10 in	3360 mm	11 ft 0 in	3360 mm	11 ft 0 in
4 Length of track on ground	2840 mm	9 ft 4 in	2840 mm	9 ft 4 in	3250 mm	10 ft 8 in	3250 mm	10 ft 8 in
5 Length of basic tractor	3860 mm	12 ft 8 in	3860 mm	12 ft 8 in	4247 mm	13 ft 11 in	4247 mm	13 ft 11 in
With following attachments add:								
Drawbar	182 mm	7 in	182 mm	7 in	—		—	
Ripper Multi-Shank (tip at ground line)	1370 mm	4 ft 6 in	1370 mm	4 ft 6 in	1370 mm	4 ft 6 in	1370 mm	4 ft 6 in
Winch	517 mm	20 in	517 mm	20 in	397 mm	16 in	397 mm	16 in
S Blade	—		—		1168 mm	3 ft 10 in	—	
SU Blade	1271 mm	4 ft 2 in	—		—		—	
A Blade	1405 mm	4 ft 7 in	—		1475 mm	4 ft 10 in	—	
VPAT Blade	—		1504 mm	4 ft 11 in	—		1412 mm	4 ft 8 in
6 Height of grouser	65 mm	2.6 in	65 mm	2.6 in	65 mm	2.6 in	65 mm	2.6 in
7 Ground clearance	384 mm	15 in	384 mm	15 in	434 mm	17 in	434 mm	17 in
Track pitch	203 mm	8 in	203 mm	8 in	203 mm	8 in	203 mm	8 in
Number of shoes per side	41		41		45		45	
Number of rollers per side	7		7		8		8	
Standard shoe	760 mm	30 in	710 mm	28 in	915 mm	36 in	785 mm	31 in
Ground contact area (std. track)	4.31 m^2	6,681 in^2	4.03 m^2	6,247 in^2	5.95 m^2	9,223 in^2	5.10 m^2	7,905 in^2
Ground pressure*	43.9 kPa	6.36 psi	52.0 kPa	7.54 psi	33.5 kPa	4.86 psi	42.8 kPa	6.20 psi
8 Drawbar height	576 mm	23 in	576 mm	23 in	626 mm	25 in	626 mm	25 in
From ground face of shoe	511 mm	20 in	511 mm	20 in	561 mm	22 in	561 mm	22 in

* XL and XW with SU blade, LGP with S blade with no rear attachments unless otherwise specified and calculated per ISO 16754.

Golder Associates Richmond, Virginia	Subject: Veneer Slope Stability Analysis of Final Grade Chesterfield Power Station FFCPMF Chesterfield County, Virginia		
	Job No: 073-660711	Made by: FKW	Date: 3/21/2012
		Checked: DPM	4/19/12
	Ref:	Reviewed: JRO	Sheet 1 of 1

Objective

Determine veneer slope stability by means of a factor of safety of the static & seismic conditions for the **geocomposite & geomembrane interface.** Note that the site is not located in a seismic impact area as defined by the EPA (MHA > 0.1g)

Method

where

$a = (W_a - N_a \cos\beta)(\cos\beta)$

$b = -\{(W_a - N_a\cos\beta)\sin\beta\tan\phi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\phi)\}$

$c = (N_a\tan\delta + C_a)\sin^2\beta\tan\phi$

and where

$$FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a}$$

Calculations

β =	slope angle	=	18.4	degrees	3 :1
ϕ =	internal friction angle cover soil	=	30	degrees	
δ =	interface friction angle	=	25.0	degrees	
c_a =	adhesion along interface	=	100	psf	(textured GM vs. GC)
c =	cohesion of cover soil	=	200	psf	
L =	slope length between benches	=	840	ft	
h =	cap thickness	=	2	ft	
γ =	unit weight of cover soil	=	120	pcf	

Then

$W_a = \gamma h^2(L/h - 1/\sin\beta - (\tan\beta)/2)$ = 200002.0731

$N_a = W_a\cos\beta$ = 189739.1228

$C_a = c_a(l - h/\sin\beta)$ = 83367.53

$W_p = \gamma h^2/\sin 2\beta$ = 800.02

$C = ch/\sin\beta$ = 1264.94

Static Conditions

$a = (W_a - N_a \cos\beta)(\cos\beta)$ = 18973.02

$b = -\{(W_a - N_a\cos\beta)\sin\beta\tan\phi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\phi)\}$ = -55748.6942

$c = (N_a\tan\delta + C_a)\sin^2\beta\tan\phi$ = 9920.54

$$\mathbf{FS} = \frac{-b + (b^2 - 4ac)^{0.5}}{2a} = \mathbf{2.75}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003

Golder Associates Richmond, Virginia	Subject: Veneer Slope Stability Analysis of Final Grade Chesterfield Power Station FFCPMF Chesterfield County, Virginia					
	Job No:	073-660711	Made by:	FKW	Date:	3/21/2012
			Checked:	DPM	4/20/12	
	Ref:		Reviewed:	JRD	Sheet 1 of 2	

Objective Determine veneer slope stability by means of a factor of safety of the static conditions for the **geocomposite & cover soil interface allowing for parallel to slope seepage.** Note that the site is not located in a seismic impact area as defined by the EPA (MHA > 0.1g)

Method

where $a = W_A \sin\beta\cos\beta + U_H(1-\cos^2\beta)$

$b = -[W_P \tan\phi + W_A(\sin^2\beta\tan\phi\cos^2\beta\tan\delta) - U_{AN}\cos\beta\tan\delta - U_{PN}\tan\phi + U_H\sin\beta\cos\beta(\tan\phi-\tan\delta)]$

$c = (W_A\cos\beta - U_{AN} + U_H\sin\beta)\sin\beta\tan\delta\tan\phi$

and where

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a}$$

and where Average of max dry density= 120 pcf @ 10% moisture (w)

Calculations

β =	slope angle	=	18.4	degrees	3:1
ϕ =	internal friction angle cover soil	=	30	degrees	
δ =	interface friction angle	=	35.0	degrees	
c_a =	adhesion along interface	=	0	psf	(geocomposite vs. clay soil)
c =	cohesion of cover soil	=	0	psf	
L =	slope length between benches	=	840	ft	
h =	cap thickness	=	2	ft	
γ =	unit weight of cover soil	=	120	pcf	
γ_w=	Unit weight of water	=	62.4	psf	
γ_{sat}=	Saturated unit weight of cover soil	=	147	psf	(@ w= 35%)
H =	Height of slope	=	186.00	ft	
h_w=	Depth of seepage in soil	=	1	ft	

Then

$W_A = 0.5[\gamma(h-h_w)(2H\cos\beta-h-h_w)+\gamma_{sat}h_w(2H\cos\beta-h_w)]/(\sin\beta\cos\beta)$ = 156200

$U_{AN}=\gamma_w h_w(H-0.5h_w\cos\beta)/\tan\beta$ = 34730.4

$U_H=0.5\gamma_w h_w^2$ = 31.20

$W_p = 0.5[\gamma(h^2-h_w^2)+\gamma_{sat}h_w^2]/(\sin\beta\cos\beta)$ = 845.00

$U_{PN}=0.5\gamma_w h_w^2/\tan\beta$ = 93.60

Static Conditions

a = $W_A \sin\beta\cos\beta + U_H(1-\cos^2\beta)$ = 46863.13

b = $-\{W_P \tan\phi + W_A(\sin^2\beta\tan\phi\cos^2\beta\tan\delta) - U_{AN}\cos\beta\tan\delta - U_{PN}\tan\phi + U_H\sin\beta\cos\beta(\tan\phi-\tan\delta)\}$ = -84815.5

c = $(W_A\cos\beta - U_{AN} + U_H\sin\beta)\sin\beta\tan\delta\tan\phi$ = 14505.20

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a} = 1.62$$

References

1 Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003

Golder Associates Richmond, Virginia	Subject: Veneer Slope Stability Analysis of Final Grade Chesterfield Power Station FFCPMF Chesterfield County, Virginia		
	Job No: 073-660711	Made by: FKW	Date: 3/21/2012
		Checked: DPM	4/20/12
	Ref:	Reviewed: JRO	Sheet 1 of 2

Objective

Determine veneer slope stability by means of a factor of safety of the static conditions for the **geocomposite & cover soil interface allowing for horizontal to slope seepage.** Note that the site is not located in a seismic impact area as defined by the EPA (MHA > 0.1g)

Method

where a = $W_A \sin\beta\cos\beta - U_h\cos^2\beta + U_h$

b = $-W_A\sin^2\beta\tan\phi + U_h\sin\beta\cos\beta\tan\phi - N_A\cos\beta\tan\delta - (W_P - U_V)\tan\phi$

c = $N_a\sin\beta\tan\delta\tan\phi$

and where

$$FS = \frac{-b + (b^2-4ac)^{0.5}}{2a}$$

and where Average of max dry density = 120 pcf @ 10% moisture (w)

Calculations

β =	slope angle	=	18.4	degrees	3 :1
ϕ =	internal friction angle cover soil	=	30	degrees	
δ =	interface friction angle	=	35.0	degrees	
c_a =	adhesion along interface	=	0	psf	(geocomposite vs. clay soil)
c =	cohesion of cover soil	=	0	psf	
L =	slope length between benches	=	840	ft	
h =	cap thickness	=	2	ft	
γ =	unit weight of cover soil	=	120	pcf	
γ_w=	Unit weight of water	=	62.4	psf	
γ_{sat}=	Saturated unit weight of cover soil	=	147	psf	(@ w= 35%)
H =	Height of slope	=	186.00	ft	
H_w=	Depth of seepage in soil	=	90	ft	

Then

$W_A = \gamma_{sat}h(2H_w\cos\beta - h)/\sin s\beta + \gamma_{dry}h(H-H_w)/\sin\beta$ = 155552.744

$U_n = \gamma_w h\cos\beta(2H_w\cos\beta - h)/\sin2\beta$ = 33301.3477

$U_h = 0.5\gamma_w h^2$ = 124.80

$N_A = W_a\cos\beta + U_h\sin\beta - U_n$ = 114308.408

$W_p = \gamma_{sat}h^2/\sin2\beta$ = 980.00

$U_v = U_h\cot\beta$ = 374.40

Static Conditions

a = $W_A \sin\beta\cos\beta - U_h\cos^2\beta + U_h$ = 46678.30

b = $-W_A \sin^2\beta\tan\phi + U_h\sin\beta\cos\beta\tan\phi - N_A\cos\beta\tan\delta - (W_P - U_V)\tan\phi$ = -85231.9098

c = $N_a \sin\beta\tan\delta\tan\phi$ = 14613.17

FS = $\dfrac{-b + (b^2 - 4ac)^{0.5}}{2a}$ = 1.63

References

1 Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003

Golder Associates, Richmond, Virginia	Subject: Veneer Slope Stability Analysis of Final Grade Chesterfield Power Station FFCPMF Chesterfield County, Virginia		
	Job No: 073-660711	Made by: FKW	Date: 3/21/2012
		Checked: DPM	4/19/12
	Ref:	Reviewed: JRD	Sheet 1 of 1

Objective

Determine veneer slope stability by means of a factor of safety of the static & seismic conditions for the **geocomposite & cover soil interface.** Note that the site is not located in a seismic impact area as defined by the EPA (MHA > 0.1g)

Method

where

$a = (W_a - N_a \cos\beta)(\cos\beta)$

$b = -\{(W_a - N_a\cos\beta)\sin\beta\tan\phi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\phi)\}$

$c = (N_a\tan\delta + C_a)\sin^2\beta\tan\phi$

and where

$$FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a}$$

and where Average of max dry density = 120 pcf @ 10% moisture (w)

Calculations

β =	slope angle	=	18.4	degrees	3 :1
ϕ =	internal friction angle cover soil	=	30	degrees	(estimated from Das)
δ =	interface friction angle	=	35.0	degrees	(estimated from DS database)
c_a =	adhesion along interface	=	0	psf	(geocomposite vs. cover soil)
c =	cohesion of cover soil	=	0	psf	
L =	slope length between benches	=	840	ft	
h =	cap thickness	=	2	ft	
γ =	unit weight of cover soil	=	120	pcf	

Then

$W_a = \gamma h^2(L/h - 1/\sin\beta - (\tan\beta)/2)$ = 200002.073

$N_a = W_a\cos\beta$ = 189739.123

$C_a = c_a(l - h/\sin\beta)$ = 0.00

$W_p = \gamma h^2/\sin 2\beta$ = 800.02

$C = ch/\sin\beta$ = 0.00

Static Conditions

$a = (W_a - N_a \cos\beta)(\cos\beta)$ = 18973.02

$b = -\{(W_a - N_a\cos\beta)\sin\beta\tan\phi + (N_a\tan\beta + Ca)\sin\beta\tan\beta + \sin\beta(C + W_p\tan\phi)\}$ = -43652.141

$c = (N_a\tan\delta + C_a)\sin^2\beta\tan\phi$ = 7669.66

$$FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a} = 2.11$$

References

1 Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2 Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".
3 Golder Direct Shear Database

Project:	Chesterfield FFCP Management Fac.		
P.N.:	073-660711	**Page:**	1 of 1
By:	DPM	**Date:**	3/12/12
Checked:	FKW	**Date:**	3/14/12
Reviewed:	JRD	**Date:**	3/14/12
Subject:	Required Geocomposite Transmissivity 5:1 sideslope		

Cap Drainage Layer - Geocomposite Drainage Net

General Data

Elevation Difference Between Drains =	143	ft		
Slope, X to 1 =	5	to 1		
Slope Angle, B =	11.31	degrees	=	20%
Slope Length Between Drains, L =	717	ft	=	218.5 m
Qin Flow Gradient, i-in =	0.196			
Permeability of Cover Soils, Kveg =	2.00E-07	cm/sec		OSB-4, SC
Qin = (Kveg)(L) =	4.37E-07	m2/sec		
Qout Flow Gradient, i-out = sinB =	0.196			

Qin = Qout

Qout = (θr)(i-out)

θr = (Qin)/(i-out)

Required Transmissivity, θr
(Qin)/(i-out) = 2.23E-06 m2/sec

Ultimate Transmissivity, θu = 5.00E-04 m2/sec

Reduction Factors

Intrusion; Rfin =	1.3	>>>>	*Range: 1.3 to 1.5*
Creep; RFcr =	1.2	>>>>	*Range: 1.1 to 1.4*
Chemical Clogging; RFcc =	1.1	>>>>	*Range: 1.0 to 1.2*
Biological Clogging; RFbc =	1.4	>>>>	*Range: 1.2 to 1.5*

Product of Reduction Factors, PRF = 2.4024

Allowable Transmissivity, θa
(θu/PRF) = 2.08E-04 m2/sec

Drainage Factor of Safety, DFS
(θa/θr) = 93.38

Minimum Drainage Factor of Safety, MDFS
MDFS = 2.0

Total Factor of Safety, TFS
(DFS x PRF) = 224.3

Minimum Total Factor of Safety, MTFS
MTFS min = 6.0

[ ] = *input data*

References:
1 *"Design Manual of Lateral Drainage Layers for Landfills"; Gregory N. Richardson, Ph.D., P.E. Jean-Pierre Giroud, E.C.P., Ph.D., Aigen Zhao, Ph.D., P.E.; 2000.*
2 *Manufacturer's data, various.*

Schnabel ENGINEERING

Calculations

Project:	Chesterfield FFCP Management Facility	**Made by:**	ERR
Subject:	Veneer Slope Stability Analysis - Cap, Seismic	**Checked by:**	SDRM
Reference No.:	23130232.030	**Reviewed by:**	JRD
Date:	9/25/2023		

Objective

*Determine the veneer slope stability by means of a factor of safety of the **seismic condition** for the **3:1 slope areas**.*

Method

Where:

$a = (C_s W_a + N_a \sin\beta)\cos\beta + C_s W_p \cos\beta$

$b = -\{(C_s W_a + N_a \sin\beta)\sin\beta \tan\varphi + (N_a \tan\delta + C_a)\cos^2\beta + (C + W_p \tan\varphi)\cos\beta\}$

$c = (N_a \tan\delta + C_a)\cos\beta \sin\beta \tan\varphi$

$$FS = \frac{-b + (b^2 - 4ac)^{0.5}}{2a}$$

Assumptions

β =	slope angle	=	18.4 °	(3:1)
φ =	internal friction angle cover soil	=	30.0 °	
δ =	interface friction angle	=	26.4 °	
c_a =	adhesion along interface	=	0.0 psf	
c =	cohesion of cover soil	=	0.0 psf	
L =	slope length	=	840.0 ft	
h =	cap thickness	=	2.0 ft	assumed placement of 12" soil lift
γ =	unit weight of cover soil	=	120 pcf	
C_s =	seismic coefficient	=	0.06 g	(1/2 peak ground acceleration)

Calculations

$W_a = \gamma h^2(L/h - 1/\sin\beta - (\tan\beta/2)$	=	200002.11 lb/ft
$N_a = W_a \cos\beta$	=	189738.66 lb/ft
$C_a = c_a(L - h/\sin\beta)$	=	0.00 psf
$W_p = \gamma h^2/\sin 2\beta$	=	800.00 lb/ft
$C = ch/\sin\beta$	=	0.00 lb/ft

Seismic Conditions

$a = (C_s W_a + N_a \sin\beta)\cos\beta + C_s W_p \cos\beta$ = 67570.41

$b = -\{(C_s W_a + N_a \sin\beta)\sin\beta \tan\varphi + (N_a \tan\delta + C_a)\cos^2\beta + (C + W_p \tan\varphi)\cos\beta\}$ = -98202.32

$c = (N_a \tan\delta + C_a)\cos\beta \sin\beta \tan\varphi$ = 16313.68

$$\mathbf{FS} = \frac{-b + (b^2 - 4ac)^{0.5}}{2a} = \mathbf{1.26}$$

References

1. Qian, Xuede; Keorner, Robert; Gray, Donald. "Geotechnical Aspects of Landfill Design and Construction". 2003
2. Das, Braja M. "Principles of Geotechnical Enginering, 3rd Edition".

ATTACHMENT 4

CLOSURE COST ESTIMATE

(Prepared by AECOM 2022)

Solid Waste Disposal Facility
Cost Estimate Form, DEQ Form CE SWDF

Facility Name: Chesterfield Power Station FFCP Management Facility   Permit No. SWP 609
Location Address: 1603 Reyment Road
City, State, Zip: North Chesterfield, VA 23237

FA Holder: Dominion Energy Virginia
Estimate Prepared by: Steve Walker, AECOM

Indicate the plan versions for which this cost estimate was prepared, identifying the following information for each plan:

Closure Plan

Title: Closure Plan Chesterfield Power FFCP Facility
Plan Date: March 2015   Approved: May 2022
Consultant: Golder Associates

Post-Closure Plan

Title: Post-Closure Care Plan Chesterfield FFCP Facility
Plan Date: March 2015   Approved: June 2016
Consultant: Golder Associates

Corrective Action Plan

Title: N/A
Plan Date: N/A   Approved: N/A
Consultant: N/A

Corrective Action Monitoring Plan

Title: N/A
Plan Date: N/A   Approved: N/A
Consultant: N/A

Cost Estimate Summary

Closure Cost Element	Total Cost	Notes
Total Closure Cost:	$20,289,112	
Total Post-Closure Cost:	$18,676,924	
Total Corrective Action Cost:	$0.00	
Total:	$38,966,036.00	

References: Please indicate references used to develop this cost estimate: RSMeans values - February 2023, Contract for construction and closure of FFCP Facility - March 2021, Leachate treatment system operation contract - November 2022

CERTIFICATION BY PREPARER

This is to certify that the cost estimates pertaining to the engineering features and monitoring requirements of this solid waste management facility have been prepared by me and are representative of the design specified in the facility's Closure Plan. The estimate is based on the cost of hiring a third party and does not incorporate any salvage value that may be realized by the sale of wastes, facility structures, or equipment, land or other facility assets at the time of closure. In my professional judgment, the cost estimates are a true, correct, and complete representation of the financial liabilities for closure and postclosure care of the facility and comply with the requirements of 9 VAC 20-70 and all other DEQ rules and statutes of the Commonwealth of Virginia.

SIGNATURE: [signature]   DATE: 3/8/2023

NAME: Steve Walker, PE
TITLE: Project Engineer

Acknowledgement by Owner / Operator:

SIGNATURE: ____________________   DATE: ____________

NAME: Robert W. Sauer
TITLE: VP System Operations

DEQ Virginia Department of Environmental Quality

Worksheet CEW-01: FORMAT FOR THE ESTIMATION OF CLOSURE COSTS

FILL IN THE BOXES. THE REST WILL BE CALCULATED FOR YOU

Soil Cap Components

		Input	Calculation or Conversion	
I.	**Slope & Fill**			
a.	Area to be capped	67 acres	x 4,840yd2/ac	324,280 yd2
b.	Depth of soil needed for slope and fill	0 inches	x 1yd/36in	0.00 yd
c.	Quantity of soil needed		a x b	0 yd3
d.	Percentage of soil from off-site	0%		
e.	Purchace unit cost for off-site material	$0.00 /yd3		
f.	Percentage of soil from on-site		(1 - d)	100%
g.	Excavation unit cost (on-site material)	$0.00 /yd3		0
h.	Total soil unit cost		(d x e) + (f x g)	$0.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$0.00 /yd3		0
j.	Compaction unit cost	/yd3		
k.	Total soil unit cost		h + i + j	$0.00 /yd3
l.	Soil subtotal		k x b	$0
m.	Percent compaction	95%		
	Total Slope & Fill Cost		l x (1 + m)	***$0***
II.	**Infiltration Layer Soil**			
	Infiltration Soil Cost			
a.	Area to be capped	67 acres	x 4,840yd2/ac	324,280 yd2
b.	Depth of infiltration soil needed	0 inches	x 1yd/36in	0.00 yd
c.	Quantity of infiltration soil needed		a x b	0 yd3
d.	Percentage of soil from off-site	0%		
e.	Purchace unit cost for off-site material	$0.00 /yd3		
f.	Percentage of soil from on-site		(1 - d)	100%
g.	Excavation unit cost (on-site material)	$0.00 /yd3		
h.	Total infiltration soil unit cost		(d x e) + (f x g)	$0.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$0.00 /yd3		
j.	Compaction unit cost	$0.00 /yd3		
k.	Total infiltration soil unit cost		h + i + j	$0.00 /yd3
l.	Infiltration soil subtotal		k x b	$0
m.	Percent compaction	95%		
n.	*Subtotal Infiltration Soil Cost*		l x (1 + m)	*$0*
	Soil Admixture Cost			
o.	Area to be capped	67 acres	x 4,840yd2/ac	324,280 yd2
p.	Soil admixture unit cost	$0.00 /yd2		
q.	*Subtotal admixture cost*		a x b	*$0*
	Soil Testing			
r.	Area to be capped	67 acres		
s.	Testing unit cost	$1,000.00 /acre		
t.	*Subtotal soil testing cost*		a x b	*$67,000*
	Total Infiltration Soil Cost (soil, admixtures, and testing)		n + q + t	***$67,000***

III. Erosion Control / Protective Cover Soil

a.	Area to be capped	67	acres	x 4,840yd2/ac	324,280 yd2
b.	Depth of soil needed	18	inches	x 1yd/36in	0.50 yd
c.	Quantity of soil needed			a x b	162,140 yd3
d.	Percentage of soil from off-site	100%			
e.	Purchace unit cost for off-site material	$22.00	/yd3		
f.	Percentage of soil from on-site			(1 - d)	0%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total erosion/protective soil unit cost			(d x e) + (f x g)	$22.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$4.00	/yd3		
j.	Compaction unit cost	$0.00	/yd3		
k.	Total soil unit cost			h + i + j	$26.00 /yd3
l.	Erosion/Protective soil subtotal			k x b	$4,215,640
m.	Percent compaction	90%			
	Total Erosion Control/Protective Cover Soil Cost			l x (1 + m)	***$8,009,716***

IV. Vegetative support soil (Topsoil)

a.	Area to be capped	67	acres	x 4,840yd2/ac	324,280 yd2
b.	Depth of topsoil needed	6	inches	x 1yd/36in	0.17 yd
c.	Quantity of topsoil needed			a x b	54,047 yd3
d.	Percentage of topsoil from off-site	100%			
e.	Purchace unit cost for off-site material	$22.00	/yd3		
f.	Percentage of topsoil from on-site	0		(1 - d)	0%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total topsoil unit cost			(d x e) + (f x g)	$22.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$4.00	/yd3		
j.	Total soil unit cost			h + i	$26.00 /yd3
	Total Topsoil Cost			c x j	***$1,405,213***

V. Vegetative Cover

a.	Area to be vegetated	67	acres		
b.	Vegetative cover (seeding) unit cost	$2,975	/acre		
c.	Erosion control matting unit cost	$10,890	/acre		
	Total Vegetative Cover Cost			a x (b + c)	***$928,955***

Soil Cap Component Subtotal (I + II + III + IV + V): $10,410,884

Geosynthetic Barrier & Infiltration Layers

VI. Flexible Membrane Liner

				Calculation or Conversion	
a.	Quantity of FML needed	67	acres	x 43,560ft2/ac	2,918,520 ft2
b.	Purchase unit cost	$0.41	/ft2		
c.	Installation unit cost	$0.18	/ft2		
d.	Total FML unit cost			b + c	$0.59
	Total FML cost			a x d	***$1,721,927***

VII. Geosynthetic Clay Liner

a.	Quantity of GCL needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total GCL unit cost			b + c	$0.00 /ft2
	Total GCL Cost			a x d	***$0***

Geosynthetic Layers Subtotal (VI + VII): $1,721,927

Drainage Components

				Calculation or Conversion	
VIII.	**Sand or Gravel Drainage**				
a.	Area to be capped	0	acres	x 4,840yd2/ac	0 yd2
b.	Depth of sand or gravel needed	0	inches	x 1yd/36in	0.00 yd
c.	Quantity of drainage material needed			a x b	0 yd3
d.	Percentage of media from off-site	0%			
e.	Purchace unit cost for off-site material	$0.00	/yd3		
f.	Percentage of material from on-site			(1 - d)	100%
g.	Excavation unit cost (on-site material)	$0.00	/yd3		
h.	Total drainage material unit cost			(d x e) + (f x g)	$0.00 /yd3
i.	Hauling, Placement and Spreading unit cost	$0.00	/yd3		
j.	Compaction unit cost	$0.00	/yd3		
k.	Total drainage material unit cost			h + i + j	$0.00 /yd3
l.	Drainage material subtotal			k x b	$0.00
m.	Percent compaction	95%			
	Total drainage material cost			l x (1 + m)	***$0***
IX.	**Geotextile**				
a.	Quantity of geotextile needed	0	acres	x 43,560ft2/ac	0 ft2
b.	Purchase unit cost	$0.00	/ft2		
c.	Installation unit cost	$0.00	/ft2		
d.	Total geotextile unit cost			b + c	$0.00 /ft2
	Total Geotextile Cost			a x d	***$0***
X.	**Geonet Composite**				
a.	Quantity of geonet composite needed	67	acres	x 43,560ft2/ac	2,918,520 ft2
b.	Purchase unit cost	$0.64	/ft2		
c.	Installation unit cost	$0.18	/ft2		
d.	Total geonet composite unit cost			b + c	$0.82 /ft2
	Total Geonet Composite Cost			a x d	***$2,393,186***
XI.	**Drainage Tile**				
a.	Length of drainage tile needed	0	LF		
b.	Purchase unit cost	$0.00	/LF		
c.	Trenching and backfilling cost	$0.00	/LF		
d.	Total drainage tile unit cost			b + c	$0.00 /ft2
	Total Drainage Tile Cost			a x d	***$0***
XII.	**Drainage Channels (Stormwater Control)**				
Drainage benches and berms					
a.	Size of drainage bench needed	***$30,690***	LF		
b.	Drainage bench unit cost	***$40***	/LF		
c.	*Subtotal drainage bench cost*			a x b	*$1,227,600*
d.	Size of drainage swale/berm needed	$5,600	LF		
e.	Drainage swale/berm unit cost	$80	/LF		
f.	*Subtotal drainage swale/berm cost*			d x e	*$448,000*
Rip Rap					
g.	Quantity of Rip Rap needed	420	yd2		
h.	Rip rap unit cost	$130.00	/yd2		
i.	*Total rip rap cost*			g x h	*$54,600*

Gabian Baskets

j.	Quantity of gabian baskets needed		yd3		
k.	Gabian basket unit cost		/yd3		
l.	Subtotal gabian basket cost			j x k	*$0*
	Total Stormwater Control			c + f + i + l	***$1,730,200***

Drainage Component Subtotal (VIII + IX + X + XI+ XII): $4,123,386

Landfill Gas and Groundwater Features

XIII. Landfill Gas Monitoring & Control Components

				Calculation	
	Landfill Perimeter System				
a.	Number of probes to be installed	0	probes		
b.	LFG probe unit cost	$0	/probe		
c.	*Subtotal LFG probe cost*			a x b	*$0*
	Landfill Control Systems				
d.	Area to be closed	0	acres		
e.	Average number of vents per acre	0	vents / acre		
f.	LFG vent unit cost	$0	/vent		
g.	*Subtotal LFG vent cost*			d x e x f	*$0*
h.	Length of header pipe needed	-	LF		
i.	Header pipe unit cost	$0.00	/LF		
j.	Header pipe installation cost	$0.00	/LF		
k.	*Subtotal LFG active vent hook-up*			h x (i + j)	*$0*
	Total Landfill Gas Management Cost			c + g + k	***$0***

XIV. Groundwater Monitoring Components

a.	Hydrogeologic study cost	$0			
b.	Number of wells to be installed	0	wells		
c.	GW Monitoring Well unit cost	$0	/well		
d.	Number of wells > 50 ft length	0	wells		
e.	Additional well length over 50 ft	0	LF/well		
f.	Unit cost for additional well length	$0	/LF		
	Total Groundwater Monitoring Well Cost			a + (b x c) + (d x e x f)	***$0***

Landfill Gas & Groundwater Features Subtotal (XIII + XIV): $0

Miscellaneous

XV. Removal and Disposal of Stockpiled Material

				Calculation	
a.	Quantity of stockpiled materials	10,000	yd3		
b.	Loading and Hauling unit cost	$15.00	/yd3		
c.	Disposal unit cost	$30.00	/yd3		
d.	***Total Removal/Disposal Cost***			a x (b + c)	***$450,000***

XVI. Erosion/Sediment Control

a.	Quantity of silt fence needed	8,000	LF		
b.	Silt Fence unit cost	$4.00	/LF		
	Total Silt Fence Cost			a x b	***$32,000***

XVII. Landfill Access Road

a.	Size of LF access road	6,300	yd2		
b.	Depth of gravel needed	12	inches	x 1yd/36in	0.3 yd
c.	Depth of asphalt needed	0	inches	x 1yd/36in	0.0 yd
d.	Total material needed			a x (b + c)	2,100 yd3
e.	Road material unit cost	$70.00	/yd3		
f.	Placement/Spreading unit cost	$10.00	/yd3		
	Total access road cost			c x (d + e)	***$168,000***

XVIII. Site Security

Fencing

a.	Length of fencing needed	- ft		
b.	Fence unit cost	$0.00 /ft		
c.	*Subtotal fencing cost*		a x b	*$0*

Gate or Barrier

d.	Number of gates required	-		
e.	Gate unit cost	$0.00 /gate		
f.	*Subtotal gate cost*		d x e	*$0*

Closed Sign

g.	Number of signs required	4		
h.	Sign unit cost	$500.00 /gate		
i.	*Subtotal sign cost*		g x h	*$2,000*
	Total site security cost		c + f + i	***$2,000***

XIX. Mobilization / Demobilization

a.	Cost for mobilization/demobilization	845409.877	5.00%	
	Total mobilization/demobilization cost			***$845,410***

Miscellaneous Subtotal (XV + ... + XIX): $1,497,410

Closure Cost Subtotal (CCS):	(I + ... + XIX)	$17,753,607
Contingency (10%):	CCS x 0.10	$1,775,361
Engineering & Documentation:		
Construction QA/QC (1%)	CCS x 0.01	$177,536
Closure Certification and CQA Report (1%)	CCS x 0.01	$177,536
Survey and as-builts (2%)	CCS x 0.02	$355,072
Cost for survey and deed notation		$50,000
Total Engineering & Documentation Costs		***$760,144***
Total Closure Cost:	CCS + Contingency + Engineering	**$20,289,112**

Facilities are not required to use Worksheets CEW-01 and CEW-02; these forms are merely provided for facility use in an effort to show the depth of items to be addressed when preparing closure and post-closure care cost estimates. Facility-specific or alternate worksheets will be accepted for review and should accompany a certified DEQ Form CE SWDF.

Worksheet CEW-02: FORMAT FOR THE ESTIMATION OF POST-CLOSURE COSTS

FILL IN THE BOXES. THE REST WILL BE CALCULATED FOR YOU

I. Groundwater Monitoring

			Calculation or Conversion	
a. Total number of monitoring wells	13	wells		
b. Total number of sampling events/year	2	events/yr	a x b	26 samples/yr
c. Quantity of additional samples (e.g. QA/QC)	1	samples/even	b x c	2 samples/yr
d. Total samples per year			b + c	28 samples/yr
e. Analysis unit cost (Table 3.1 constituents)	$712.00	/sample		
f. *Total Analysis cost*			d x e	*$19,936.00 /yr*
g. GW Monitoring unit cost	$3,050.00	/event		
i. *Total sampling cost*			f + (g x b)	*$26,036.00 /yr*
j. Engineering fees & reports	$20,000	/yr		
Yearly Groundwater Monitoring Cost			i + j	***$46,036 /yr***

II. Landfill Gas Monitoring, Maintenance, and Control

a. Frequency of LFG compliance monitoring	0	events/yr		
b. LFG Monitoring unit cost	$0.00	/event		
c. *Total perimeter LFG monitoring cost*			a x b	*$0 /yr*
d. Frequency of suface monitoring (air permit)	0	events/yr		
e. Surface monitoring unit cost	$0.00	/event		
f. *Total surface monitoring cost*			d x e	*$0 /yr*
g. Control system operating unit cost	$0	/yr		
h. Frequency of LFG control system inspections	0	events/yr		
i. Control system inspection cost	$0.00	/event		
j. *Total constrol system cost*			g + (h x i)	*$0 /yr*
Yearly Landfill Gas Monitoring, Maintenance, & Control Cost			c + f + j	***$0 /yr***

III. Leachate Management

a. Quantity of leachate generated	1,124,000	gal/yr		
On-site Leachate Management or Pre-Treatment				
b. On-site treatment operating unit cost	$0.22	/gal		
c. *Total on-site management cost*			a x b	*$247,280 /yr*
Leachate Disposal				
d. Private disposal unit cost	$0.00	/gal		
e. POTW disposal unit cost	$0.00	/gal		
f. Direct discharge to POTW unit cost	$0.00	/gal		
g. Pump & Haul unit cost	$0.00	/gal		
h. Subtotal leachate disposal unit cost			d + e + f + g	$0.00
i. *Total leachate disposal cost*			a x h	*$0 /yr*
j. Leachate sampling & analysis unit cost	$2,713.00	/sample		
k. Frequency of leachate sampling & analysis	12	sample/yr		
l. *Total leachate sampling & analysis cost*			j x k	*$32,556.00 /yr*
Yearly Leachate Management Cost			c + i + l	***$279,836 /yr***
Closure of Leachate Storage Units				
m. Total Cost to Decommission/Remove	$1,500,000.00			
One-time Leachate Unit Closure Cost at end of PCC			m	***$1,500,000***

IV. Cap Maintenance & Repair

a. Closed Landfill Area	67 acres		
Mowing & Fertilization			
b. Mowing frequency	3 visits/yr		
c. Mowing unit cost	$144.00 /acre/visit		
d. *Total mowing cost*		a x b x c	*$28,944* /yr
e. Fertilizer frequency	1 visits/yr		
f. Fertilizer unit cost	$475.00 /acre/visit		
g. *Total fertilizer cost*		a x e x f	*$31,825* /yr
Cap Erosion & Repair			
h. Area to reseed/year		33% x a	22.3 acres
i. Reseeding unit cost	$4,997.00 /acre		
j. *Total reseeding cost*		h x i	*$111,599.67* /yr
k. Area of cap erosion/year		10% x a	6.7 acres
l. Cap erosion repair unit cost	$6,000.00 /acre		
m. Mobilization/Demobilization	$500.00 /yr		
n. *Total cap erosion repair cost*		(k x l) + m	*$40,700* /yr
Yearly Cap Maintenance & Repair cost		d + g + j + n	***$213,069 /yr***

V. Sediment Basin Maintenance & Repair

a. Sediment basin cleanout frequency, 1 per	3 years	1 / a	0.33 event/yr
b. Sediment basin cleanout unit cost	$45,000 /event		
c. Mobilization/Demobilization	$2,500 /event		
d. *Total sediment basin maintenance cost*		a x (b + c)	*$15,833* /yr
e. Total number of stormwater sampling locations	1 locations		
f. Stormwater sampling frequency	1 events/yr		
g. Total number of stormwater samples		e x f	1 samples/yr
h. Analysis unit cost (VPDES permit parameters)	$350 /sample		
i. *Total Analysis cost*		g x h	*$350* /yr
j. Mobilization unit cost	$321.00 /event		
k. Technician field unit cost	$272.00 /event		
l. *Total sampling cost*		f x (j + k)	*$593.00* /yr
m. Engineering fees & reports	$1,628 /yr		
n. *Total Stormwater Sampling & Analysis cost*		i + l + m	*$2,571 /yr*
Yearly Sediment Basin Maintenance & Repair		d + n	***$18,404 /yr***

VI. Vector & Rodent Control

a. Vector and rodent control unit cost	$5,000 /yr		
Yearly Vector and Rodent Control Cost		a	***$5,000 /yr***

VII. Post-Closure Care General Inspections

a. General Inspection unit cost	$5,162 /inspection		
b. Number of inspections per year	1		
Yearly Post-Closure Care General Inspection Cost		a x b	***$5,162 /yr***

VIII. Underdrain Monitoring

	Input		Calculation or Conversion	
a. Total number of monitoring locations	0	wells		
b. Total number of sampling events/year	0	events/yr	a x b	0 samples/yr
c. Quantity of additional samples (e.g. QA/QC)	0	samples/even	b x c	0 samples/yr
d. Total samples per year			b + c	0 samples/yr
e. Analysis unit cost (leachate indicator parameters)	$0.00	/sample		
f. *Total Analysis cost*			d x e	*$0.00* /yr
g. Underdrain Monitoring unit cost	$0.00	/event		
i. *Total sampling cost*			f + (g x b)	*$0.00* /yr
j. Engineering fees & reports	$0	/yr		
Yearly Underdrain Monitoring Cost			i + j	***$0 /yr***

	Input		Calculation or Conversion	
Annual Post-Closure Care Cost (APCC)			I + ... + VIII	$567,507 /yr
Length of post-closure care (LPCC)	30	years		
Post-Closure Care Cost			(APCC x LPCC) + III.m.	$18,525,210
Engineering & Documentation			Engineering Sum	$36,064
Post-Closure Care Evaluation	$19,443			
Post-Closure Care Certification	$3,153			
Cost for survey and deed notation (if not completed at time of landfill closure)	$13,468			
FA Mechanism Maintenance Cost	$3,855	/yr	FA maintenance x LPCC	$115,650
Total Post-Closure Care Cost			Post-Closure Cost + Engineering + FA Maintenance	**$18,676,924**

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