Part III
Attachment III-D
Appendix III-D.8-3

ALTERNATIVE FINAL COVER WITH FML DEMONSTRATION

Pescadito Environmental Resource Center
MSW-2374
Webb County, Texas

PESCADITO
ENVIRONMENTAL RESOURCE CENTER

August 2016

8-4-2016

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

This document is released for the purpose of permitting only under the authority of Michael W. Oden, P.E. #67165. It is not to be used for bidding or construction. Texas Registered Engineering Firm F-5650.

Prepared for:
Rancho Viejo Waste Management, LLC
1116 Calle del Norte
Laredo, TX 78041

Prepared by:
CB&I Environmental and Infrastructure, Inc.

CB&I

12005 Ford Rd, Suite 600
Dallas, TX 75234

Table of Contents

List of Attachments

8-4-2016

STATE OF TEXAS
MICHAEL W. ODEN
67165
REGISTERED PROFESSIONAL ENGINEER

This document is released for the purpose of permitting only under the authority of Michael W. Oden, P.E. #67165. It is not to be used for bidding or construction. Texas Registered Engineering Firm F-5650.

1.0 INTRODUCTION

This appendix and attachments are provided to demonstrate that the proposed composite Alternate Final Cover (AFC) with geosynthetic components to be used over cells that contain Class 1 non-hazardous industrial waste meets the prescriptive requirements of 30TAC330.457(a)(1), the Class 1 industrial solid waste requirements of 30TAC330.457(b), and the performance standards (equivalency) requirements of 30TAC330.457(d). The AFC geosynthetic components consist of a geocomposite drainage layer and a flexible membrane liner (FML). Cells that will not accept Class 1 non-hazardous industrial waste may be re-designated in the future, through a permit modification, and will be provided with a soil-only, water balance alternative final cover system meeting the design specified in Part III, Appendix III-D.8.

As specified in 30 TAC 330.457(d), the proposed AFC system with geosynthetic components meets the following performance standards:

1. The AFC achieves an equivalent reduction in infiltration as the clay-rich soil cover layer specified in 30 TAC 330.457(a)(1) or (2). In fact the AFC produces less infiltration than the prescriptive composite liner specified in 30TAC330.457(a)(1).

2. The final cover provides equivalent protection from wind and water erosion as the erosion layer specified in 30 TAC 330.457(a)(3).

As discussed in **Part III, Appendix III-D.8**, Type I Landfills are typically designed with a prescriptive final cover system as detailed in 30TAC330.457(a)(1). This document presents the design of the AFC system with geosynthetic components and a demonstration that this design provides equivalent performance to a prescriptive composite final cover configuration based on standards recognized by the TCEQ. This final cover system has been designed in accordance with TCEQ's "Guidance for Requesting a Water Balance Alternative Final Cover for a Municipal Solid Waste Landfill" (Revised January 27, 2012).

2.0 ALTERNATE FINAL COVER WITH FML SYSTEM DESIGN

This proposed AFC with geosynthetic components will consist of the following layers from top to bottom, as shown on drawings provided in **Appendix III-D.3** and will be used over designated cells that contain Class 1 non-hazardous industrial waste:

- Vegetation (or other appropriate material)
- 7 inch thick soil erosion layer.
- 30 inch thick soil infiltration layer
- 150 mil geocomposite drainage layer
- 40 mil LLDPE flexible membrane liner or geomembrane liner

Vegetation or other appropriate material will be used to minimize erosion, slow stormwater velocities, and provide transpiration of the AFC. The erosion layer serves to protect the infiltration layer and shed water from the waste mass. The infiltration layer is used to temporarily store atmospheric waters prior to evapotranspiration in order to minimize infiltration into the waste mass, as all infiltrated waters must be handled as leachate.

It is noted that the TCEQ requires a minimum thickness of 6 inches for the erosion control layer. However, an additional inch was added to account for erosion loss, as further described in **Appendix III-C**. The purpose of the infiltration layer is to store moisture that percolates through the erosion control layer until it can be removed through evaporation and transpiration.

Due to the fact that vegetation is not required for infiltration control and is solely for erosion and stormwater velocity control, a detailed planting plan typically associated with transpirative properties is not necessary. However, plantings are anticipated to be selected based on climatic and regional consideration with input drawn from the U.S. Department of Agriculture's publications on local and county soil and vegetation types. A coverage rate of 70 percent will be targeted.

3.0 EQUIVALENCY DEMONSTRATION REQUIREMENTS

TCEQ regulations at 330.457(d) states "(d) The executive director may approve an alternative final cover design that:

> *"(1) a cover achieves an equivalent reduction in infiltration as the clay-rich soil cover layer specified in subsection (a)(1) or (2) of this section"*

HELP models were developed to simulate an approximately 3-foot thick AFC with geosynthetic components and to determine the infiltration through the AFC system. Models were based on properties of available on-site soil materials. For the purpose of analyzing the AFC, models were run for bare ground, i.e., Leaf Area Index (LAI) = 0 and also for very minimal vegetation, i.e., LAI=1.0 to demonstrate the impacts of even very small amounts of vegetation on the percolation. Bare ground models rely solely on evaporation and storage in the erosion and infiltration layers.

The previous soil-only AFC HELP models AFC_WB13 (presented as III-D.8-1A) and AFC_WB19 (presented as III-D.8-1B) were modified to include the geosynthetic components and are labeled AFCFML1 (presented as III-D.8-3A) and AFCFML2 (presented as III-D.8-3B) respectively. The composite AFC with geosynthetic components model results show an equivalent or greater, reduction in infiltration compared to the clay-rich soil cover layer specified in 330.457(a)(1). In fact the AFC produces less infiltration than the complete prescriptive composite liner specified in 30TAC330.457(a)(1).

As described in **Part III, Appendix III-D.8**, two models of the prescriptive final cover were run. The first model matched the prescriptive final cover specified in 330.457(a)(1). This model is included in **Appendix III-D.8** as PRE_FC3 (presented as III-D.8-1C). The second prescriptive cover model used the more common configuration of a composite final cover recognized by TCEQ which has the FML over the infiltration layer. This model is included as PRE_FC4 (presented as III-D.8-1D). It should be noted that the proposed composite AFC with geosynthetic components produces less infiltration than either of the two prescriptive composite final cover systems.

In addition to meeting the performance standards (equivalency) requirements of 30TAC330.457(d), the proposed composite AFC system with geosynthetic components to be used over cells that contain Class 1 industrial solid waste meets the prescriptive requirements of 30TAC330.457(a)(1) and the Class 1 industrial solid waste requirements of 330.457(b).

4.0 SOIL LOSS DUE TO EROSION

The proposed erosion layer for the AFC with FML is the same as the erosion layer for the AFC as described in **Part III, Appendix III-D.8**, further discussion on the soil loss due to erosion is provided in the same section.

5.0 HELP MODEL

The USEPA Hydrologic Evaluation of Landfill Performance (HELP) Model version 3.07 was selected to model the AFC with the FML. The program was developed by the U.S. Army Engineer Waterways Experiment Station (WES) to conduct water balance analysis of landfills, cover systems and solid waste disposal and containment facilities. The HELP model is an unsaturated flow, water balance model that uses site-specific climate, soil and design data to simulate landfill conditions over a specified time period.

The HELP 3.07 Model is a water storage routing-based model for unsaturated flow. The HELP model uses historical data, weather generation, or the manual input for the precipitation data. The SCS curve number or modified SCS curve number methods are used for calculating runoff. The model takes into account vertical drainage and/or lateral drainage through the layers. The model also uses inputs regarding solute transport, plant growth, root growth distribution and density. The soil properties for the model can be based on HELP default layers or can be changed to reflect site conditions. The characteristics of the soil layers entered into the model include: thickness, total porosity, field capacity, wilting point, and saturated hydraulic conductivity. Geomembrane properties that are entered into the model are the thickness and the saturated hydraulic conductivity, along with parameters relating to the installation quality of the geomembrane.

5.1 Input Parameters

The HELP model input parameters for the modeled scenarios are described in the following sections. The input parameters were determined based on the proposed landfill design details, 30 TAC Chapter 330 requirements, site-specific data collected during geotechnical site investigations, local weather data and local industry experience.

5.1.1 Evapotranspiration Data

Evapotranspiration data was generated by HELP from Brownsville, Texas data within the model. Brownsville was selected as the nearest and most representative location of the site from the available locations within the HELP model. The evaporative zone depth was set to thickness of the AFC and the Prescriptive Cover, which are 37 inches and 25 inches respectively.

The leaf area index was set to 1 (poor stand of grass) for AFCFML1, which would be expected to occur from volunteer vegetation after placement of the soil. The leaf area index was set to 0 (bare ground) in the HELP Model for all other modeled scenarios.

5.1.2 Climate Data

In Laredo, Texas the weather is semi-arid during the summer and mild during the winter. The climate data was synthetically generated using coefficients for Brownsville, Texas. The default temperature and precipitation coefficients were modified by using data obtained from the NOAA Climate Online Database for the last 45 years (1968-2013) at the weather station located in Laredo, Texas.

Table III-D.8-3.1: HELP Climate Data Inputs summarizes the precipitation and temperature values input in the HELP model.

Table III-D.8-3.1: HELP Climate Data Inputs		
Month	**Avg Precip (in)**	**Avg Temp (°F)**
1	0.82	56.5
2	0.86	61.0
3	0.88	68.8
4	1.37	76.0
5	2.65	82.0
6	2.68	86.5
7	1.93	87.9
8	2.29	87.9
9	3.09	82.9
10	2.41	75.4
11	1.07	65.5
12	0.91	57.7

5.1.3 Runoff Potential

The closed conditions model assumes a runoff potential for 100% of the surface area, since the final landform will be constructed and maintained to effectively control stormwater runoff and minimize ponding of water on top of the final cover.

5.1.4 Runoff Curve Number

A runoff curve number of 92 was selected to be the same as that used in the Stormwater and Drainage Analysis in **Attachment III.C**.

5.1.5 Soil Layers

Two hydraulic conductivities were evaluated for the erosion layer and infiltration layer of the AFC with FML, the first used hydraulic conductivities of 1×10^{-5} cm/sec, which is the same as the prescriptive cover, while the second used hydraulic conductivities of 1×10^{-6} cm/sec, which would be achieved through a slight compaction of the soils available on-site. The hydraulic conductivity for each of the prescriptive cover scenarios was modeled at 1×10^{-5} cm/sec for both the erosion layer and the infiltration layer. The HELP default values for Total Porosity, Field Capacity, Wilting Point and Saturated Hydraulic Conductivity were used for each soil and geosynthetic layer.

Although vegetation may be used for erosion control for the AFC with, the HELP Model evaluation assumes there will be no planted vegetation on the final cover.

5.1.6 HELP Model Input Summary

The table below (III-D.8-3.2) summarizes the input values that were entered into the HELP model for the Alternative Final Cover with FML scenarios.

Table III-D.8-2: HELP Model Input Parameters				
Parameter	AFC Model Runs		Prescriptive Cover Model Runs	
	AFCFML1	AFCFML2	PRE_FC3	PRE_FC4
General Design and Evapotranspiration Data				
Number of Years Modeled	30	30	30	30
Runoff Curve Number	92	92	92	92
Area Allowing Runoff (%)	100	100	100	100
Evaporative Zone Depth (in)	37	37	25	7
Maximum Leaf Area Index	1	0	0	0
Average Annual Wind Speed (mph)	11.6	11.6	11.6	11.6
Erosion Layer				
Layer No.	1	1	1	1
Layer Type	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)
Thickness (in)	7	7	7	7
Hydraulic Conductivity (cm/s)	$1.0X10^{-5}$	$1.0X10^{-6}$	$1.0X10^{-5}$	$1.0X10^{-5}$
Geomembrane Liner				
Layer No.	N/A	N/A	N/A	2
Layer Type				Flexible Membrane Liner (Type 4)
Thickness (in)				0.06
Hydraulic Conductivity (cm/s)				$2x10^{-13}$
Infiltration Layer				
Layer No.	2	2	2	3
Layer Type	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)	Vertical Percolation (Type 1)
Thickness (in)	30	30	18	18
Hydraulic Conductivity (cm/s)	$1x10^{-5}$	$1.0x10^{-6}$	$1x10^{-5}$	$1x10^{-5}$
Geocomposite Layer				
Layer No.	3	3	N/A	N/A
Layer Type	Lateral Drainage (Type 2)	Lateral Drainage (Type 2)		
Layer Thickness (in)	0.15	0.15		
Hydraulic Conductivity (cm/s)	5.19	5.19		
Geomembrane Liner				
Layer No.	4	4	3	N/A
Layer Type	Flexible Membrane Liner (Type 4)	Flexible Membrane Liner (Type 4)	Flexible Membrane Liner (Type 4)	
Thickness (in)	0.04	0.04	0.06	
Hydraulic Conductivity (cm/s)	$4.0x10^{-13}$	$4.0x10^{-13}$	$2x10^{-13}$	

5.1.7 HELP Model Results

The results of the HELP model are summarized in the table below. The average annual percolation for the bottom-most layer for each final cover figuration is shown in **Table III-D.8-3**. As can be seen, average annual percolation through the AFC configurations with or without the FML is less than either of the prescriptive cover configurations. The table below (III-D.8-3.3) contains percolation information pertaining to the soil only AFC for information purposes.

Table III-D.8-3.3: HELP Model Results			
Model File Name	Average Annual Percolation Through Final Cover System		Average Annual Lateral Drainage from Geocomposite
	in/year	mm/year	inches/year
AFC_WB13	0.00243	0.061722	N/A
AFC_WB19	0.01509	0.383286	N/A
AFCFML1	0.00000	0.00000	0.00000
AFCFML2	0.00488	0.123952	0.00039
PRE_FC3	0.06869	1.744736	N/A
PRE_FC4	0.06801	1.72745	N/A

It is noted that the drainage geocomposite proposed as part of the AFC system is not part of the prescriptive cover requirements found at 30TAC330.457. It is further noted, and shown in the table above, that this drainage feature only collects a negligible amount of water for one of the AFC scenarios modeled and none for the other.

6.0 ALTERNATIVE FINAL COVER QUALITY CONTROL PLAN

The AFC with FML will be constructed in accordance with the Final Cover Quality Control Plan (FCQCP) found in **Appendix III-D.9**. The FCQCP will provide guidance for the materials, equipment, and construction methods to be used for final cover construction and the cover testing, evaluation and reporting procedures.

7.0 CONCLUSION

In accordance with TCEQ regulations at 330.457(d)(1) both of the AFC with geosynthetic component scenarios modeled achieve more than an equivalent reduction in infiltration compared to the two prescriptive cover scenarios modeled. Therefore, the AFC geosynthetic components design provides appropriate protection from infiltration and associated leachate generation.

The proposed composite Alternative Final Cover (AFC) system with geosynthetic components to be used over cells that contain Class 1 industrial solid waste meets the prescriptive requirements of 30TAC330.457(a)(1) and the Class 1 industrial solid waste requirements of 330.457(b).

As demonstrated in **Attachment III-C** the proposed surface water protection and erosion control practices will maintain non-erodible velocities and will minimize soil erosion losses to less than 3 tons/acre/year. All final cover and stormwater management controls have been evaluated and been determined to provide adequate performance for all storms up to the 100-year storm without resulting in erodible velocities without adequate erosion protection.

A geotechnical analysis of the AFC with FML has determined that it will function with appropriate factors of safety, as shown in **Appendix III-D.5-7**.

The AFC will be constructed in accordance with the Final Cover Quality Control Plan (FCQCP) found in **Appendix III-D.9**. The FCQCP will provide guidance for the materials, equipment, and construction methods to be used for final cover construction and the cover testing, evaluation and reporting procedures

Attachment A to Appendix III-D.8-3

HELP Model Output for AFCFML1

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**             HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                   **
**              DEVELOPED BY ENVIRONMENTAL LABORATORY                       **
**                USAE WATERWAYS EXPERIMENT STATION                         **
**           FOR USEPA RISK REDUCTION ENGINEERING LABORATORY                **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:    C:\HELP3\pesc\afc\PRECIP.D4
TEMPERATURE DATA FILE:      C:\HELP3\pesc\afc\TEMP.D7
SOLAR RADIATION DATA FILE:  C:\HELP3\pesc\afc\SOL.D13
EVAPOTRANSPIRATION DATA:    C:\HELP3\pesc\afc\EVAP_FC1.D11
SOIL AND DESIGN DATA FILE:  C:\HELP3\pesc\afc\AFCFML1.D10
OUTPUT DATA FILE:           C:\HELP3\pesc\afc\AFCFML1.OUT


TIME:   5:13     DATE:   8/ 3/2016


******************************************************************************

     TITLE:  PERC AFC (vegetated) with FML and Geocomposite (211ft @16%)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                              LAYER  1
                              --------

                   TYPE 1 - VERTICAL PERCOLATION LAYER
                       MATERIAL TEXTURE NUMBER   0
          THICKNESS                 =       7.00   INCHES
          POROSITY                  =       0.4370 VOL/VOL
          FIELD CAPACITY            =       0.3730 VOL/VOL
          WILTING POINT             =       0.2660 VOL/VOL
          INITIAL SOIL WATER CONTENT  =     0.2711 VOL/VOL
          EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 CM/SEC
```

LAYER 2

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =      30.00   INCHES
POROSITY                     =       0.4750 VOL/VOL
FIELD CAPACITY               =       0.3780 VOL/VOL
WILTING POINT                =       0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2649 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC
```

LAYER 3

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 0

```
THICKNESS                    =       0.15   INCHES
POROSITY                     =       0.8500 VOL/VOL
FIELD CAPACITY               =       0.0100 VOL/VOL
WILTING POINT                =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.2587 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =   5.19000006000      CM/SEC
SLOPE                        =     16.00    PERCENT
DRAINAGE LENGTH              =    211.0     FEET
```

LAYER 4

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

```
THICKNESS                    =       0.04   INCHES
POROSITY                     =       0.0000 VOL/VOL
FIELD CAPACITY               =       0.0000 VOL/VOL
WILTING POINT                =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =       3.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =       3.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER	=	92.00	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	1.000	ACRES
EVAPORATIVE ZONE DEPTH	=	37.2	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	9.883	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	17.437	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	9.813	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	9.883	INCHES
TOTAL INITIAL WATER	=	9.883	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BROWNSVILLE TEXAS

STATION LATITUDE	=	27.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	1.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	
END OF GROWING SEASON (JULIAN DATE)	=	365	
EVAPORATIVE ZONE DEPTH	=	37.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	11.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	76.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.82	0.86	0.88	1.37	2.65	2.68
1.93	2.29	3.09	2.41	1.07	0.91

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
56.50	61.00	68.80	76.00	82.00	86.50
87.90	87.90	82.90	75.40	65.50	57.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS
AND STATION LATITUDE = 27.34 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.66	0.98	0.79	1.08	1.97	2.35
	1.65	2.31	3.57	2.49	0.96	0.97
STD. DEVIATIONS	0.44	0.81	0.69	1.17	1.76	1.81
	1.61	1.57	1.65	1.44	0.97	0.57
RUNOFF						
TOTALS	0.024	0.117	0.075	0.402	0.949	1.007
	0.700	0.751	1.207	0.805	0.153	0.090
STD. DEVIATIONS	0.072	0.206	0.138	0.616	1.104	1.073
	1.089	0.947	0.977	0.774	0.312	0.154
EVAPOTRANSPIRATION						
TOTALS	0.730	0.770	0.893	0.775	0.998	1.292
	0.974	1.543	2.153	1.616	0.884	0.836
STD. DEVIATIONS	0.361	0.501	0.686	0.689	0.713	0.881
	0.581	0.786	0.866	0.654	0.447	0.338
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

-

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

-

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

-

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.78 (3.525)	71796.6	100.00
RUNOFF	6.280 (2.0138)	22795.36	31.750
EVAPOTRANSPIRATION	13.463 (2.2541)	48870.06	68.067
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00000 (0.00000)	0.000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00000 (0.00000)	0.000	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)		
CHANGE IN WATER STORAGE	0.036 (0.4290)	131.14	0.183

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.24	15391.199
RUNOFF	3.583	13004.9297
DRAINAGE COLLECTED FROM LAYER 3	0.00000	0.00000
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000000	0.00000
AVERAGE HEAD ON TOP OF LAYER 4	0.000	

```
MAXIMUM HEAD ON TOP OF LAYER  4              0.000

LOCATION OF MAXIMUM HEAD IN LAYER  3
      (DISTANCE FROM DRAIN)                  0.0 FEET

SNOW WATER                                   0.00             0.0000


MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3250

MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.2641

 ***  Maximum heads are computed using McEnroe's equations.  ***

      Reference:  Maximum Saturated Depth over Landfill Liner
                  by Bruce M. McEnroe, University of Kansas
                  ASCE Journal of Environmental Engineering
                  Vol. 119, No. 2, March 1993, pp. 262-270.

******************************************************************************


******************************************************************************

              FINAL WATER STORAGE AT END OF YEAR   30
     ----------------------------------------------------------------------
               LAYER        (INCHES)       (VOL/VOL)
               -----        --------       ---------
                 1           2.6444          0.3778

                 2           8.2840          0.2761

                 3           0.0388          0.2587

                 4           0.0000          0.0000

             SNOW WATER      0.000

******************************************************************************
******************************************************************************
```

Attachment B to Appendix III-D.8-3

HELP Model Output for AFCFML2

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE               **
**                HELP MODEL VERSION 3.07  (1 NOVEMBER 1997)                **
**                  DEVELOPED BY ENVIRONMENTAL LABORATORY                   **
**                    USAE WATERWAYS EXPERIMENT STATION                     **
**              FOR USEPA RISK REDUCTION ENGINEERING LABORATORY             **
**                                                                          **
**                                                                          **
******************************************************************************
******************************************************************************


PRECIPITATION DATA FILE:     C:\HELP3\pesc\afc\PRECIP.D4
TEMPERATURE DATA FILE:       C:\HELP3\pesc\afc\TEMP.D7
SOLAR RADIATION DATA FILE:   C:\HELP3\pesc\afc\SOL.D13
EVAPOTRANSPIRATION DATA:     C:\HELP3\pesc\afc\EVAP_FC.D11
SOIL AND DESIGN DATA FILE:   C:\HELP3\pesc\afc\AFCFML2.D10
OUTPUT DATA FILE:            C:\HELP3\pesc\afc\AFCFML2.OUT


TIME:   7: 6     DATE:   8/ 3/2016


******************************************************************************

     TITLE:  PERC AFC (no veg.) with FML and Geocomposite (211ft @16%)

******************************************************************************


     NOTE:  INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER WERE
              COMPUTED AS NEARLY STEADY-STATE VALUES BY THE PROGRAM.


                                  LAYER  1
                                  --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =       7.00   INCHES
           POROSITY                     =       0.4370 VOL/VOL
           FIELD CAPACITY               =       0.3730 VOL/VOL
           WILTING POINT                =       0.2660 VOL/VOL
           INITIAL SOIL WATER CONTENT   =       0.2737 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.999999997000E-06 CM/SEC
```

```
                    LAYER  2
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      30.00   INCHES
POROSITY                   =       0.4750 VOL/VOL
FIELD CAPACITY             =       0.3780 VOL/VOL
WILTING POINT              =       0.2650 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.3309 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   0.999999997000E-06 CM/SEC

                    LAYER  3
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                  =       0.15   INCHES
POROSITY                   =       0.8500 VOL/VOL
FIELD CAPACITY             =       0.0100 VOL/VOL
WILTING POINT              =       0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.3691 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =    5.19000006000      CM/SEC
SLOPE                      =      16.00   PERCENT
DRAINAGE LENGTH            =     211.0    FEET

                    LAYER  4
                    --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
             MATERIAL TEXTURE NUMBER  36
THICKNESS                  =       0.04   INCHES
POROSITY                   =       0.0000 VOL/VOL
FIELD CAPACITY             =       0.0000 VOL/VOL
WILTING POINT              =       0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =       0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY        =       3.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =       3.00   HOLES/ACRE
FML PLACEMENT QUALITY      =   3 - GOOD


        GENERAL DESIGN AND EVAPORATIVE ZONE DATA
        ----------------------------------------

NOTE:  SCS RUNOFF CURVE NUMBER WAS USER-SPECIFIED.

SCS RUNOFF CURVE NUMBER             =      92.00
FRACTION OF AREA ALLOWING RUNOFF    =     100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =       1.000  ACRES
EVAPORATIVE ZONE DEPTH              =      37.2    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      11.899  INCHES
```

UPPER LIMIT OF EVAPORATIVE STORAGE	=	17.437	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	9.813	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	11.899	INCHES
TOTAL INITIAL WATER	=	11.899	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
BROWNSVILLE TEXAS

STATION LATITUDE	=	27.34	DEGREES
MAXIMUM LEAF AREA INDEX	=	0.00	
START OF GROWING SEASON (JULIAN DATE)	=	0	
END OF GROWING SEASON (JULIAN DATE)	=	365	
EVAPORATIVE ZONE DEPTH	=	37.2	INCHES
AVERAGE ANNUAL WIND SPEED	=	11.60	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	76.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	75.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	74.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	76.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
0.82	0.86	0.88	1.37	2.65	2.68
1.93	2.29	3.09	2.41	1.07	0.91

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
56.50	61.00	68.80	76.00	82.00	86.50
87.90	87.90	82.90	75.40	65.50	57.70

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR BROWNSVILLE TEXAS
AND STATION LATITUDE = 27.34 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	0.66	0.98	0.79	1.08	1.97	2.35
	1.65	2.31	3.57	2.49	0.96	0.97
STD. DEVIATIONS	0.44	0.81	0.69	1.17	1.76	1.81
	1.61	1.57	1.65	1.44	0.97	0.57
RUNOFF						
TOTALS	0.218	0.440	0.319	0.621	1.270	1.429
	0.959	1.283	2.100	1.523	0.451	0.419
STD. DEVIATIONS	0.240	0.500	0.346	0.796	1.296	1.384
	1.232	1.187	1.283	1.092	0.665	0.371
EVAPOTRANSPIRATION						
TOTALS	0.460	0.523	0.497	0.474	0.691	0.898
	0.697	1.015	1.441	0.994	0.498	0.554
STD. DEVIATIONS	0.230	0.336	0.344	0.405	0.503	0.524
	0.418	0.485	0.484	0.406	0.316	0.247
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0004	0.0004	0.0005	0.0004	0.0005	0.0003
	0.0003	0.0006	0.0005	0.0005	0.0003	0.0003
STD. DEVIATIONS	0.0011	0.0009	0.0011	0.0010	0.0009	0.0007
	0.0008	0.0008	0.0006	0.0009	0.0008	0.0008

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
STD. DEVIATIONS	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 30

	INCHES	CU. FEET	PERCENT
PRECIPITATION	19.78 (3.525)	71796.6	100.00
RUNOFF	11.031 (2.5878)	40043.23	55.773
EVAPOTRANSPIRATION	8.742 (1.2048)	31731.81	44.197
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00039 (0.00071)	1.407	0.00196
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.00488 (0.00844)	17.726	0.02469
AVERAGE HEAD ON TOP OF LAYER 4	0.000 (0.000)		
CHANGE IN WATER STORAGE	0.001 (0.0883)	2.39	0.003

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	4.24	15391.199
RUNOFF	3.805	13811.9873
DRAINAGE COLLECTED FROM LAYER 3	0.00002	0.06468

PERCOLATION/LEAKAGE THROUGH LAYER 4	0.000177	0.64097
AVERAGE HEAD ON TOP OF LAYER 4	0.000	
MAXIMUM HEAD ON TOP OF LAYER 4	0.042	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	0.00	0.0000

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3256
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.3172

*** Maximum heads are computed using McEnroe's equations. ***

Reference: Maximum Saturated Depth over Landfill Liner
by Bruce M. McEnroe, University of Kansas
ASCE Journal of Environmental Engineering
Vol. 119, No. 2, March 1993, pp. 262-270.

****

****

FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	1.9886	0.2841
2	9.8744	0.3291
3	0.0554	0.3691
4	0.0000	0.0000
SNOW WATER	0.000	

****
****