ATTACHMENT XVI – ALTERNATE FINAL COVER DEMONSTRATION

ALTERNATE FINAL COVER DEMONSTRATION

Bremo Bluff FFCP Management Facility
Solid Waste Permit 627
Fluvanna County, Virginia

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CERTIFICATION

This Alternate Final Cover Demonstration for the Bremo Bluff 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	Principal / Practice Leader Solid Waste
Name	Title
	November 15, 2024
Signature	Date

1.0 INTRODUCTION

This Alternate Final Cover Demonstration (AFCD) has been prepared for the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) located in Bremo Bluff, Virginia. The Facility will accept coal combustion residuals (CCR) previously generated at the Bremo Station (Station) and operate as a new, captive industrial landfill (CCR Unit) under the Virginia Department of Environmental Quality (DEQ) Solid Waste Permit (SWP) 627. Schnabel Engineering (Schnabel) has prepared this AFCD on behalf of the Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy).

The Facility is subject to the design 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).

2.0 OBJECTIVE

The objective of these calculations is to demonstrate the adequacy of the proposed final cover systems for the CCR Unit as well as compliance with the CCR Rule. Although an AFCD is not a requirement of 40 CFR §257.102(d)(3), this demonstration is being provided as justification for the qualified professional engineer's self-certification that the design of the final cover system meets the requirements of 40 CFR §257.102(d)(3), as required under 40 CFR §257.102(d)(3)(iii).

2.1 Performance Requirements

The proposed final cover systems for the CCR Unit are in accordance with the design requirements for industrial landfills outlined in 9VAC20-81-160.D.2.e; however, this demonstration is provided to show compliance with 40 CFR §257.102. Per 40 CFR §257.102(d)(3)(i), the "permeability of the final cover system must be less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than 1 $x10^{-5}$ centimeters per second (cm/s), whichever is less; and the infiltration of liquids through the closed CCR unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material." However, as stated in 40 CFR §257.102(d)(3)(ii), the owner or operator may select an alternative final cover system design that includes an infiltration layer that achieves an equivalent reduction in infiltration as the infiltration layer specified in 40 CFR §257.102(d)(3)(i).

For the proposed final cover systems, the geomembrane components in the final cover and bottom liner systems have nearly identical hydraulic conductivities. This demonstration shows that during peak liquid collection conditions, the percolation through the final cover systems is less than the percolation through the bottom liner systems and meets the regulatory infiltration reduction requirements discussed above.

2.2 Proposed Final Cover Descriptions

Four final cover systems are proposed for the CCR Unit, two final cover systems for the sideslope areas constructed at 3H:1V (horizontal to vertical) and two final cover systems for the top deck areas, which include a geosynthetic clay liner (GCL) component. The proposed final cover systems will be placed directly on a prepared and compacted subgrade of CCR or 12 inches of soil meeting the requirements outlined in Attachment VII of the Part B Permit Application (Technical Specifications). The final cover systems will include an 18-inch-thick protective cover soil layer and a six-inch-thick vegetative support soil layer, which collectively make up the regulatory 24-inch-thick erosion layer. Detailed information on the

final cover systems, as well as the bottom liner system, are described below. The final cover systems are also depicted in Attachment III of the Part B Permit Application (Design Plans).

2.2.1 Sideslope Final Cover System Option 1

This sideslope final cover system features a textured linear low-density polyethylene (LLDPE) or high-density polyethylene (HDPE) geomembrane and a drainage geocomposite. The textured geomembrane has a minimum thickness of 40 mils and is overlain by a double-sided 275-mil geocomposite, which provides drainage for the overlying 24-inch-thick erosion layer. The geomembrane will be placed over a prepared and compacted subgrade of CCR or 12 inches of soil.

2.2.2 Sideslope Final Cover System Option 2

This sideslope final cover system features a 50-mil Agru MicroDrain® LLDPE geomembrane or Agru Super Gripnet® LLDPE geomembrane. Each geomembrane incorporates a drainage component directly, consisting of 130-mil high drainage “studs,” eliminating the need for a separate drainage layer such as a geocomposite. An overlying 8-ounce per square yard (oz) non-woven, heat-burnished geotextile provides separation and filtration between the drainage “studs” and the erosion layer soil. The geomembrane will be placed over a prepared and compacted subgrade of CCR or 12 inches of soil.

2.2.3 Top Deck Final Cover System Option 1

This top deck final cover system features a textured LLDPE or HDPE geomembrane and a drainage geocomposite. The textured geomembrane has a minimum thickness of 40 mils and is overlain by a double-sided 275-mil geocomposite, which provides drainage for the overlying 24-inch-thick erosion layer. The geomembrane will be placed over a GCL, which will be placed over a prepared and compacted subgrade of CCR or 12 inches of soil.

2.2.4 Top Deck Final Cover System Option 2

This top deck final cover system features a 50-mil Agru MicroDrain® LLDPE geomembrane. This geomembrane incorporates a drainage component directly, eliminating the need for a separate drainage layer such as a geocomposite. The drainage component of the MicroDrain® LLDPE geomembrane consists of 130-mil high drainage “studs.” An overlying 8-oz non-woven, heat-burnished geotextile provides separation and filtration between the drainage “studs” and the erosion layer soil. The geomembrane will be placed over a GCL, which will be placed over a prepared and compacted subgrade of CCR or 12 inches of soil.

2.2.5 Bottom Liner System

The proposed bottom liner system for the CCR Unit includes a GCL placed atop a minimum 12-inch-thick controlled subgrade and overlain by a 60-mil textured HDPE geomembrane liner. A 250-mil geocomposite drainage layer will be placed atop the geomembrane and will be overlain by an 18-inch-thick aggregate layer. A depiction of the bottom liner system is included in the Design Plans.

3.0 METHODOLOGY

The abilities of each proposed final cover system to meet the criteria stated above were determined through the Hydrologic Evaluation of Landfill Performance (HELP) Model Program Version 4.0.1, as developed by the U.S. Army Engineering Waterways Experiment Station in Vicksburg, Mississippi for the

U.S. Environmental Protection Agency (USEPA). Infiltration results from the final cover system HELP models were analyzed and compared to the HELP model for the proposed bottom liner system to provide this demonstration.

4.0 HELP MODEL

4.1 Inputs and Assumptions

The following HELP Model inputs and assumptions are based on the condition of the proposed final cover and bottom liner systems during their peak liquid collection conditions. To compare the performance of the final cover systems and the bottom liner in the HELP Model Program, the bottom liner system was modeled in a state where leachate is being produced and there is an accumulation of head on the bottom liner. To simulate these conditions, the bottom liner system was modeled with an open 10-foot lift of CCR. The final cover systems were modeled for the closed condition (i.e., installed final cover system with established vegetation).

Each model was assigned surface water runoff parameters based on the intended condition. Based on guidance from Technical Release 55 (TR-55), the final cover system conditions used a weighted National Resource Conservation Service (NRCS) Curve Number (CN) of 61 (good condition grassland, hydrologic soil group B) and the bottom liner system conditions used a CN of 91 (newly graded areas, hydrologic soil groups C). The final cover system conditions were set to allow runoff, while the bottom liner model was not, which was done to account for the bottom liner system's collection of precipitation as leachate. The bottom liner was assigned an evaporative zone depth of 6 inches to correspond to bare CCR, and the final cover systems were assigned an evaporative zone depth of 24 inches to correspond with the depth of anticipated soil cover.

The climate data for the models consist of precipitation, temperature, solar radiation, and evapotranspiration. Precipitation and temperature data was generated by the HELP Model Program using historical data from Stations USC00440993 (Bremo Bluff, VA) and USC00446491 (Scottsville, VA), which are part of the National Oceanic and Atmospheric Administration's (NOAA) Global Historical Climatology Network (GHCN). Solar radiation and evapotranspiration data were synthetically generated by the HELP Model Program for a longitude of -78.27° N. Wind speed and relative humidity were generated by the HELP Model Program using historical data from the National Solar Radiation Database (NSRD) Station 724016 (Charlottesville, VA). The final cover conditions were assigned a leaf area index (LAI) of 4 for a good to excellent stand of vegetation, and the bottom liner condition was assigned an LAI of 0 for bare earth. Values for the start and end of the growing season were assigned based on the average monthly temperature data for Bremo Bluff, VA.

The final cover systems were modeled at 33% (3H:1V sideslopes) with a lateral drainage length of 105 feet and at 6.5% (top deck) with a lateral drainage length of 75 feet. The sideslope final cover systems were assumed to be placed on a prepared and compacted subgrade of 12 inches of soil and the top deck final cover systems were assumed to be placed directly on prepared and compacted CCR. The bottom liner system was modeled with 2.5% and 5% grades with a lateral drainage length of 225 feet and 425 feet, respectively. The 18-inch-thick aggregate layer in the bottom liner system was modeled as coarse aggregate, which was determined in Attachment VIII of the Part B Permit Application (Leachate Management Plan) to result in the most head on the bottom liner.

Based on laboratory testing performed by TRI/Environmental, Inc., the drainage studs overlain by a

heat-burnished geotextile have a measured transmissivity of $6.5x10^{-4}$ square meters per second (m^2/s) under a loading of 240 pounds per square foot (psf), which represents an approximate soil load for the protective cover soil and vegetative support layer. Using the "stud" height of 0.13 inches (0.0033 meters), the hydraulic conductivity for the drainage component is computed to be 19.0 cm/s under laboratory conditions. Based on manufacturers data, the geocomposites are assumed to exhibit a transmissivity of $1.13x10^{-3}$ m^2/s, which corresponds to a hydraulic conductivity of approximately 15.7 cm/s under laboratory conditions. To simulate in-place conditions, reduction factors for intrusion, creep, chemical, and biological clogging were applied to the drainage components. This reduced the hydraulic conductivity of the LLDPE geomembrane overlain by geotextile and the final cover and bottom liner geocomposites to 10.9 cm/s, 7.5 cm/s, and 2.2 cm/s respectively.

Each final cover system model was run for a period of 20 simulated years for a one-acre area and the results were evaluated. The peak daily heads for each section were checked to verify containment within the drainage layer for the final cover systems and compliance with the regulatory 12-inch maximum head for the bottom liner system. The peak daily percolation/leakage volumes through the bottom component of each system were then compared to evaluate infiltration performance.

4.2 HELP Models

The tables below show the composition of each modeled section. The vegetative support soil, protective cover soil, and prepared and compacted subgrade were assumed to be sandy loam (Unified Soil Classification System SM) in accordance with the silty sands and sand-silt mixtures on-site. The values used for these soils correspond with existing boring logs and laboratory testing completed for the Facility and are assumed to be characteristic of on-site soils. Except in cases where the hydraulic conductivity can be estimated with some degree of certainty, such as the LLDPE geomembrane drainage studs mentioned above, or in cases where a minimum or maximum hydraulic conductivity has been established, such as the GCL in the bottom liner system [discussed in Attachment XIV of the Part B Permit Application (Alternate Liner Demonstration)] and the regulatory requirements for the aggregate layer in the bottom liner system, the default HELP Model Program values were used.

Table 1: Sideslope Final Cover System Option 1

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	Vegetative Cover	1	6.0	0.4530	0.2252	7.20E-04
2	Protective Cover	1	18.0	0.4530	0.1036	7.20E-04
3	275-mil Geocomposite	2	0.275	0.8500	0.0145	7.51E+00
4	40-mil LLDPE or HDPE Geomembrane	4	0.04	N/A	N/A	4.00E-13
5	Prepared and Compacted Subgrade	1	12.0	0.4530	0.1900	7.20E-04
6	CCR	1	12.0	0.5410	0.1870	5.00E-05

Table 2: Sideslope Final Cover System Option 2

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	Vegetative Cover	1	6.0	0.4530	0.2249	7.20E-04
2	Protective Cover	1	18.0	0.4530	0.1036	7.20E-05
3	Geotextile and Drainage Studs	2	0.13	0.8500	0.0166	1.09E+01
4	50-mil LLDPE MicroDrain® or Super Gripnet®	4	0.05	N/A	N/A	4.00E-13
5	Prepared and Compacted Subgrade	1	12.0	0.4530	0.1900	7.20E-04
6	CCR	1	12.0	0.5410	0.1870	5.00E-05

Table 3: Top Deck Final Cover System Option 1

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	Vegetative Cover	1	6.0	0.4530	0.2214	7.20E-04
2	Protective Cover	1	18.0	0.4530	0.2983	7.20E-05
3	275-mil Geocomposite	2	0.275	0.8500	0.0607	7.51E+00
4	40-mil LLDPE Geomembrane	4	0.04	N/A	N/A	4.00E-13
5	GCL	3	0.276	0.7500	0.7500	5.00E-09
6	CCR	1	12.0	0.5410	0.1678	5.00E-05

Table 4: Top Deck Final Cover System Option 2

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	Vegetative Cover	1	6.0	0.4530	0.2225	7.20E-04
2	Protective Cover	1	18.0	0.4530	0.2995	7.20E-04
3	Geotextile and Drainage Studs	2	0.13	0.8500	0.0864	1.09E+01
4	50-mil LLDPE MicroDrain®	4	0.05	N/A	N/A	4.00E-13
5	GCL	3	0.276	0.7500	0.7500	5.00E-09
6	CCR	1	12.0	0.5410	0.1673	5.00E-05

Table 5: Bottom Liner System at 2.5%

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	CCR	1	120.0	0.5410	0.3177	5.00E-05
2	Aggregate Layer	2	18.0	0.3900	0.1468	1.00E-03
3	250-mil Geocomposite	2	0.25	0.8500	0.1186	2.20E+00
4	60-mil HDPE Geomembrane	4	0.06	N/A	N/A	2.00E-13
5	GCL	3	0.28	0.7500	0.7500	3.40E-09

Table 6: Bottom Liner System at 5%

Layer No.	Layer ID	Layer Type	Thickness (in)	Porosity (vol/vol)	Initial Soil Water Content (vol/vol)	Effective Saturated Hydraulic Conductivity (cm/s)
1	CCR	1	120.0	0.5410	0.3177	5.00E-05
2	Aggregate Layer	2	18.0	0.3900	0.1468	1.00E-03
3	250-mil Geocomposite	2	0.25	0.8500	0.1132	2.20E+00
4	60-mil HDPE Geomembrane	4	0.06	N/A	N/A	2.00E-13
5	GCL	3	0.28	0.7500	0.7500	3.40E-09

4.3 HELP Model Results

Based on the HELP Model calculations, Sideslope Final Cover System Option 1 has a negligible peak daily percolation rate [(less than 0.0000 cubic feet per day (cf/day)], and the peak daily maximum head obtained on the geomembrane is estimated at 0.0342 inches. Sideslope Final Cover System Option 2 also has a negligible peak daily percolation rate (less than 0.0000 cf/day), and the peak daily maximum head obtained on the geomembrane is estimated at 0.0366 inches. Top Deck Final Cover System Option 1 has an estimated peak daily percolation rate of 0.0003 cf/day, and the peak daily maximum head obtained on the geomembrane is estimated at 0.1965 inches. Top Deck Final Cover System Option 2 has a peak daily percolation of 0.0003 cf/day, and the peak daily maximum head obtained on the geomembrane is 0.3017 inches. The bottom liner system at 2.5% has a peak daily percolation of 0.0032 cf/day, and the peak daily maximum head obtained on the geomembrane is 11.6341 inches. The bottom liner system at 5% has a peak daily percolation of 0.0024 cf/day, and the peak daily maximum head obtained on the geomembrane is 10.5336 inches. These results are summarized in the following table.

Table 7: HELP Model Results

HELP Model Condition	Peak Daily Maximum Head (in)	Peak Daily Percolation (cf/day)
Sideslope Final Cover System Option 1	0.0342	0.0000
Sideslope Final Cover System Option 2	0.0366	0.0000
Top Deck Final Cover System Option 1	0.1965	0.0003
Top Deck Final Cover System Option 2	0.3017	0.0003
Bottom Liner System at 2.5%	11.6341	0.0032
Bottom Liner System at 5%	10.5336	0.0024

5.0 CONCLUSION

Based on these calculations and HELP model results, the peak daily percolations through the proposed final cover system options are less than the peak daily percolation through the bottom liner system, thus demonstrating that the proposed final cover systems meet 40 CFR §257.102(d)(3).

ATTACHMENT 1

SIDESLOPE FINAL COVER SYSTEM OPTION 1 HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: FFCP Mgmt Facility (SS FC 1) **Simulated On:** 6/12/2023 17:16

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SL - Sandy Loam
Material Texture Number 6

Thickness	=	6	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2252	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	18	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.1036	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
275-mil Geocomposite
Material Texture Number 124

Thickness	=	0.275	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.0145	vol/vol
Effective Sat. Hyd. Conductivity	=	7.51E+00	cm/sec
Slope	=	33.33	%
Drainage Length	=	105	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	12	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.19	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer (Waste)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	12	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.187	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	61	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	24	inches
Initial Water in Evaporative Zone	=	3.216	inches
Upper Limit of Evaporative Storage	=	10.872	inches
Lower Limit of Evaporative Storage	=	2.04	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	7.743	inches
Total Initial Water	=	7.743	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	4	
Start of Growing Season (Julian Date)	=	90	days
End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: FFCP Mgmt Facility (SS FC 1)
Simulated on: 6/12/2023 17:17

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.487	[1.07]	1,769.4	1.05
Evapotranspiration	22.344	[4.256]	81,108.3	48.08
Subprofile1				
Lateral drainage collected from Layer 3	23.5899	[6.0071]	85,631.3	50.76
Percolation/leakage through Layer 4	0.000004	[0]	0.0130	0.00
Average Head on Top of Layer 4	0.0005	[0.0001]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.000122	[0.000217]	0.4423	0.00
Water storage				
Change in water storage	0.0541	[1.3477]	196.5	0.12

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: FFCP Mgmt Facility (SS FC 1)
Simulated on: 6/12/2023 17:17

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	0.917		3,328.2
Subprofile1			
Drainage collected from Layer 3	2.0790		7,546.8
Percolation/leakage through Layer 4	0.000000		0.0000
Average head on Layer 4	0.0171		---
Maximum head on Layer 4	0.0342		---
Location of maximum head in Layer 3	0.00	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000488		1.7730
Other Parameters			
Snow water	3.6538		13,263.3
Maximum vegetation soil water	0.3568	(vol/vol)	
Minimum vegetation soil water	0.0850	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: FFCP Mgmt Facility (SS FC 1)
Simulated on: 6/12/2023 17:17
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.1681	0.1947
2	3.1336	0.1741
3	0.0032	0.0117
4	0.0000	0.0000
5	2.2790	0.1899
6	2.2421	0.1868
Snow water	0.0000	---

ATTACHMENT 2

SIDESLOPE FINAL COVER SYSTEM OPTION 2 HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: FFCP Mgmt Facility (SS FC 2) **Simulated On:** 6/12/2023 17:21

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SL - Sandy Loam
Material Texture Number 6

Thickness	=	6	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2249	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	18	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.1036	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
MicroDrain/Super Gripnet
Material Texture Number 125

Thickness	=	0.13	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.0166	vol/vol
Effective Sat. Hyd. Conductivity	=	1.09E+01	cm/sec
Slope	=	33.33	%
Drainage Length	=	105	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.05	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	12	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.19	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer (Waste)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	12	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.187	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	61	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	24	inches
Initial Water in Evaporative Zone	=	3.214	inches
Upper Limit of Evaporative Storage	=	10.872	inches
Lower Limit of Evaporative Storage	=	2.04	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	7.74	inches
Total Initial Water	=	7.74	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	4	
Start of Growing Season (Julian Date)	=	90	days
End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: FFCP Mgmt Facility (SS FC 2)
Simulated on: 6/12/2023 17:23

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.433	[0.941]	1,572.9	0.93
Evapotranspiration	16.079	[2.918]	58,365.0	34.60
Subprofile1				
Lateral drainage collected from Layer 3	29.9434	[5.9339]	108,694.5	64.43
Percolation/leakage through Layer 4	0.000004	[0]	0.0129	0.00
Average Head on Top of Layer 4	0.0005	[0.0001]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.000122	[0.000217]	0.4423	0.00
Water storage				
Change in water storage	0.0202	[0.6818]	73.2	0.04

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: FFCP Mgmt Facility (SS FC 2)
Simulated on: 6/12/2023 17:23

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	0.917		3,326.9
Subprofile1			
Drainage collected from Layer 3	3.2236		11,701.7
Percolation/leakage through Layer 4	0.000000		0.0000
Average head on Layer 4	0.0183		---
Maximum head on Layer 4	0.0366		---
Location of maximum head in Layer 3	0.00	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000488		1.7730
Other Parameters			
Snow water	3.6538		13,263.3
Maximum vegetation soil water	0.3043	(vol/vol)	
Minimum vegetation soil water	0.0850	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: FFCP Mgmt Facility (SS FC 2)
Simulated on: 6/12/2023 17:24
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.1781	0.1964
2	2.4424	0.1357
3	0.0015	0.0118
4	0.0000	0.0000
5	2.2790	0.1899
6	2.2421	0.1868
Snow water	0.0000	---

ATTACHMENT 3

TOP DECK FINAL COVER SYSTEM OPTION 1 HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: FFCP Mgmt Facility (TD 1) **Simulated On:** 6/12/2023 17:27

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SL - Sandy Loam
Material Texture Number 6

Thickness	=	6	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2214	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	18	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2983	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
275-mil Geocomposite
Material Texture Number 124

Thickness	=	0.275	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.0607	vol/vol
Effective Sat. Hyd. Conductivity	=	7.51E+00	cm/sec
Slope	=	6.5	%
Drainage Length	=	75	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5

Type 3 - Barrier Soil Liner
Geosynthetic Clay Liner
Material Texture Number 43

Thickness	=	0.276	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-09	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer (Waste)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	12	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1678	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	61	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	24	inches
Initial Water in Evaporative Zone	=	6.698	inches
Upper Limit of Evaporative Storage	=	10.872	inches
Lower Limit of Evaporative Storage	=	2.04	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	8.936	inches
Total Initial Water	=	8.936	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	4	
Start of Growing Season (Julian Date)	=	90	days
End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: FFCP Mgmt Facility (TD 1)
Simulated on: 6/12/2023 17:28

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.511	[1.091]	1,856.3	1.10
Evapotranspiration	29.389	[3.236]	106,681.9	63.24
Subprofile1				
Lateral drainage collected from Layer 3	16.6247	[5.9567]	60,347.7	35.77
Percolation/leakage through Layer 5	0.000003	[0]	0.0116	0.00
Average Head on Top of Layer 4	0.0013	[0.0005]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.029427	[0.028614]	106.8	0.06
Water storage				
Change in water storage	-0.0789	[0.6333]	-286.6	-0.17

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: FFCP Mgmt Facility (TD 1)
Simulated on: 6/12/2023 17:28

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	1.013		3,677.3
Subprofile1			
Drainage collected from Layer 3	2.3159		8,406.7
Percolation/leakage through Layer 5	0.000000		0.0003
Average head on Layer 4	0.1965		---
Maximum head on Layer 4	0.1247		---
Location of maximum head in Layer 3	0.52	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000569		2.0653
Other Parameters			
Snow water	3.6538		13,263.3
Maximum vegetation soil water	0.3610	(vol/vol)	
Minimum vegetation soil water	0.0850	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: FFCP Mgmt Facility (TD 1)
Simulated on: 6/12/2023 17:28
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.1460	0.1910
2	4.5726	0.2540
3	0.0053	0.0194
4	0.0000	0.0000
5	0.2070	0.7500
6	1.4256	0.1188
Snow water	0.0000	---

ATTACHMENT 4

TOP DECK FINAL COVER SYSTEM OPTION 2 HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: FFCP Mgmt Facility (TD 2) **Simulated On:** 6/12/2023 17:33

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SL - Sandy Loam
Material Texture Number 6

Thickness	=	6	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2225	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SL - Sandy Loam
Material Texture Number 6

Thickness	=	18	inches
Porosity	=	0.453	vol/vol
Field Capacity	=	0.19	vol/vol
Wilting Point	=	0.085	vol/vol
Initial Soil Water Content	=	0.2995	vol/vol
Effective Sat. Hyd. Conductivity	=	7.20E-04	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
MicroDrain/Super Gripnet
Material Texture Number 125

Thickness	=	0.13	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.0864	vol/vol
Effective Sat. Hyd. Conductivity	=	1.09E+01	cm/sec
Slope	=	6.5	%
Drainage Length	=	75	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.05	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5

Type 3 - Barrier Soil Liner
Geosynthetic Clay Liner
Material Texture Number 43

Thickness	=	0.276	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-09	cm/sec

Layer 6

Type 1 - Vertical Percolation Layer (Waste)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	12	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.1673	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	61	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	24	inches
Initial Water in Evaporative Zone	=	6.726	inches
Upper Limit of Evaporative Storage	=	10.872	inches
Lower Limit of Evaporative Storage	=	2.04	inches
Initial Snow Water	=	0	inches

Initial Water in Layer Materials	=	8.952	inches
Total Initial Water	=	8.952	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	4	
Start of Growing Season (Julian Date)	=	90	days
End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: FFCP Mgmt Facility (TD 2)
Simulated on: 6/12/2023 17:34

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.491	[1.047]	1,781.6	1.06
Evapotranspiration	28.661	[3.528]	104,039.2	61.67
Subprofile1				
Lateral drainage collected from Layer 3	17.3744	[5.9924]	63,068.9	37.38
Percolation/leakage through Layer 5	0.000003	[0]	0.0126	0.00
Average Head on Top of Layer 4	0.0009	[0.0004]	---	---
Subprofile2				
Percolation/leakage through Layer 6	0.029659	[0.029193]	107.7	0.06
Water storage				
Change in water storage	-0.0803	[0.7523]	-291.3	-0.17

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: FFCP Mgmt Facility (TD 2)
Simulated on: 6/12/2023 17:34

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	1.005		3,647.5
Subprofile1			
Drainage collected from Layer 3	2.3250		8,439.7
Percolation/leakage through Layer 5	0.000000		0.0003
Average head on Layer 4	0.3017		---
Maximum head on Layer 4	0.1998		---
Location of maximum head in Layer 3	0.90	(feet from drain)	
Subprofile2			
Percolation/leakage through Layer 6	0.000554		2.0108
Other Parameters			
Snow water	3.6127		13,114.1
Maximum vegetation soil water	0.3622	(vol/vol)	
Minimum vegetation soil water	0.0850	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: FFCP Mgmt Facility (TD 2)
Simulated on: 6/12/2023 17:34
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	1.1471	0.1912
2	4.5755	0.2542
3	0.0031	0.0235
4	0.0000	0.0000
5	0.2070	0.7500
6	1.4142	0.1179
Snow water	0.0000	---

ATTACHMENT 5

BOTTOM LINER SYSTEM AT 2.5% HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Bremo FFCP Mgmt Facility **Simulated On:** 6/14/2023 10:24

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	120	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.3177	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Layer 2

Type 2 - Lateral Drainage Layer
VDOT Stone
Material Texture Number 44

Thickness	=	18	inches
Porosity	=	0.39	vol/vol
Field Capacity	=	0.04	vol/vol
Wilting Point	=	0.013	vol/vol
Initial Soil Water Content	=	0.1468	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-03	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
250-mil Geocomposite
Material Texture Number 123

Thickness	=	0.25	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.1186	vol/vol
Effective Sat. Hyd. Conductivity	=	2.20E+00	cm/sec
Slope	=	2.5	%
Drainage Length	=	225	ft

Layer 4

Type 4 - Flexible Membrane Liner
HDPE Membrane
Material Texture Number 35

Thickness	=	0.06	inches
Effective Sat. Hyd. Conductivity	=	2.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5
Type 3 - Barrier Soil Liner
Geosynthetic Clay Liner
Material Texture Number 43

Thickness	=	0.276	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	3.40E-09	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	91	
Fraction of Area Allowing Runoff	=	0	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	6	inches
Initial Water in Evaporative Zone	=	2.603	inches
Upper Limit of Evaporative Storage	=	3.246	inches
Lower Limit of Evaporative Storage	=	0.282	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	41.005	inches
Total Initial Water	=	41.005	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	0	
Start of Growing Season (Julian Date)	=	90	days

End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:25

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.000	[0]	0.0000	0.00
Evapotranspiration	27.868	[3.098]	101,159.5	59.96
Subprofile1				
Lateral drainage collected from Layer 3	18.2642	[7.4105]	66,299.1	39.30
Percolation/leakage through Layer 5	0.000003	[0]	0.0098	0.00
Average Head on Top of Layer 4	0.0374	[0.017]	---	---
Water storage				
Change in water storage	0.3437	[4.92]	1,247.5	0.74

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:25

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	0.000		0.0000
Subprofile1			
Drainage collected from Layer 3	0.3515		1,275.8
Percolation/leakage through Layer 5	0.000001		0.0032
Average head on Layer 4	7.8052		---
Maximum head on Layer 4	11.6341		---
Location of maximum head in Layer 3	57.21	(feet from drain)	
Other Parameters			
Snow water	3.6144		13,120.2
Maximum vegetation soil water	0.5410	(vol/vol)	
Minimum vegetation soil water	0.0470	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:25
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	44.7764	0.3731
2	2.8143	0.1563
3	0.0808	0.3234
4	0.0000	0.0000
5	0.2070	0.7500
Snow water	0.0000	---

ATTACHMENT 6

BOTTOM LINER SYSTEM AT 5% HELP MODEL SUMMARY

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: Bremo FFCP Mgmt Facility **Simulated On:** 6/14/2023 10:52

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
High-Density Electric Plant Coal Fly Ash
Material Texture Number 30

Thickness	=	120	inches
Porosity	=	0.541	vol/vol
Field Capacity	=	0.187	vol/vol
Wilting Point	=	0.047	vol/vol
Initial Soil Water Content	=	0.3177	vol/vol
Effective Sat. Hyd. Conductivity	=	5.00E-05	cm/sec

Layer 2

Type 2 - Lateral Drainage Layer
VDOT Stone
Material Texture Number 44

Thickness	=	18	inches
Porosity	=	0.39	vol/vol
Field Capacity	=	0.04	vol/vol
Wilting Point	=	0.013	vol/vol
Initial Soil Water Content	=	0.1468	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E-03	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
250-mil Geocomposite
Material Texture Number 123

Thickness	=	0.25	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.1132	vol/vol
Effective Sat. Hyd. Conductivity	=	2.20E+00	cm/sec
Slope	=	5	%
Drainage Length	=	425	ft

Layer 4

Type 4 - Flexible Membrane Liner
HDPE Membrane
Material Texture Number 35

Thickness	=	0.06	inches
Effective Sat. Hyd. Conductivity	=	2.00E-13	cm/sec
FML Pinhole Density	=	0	Holes/Acre
FML Installation Defects	=	0	Holes/Acre
FML Placement Quality	=	2	Excellent

Layer 5
Type 3 - Barrier Soil Liner
Geosynthetic Clay Liner
Material Texture Number 43

Thickness	=	0.276	inches
Porosity	=	0.75	vol/vol
Field Capacity	=	0.747	vol/vol
Wilting Point	=	0.4	vol/vol
Initial Soil Water Content	=	0.75	vol/vol
Effective Sat. Hyd. Conductivity	=	3.40E-09	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	91	
Fraction of Area Allowing Runoff	=	0	%
Area projected on a horizontal plane	=	1	acres
Evaporative Zone Depth	=	6	inches
Initial Water in Evaporative Zone	=	2.603	inches
Upper Limit of Evaporative Storage	=	3.246	inches
Lower Limit of Evaporative Storage	=	0.282	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	41.004	inches
Total Initial Water	=	41.004	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was User-Specified.

Evapotranspiration and Weather Data

Station Latitude	=	37.71	Degrees
Maximum Leaf Area Index	=	0	
Start of Growing Season (Julian Date)	=	90	days

End of Growing Season (Julian Date)	=	304	days
Average Wind Speed	=	5	mph
Average 1st Quarter Relative Humidity	=	58	%
Average 2nd Quarter Relative Humidity	=	66	%
Average 3rd Quarter Relative Humidity	=	77	%
Average 4th Quarter Relative Humidity	=	61	%

Note: Evapotranspiration data was obtained for Bremo Bluff, Virginia

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
3.365862	2.758621	3.928621	3.318276	4.841379	4.375517
4.655517	3.91	4.344828	3.914483	3.501724	3.806552

Note: Precipitation was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
36.4	38.7	46.2	56.3	64.7	73.3
77.5	76	69.3	58.1	47.8	40.4

Note: Temperature was simulated using NOAA data for the following weather station
BREMO BLUFF, VA US, SCOTTSVILLE 6 SE, VA US, SCOTTSVILLE 1.2 E, VA US
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 37.71/-78.27

Average Annual Totals Summary

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:53

	Average Annual Totals for Years 1 - 20*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	46.48	[8.08]	168,706.1	100.00
Runoff	0.000	[0]	0.0000	0.00
Evapotranspiration	27.868	[3.098]	101,159.5	59.96
Subprofile1				
Lateral drainage collected from Layer 3	18.2643	[7.41]	66,299.5	39.30
Percolation/leakage through Layer 5	0.000003	[0]	0.0097	0.00
Average Head on Top of Layer 4	0.0352	[0.0156]	---	---
Water storage				
Change in water storage	0.3435	[4.9191]	1,247.1	0.74

* Note: Average inches are converted to volume based on the user-specified area.

Peak Values Summary

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:53

	Peak Values for Years 1 - 20*		
	(inches)		(cubic feet)
Precipitation	5.45		19,783.5
Runoff	0.000		0.0000
Subprofile1			
Drainage collected from Layer 3	0.3669		1,332.0
Percolation/leakage through Layer 5	0.000001		0.0024
Average head on Layer 4	5.9315		---
Maximum head on Layer 4	10.5336		---
Location of maximum head in Layer 3	43.33	(feet from drain)	
Other Parameters			
Snow water	3.6144		13,120.2
Maximum vegetation soil water	0.5410	(vol/vol)	
Minimum vegetation soil water	0.0470	(vol/vol)	

Final Water Storage in Landfill Profile at End of Simulation Period

Title: Bremo FFCP Mgmt Facility
Simulated on: 6/14/2023 10:53
Simulation period: 20 years

	Final Water Storage	
Layer	(inches)	(vol/vol)
1	44.7764	0.3731
2	2.8143	0.1563
3	0.0772	0.3088
4	0.0000	0.0000
5	0.2070	0.7500
Snow water	0.0000	---

ATTACHMENT 7

FINAL COVER DRAINAGE SYSTEMS HYDRAULIC CONDUCTIVITY CALCULATIONS

CALCULATIONS

Date: 8/27/2024
Project No.: 22130437.031
Subject: Final Cover System Geocomposite Hydraulic Conductivity
Project Title: Bremo Bluff FFCP Management Facility

Made by: J. Frantz
Checked by: S. McHenry
Reviewed by: R. DiFrancesco

1.0 Methodology: Based on methodology presented in Designing With Geosynthetics, Fifth Edition, Section 9.4 - Apply reduction factors to estimate transmissivity of landfill geosynthetic drainage systems

Input	Values	Unit	Notes:
Performance Transmissivity	1.13E-03	m^2/sec	Per GSE 100-HR Transmissivity Data and Proposed FFCP Facility Design
RFin	1.3		Intrusion (Range of Reduction: 1.3 - 1.5)
RFcr	1.1		Creep (Range of Reduction: 1.1 - 1.4)
RFcc	1.0		Chemical Clogging (Range of Reduction: 1.0 - 1.2)
RFbc	1.5		Biological Clogging (Range of Reduction: 1.5 - 2.0)
Design Transmissivity	5.24E-04	m^2/sec	$T_{design} = T_{manufactured}\left[\frac{1}{RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}}\right]$

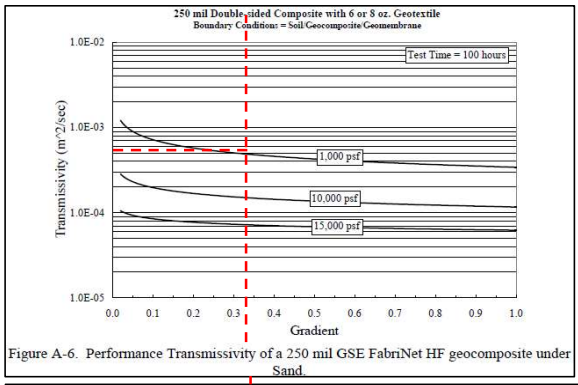

Figure A-6. Performance Transmissivity of a 250 mil GSE FabriNet HF geocomposite under Sand.

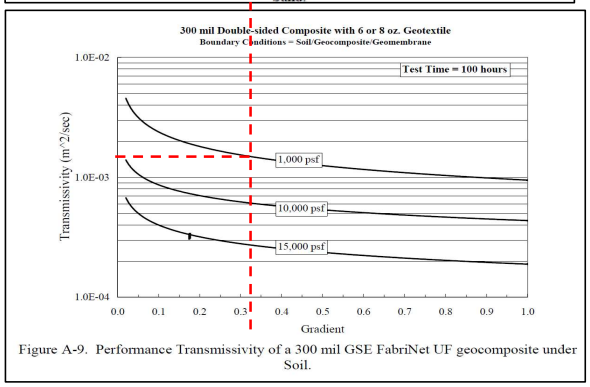

Figure A-9. Performance Transmissivity of a 300 mil GSE FabriNet UF geocomposite under Soil.

Final Cover Design Values:		
GC Thickness (mils)	250	300
Soil Density (lb/ft^3)	112	112
Gradient (ft/ft)	0.33	0.33
Soil Height (Ft)	2	2
Load (lb/ft^2)[1]	224	224
Performance Transmissivity	5.25E-04	1.73E-03

1. Conservatively use 1,000 psf loading
2. Interpolate between 250 & 300 mil geocomposite charts

2.0 Methodology: Convert transmissivity to equivalent hydraulic conductivity considering geocomposite as unconfined aquifer.

Item	Values	Unit	Notes:
Design Transmissivity	5.24E-04	m^2/sec	
Geonet Thickness	275	mils	

Equivalent Hydraulic Conductivity	**7.5**	**cm/sec**	$K_{design} = T_{design} \times Thickness$

CALCULATIONS

Date: 8/27/2024
Project No.: 22130437.031
Subject: Final Cover System SuperGripNet or MicroDrain
Project Title: Bremo Bluff FFCP Management Facility

Made by: J. Frantz
Checked by: S. McHenry
Reviewed by: R. DiFrancesco

1.0 Methodology: Based on methodology presented in Designing With Geosynthetics, Fifth Edition, Section 9.4 - Apply reduction factors to estimate transmissivity of landfill geosynthetic drainage systems

Input	Values	Unit	Notes:
Performance Transmissivity	6.50E-04	m^2/sec	Per TRI Lab Test Data for Agru SuperGripNet at compressive load of 240 psf
RFin	1.3		Intrusion (Range of Reduction: 1.3 - 1.5)
RFcr	1.1		Creep (Range of Reduction: 1.1 - 1.4)
RFcc	1.0		Chemical Clogging (Range of Reduction: 1.0 - 1.2)
RFbc	1.5		Biological Clogging (Range of Reduction: 1.5 - 2.0)
Design Transmissivity	3.60E-04	m^2/sec	$T_{design} = T_{manufactured}\ [\frac{1}{RF_{IN} \times RF_{CR} \times RF_{CC} \times RF_{BC}}]$

2.0 Methodology: Convert transmissivity to equivalent hydraulic conductivity considering geocomposite as unconfined aquifer.

Item	Values	Unit	Notes:
Design Transmissivity	3.60E-04	m^2/sec	
Geonet Thickness	130	mils	

Equivalent Hydraulic Conductivity	**10.9**	**cm/sec**	$K_{design} = T_{design} \times Thickness$