Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Perimeter Containment** **North Dredge Cell (Dike C) Segment 1** **Sta. A161+50 to A179+50**

Document Control Number	RDP-0113-E
Calculation Package	FPGKIFFESCDX00030020100006

Stantec

Exhibit 4
Infiltration Rate Through Final Cover

Purpose:

- Predict the rate of surface water infiltration through the final cover and into the closed landfill.

Methods:

- HELP Model.
- Climate data (rainfall, temperature, etc.) from historic records for Nashville, Tennessee.

Results:

- A Flexible Membrane Liner (FML) is planned as key element of the cover system. However, details of the final cover system will be determined in a future project design package.

- Model predictions indicate average infiltration rates as follows:
  0.146 inch/year for FML - Excellent Installation
  0.372 inch/year for FML – Good Installation
  1.410 inch/year for Clay Cover
- The “best estimate” prediction is assumed to 0.372 inches per year.

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: JM 6-Jul-10	*Reviewed by:* DEH 7-Jul-10
Revisions:	

Project : Kingston - FML Cap - No Pipes

100 Years - Capped Condition

TVA - Kingston Fossil Plant

Roane County, Tennessee

Model : HELP
An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Stantec Consulting Services Inc.

Client : Tennessee Valley Authority

Location : Nashville, TN

7/6/2010

1. Profile. EPA profile1

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Poor stand of grass	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Cap Barrier - Clay (Moderately Compacted)	0.0000	-2.0000	2.0000
Low Density Polyethylene (LDPE)	-1.9995	-2.0028	0.0033
Coal Combustion By-Products1	-2.0018	-37.5018	35.5000
Drainage Net (0.5cm)	-37.5013	-37.5177	0.0164
Gravel	-37.5172	-38.5172	1.0000
Coal Combustion By-Products	-38.5167	-63.5167	25.0000

1.1. Layer. Cap Barrier - Clay (Moderately Compacted)

Top Slope Length: 1000.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.451	(vol/vol)
field capacity	0.419	(vol/vol)
wilting point	0.332	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.419	(vol/vol)

1.2. Layer. Low Density Polyethylene (LDPE)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	4E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	4	(#/ha)
placement quality	2	(-)
geotextile transmissivity	0	(cm2/sec)

1.3. Layer. Coal Combustion By-Products1

Top Slope Length: 0.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.0000
Bottom Slope : 0.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units

total porosity	0.541	(vol/vol)
field capacity	0.187	(vol/vol)
wilting point	0.047	(vol/vol)
sat.hydr.conductivity	1E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.2868	(vol/vol)

1.4. Layer. Drainage Net (0.5cm)

Top Slope Length: 1900.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.5000
Bottom Slope : 0.5000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	0.3	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.2015	(vol/vol)

1.5. Layer. Gravel

Top Slope Length: 1900.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.5000
Bottom Slope : 0.5000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	1	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.032	(vol/vol)

1.6. Layer. Coal Combustion By-Products

Top Slope Length: 1900.0000
Bottom Slope Length: 0.0000
Top Slope: 0.5000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.5410	(vol/vol)
field capacity	0.1870	(vol/vol)
wilting point	0.0470	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0.0000	(cm/day)

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**                                                                          **
**              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             **
**                                                                          **
**                                                                          **
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PRECIPITATION DATA FILE:      C:\WHI\VHELP22\data\P13488.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\VHELP22\data\P13488.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\VHELP22\data\P13488.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\VHELP22\data\P13488.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\VHELP22\data\P13488.VHP\I_394087.inp
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OUTPUT DATA FILE: C:\WHI\VHELP22\data\P13488.VHP\O_394087.prt

TIME: 10:24 DATE: 7/ 6/2010

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TITLE: EPA profile1

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
WERE SPECIFIED BY THE USER.

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Nashville TN

STATION LATITUDE = 35.97 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 85
END OF GROWING SEASON (JULIAN DATE) = 307
EVAPORATIVE ZONE DEPTH = 9.0 INCHES
AVERAGE ANNUAL WIND SPEED = 7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 76.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.65	4.18	5.49	3.87	3.71	3.95
4.33	3.02	2.90	2.70	3.70	4.50

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
38.20	41.50	49.70	59.60	67.40	74.30
77.60	77.00	71.50	59.50	48.80	41.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN
AND STATION LATITUDE = 35.91 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.31	4.31	5.21	3.82	4.03	3.81

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                          4.50      3.15      3.26      2.67      3.66      4.62

   STD. DEVIATIONS        1.93      1.98      2.45      1.85      1.72      1.77
                          2.07      1.31      1.76      1.63      1.89      2.54

  RUNOFF
  ------
   TOTALS                 3.020     3.009     2.624     0.935     0.708     0.651
                          0.907     0.317     0.785     1.005     2.177     3.414

   STD. DEVIATIONS        2.050     1.954     2.222     1.172     0.952     0.868
                          1.011     0.569     1.023     1.231     1.700     2.416

  EVAPOTRANSPIRATION
  ------------------
   TOTALS                 1.228     1.602     2.784     3.065     3.432     3.199
                          3.495     2.921     2.254     1.429     1.190     1.053

   STD. DEVIATIONS        0.217     0.287     0.381     0.898     1.082     1.147
                          1.250     0.921     0.902     0.422     0.160     0.156

  PERCOLATION/LEAKAGE THROUGH LAYER   2
  -------------------------------------
   TOTALS                 0.0138    0.0123    0.0129    0.0115    0.0116    0.0110
                          0.0115    0.0113    0.0111    0.0122    0.0129    0.0139

   STD. DEVIATIONS        0.0009    0.0006    0.0008    0.0006    0.0005    0.0003
                          0.0004    0.0003    0.0005    0.0010    0.0008    0.0006

  LATERAL DRAINAGE COLLECTED FROM LAYER   5
  -----------------------------------------
   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    0.0002    0.0002    0.0002    0.0002    0.0002
                          0.0001    0.0001    0.0001    0.0001    0.0001    0.0001

  PERCOLATION/LEAKAGE THROUGH LAYER   6
  -------------------------------------
   TOTALS                 0.0527    0.0514    0.0553    0.0508    0.0503    0.0471
                          0.0471    0.0454    0.0427    0.0434    0.0421    0.0427

   STD. DEVIATIONS        0.1528    0.1757    0.1918    0.1730    0.1673    0.1541
                          0.1486    0.1384    0.1259    0.1218    0.1122    0.1094


-------------------------------------------------------------------------------
                 AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)
-------------------------------------------------------------------------------


  DAILY AVERAGE HEAD ON TOP OF LAYER   2
  --------------------------------------
   AVERAGES               21.3802   20.7581   19.3170   17.0718   16.3210   15.8292
                         16.0988   15.6476   16.1832   17.8853   20.4800   21.6941

   STD. DEVIATIONS        1.9756    1.5092    1.7204    1.3459    1.0784    0.8020
                          0.9670    0.7611    1.2665    2.2706    1.9050    1.3180

  DAILY AVERAGE HEAD ON TOP OF LAYER   6
  --------------------------------------
   AVERAGES               0.0005    0.0005    0.0005    0.0005    0.0005    0.0005
                          0.0004    0.0004    0.0004    0.0004    0.0004    0.0004

   STD. DEVIATIONS        0.0014    0.0018    0.0018    0.0017    0.0015    0.0015
                          0.0014    0.0013    0.0013    0.0011    0.0011    0.0010

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS      1 THROUGH   100
-------------------------------------------------------------------------------
                                  INCHES              CU. FEET         PERCENT
                             -------------------   -------------   ---------
 PRECIPITATION                  47.36     (    6.775)      171897.4       100.00

 RUNOFF                        19.552     (   5.4544)       70970.87       41.287

 EVAPOTRANSPIRATION              27.652     (   2.4980)      100373.37       58.391
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PERCOLATION/LEAKAGE THROUGH LAYER 2	0.14596 (0.00248)	529.832	0.30823
AVERAGE HEAD ON TOP OF LAYER 2	18.222 (0.474)		
LATERAL DRAINAGE COLLECTED FROM LAYER 5	0.00025 (0.00170)	0.897	0.00052
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.57107 (1.76616)	2072.923	1.20591
AVERAGE HEAD ON TOP OF LAYER 6	0.000 (0.001)		
CHANGE IN WATER STORAGE	-0.419 (1.8428)	-1520.62	-0.885

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100 and their dates (DDDYYYY)

	(INCHES)	(CU. FT.)	
PRECIPITATION	4.40	15971.65188	1180037
RUNOFF	4.217	15308.19893	1180037
PERCOLATION/LEAKAGE THROUGH LAYER 2	0.000482	1.74932	450001
AVERAGE HEAD ON TOP OF LAYER 2	24.000		
DRAINAGE COLLECTED FROM LAYER 5	0.00010	0.34647	490001
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.070382	255.47950	510001
AVERAGE HEAD ON TOP OF LAYER 6	0.019		
MAXIMUM HEAD ON TOP OF LAYER 6	0.013		
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	1.7 FEET		
SNOW WATER	5.09	18460.6766	360099
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4510		
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.3320		

*** 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.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	10.6997	0.4458
2	0.0000	0.0000
3	79.6620	0.1870

4	0.0193	0.0982
5	0.3841	0.0320
6	162.3000	0.5410

SNOW WATER 0.000

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Project : Kingston - FML Cap Gd - No Pipes

100 Years - Capped Condition

TVA - Kingston Fossil Plant

Roane County, Tennessee

Model : HELP
An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Stantec Consulting Services Inc.

Client : Tennessee Valley Authority

Location : Nashville, TN

7/6/2010

1. Profile. EPA Profile1

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Runoff Method	Model calculated	(-)
Initial Moisture Settings	User specified	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Poor stand of grass	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Cap Barrier - Clay (Moderately Compacted)	0.0000	-2.0000	2.0000
Low Density Polyethylene (LDPE)	-1.9995	-2.0028	0.0033
Coal Combustion By-Products1	-2.0018	-37.5018	35.5000
Drainage Net (0.5cm)	-37.5013	-37.5177	0.0164
Gravel	-37.5172	-38.5172	1.0000
Coal Combustion By-Products	-38.5167	-63.5167	25.0000

1.1. Layer. Cap Barrier - Clay (Moderately Compacted)

Top Slope Length: 1000.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.451	(vol/vol)
field capacity	0.419	(vol/vol)
wilting point	0.332	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.419	(vol/vol)

1.2. Layer. Low Density Polyethylene (LDPE)

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Geomembrane Liner Parameters

Parameter	Value	Units
sat.hydr.conductivity	4E-13	(cm/sec)
pinhole density	2	(#/ha)
installation defects	4	(#/ha)
placement quality	3	(-)
geotextile transmissivity	0	(cm2/sec)

1.3. Layer. Coal Combustion By-Products1

Top Slope Length: 0.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.0000
Bottom Slope : 0.5000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units

total porosity	0.541	(vol/vol)
field capacity	0.187	(vol/vol)
wilting point	0.047	(vol/vol)
sat.hydr.conductivity	1E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.2868	(vol/vol)

1.4. Layer. Drainage Net (0.5cm)

Top Slope Length: 1900.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.5000
Bottom Slope : 0.5000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	0.3	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.2015	(vol/vol)

1.5. Layer. Gravel

Top Slope Length: 1900.0000
Bottom Slope Length: 1900.0000
Top Slope: 0.5000
Bottom Slope : 0.5000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	1	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.032	(vol/vol)

1.6. Layer. Coal Combustion By-Products

Top Slope Length: 1900.0000
Bottom Slope Length: 0.0000
Top Slope: 0.5000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.5410	(vol/vol)
field capacity	0.1870	(vol/vol)
wilting point	0.0470	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0.0000	(cm/day)

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**              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             **
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PRECIPITATION DATA FILE:      C:\WHI\VHELP22\data\P14098.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\VHELP22\data\P14098.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\VHELP22\data\P14098.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\VHELP22\data\P14098.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\VHELP22\data\P14098.VHP\I_394817.inp
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OUTPUT DATA FILE: C:\WHI\VHELP22\data\P14098.VHP\O_394817.prt

TIME: 10:43 DATE: 7/ 6/2010

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TITLE: EPA profile1

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
WERE SPECIFIED BY THE USER.

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #55 WITH A
POOR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 305. METERS.

SCS RUNOFF CURVE NUMBER = 0.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 0.4047 HECTARES
EVAPORATIVE ZONE DEPTH = 22.9 CM
INITIAL WATER IN EVAPORATIVE ZONE = 9.578 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 10.310 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 7.590 CM
INITIAL SNOW WATER = 0.000 CM
INITIAL WATER IN LAYER MATERIALS = 749.189 CM
TOTAL INITIAL WATER = 749.189 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Nashville TN

STATION LATITUDE = 35.97 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 85
END OF GROWING SEASON (JULIAN DATE) = 307
EVAPORATIVE ZONE DEPTH = 9.0 INCHES
AVERAGE ANNUAL WIND SPEED = 7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 76.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.65	4.18	5.49	3.87	3.71	3.95
4.33	3.02	2.90	2.70	3.70	4.50

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

38.20	41.50	49.70	59.60	67.40	74.30
77.60	77.00	71.50	59.50	48.80	41.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN
AND STATION LATITUDE = 35.91 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.31	4.31	5.21	3.82	4.03	3.81
	4.50	3.15	3.26	2.67	3.66	4.62
STD. DEVIATIONS	1.93	1.98	2.45	1.85	1.72	1.77
	2.07	1.31	1.76	1.63	1.89	2.54
RUNOFF						
TOTALS	2.999	2.991	2.608	0.927	0.697	0.644
	0.895	0.310	0.774	0.992	2.150	3.389
STD. DEVIATIONS	2.049	1.950	2.218	1.169	0.946	0.862
	1.006	0.566	1.018	1.223	1.696	2.412
EVAPOTRANSPIRATION						
TOTALS	1.227	1.600	2.781	3.056	3.425	3.192
	3.487	2.913	2.245	1.429	1.190	1.053
STD. DEVIATIONS	0.217	0.287	0.384	0.898	1.083	1.145
	1.248	0.918	0.901	0.420	0.160	0.157
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.0349	0.0312	0.0328	0.0295	0.0297	0.0282
	0.0294	0.0289	0.0285	0.0312	0.0327	0.0352
STD. DEVIATIONS	0.0022	0.0015	0.0018	0.0014	0.0012	0.0009
	0.0011	0.0009	0.0014	0.0025	0.0021	0.0014
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
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	0.0002	0.0003	0.0002	0.0002	0.0001
	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0733	0.0701	0.0748	0.0688	0.0683	0.0645
	0.0652	0.0636	0.0606	0.0629	0.0617	0.0636
STD. DEVIATIONS	0.1480	0.1731	0.1860	0.1690	0.1614	0.1481
	0.1415	0.1353	0.1226	0.1185	0.1072	0.1054

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	21.3154	20.6866	19.2528	16.9622	16.1661	15.6383
	15.8998	15.3775	15.9014	17.6107	20.2736	21.6035
STD. DEVIATIONS	1.9795	1.5440	1.7501	1.4061	1.1602	0.8959
	1.0799	0.8881	1.4103	2.4712	2.1181	1.3869
DAILY AVERAGE HEAD ON TOP OF LAYER 6						

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AVERAGES                    0.0007    0.0007    0.0007    0.0007    0.0006    0.0006
                          0.0006    0.0006    0.0006    0.0006    0.0006    0.0006

STD. DEVIATIONS             0.0013    0.0018    0.0018    0.0016    0.0015    0.0015
                          0.0013    0.0013    0.0012    0.0011    0.0010    0.0010

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS      1 THROUGH   100
-------------------------------------------------------------------------------
                                      INCHES              CU. FEET          PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                      47.36      (    6.775)       171897.4       100.00

 RUNOFF                             19.379     (   5.4519)        70342.96       40.921

 EVAPOTRANSPIRATION                 27.598     (   2.4961)       100179.98       58.279

 PERCOLATION/LEAKAGE THROUGH        0.37224 (   0.00630)         1351.219       0.78606
   LAYER   2

 AVERAGE HEAD ON TOP                18.057 (      0.522)
   OF LAYER   2

 LATERAL DRAINAGE COLLECTED         0.00026 (   0.00170)            0.932      0.00054
   FROM LAYER   5

 PERCOLATION/LEAKAGE THROUGH        0.79731 (   1.71136)         2894.184       1.68367
   LAYER   6

 AVERAGE HEAD ON TOP                 0.001 (      0.001)
   OF LAYER   6

 CHANGE IN WATER STORAGE            -0.419     (   1.7937)        -1520.61       -0.885

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                 PEAK DAILY VALUES FOR YEARS      1 THROUGH   100          and their dates (DDDYYYY)
   ---------------------------------------------------------------------
                                                  (INCHES)        (CU. FT.)
                                                 ----------    -------------
      PRECIPITATION                                   4.40            15971.65188     1180037

      RUNOFF                                         4.216            15305.54162     1180037

      PERCOLATION/LEAKAGE THROUGH LAYER   2        0.001214             4.40663      610001

      AVERAGE HEAD ON TOP OF LAYER   2               24.000

      DRAINAGE COLLECTED FROM LAYER   5              0.00010             0.34687      480001

      PERCOLATION/LEAKAGE THROUGH LAYER   6        0.070392           255.51641      510001

      AVERAGE HEAD ON TOP OF LAYER   6               0.019

      MAXIMUM HEAD ON TOP OF LAYER   6               0.013

      LOCATION OF MAXIMUM HEAD IN LAYER   5
            (DISTANCE FROM DRAIN)                   1.7 FEET

      SNOW WATER                                     5.09            18460.6766      360099


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                          0.4510

      MINIMUM VEG. SOIL WATER (VOL/VOL)                          0.3320

       ***   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
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Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	10.6975	0.4457
2	0.0000	0.0000
3	79.6620	0.1870
4	0.0216	0.1098
5	0.3843	0.0320
6	162.3000	0.5410
SNOW WATER	0.000	

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Project : Kingston - Clay Cap - w Pipes

100 Years - Capped Condition

TVA - Kingston Fossil Plant

Roane County, Tennessee

Model : HELP
An US EPA model for predicting landfill hydrologic processes and testing of effectiveness of landfill designs

Author : Stantec Consulting Services Inc.

Client : Tennessee Valley Authority

Location : Nashville, TN

7/6/2010

1. Profile. EPA profile1

Model Settings

[HELP] Case Settings

Parameter	Value	Units
Initial Moisture Settings	User specified	(-)
Runoff Method	Model calculated	(-)

[HELP] Surface Water Settings

Parameter	Value	Units
Runoff Area	100	(%%)
Initial Surface Water	0	(ft)
Vegetation Class	Poor stand of grass	(-)

Profile Structure

Layer	Top (ft)	Bottom (ft)	Thickness (ft)
Cap Barrier - Clay (Moderately Compacted)	0.0000	-1.0000	1.0000
Clay, moderately compacted	-0.9995	-2.9995	2.0000
Coal Combustion By-Products1	-2.9990	-38.4990	35.5000
Drainage Net (0.5cm)	-38.4985	-38.5149	0.0164
Gravel	-38.5144	-39.5144	1.0000
Coal Combustion By-Products	-39.5139	-64.5139	25.0000

1.1. Layer. Cap Barrier - Clay (Moderately Compacted)

Top Slope Length: 1000.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units
total porosity	0.451	(vol/vol)
field capacity	0.419	(vol/vol)
wilting point	0.332	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.419	(vol/vol)

1.2. Layer. Clay, moderately compacted

Top Slope Length: 0.0000
Bottom Slope Length: 0.0000
Top Slope: 0.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.451	(vol/vol)
field capacity	0.419	(vol/vol)
wilting point	0.332	(vol/vol)
sat.hydr.conductivity	1E-7	(cm/sec)
subsurface inflow	0	(mm/year)

1.3. Layer. Coal Combustion By-Products1

Top Slope Length: 0.0000
Bottom Slope Length: 1000.0000
Top Slope: 0.0000
Bottom Slope : 2.0000

[HELP] Vertical Perc. Layer Parameters

Parameter	Value	Units

total porosity	0.541	(vol/vol)
field capacity	0.187	(vol/vol)
wilting point	0.047	(vol/vol)
sat.hydr.conductivity	1E-4	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	.2708	(vol/vol)

1.4. Layer. Drainage Net (0.5cm)

Top Slope Length: 1000.0000
Bottom Slope Length: 1000.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Geotextiles and Geonets Parameters

Parameter	Value	Units
total porosity	0.85	(vol/vol)
field capacity	0.01	(vol/vol)
wilting point	0.005	(vol/vol)
sat.hydr.conductivity	0.3	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.2015	(vol/vol)

1.5. Layer. Gravel

Top Slope Length: 1000.0000
Bottom Slope Length: 1000.0000
Top Slope: 2.0000
Bottom Slope : 2.0000

[HELP] Lateral Drainage Layer Parameters

Parameter	Value	Units
total porosity	0.397	(vol/vol)
field capacity	0.032	(vol/vol)
wilting point	0.013	(vol/vol)
sat.hydr.conductivity	1	(cm/sec)
subsurface inflow	0	(mm/year)
Initial moisture content	0.032	(vol/vol)

1.6. Layer. Coal Combustion By-Products

Top Slope Length: 1000.0000
Bottom Slope Length: 0.0000
Top Slope: 2.0000
Bottom Slope : 0.0000

[HELP] Barrier Soil Liner Parameters

Parameter	Value	Units
total porosity	0.5410	(vol/vol)
field capacity	0.1870	(vol/vol)
wilting point	0.0470	(vol/vol)
sat.hydr.conductivity	1E-5	(cm/sec)
subsurface inflow	0.0000	(cm/day)

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**                                                                          **
**                                                                          **
**              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:\WHI\VHELP22\data\P14066.VHP\_weather1.dat
TEMPERATURE DATA FILE:        C:\WHI\VHELP22\data\P14066.VHP\_weather2.dat
SOLAR RADIATION DATA FILE:    C:\WHI\VHELP22\data\P14066.VHP\_weather3.dat
EVAPOTRANSPIRATION DATA:      C:\WHI\VHELP22\data\P14066.VHP\_weather4.dat
SOIL AND DESIGN DATA FILE:    C:\WHI\VHELP22\data\P14066.VHP\I_394779.inp
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OUTPUT DATA FILE: C:\WHI\VHELP22\data\P14066.VHP\O_394779.prt

TIME: 10:39 DATE: 7/ 6/2010

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TITLE: EPA profile1

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NOTE: INITIAL MOISTURE CONTENT OF THE LAYERS AND SNOW WATER
WERE SPECIFIED BY THE USER.

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
SOIL DATA BASE USING SOIL TEXTURE #55 WITH A
POOR STAND OF GRASS, A SURFACE SLOPE OF 2.%
AND A SLOPE LENGTH OF 305. METERS.

SCS RUNOFF CURVE NUMBER = 0.00
FRACTION OF AREA ALLOWING RUNOFF = 100.0 PERCENT
AREA PROJECTED ON HORIZONTAL PLANE = 0.4047 HECTARES
EVAPORATIVE ZONE DEPTH = 22.9 CM
INITIAL WATER IN EVAPORATIVE ZONE = 9.578 CM
UPPER LIMIT OF EVAPORATIVE STORAGE = 10.310 CM
LOWER LIMIT OF EVAPORATIVE STORAGE = 7.590 CM
INITIAL SNOW WATER = 0.000 CM
INITIAL WATER IN LAYER MATERIALS = 746.599 CM
TOTAL INITIAL WATER = 746.599 CM
TOTAL SUBSURFACE INFLOW = 0.00 MM/YR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
Nashville TN

STATION LATITUDE = 35.97 DEGREES
MAXIMUM LEAF AREA INDEX = 4.50
START OF GROWING SEASON (JULIAN DATE) = 85
END OF GROWING SEASON (JULIAN DATE) = 307
EVAPORATIVE ZONE DEPTH = 9.0 INCHES
AVERAGE ANNUAL WIND SPEED = 7.10 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY = 68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY = 69.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY = 76.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY = 72.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.65	4.18	5.49	3.87	3.71	3.95
4.33	3.02	2.90	2.70	3.70	4.50

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC

38.20	41.50	49.70	59.60	67.40	74.30
77.60	77.00	71.50	59.50	48.80	41.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR Nashville TN
AND STATION LATITUDE = 35.91 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.31	4.31	5.21	3.82	4.03	3.81
	4.50	3.15	3.26	2.67	3.66	4.62
STD. DEVIATIONS	1.93	1.98	2.45	1.85	1.72	1.77
	2.07	1.31	1.76	1.63	1.89	2.54
RUNOFF						
TOTALS	2.894	2.900	2.529	0.885	0.650	0.609
	0.845	0.286	0.736	0.933	2.036	3.271
STD. DEVIATIONS	2.036	1.928	2.196	1.149	0.929	0.840
	0.982	0.550	0.995	1.185	1.667	2.400
EVAPOTRANSPIRATION						
TOTALS	1.226	1.595	2.756	3.023	3.387	3.154
	3.460	2.884	2.221	1.421	1.190	1.054
STD. DEVIATIONS	0.219	0.290	0.392	0.899	1.078	1.136
	1.237	0.909	0.889	0.424	0.164	0.157
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.1443	0.1288	0.1353	0.1182	0.1126	0.1024
	0.1038	0.0944	0.0912	0.1076	0.1265	0.1449
STD. DEVIATIONS	0.0109	0.0099	0.0105	0.0162	0.0219	0.0251
	0.0270	0.0357	0.0352	0.0403	0.0275	0.0105
LATERAL DRAINAGE COLLECTED FROM LAYER 5						
TOTALS	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002
STD. DEVIATIONS	0.0004	0.0007	0.0007	0.0007	0.0007	0.0006
	0.0005	0.0005	0.0004	0.0004	0.0003	0.0004
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.1692	0.1429	0.1432	0.1275	0.1217	0.1142
	0.1220	0.1308	0.1296	0.1398	0.1457	0.1667
STD. DEVIATIONS	0.0851	0.0995	0.1134	0.1056	0.1052	0.0982
	0.0964	0.0920	0.0876	0.0868	0.0754	0.0758

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	8.9868	8.3174	6.8788	4.3580	3.3267	2.7463
	2.9693	2.3520	2.8158	4.6364	7.5825	9.1466
STD. DEVIATIONS	1.7864	1.7304	1.9621	1.7264	1.6151	1.3099
	1.5272	1.3324	1.8519	2.9010	2.4786	1.7038
DAILY AVERAGE HEAD ON TOP OF LAYER 6						

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AVERAGES                    0.0016    0.0015    0.0013    0.0012    0.0011    0.0011
                          0.0011    0.0012    0.0012    0.0013    0.0014    0.0015

STD. DEVIATIONS             0.0008    0.0011    0.0010    0.0010    0.0010    0.0010
                          0.0009    0.0009    0.0008    0.0008    0.0007    0.0007

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS      1 THROUGH   100
-------------------------------------------------------------------------------
                                      INCHES              CU. FEET          PERCENT
                                  -------------------   -------------   ---------
 PRECIPITATION                      47.36      (    6.775)       171897.4       100.00

 RUNOFF                             18.573     (   5.3938)        67420.05       39.221

 EVAPOTRANSPIRATION                 27.370     (   2.4935)        99350.47       57.796

 PERCOLATION/LEAKAGE THROUGH        1.40995 (   0.10477)         5117.997       2.97735
   LAYER   2

 AVERAGE HEAD ON TOP                5.343 (      0.624)
   OF LAYER   2

 LATERAL DRAINAGE COLLECTED         0.00217 (   0.00615)            7.884      0.00459
   FROM LAYER   5

 PERCOLATION/LEAKAGE THROUGH        1.65327 (   1.07834)         6001.253       3.49118
   LAYER   6

 AVERAGE HEAD ON TOP                0.001 (      0.001)
   OF LAYER   6

 CHANGE IN WATER STORAGE            -0.243     (   1.2698)         -882.21       -0.513

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                 PEAK DAILY VALUES FOR YEARS      1 THROUGH   100          and their dates (DDDYYYY)
   ---------------------------------------------------------------------
                                                  (INCHES)        (CU. FT.)
                                                ----------    -------------
      PRECIPITATION                                  4.40            15971.65188     1180037

      RUNOFF                                        4.213            15291.42748     1180037

      PERCOLATION/LEAKAGE THROUGH LAYER   2        0.005102           18.52077      450001

      AVERAGE HEAD ON TOP OF LAYER   2              12.000

      DRAINAGE COLLECTED FROM LAYER   5             0.00036            1.32036       10001

      PERCOLATION/LEAKAGE THROUGH LAYER   6        0.044704          162.27208      600001

      AVERAGE HEAD ON TOP OF LAYER   6              0.014

      MAXIMUM HEAD ON TOP OF LAYER   6              0.006

      LOCATION OF MAXIMUM HEAD IN LAYER   5
            (DISTANCE FROM DRAIN)                   0.0 FEET

      SNOW WATER                                    5.09            18460.6766      360099


      MAXIMUM VEG. SOIL WATER (VOL/VOL)                          0.4510

      MINIMUM VEG. SOIL WATER (VOL/VOL)                          0.3320

       ***   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
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Vol. 119, No. 2, March 1993, pp. 262-270.

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FINAL WATER STORAGE AT END OF YEAR 100

LAYER	(INCHES)	(VOL/VOL)
1	5.2740	0.4395
2	10.8240	0.4510
3	90.8250	0.2132
4	0.0247	0.1253
5	0.3849	0.0321
6	162.3000	0.5410
SNOW WATER	0.000	

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