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Revision 0

KEY WORDS:

Saltstone Disposal Facility

Performance Assessment

Closure Cap

SALTSTONE DISPOSAL FACILITY MECHANICALLY STABILIZED EARTH VAULT CLOSURE CAP DEGRADATION: SENSITIVITY ANALYSIS (U)

FEBRUARY 12, 2004

PREPARED BY:

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Aiken, SC 29808

Prepared for the U.S. Department of Energy under Contract No. DE-AC09-96SR18500

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LIST OF ACRONYMS AND ABBREVIATIONS

ACRONYMS

CLSM	Controlled Low Strength Material
CN	Curve Number
FC	field capacity
FML	flexible membrane liner
GCL	geosynthetic clay liner
GSE	GSE Lining Technology, Inc.
HELP	Hydrologic Evaluation of Landfill Performance
LBS	Lower Bounding Scenario
MMES	Martin Marietta Energy Systems, Inc.
MSE	Mechanically Stabilized Earth
PA	Performance Assessment
PORFLOW	Software for multiphase fluid flow, heat and mass transport in fractured porous media
SCS	Soil Conservation Service
SDF	Saltstone Disposal Facility
SRS	Savannah River Site
UBS	Upper Bounding Scenario
U.S.	United States
USCS	Unified Soil Classification System
USLE	Universal Soil Loss Equation
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
WP	wilting point
WSRC	Westinghouse Savannah River Company

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

ABBREVIATIONS

A	Area
A	Universal Soil Loss Equation soil loss
C	Universal Soil Loss Equation vegetative cover factor
cm	centimeter
cm^2	square centimeter
cm^3	cubic centimeter
d	thickness or depth
F	fraction
ft	feet
ft^2	square feet
ft^3	cubic feet
ft-msl	feet above mean sea level
g	gram
I	infiltration
in	inch
Instal.	installation
K	saturated hydraulic conductivity
K	Universal Soil Loss Equation soil erodibility factor
L	liter
lbs	pounds
LS	Universal Soil Loss Equation slope length and steepness factor
m^3	cubic meter
mg	milligram
mil	thousandth of an inch
mph	miles per hour
n	porosity
N	no
No.	number
P	Universal Soil Loss Equation erosion control practice factor
R	Universal Soil Loss Equation rainfall erosion index

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

ABBREVIATIONS (continued)

Recirc.	Recirculation
s	second
Sat. Hyd. Cond.	saturated hydraulic conductivity
sec	second
STD.	Standard
T	time
VEG.	Vegetative
V	volume
Vol	volume
Y	yes
yr	year
ρ_b	bulk density
ρ_p	particle density
‘	foot
“	inch
%	percent
#	number
/	per
~	approximately

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1.0 EXECUTIVE SUMMARY

As part of the current Saltstone Disposal Facility (SDF) Performance Assessment (PA) revision, Mechanically Stabilized Earth (MSE) vault closure cap degradation mechanisms and their impact upon infiltration through the MSE vault closure cap were evaluated for the base case land use scenario (i.e. institutional control to pine forest). The degradation mechanisms evaluated included pine forest succession, erosion, and colloidal clay migration (Phifer 2003). Infiltration through the upper hydraulic barrier layer of the closure cap as determined by this evaluation will be utilized as the infiltration input to subsequent PORFLOW vadose zone contaminant transport modeling, which will also be performed as part of the PA revision.

Additionally as part of the PA revision, a sensitivity analysis has been performed and documented herein, to bound the previous base case land use scenario results. The same degradation mechanisms utilized for the base case, as appropriate, have been utilized in the sensitivity analysis. The bounding sensitivity analysis includes the following two MSE vault, closure cap, land use scenarios:

- Continuous bamboo cover (this scenario bounds the lower end of infiltration), and
- Institutional control to farm to pine forest (this scenario bounds the upper end of infiltration).

The estimated infiltration through the upper GCL for the lower bounding, base case, and upper bounding scenarios at year 1000 were 1.75, 12.04, and 19.46 inches/year, respectively. The maximum infiltration estimated through the upper GCL within the first 10,000 years infiltration for the lower bounding, base case, and upper bounding scenarios were 6.46 inches/year at year 3,400, 14.09 inches/year at year 10,000, and 21.42 inches/year at year 3,400, respectively. The estimated infiltration through the upper GCL at complete degradation of the closure cap for the lower bounding, base case, and upper bounding scenarios were 4.75 inches/year at year 280,000, 18.12 inches/year at year 280,000, and 18.60 at approximately year 38,250.

Based upon the results of this sensitivity analysis, it was estimated that the pine forest succession, degradation mechanism results in the greatest increase in infiltration at approximately 13.5 inches/year. It was estimated that colloidal clay migration into the drainage layer results in an infiltration increase of approximately 6 inches/year. Finally it was estimated that erosion results in the least infiltration increase of the degradation mechanisms at approximately 1 inch/year. Based upon this, it is evident that elimination of the pine forest succession, degradation mechanism would do the most to minimize increases in the infiltration over time.

In addition to infiltration over time, the saturated hydraulic conductivity of the lower drainage layer over time is an important parameter. It is estimated that the lower drainage layer completely silts-in (i.e. has a saturated hydraulic conductivity of 0.0001 cm/s) in year 26,000 for the lower bounding scenario, in year 12,000 for the base case scenario, and in year 8,300 for the upper bounding scenario.

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2.0 INTRODUCTION

As part of the current Saltstone Disposal Facility (SDF) Performance Assessment (PA) revision, the closure cap configuration was reevaluated and closure cap degradation mechanisms and their impact upon infiltration through the closure cap were evaluated for the base case land use scenario (i.e. institutional control to pine forest). This land use scenario assumes a 100-year institutional control period following final SDF closure during which the closure cap is maintained. At the end of institutional control, it is assumed that a pine forest succeeds the cap's original bamboo cover (Phifer and Nelson 2003).

The revised closure cap configuration is presented in Figure 2.0-1 (Phifer and Nelson 2003). The degradation mechanisms evaluated for this closure cap included pine forest succession, erosion, and colloidal clay migration. These degradation mechanisms resulted in changes in the hydraulic properties of the closure cap layers and resulting increases in infiltration through the closure cap over time. The primary changes caused by the degradation mechanisms that result in increased infiltration are the formation of holes in the upper geosynthetic clay liner (GCL) by pine forest succession and the reduction in the saturated hydraulic conductivity of the drainage layers due to colloidal clay migration into the layers. Erosion can also result in significant increases in infiltration if it causes the removal of soil layers, which provide water storage for the promotion of evapotranspiration.

The infiltration results for the existing SDF concrete vaults (i.e. vaults 1 and 4) and for the proposed Mechanically Stabilized Earth (MSE) vaults were documented within Phifer and Nelson (2003) and Phifer (2003), respectively. The existing SDF vaults (i.e. vaults 1 and 4) are above grade, roofed, reinforced concrete vaults. The proposed MSE vault configuration is presented in Figure 2.0-2 (Phifer 2003). Infiltration through the upper hydraulic barrier layer of the closure cap as determined by these evaluations will be utilized as the infiltration input to subsequent PORFLOW vadose zone contaminant transport modeling, which will also be performed as part of the PA revision.

Additionally as part of the PA revision, a sensitivity analysis has been performed and documented herein, to bound the previous results for the MSE vault, closure cap, base case land use scenario (i.e. institutional control to pine forest). The bounding sensitivity analysis includes the following two MSE vault, closure cap, land use scenarios:

- Continuous bamboo cover, and
- Institutional control to farm to pine forest.

The continuous bamboo cover land use scenario assumes that bamboo, which is shallow-rooted, is the climax species for the closure cap (i.e. pine trees will not encroach upon the bamboo). This scenario results in the least amount of infiltration through the upper hydraulic barrier layer (i.e. lower bounding scenario). The institutional control to farm to pine forest, land use scenario assumes a 100-year institutional control period following final SDF closure during which the closure cap is maintained. At the end of institutional control, it is assumed that the cap's original bamboo cover is removed and that corn is grown until the closure cap layers above the erosion barrier are completely eroded. After the layers above the erosion barrier are gone, it is assumed that a pine forest succeeds corn farming. This scenario results in the greatest amount of infiltration through the upper hydraulic barrier layer (i.e. upper bounding scenario). The same degradation mechanisms, as appropriate, have been evaluated for both the lower and upper bounding scenarios.

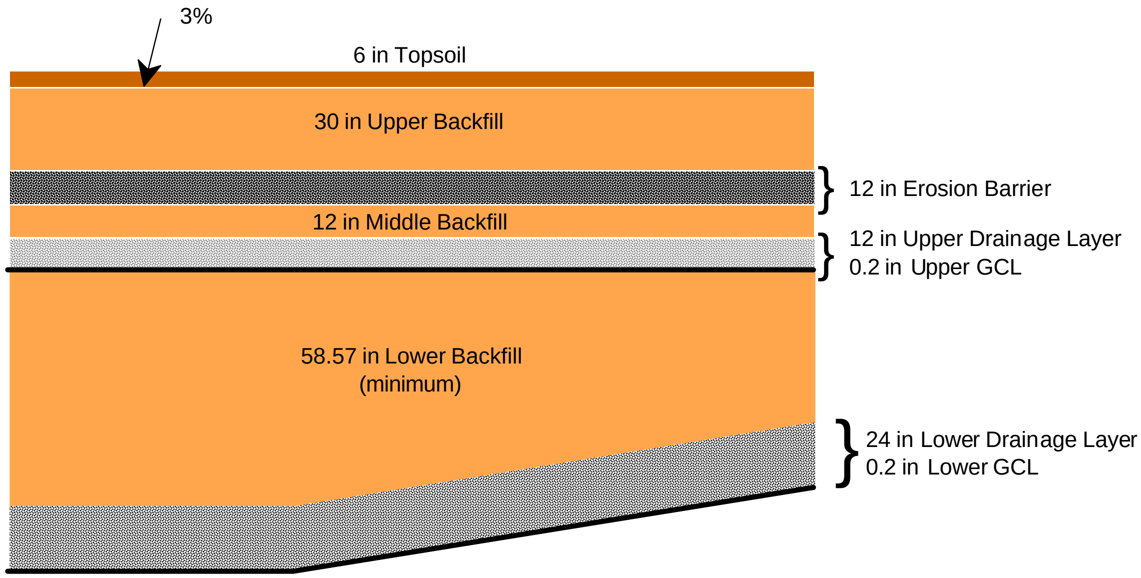

Figure 2.0-1. Saltstone Disposal Facility Closure Cap (Phifer and Nelson 2003)

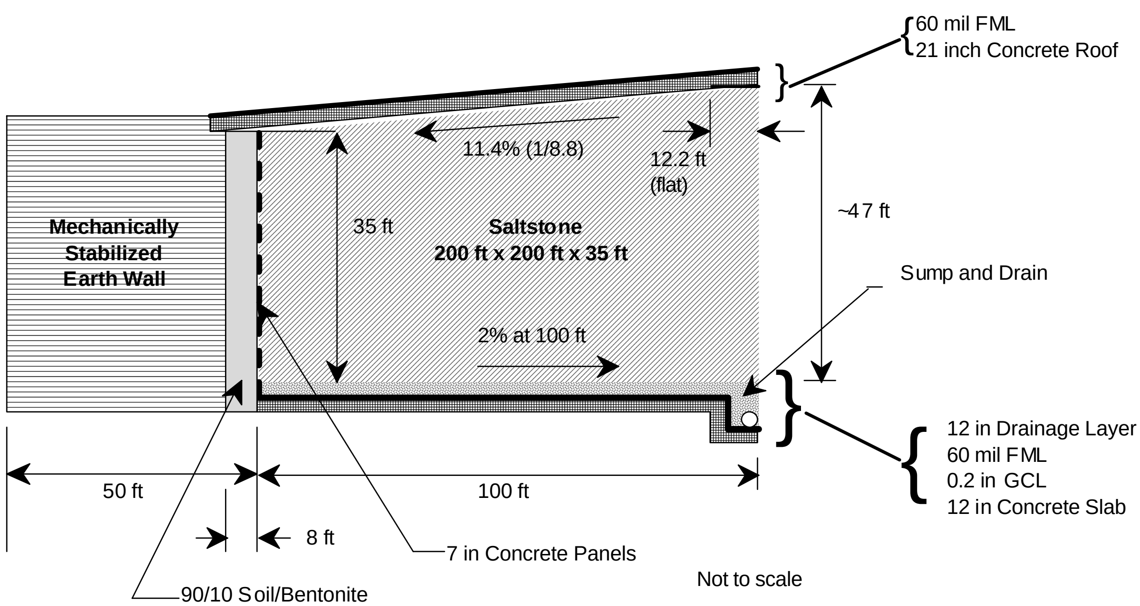

Figure 2.0-2. Saltstone Disposal Facility MSE Vault (Phifer 2003)

3.0 INTACT CLOSURE CAP INFILTRATION

3.1 Intact SDF GCL Closure Cap Footprint, Configuration, and Properties

The MSE vault layout (Figure 3.1-1) and the closure cap footprint and drainage system configuration (Figure 3.1-2) developed by Phifer (2003) has been utilized for the sensitivity analysis presented herein. Figure 3.1-3 presents the MSE vault and closure cap cross-section as previously described in Section 2.0. The assumption has been made that the lower GCL only covers the MSE vault roof whereas the upper GCL is continuous over the entire closure cap footprint presented in Figure 3.1-2. Table 3.1-1 presents the intact SDF MSE Vault closure cap configuration and soil properties as developed by Phifer and Nelson (2003).

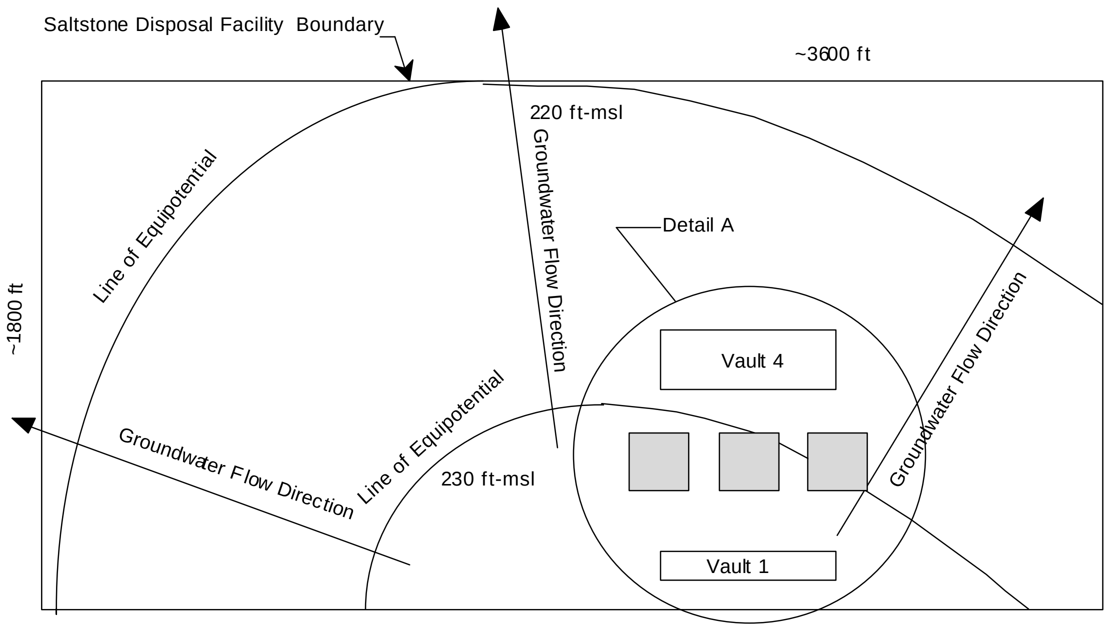

Figure 3.1-1. MSE Vault Layout (Phifer 2003)

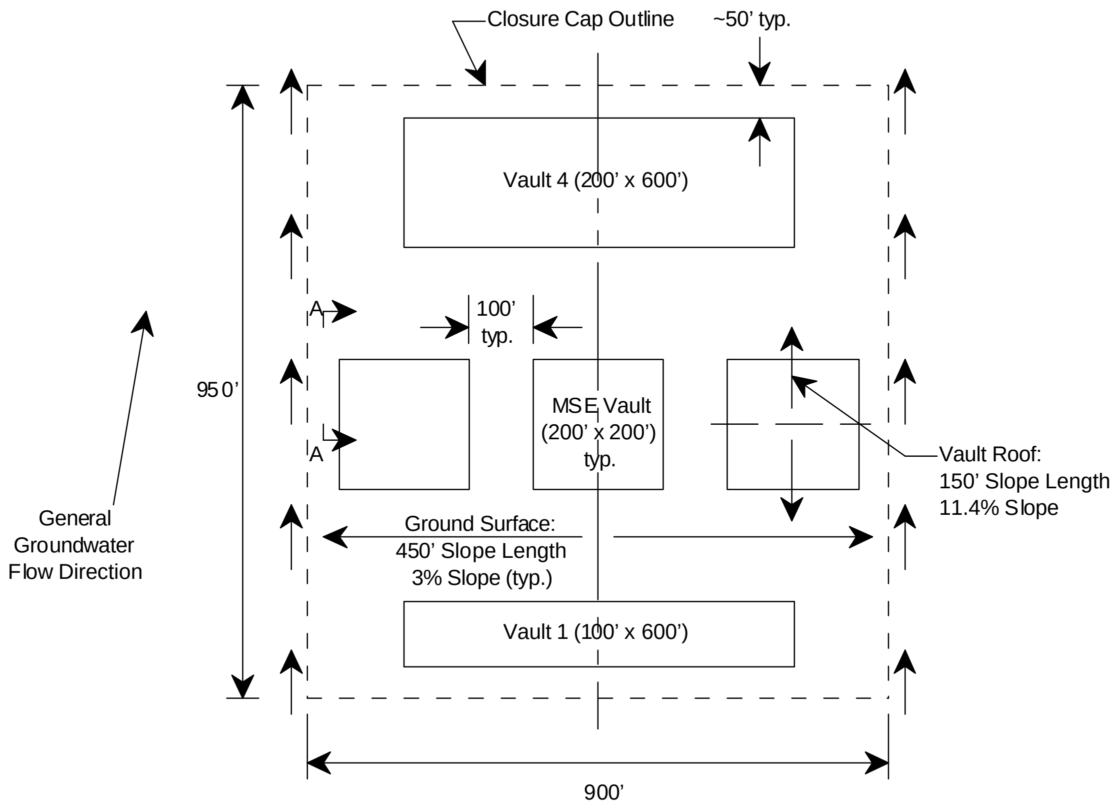

Figure 3.1-2. Closure Cap Footprint and Drainage System (Detail A) (Phifer 2003)

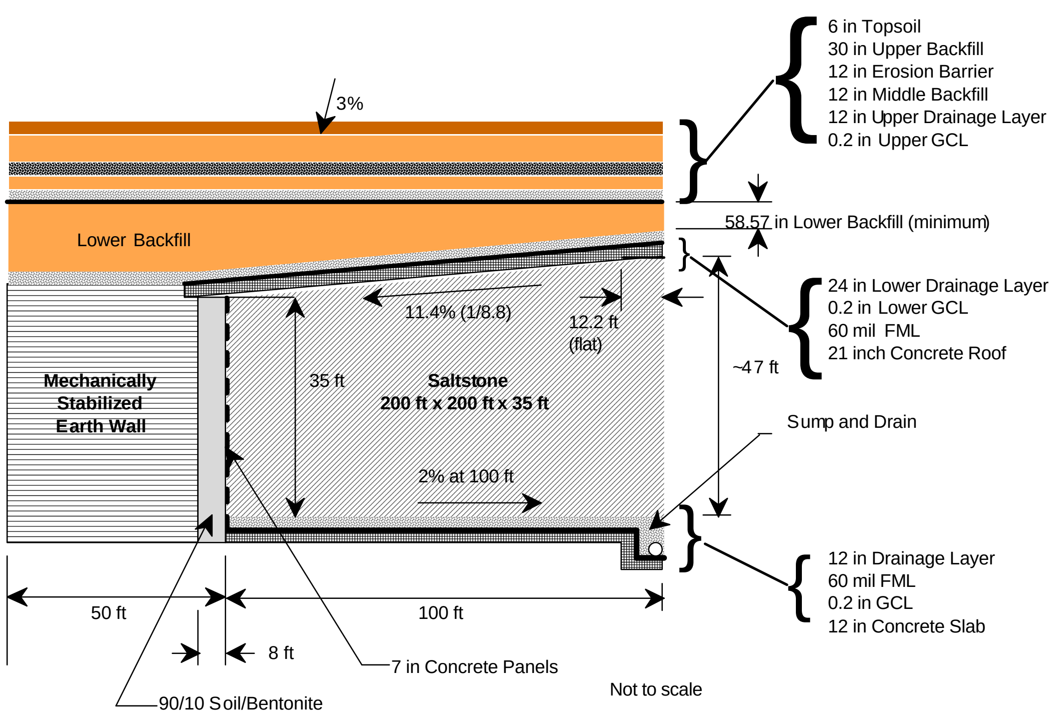

Figure 3.1-3. MSE Vault and Closure Cap Cross-Section (Section A-A) (Phifer 2003)

Table 3.1-1. Intact SDF MSE Vault Closure Cap Configuration and Properties (Phifer and Nelson 2003)

Layer	Thickness (inches)	Saturated Hydraulic Conductivity (cm/sec)	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)
Topsoil [1]	6	1.00E-03	0.4	0.11	0.058
Upper Backfill [1]	30	1.00E-04	0.37	0.24	0.136
Erosion Barrier [2]	12	3.97E-04	0.06	0.056	0.052
Middle Backfill [1]	12	1.00E-04	0.37	0.24	0.136
Geotextile Filter Fabric [3]	-	-	-	-	-
Upper Drainage Layer [1]	12	1.00E-01	0.38	0.08	0.013
Upper GCL	0.2 [4]	5.00E-09 [5]	0.75 [6]	0.747 [6]	0.40 [6]
Lower Backfill [1]	58.57 (minimum)	1.00E-04	0.37	0.24	0.136
Geotextile Filter Fabric [5]	-	-	-	-	-
Lower Drainage Layer [1]	24	1.00E-01	0.38	0.08	0.013
Lower GCL	0.2 [4]	5.00E-09 [5]	0.75 [6]	0.747 [6]	0.40 [6]

[1] WSRC 2002
[2] Phifer and Nelson 2003; The erosion barrier is assumed to consist of a one foot thick layer of 2-inch to 6-inch granite stone whose voids are filled with a Controlled Low Strength Material (CLSM) or flowable fill.
[3] It is assumed that a geotextile filter fabric will be placed above the drainage layers to minimize the infiltration of fines from the overlying layers into the drainage layer. However it is not necessary to include the filter fabric in the HELP models.
[4] USEPA 2001
[5] GSE 2002
[6] USEPA 1994a and USEPA 1994b

3.2 HELP Model and Generic Input Data

The Hydrologic Evaluation of Landfill Performance (HELP) model has been utilized to conduct the evaluation of the impact of closure cap degradation upon infiltration for each bounding sensitivity land use scenario (see Section 2.0) for the MSE vault closure cap (see Section 3.1). The HELP model is a quasi-two-dimensional water balance model designed to conduct landfill water balance analyses. The model requires the input of weather, soil, and design data. It provides estimates of runoff, evapotranspiration, lateral drainage, vertical percolation (infiltration), hydraulic head, and water storage for the evaluation of various landfill designs. Personnel at the U.S. Army Engineer Waterways Experiment Station in Vicksburg, Mississippi developed the HELP model, under an interagency agreement with the U.S. Environmental Protection Agency (USEPA). HELP model version 3.07, issued on November 1, 1997, is the latest version of the model available from the Waterways Experiment Station (USEPA 1994a and USEPA 1994b).

The HELP model requires the input of evapotranspiration, precipitation, temperature, and solar radiation data. Phifer and Nelson (2003) developed the weather data utilized to conduct this evaluation. The HELP model weather data input files, which were utilized for all HELP model runs, are provided in the following appendices:

- Appendix A, Augusta Synthetic Precipitation Modified with SRS Specific Average Monthly Precipitation Data over 100 Years (file name: Zprec.d4),
- Appendix B, Augusta Synthetic Temperature Modified with SRS Specific Average Monthly Temperature Data over 100 Years (file name: Ztemp.d7),
- Appendix C, Augusta Synthetic Solar Radiation Data over 100 Years (file name: Zsolar.d13), and
- Appendix D, Augusta Evapotranspiration Data (file name: Zevap.d11).

Table 3.2-1 provides a listing of generic input parameters (i.e., HELP model query) and the associated values selected. Use of selected fixed values for these HELP model queries provides compatibility between the different HELP model runs. The landfill area is based upon the Figure 3.1-2 length (950 feet) and width (900 feet), which results in a surface area of 760,000 feet squared or 19.63 acres. It has been assumed that the final covers are appropriately sloped so that 100 percent of the covers allow runoff to occur (i.e., there are no depressions). A yes response has been provided to the HELP model query, which asks, "Do you want to specify initial moisture storage? (Y/N)." The amount of water or snow on the surface of the covers was assumed to be zero as the initial model condition.

Table 3.2-1. Generic Input Parameter Values – Area and Initial Moisture

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area	19.63 acres
Percent of area where runoff is possible	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface	0 in.

As stated the initial moisture storage has been specified for all soil layers. While the initial moisture storage is not a fixed value for all runs, a fixed method of selecting the initial moisture storage value has been utilized for consistency. The initial, soil moisture storage value has been selected as follows:

- The initial moisture storage of soil layers designated as either a vertical percolation layer or a lateral drainage layer was set at the field capacity of the soil.
- The initial moisture storage of soil layers designated as a barrier soil liner was set at the porosity of the soil.

3.3 Intact Closure Cap Curve Number Input Parameter Values

The Soil Conservation Service (SCS) runoff curve number (CN) is another required HELP model input parameter. The HELP model provides three options to specify the CN. The option that produces a HELP model computed curve number, based on surface slope and slope length, soil texture of the top layer, and vegetation, was utilized for the intact closure cap. Table 3.3-1 provides the input values of surface slope and slope length, soil texture of the top layer, and vegetation that were utilized to produce the HELP model computed curve number. The 3 percent slope is that specified for the top surface of the Saltstone final cover within the Saltstone closure plan (Cook et al. 2000). The 450-foot slope length is based upon Figure 3.1-2. The soil texture, selected as an input for calculation of the CN, is a loamy fine sand per the United States Department of Agriculture (USDA) and a silty sand per Unified Soil Classification System (USCS). This soil texture closely represents the typical vegetative soil layers utilized at the Savannah River Site (SRS). The corresponding number in the HELP default soil texture list is 5. Based upon these input parameter values the HELP model computed a CN of 54.4 for the intact closure cap case.

Table 3.3-1. Curve Number (CN) Input Parameter Values for Intact Closure Cap

CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope	3%
Slope length	450 ft
Soil Texture	5 (HELP model default soil texture)
Vegetation	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number	54.4

3.4 Intact Closure Cap Infiltration

HELP modeling of the Table 3.1-1 intact SDF MSE vault closure cap configuration has been performed utilizing the Section 3.2 input data. As documented in Phifer and Nelson (2003), the HELP model does not need to include the vault in order to obtain an appropriate infiltration through the upper GCL. Therefore the vault has not been included in any of the HELP modeling presented herein. Based upon this modeling the infiltration through the upper GCL has been estimated to be 0.36 inches per year for intact conditions. The following appendix provides the detailed HELP model, input data and output file for the intact condition:

- Appendix E, Intact SDF MSE Vault Closure Cap (0 Years): HELP Model Input Data and Output File (output file name: ZMSEIout.OUT)

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4.0 CLOSURE CAP DEGRADATION

The following two primary closure cap degradation mechanisms have been assumed to significantly impact the infiltration through the MSE vault closure cap over time for the continuous bamboo cover land use scenario (i.e. lower bounding scenario):

- Erosion
- Colloidal clay migration

The pine forest succession, degradation mechanism is not applicable to the continuous bamboo cover land use scenario.

The following three primary closure cap degradation mechanisms have been assumed to significantly impact the infiltration through the MSE vault closure cap over time for the institutional control to farm to pine forest land use scenario (i.e. upper bounding scenario):

- Pine forest succession
- Erosion
- Colloidal clay migration

Phifer and Nelson (2003) discussed each of these degradation mechanisms in detail.

4.1 Pine Forest Succession

Pine forest succession is only a degradation mechanism for the upper bounding scenario as outlined above. Corn is a shallow-rooted, single harvest per year farm crop in the vicinity of SRS. For the upper bounding scenario, it is assumed that pine trees succeed corn farming after erosion exposes the erosion barrier. Pine trees are the most deeply rooted naturally occurring plants at SRS. (MMES 1992; Cook et al. 2000). The following assumptions, which were made relative to pine forest succession by Phifer and Nelson (2003), have also been utilized for this evaluation as appropriate:

- 200 years after the end of farming it is assumed that the entire cap is dominated by pine.
- Complete turnover of the 400 mature trees per acre occurs every 100 years (in a staggered manner).
- There are 400 mature trees per acre with 4 roots to 6 feet and 1 root to 12 feet. The roots are 3 inches in diameter at a depth of 1 foot and 0.25 inches in diameter at either 6 or 12 feet, whichever is applicable.

4.2 Erosion

The topsoil and upper backfill layers, which are located above the erosion barrier, are subject to erosion. For the lower bounding scenario erosion is assumed to occur with a bamboo vegetative cover only. For the upper bounding scenario erosion is assumed to occur with a bamboo vegetative cover for the first 100 years followed by erosion with corn cover until both the topsoil and upper backfill layers are completely eroded. The projected erosion rate for both the topsoil and upper backfill layers has been determined utilizing the Universal Soil Loss Equation for both bamboo and corn vegetative covers. The Universal Soil Loss Equation (USLE) is expressed as:

$$A = R \times K \times LS \times C \times P \qquad \text{(Eq. 5.2-1)}$$

where

A = soil loss (tons/acre/year)

R = rainfall erosion index (100 ft·ton/acre per in/hr)

K = soil erodibility factor, tons/acre per unit of R

LS = slope length and steepness factor, dimensionless

C = vegetative cover factor, dimensionless

P = erosion control practice factor, dimensionless

Table 4.2-1 presents the USLE parameter values utilized and the source of the values for both the topsoil and backfill cover with bamboo and corn.

Table 4.2-1. USLE Parameter Values

USLE Parameter	Value Utilized	Source
R for SRS location	260	Horton and Wilhite 1978
K for topsoil	0.28	Phifer and Nelson 2003 and Goldman et al. 1986 Figure 5.6
K for backfill	0.20	Phifer and Nelson 2003 and Goldman et al. 1986 Figure 5.6
LS for 450-foot 3% slope (see Figure 3.1-2)	0.45	Goldman et al. 1986 Table 5.5
C for bamboo [1]	0.001	Horton and Wilhite 1978
C for corn	0.54	Horton and Wilhite 1978
P for no supporting practices	1	Not applicable

[1] Assumed to be the same as a natural successional forest.

Based upon the Universal Soil Loss Equation and the Table 4.2-1 parameter values the following soil losses were estimated:

- Topsoil with bamboo has an estimated soil loss of 0.0328 tons/acre/year ($A = 260 \times 0.28 \times 0.45 \times 0.001 \times 1$). Based upon the dry bulk density the estimated soil loss can be converted to a loss in terms of depth of loss per year. From Jones and Phifer (2002), the dry bulk density of topsoil was taken as 90 lbs/ft^3. Topsoil with bamboo has an estimated depth of soil loss of approximately 2.0E-04 inches/year.

  $$(Loss = \frac{0.0328\ tons/acre/year \times 2000\ lbs/ton \times 12\ inches/foot}{43560\ ft^2/acre \times 90\ lbs/ft^3}).$$

- Topsoil with corn has an estimated soil loss of 17.69 tons/acre/year ($A = 260 \times 0.28 \times 0.45 \times 0.54 \times 1$). Based upon the dry bulk density the estimated soil loss can be converted to a loss in terms of depth of loss per year. From Jones and Phifer (2002), the dry bulk density of topsoil was taken as 90 lbs/ft^3. Topsoil with corn has an estimated depth of soil loss of approximately 0.11 inches/year.

$$(Loss = \frac{17.69\ tons/acre/year \times 2000\ lbs/ton \times 12\ inches/foot}{43560\ ft^2/acre \times 90\ lbs/ft^3}).$$

- Backfill with bamboo has an estimated soil loss of 0.0234 tons/acre/year ($A = 260 \times 0.20 \times 0.45 \times 0.001 \times 1$). Based upon the dry bulk density the estimated soil loss can be converted to a loss in terms of depth of loss per year. From Jones and Phifer (2002), the dry bulk density of backfill was taken as 104 lbs/ft^3. Backfill with bamboo has an estimated depth of soil loss of approximately 1.2E-04 inches/year.

$$(Loss = \frac{0.0234\ tons/acre/year \times 2000\ lbs/ton \times 12\ inches/foot}{43560\ ft^2/acre \times 104\ lbs/ft^3}).$$

- Backfill with corn has an estimated soil loss of 12.64 tons/acre/year ($A = 260 \times 0.20 \times 0.45 \times 0.54 \times 1$). Based upon the dry bulk density the estimated soil loss can be converted to a loss in terms of depth of loss per year. From Jones and Phifer (2002), the dry bulk density of backfill was taken as 104 lbs/ft^3. Backfill with corn has an estimated depth of soil loss of approximately 0.067 inches/year.

$$(Loss = \frac{12.64\ tons/acre/year \times 2000\ lbs/ton \times 12\ inches/foot}{43560\ ft^2/acre \times 104\ lbs/ft^3}).$$

4.3 Colloidal Clay Migration

It is assumed that colloidal clay migrates from overlying backfill layers and accumulates in the drainage layers reducing the saturated hydraulic conductivity of the drainage layers over time. As previously documented in Phifer and Nelson (2003), it will be assumed that water flux driven colloidal clay migration at a concentration of 63 mg/L occurs from overlying backfill layers to the drainage layers. It will be further assumed that the colloidal clay accumulates in the drainage layer from the bottom up filling the void space of the drainage layer with clay at a density of 1.1 g/cm^3 (Hillel 1982).

4.4 Closure Cap Degradation Summary

Based upon the erosion and colloidal clay migration degradation mechanisms, degradation assumptions for each closure cap layer has been made as outlined in Table 4.4-1 for the lower bounding scenario (i.e. continuous bamboo cover). Based upon the pine forest succession, erosion, and colloidal clay migration degradation mechanisms, degradation assumptions for each closure cap layer has been made as outlined and in Table 4.4-2 for the upper bounding scenario (i.e. institutional control to farm to pine forest). These degradation scenarios form the basis for modifying the thickness and hydraulic properties of each layer over time. This information has been utilized in Section 5.0 to determine infiltration though the upper GCL over time.

Table 4.4-1. Lower Bounding Scenario Closure Cap Layer Degradation Assumptions (modified from Phifer and Nelson 2003)

Layer	Degradation Assumption
Vegetation	Bamboo covers the closure cap continuously
Topsoil	Topsoil erosion occurs at 2.0E-04 inches per year with bamboo.
Upper Backfill	Backfill erosion occurs at 1.2E-04 inches per year with bamboo, after the topsoil layer has been depleted.
Erosion Control Barrier	None. Bamboo roots are assumed to have no impact upon the erosion control barrier.
Middle Backfill	Colloidal clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the saturated hydraulic conductivity to increase over time.
Geotextile Filter Fabric	For purposes of colloidal clay migration into the underlying drainage layer the geotextile filter fabric is assumed to be ineffective over the time period under consideration.
Upper Drainage Layer	Colloidal clay migration from the overlying 1-foot-thick backfill into the 1-foot-thick upper drainage layer causes the saturated hydraulic conductivity to decrease over time.
Upper GCL	None. Bamboo roots are assumed to have no impact upon the upper GCL, since the upper GCL is located at a depth beyond the penetration of bamboo roots.
Lower Backfill	None. While it is assumed that colloidal clay migration from this layer to the underlying lower drainage layer occurs, it is also assumed that the thickness of the lower backfill layer (minimum 5-foot) relative to the lower drainage layer (2-foot) prevents the quantity of clay loss necessary to change the hydraulic properties of the lower backfill.
Geotextile Filter Fabric	For purposes of colloidal clay migration into the underlying drainage layer the geotextile filter fabric is assumed to be ineffective over the time period under consideration.
Lower Drainage Layer	Colloidal clay migration from the overlying minimum 5-foot-thick lower backfill into the 1-foot-thick lower drainage layer reduces its saturated hydraulic conductivity over time.
Lower GCL	None. Bamboo roots are assumed to have no impact upon the lower GCL, since the lower GCL is located at a depth beyond the penetration of bamboo roots.

Table 4.4-2. Upper Bounding Scenario Closure Cap Layer Degradation Assumptions (modified from Phifer and Nelson 2003)

Layer	Degradation Assumption
Vegetation	Bamboo is maintained during the 100-year institutional control period, corn is grown until the erosion barrier is exposed, pine trees begin to encroach after farming has ceased, and a pine forest covers the cap 200 years after farming has ceased.
Topsoil	Topsoil erosion occurs at 2.0E-04 inches per year with bamboo and 0.11 inches per year with corn.
Upper Backfill	Backfill erosion occurs at 1.2E-04 inches per year with bamboo and 0.067 inches per year with corn, after the topsoil layer has been depleted.
Erosion Control Barrier	Maintenance and farm practices during institutional control and corn farming prevent degradation of the erosion control barrier. Subsequent to corn farming after complete erosion of the topsoil and upper backfill, pine forest succession will result in root penetration through the erosion control barrier. This does not impact its ability to function as an erosion barrier. It will be assumed that root penetration breaks up the flowable fill and separates it from the granite stone. After the root decomposes it will be assumed that segregation of the granite stone and broken up flowable fill occurs, resulting in the flowable fill at the bottom of the hole and the granite stone at the top.
Middle Backfill	Colloidal clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the saturated hydraulic conductivity to increase over time.
Geotextile Filter Fabric	For purposes of colloidal clay migration into the underlying drainage layer the geotextile filter fabric is assumed to be ineffective over the time period under consideration.
Upper Drainage Layer	Colloidal clay migration from the overlying 1-foot-thick backfill into the 1-foot-thick upper drainage layer causes the saturated hydraulic conductivity to decrease over time.
Upper GCL	Maintenance during institutional control period and farming practices prevent degradation of the upper GCL. Subsequent to the institutional control period and corn farming after all of the topsoil and upper backfill have been completely eroded, pine forest succession will result in root penetration through the GCL. This allows the overlying drainage layer to fill the holes after the roots decompose.
Lower Backfill	None. While it is assumed that colloidal clay migration from this layer to the underlying lower drainage layer occurs, it is also assumed that the thickness of the lower backfill layer (minimum 5-foot) relative to the lower drainage layer (2-foot) prevents the quantity of clay loss necessary to change the hydraulic properties of the lower backfill.
Geotextile Filter Fabric	For purposes of colloidal clay migration into the underlying drainage layer the geotextile filter fabric is assumed to be ineffective over the time period under consideration.
Lower Drainage Layer	Colloidal clay migration from the overlying minimum 5-foot-thick lower backfill into the 1-foot-thick lower drainage layer reduces its saturated hydraulic conductivity over time.
Lower GCL	None. Pine tree roots do not penetration to a sufficient enough depth to impact this layer. Additionally the underlying concrete vault roof along with the GCL produces a hard layer and continuous water saturation within and above these layers so that root elongation is stopped.

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5.0 CLOSURE CAP INFILTRATION FOR LOWER BOUNDING SCENARIO (CONTINUOUS BAMBOO COVER)

5.1 LBS Degraded Layer Properties over Time

The SDF GCL closure cap initial (0 year) intact layer thickness and hydraulic property values from top to bottom are provided in Table 3.1-1. The degradation assumptions for each layer of the lower bounding scenario are provided in Table 4.4-1. Based upon the Table 4.4-1 degradation assumptions, the Table 3.3-1 initial SDF closure cap layer thickness and hydraulic property values have been modified to account for degradation at 100, 300, 550, 1,000, 1,800, 3,400, 5,600 and 10,000 years after closure of the SDF. The following discussions provide additional detail associated with determination of the degraded properties for the middle backfill, upper drainage layer, and lower drainage layer as originally presented by Phifer and Nelson (2003).

5.1.1 LBS Middle Backfill and Upper Drainage Layer

It is assumed that water flux driven colloidal-clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the middle backfill saturated hydraulic conductivity to increase over time and that of the upper drainage layer to decrease over time. It has been assumed that clay migration occurs out of the backfill into the drainage layer with the water flux containing 63 mg/L of colloidal clay. Since both layers are of the same thickness and the middle backfill layer has limited clay content, it has been assumed that half the clay content of the backfill will migrate into the drainage layer. At which point the two layers essentially become the same material and material property changes cease. Based upon this it will be assumed that the endpoint saturated hydraulic conductivity of the layers will become that of the log mid-point between the initial backfill and upper drainage layer conditions. It will also be assumed that the endpoint porosity, field capacity, and wilting point will become the arithmetic average of the backfill and upper drainage layer. The hydraulic properties at times prior to the endpoint have been proportioned between that of the endpoint properties and the initial properties based upon the fraction of clay that has migrated out of the backfill.

5.1.2 LBS Lower Drainage Layer

It is assumed that colloidal clay migration from the minimum 5-foot-thick overlying backfill into the 2-foot-thick lower drainage layer is driven by the water flux through the upper GCL. This water flux driven clay migration enters into the lower drainage layer and fills the lower drainage layer from the bottom up. This reduces the saturated hydraulic conductivity of the clay-filled portion from 1.0E-01 to 1.0E-04 cm/s (i.e. to the saturated hydraulic conductivity of the overlying backfill), while the conductivity of the clean portion remains at 1.0E-01 cm/s. As the thickness of the lower drainage layer filled with clay increases, the equivalent hydraulic conductivity of the entire layer decreases. The equivalent horizontal hydraulic conductivity for this layer has been determined from the following equation (Freeze and Cherry 1979):

$$K_h = \sum_{i=1}^{n} \frac{K_i \ d_i}{d} \qquad \text{(Eq. 6.1-1)}$$

where

K_h = equivalent horizontal saturated hydraulic conductivity,

K_i = horizontal saturated hydraulic conductivity of i^{th} layer,

d_i = thickness of i^{th} layer,

d = total thickness

This is different from that assumed for the upper drainage layer, since the lower drainage layer has significantly more backfill overlying it.

5.1.3 LBS Summary Material Properties over Time

The lower bounding scenario calculations associated with determination of the layer thicknesses and hydraulic property values over time are provided in Appendix F. Table 5.1-1 provides the primary Appendix F, material property results (thickness and saturated hydraulic conductivity), for layers which change with time and were utilized in subsequent HELP modeling. The porosity, field capacity, and wilting points are not provided in Table 5.1-1. Values for these parameters are provided in Appendix F.

Table 5.1-1. Lower Bounding Scenario Material Property Summary Results

Year	Topsoil Layer Thickness (inches)	Middle Backfill Layer Saturated Hydraulic Conductivity (cm/s)	Upper Drainage Layer Saturated Hydraulic Conductivity (cm/s)	Lower Drainage Layer Saturated Hydraulic Conductivity (cm/s)
0	6	1.00E-04	1.00E-01	1.00E-01
100	5.980	1.20E-04	8.60E-02	1.00E-01
300	5.940	1.60E-04	6.30E-02	9.98E-02
550	5.890	2.30E-04	4.30E-02	9.89E-02
1,000	5.800	4.60E-04	2.10E-02	9.61E-02
1,800	5.640	1.60E-03	6.30E-03	8.96E-02
3,400	5.320	3.20E-03	3.20E-03	7.56E-02
5,600	4.880	3.20E-03	3.20E-03	5.62E-02
10,000	4.0	3.20E-03	3.20E-03	1.74E-02

5.2 LBS Degraded Closure Cap Infiltration over Time

Table 5.1-1 and Appendix F data were utilized as input to the HELP model (USEPA 1994a and USEPA 1994b) in order to determine infiltration through the upper GCL for the lower bounding scenario at each degraded time step. The following appendices provide the detailed HELP model, input data and output files for each time step:

- Appendix G, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (100 Years): HELP Model Input Data and Output File (output file name: ZLBS1out.OUT)
- Appendix H, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (300 Years): HELP Model Input Data and Output File (output file name: ZLBS2out.OUT)
- Appendix I, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (550 Years): HELP Model Input Data and Output File (output file name: ZLBS3out.OUT)
- Appendix J, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,000 Years): HELP Model Input Data and Output File (output file name: ZLBS4out.OUT)
- Appendix K, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,800 Years): HELP Model Input Data and Output File (output file name: ZLBS5out.OUT)

- Appendix L, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (3,400 Years): HELP Model Input Data and Output File (output file name: ZLBS6out.OUT)
- Appendix M, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (5,600 Years): HELP Model Input Data and Output File (output file name: ZLBS7out.OUT)
- Appendix N, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (10,000 Years): HELP Model Input Data and Output File (output file name: ZLBS8out.OUT)

The following outputs from this evaluation are lower bounding sensitivity values, which will be utilized within the Performance Assessment:

- Infiltration through the upper GCL
- Saturated hydraulic conductivity of the 2-foot-thick lower Drainage Layer

Table 5.2-1 provides a summary of these parameter values.

Table 5.2-1. Lower Bounding Sensitivity Values

Year	Infiltration through Upper GCL (in/yr)	Lower Drainage Layer Saturated Hydraulic Conductivity (cm/s)
0	0.36	1.00E-01
100	0.41	1.00E-01
300	0.55	9.99E-02
550	0.80	9.98E-02
1,000	1.75	9.94E-02
1,800	5.05	9.77E-02
3,400	6.46	9.20E-02
5,600	6.44	8.30E-02
10,000	6.40	6.53E-02
26,250	ND	1.00E-04 (year lower drainage layer completely silts in)
280,000	4.75 (infiltration at complete degradation of the closure cap)	1.00E-04

ND = not determined

5.3 LBS Infiltration After Complete Closure Cap Degradation

The infiltration through the upper GCL at complete closure cap degradation for the lower bounding scenario and the associated time of occurrence have been determined based upon the following:

- Complete closure cap degradation occurs when both the topsoil and upper backfill have eroded away.
- As outlined in Appendix F, it is assumed that the material properties of the middle backfill and upper drainage layer become the same at year 2246 and remain constant thereafter. Therefore the middle backfill and upper drainage layer material properties will be taken as those determined at year 2246.

- As previously demonstrated in Appendix F, the material properties of the lower drainage layer do not impact infiltration through the upper GCL. Completely silted in conditions will be assumed for the lower drainage layer for determination of this infiltration.

Appendix F provides the material property calculations based upon the above assumptions and the detailed HELP model input data and output file associated with this infiltration through the upper GCL. This infiltration through the upper GCL was determined to be 4.75 inches/year in year 280,000. This infiltration has been included in Table 5.2-1 for comparison purposes.

In addition, the time that the lower drainage layer completely silts in and assumes the properties of the overlying backfill has been estimated to occur in the year 26,250 (see Appendix F). This has also been included in Table 5.2-1.

6.0 CLOSURE CAP INFILTRATION FOR UPPER BOUNDING SCENARIO (INSTITUTIONAL CONTROL TO FARM TO PINE FOREST)

6.1 UBS Degraded Layer Properties over Time

The SDF GCL closure cap initial (0 year) intact layer thickness and hydraulic property values from top to bottom are provided in Table 3.1-1. The degradation assumptions for each layer are provided in Table 4.4-2. Based upon the Table 4.4-2 degradation assumptions, the Table 3.3-1 initial SDF closure cap layer thickness and hydraulic property values have been modified to account for degradation at 100, 154, 300, 550, 602, 802, 1,000, 1,800, 3,400, 5,600 and 10,000 years after closure of the SDF. The following discussions provide additional detail associated with determination of the degraded properties for the erosion barrier, upper GCL, middle backfill, upper drainage layer, and lower drainage layer as originally presented by Phifer and Nelson (2003).

6.1.1 UBS Erosion Barrier

As outlined in Phifer and Nelson 2003, the erosion barrier is assumed to consist of a one foot thick layer of 2-inch to 6-inch granite stone whose voids are filled with a Controlled Low Strength Material (CLSM) or flowable fill. Under the upper bounding scenario maintenance during the institutional control period and farming practices during corn farming prevent degradation of the erosion control barrier. Subsequent to the institutional control period and corn farming, pine forest succession will result in root penetration through the erosion control barrier. This does not impact its ability to function as an erosion barrier. For this scenario pine forest succession occurs after all of the topsoil and upper backfill have been completely eroded, therefore the upper backfill is not available to fill holes in the erosion barrier after the roots decompose. However it will be assumed that root penetration breaks up the flowable fill and separates it from the granite stone. After the root decomposes it will be assumed that segregation of the granite stone and broken up flowable fill occurs, resulting in the flowable fill at the bottom of the hole and the granite stone at the top. For the purposes of this calculation the properties of the broken up flowable fill will be ignored. Therefore will assume that the degraded barrier consists of intact erosion barrier with holes filled with the granite stone. The equivalent hydraulic properties of the overall erosion barrier change as the area of holes filled with separated and segregated granite stone and broken up flowable fill increases with time. The equivalent hydraulic properties have been estimated over time by area proportioning the properties between that of the intact erosion barrier and infiltrating backfill.

6.1.2 UBS Upper GCL

Under the upper bounding scenario maintenance during the institutional control period and farming practices during corn farming prevent degradation of the upper GCL. Subsequent to the institutional control period and corn farming after all of the topsoil and upper backfill have been completely eroded, pine forest succession will result in root penetration through the GCL. This allows the overlying drainage layer to fill the holes after the roots decompose. The holes in the GCL essentially act as direct conduits from the upper drainage layer to the lower backfill layer. When saturated conditions occur in the drainage layer after major precipitation events, cones of depression are created around the holes in the GCL with a radius of influence much greater than the radius of the hole. This means that a small area of GCL holes can greatly reduce the lateral flow of water in the drainage layer and increase the vertical flow into the lower backfill. Due to the significant influence of holes in the GCL to the quantity of infiltration, the use of equivalent hydraulic properties is not appropriate, since it does not consider the radius of influence associated with holes. Therefore, within the HELP model the degraded GCL has been modeled as a geomembrane liner with leakage through holes when appropriate. The HELP model considers both water flux through intact portions of the geomembrane using an "equivalent geomembrane hydraulic conductivity" and water flux through holes in the geomembrane. The HELP model does not assign a porosity, field capacity, or wilting point to geomembranes, however this is not considered essential to the GCL, since it is assumed that the GCL will remain fully saturated and it is below the depth where evapotranspiration is assumed to occur. The HELP model allows the input of up to 999,999 one square centimeter installation defects for a geomembrane liner. Therefore the calculated area of holes created by root penetration has been converted into an equivalent number of one square centimeter installation defects for input to the HELP model when appropriate. Excellent contact is assumed between the GCL and underlying backfill layer as a HELP model input, since the GCL is put in dry and swells into the surrounding soil as it hydrates. As outlined in Phifer (2003) a GCL with randomly spaced holes equivalent to approximately 0.3 percent (i.e. ~120,000 installation defects) of the GCL area results in an infiltration equivalent to that produced without the GCL. Therefore for cases where the equivalent number of installation defects exceeds 999,999, the GCL has been assigned as a barrier soil liner with the same material properties as the overlying upper drainage layer.

6.1.3 UBS Middle Backfill and Upper Drainage Layer

It is assumed that water flux driven colloidal-clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the middle backfill saturated hydraulic conductivity to increase over time and that of the upper drainage layer to decrease over time. It has been assumed that clay migration occurs out of the backfill into the drainage layer with the water flux containing 63 mg/L of colloidal clay. Since both layers are of the same thickness and the middle backfill layer has limited clay content, it has been assumed that half the clay content of the backfill will migrate into the drainage layer. At which point the two layers essentially become the same material and material property changes cease. Based upon this it will be assumed that the endpoint saturated hydraulic conductivity of the layers will become that of the log mid-point between the initial backfill and upper drainage layer conditions. It will also be assumed that the endpoint porosity, field capacity, and wilting point will become the arithmetic average of the backfill and upper drainage layer. The hydraulic properties at times prior to the endpoint have been proportioned between that of the endpoint properties and the initial properties based upon the fraction of clay that has migrated out of the backfill.

6.1.4 UBS Lower Drainage Layer

It is assumed that colloidal clay migration from the minimum 5-foot-thick overlying backfill into the 2-foot-thick lower drainage layer is driven by the water flux through the upper GCL. This water flux driven clay migration enters into the lower drainage layer and fills the lower drainage layer from the bottom up. This reduces the saturated hydraulic conductivity of the clay-filled portion from 1.0E-01 to 1.0E-04 cm/s (i.e. to the saturated hydraulic conductivity of the overlying backfill), while the conductivity of the clean portion remains at 1.0E-01 cm/s. As the thickness of the lower drainage layer filled with clay increases, the equivalent hydraulic conductivity of the entire layer decreases. The equivalent horizontal hydraulic conductivity for this layer has been determined from the following equation (Freeze and Cherry 1979):

$$K_h = \sum_{i=1}^{n} \frac{K_i \ d_i}{d} \qquad \text{(Eq. 6.1-1)}$$

where

K_h = equivalent horizontal saturated hydraulic conductivity,

K_i = horizontal saturated hydraulic conductivity of i^{th} layer,

d_i = thickness of i^{th} layer,

d = total thickness

This is different from that assumed for the upper drainage layer, since the lower drainage layer has significantly more backfill overlying it.

6.1.5 UBS Summary Material Properties over Time

The upper bounding scenario calculations associated with determination of the layer thicknesses and hydraulic property values over time are provided in Appendix O. Table 6.1-1 provides the primary Appendix O, material property results (thickness, saturated hydraulic conductivity, and holes in the upper GCL), for layers which change with time and were utilized in subsequent HELP modeling. The porosity, field capacity, and wilting points are not provided in Table 6.1-1. Values for these parameters are provided in Appendix O. By year 10,000 all closure cap layers except the erosion barrier have reached their assumed degradation endpoint.

Table 6.1-1. Upper Bounding Scenario Material Property Summary Results

Year	Vegetation	Topsoil Layer Thickness (inches)	Upper Backfill Layer Thickness (inches)	Erosion Barrier Saturated Hydraulic Conductivity (cm/s)
0	Bamboo	6	30	3.97E-04
100	Bamboo	5.980	30	3.97E-04
154	Corn	0	30	3.97E-04
300	Corn	0	20.2	3.97E-04
550	Corn	0	3.5	3.97E-04
602	Corn	0	0	3.97E-04
802	Pine Forest	0	0	1.2E-03
1,000	Pine Forest	0	0	2.8E-03
1,800	Pine Forest	0	0	9.1E-03
3,400	Pine Forest	0	0	2.2E-02
5,600	Pine Forest	0	0	3.9E-02
10,000	Pine Forest	0	0	7.5E-02
Year	Middle Backfill Layer Saturated Hydraulic Conductivity (cm/s)	Upper Drainage Layer Saturated Hydraulic Conductivity (cm/s)	Saturated Hydraulic Conductivity (cm/s) / One Square Centimeter Holes in Upper GCL [1] (#/acre)	Lower Drainage Layer Saturated Hydraulic Conductivity (cm/s)
0	1.00E-04	1.00E-01	5.00E-09 / 0	1.00E-01
100	1.20E-04	8.20E-02	5.00E-09 / 0	1.00E-01
154	1.40E-04	7.40E-02	5.00E-09 / 0	1.00E-01
300	1.80E-04	5.60E-02	5.00E-09 / 0	9.99E-02
550	2.90E-04	3.40E-02	5.00E-09 / 0	9.98E-02
602	3.20E-04	3.10E-02	5.00E-09 / 0	9.97E-02
802	4.70E-04	2.10E-02	5.00E-09 / 40,877	9.86E-02
1,000	6.90E-04	1.40E-02	5.00E-09 / 121,703	9.64E-02
1,800	3.20E-03	3.20E-03	5.00E-09 / 448,722	8.62E-02
3,400	3.20E-03	3.20E-03	3.20E-03 / 0	6.47E-02
5,600	3.20E-03	3.20E-03	3.20E-03 / 0	3.54E-02
10,000	3.20E-03	3.20E-03	3.20E-03 / 0	1.00E-04

[1] Number of HELP model installation defects

6.2 UBS Degraded Closure Cap Infiltration over Time

Table 6.1-1 and Appendix O data were utilized as input to the HELP model (USEPA 1994a and USEPA 1994b) in order to determine infiltration through the upper GCL for the upper bounding scenario at each degraded time step. The following appendices provide the detailed HELP model, input data and output files for each time step:

- Appendix P, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (100 Years): HELP Model Input Data and Output File (output file name: ZUBSD1ou.OUT)
- Appendix Q, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (154 Years): HELP Model Input Data and Output File (output file name: ZUBSD2ou.OUT)
- Appendix R, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (300 Years): HELP Model Input Data and Output File (output file name: ZUBSD3ou.OUT)
- Appendix S, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (550 Years): HELP Model Input Data and Output File (output file name: ZUBSD4ou.OUT)
- Appendix T, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (602 Years): HELP Model Input Data and Output File (output file name: ZUBSD5ou.OUT)
- Appendix U, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (802 Years): HELP Model Input Data and Output File (output file name: ZUBSD6ou.OUT)
- Appendix V, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,000 Years): HELP Model Input Data and Output File (output file name: ZUBSD7ou.OUT)
- Appendix W, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,800 Years): HELP Model Input Data and Output File (output file name: ZUBSD8ou.OUT)
- Appendix X, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (3,400 Years): HELP Model Input Data and Output File (output file name: ZUBSD9ou.OUT)
- Appendix Y, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (5,600 Years): HELP Model Input Data and Output File (output file name: ZUBSD10o.OUT)
- Appendix Z, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (10,000 Years): HELP Model Input Data and Output File (output file name: ZUBSD11o.OUT)

The following outputs from this evaluation are upper bounding sensitivity values, which will be utilized within the Performance Assessment:

- Infiltration through the upper GCL
- Saturated hydraulic conductivity of the 2-foot-thick lower Drainage Layer

Table 6.2-1 provides a summary of these parameter values.

Table 6.2-1. Upper Bounding Sensitivity Values

Year	Infiltration through Upper GCL (in/yr)	Lower Drainage Layer Saturated Hydraulic Conductivity (cm/s)
0	0.36	1.00E-01
100	0.43	1.00E-01
154	0.42	1.00E-01
300	0.56	9.99E-02
550	1.22	9.98E-02
602	1.37	9.97E-02
802	16.12	9.86E-02
1,000	19.46	9.64E-02
1,800	21.32	8.62E-02
3,400	21.42	6.47E-02
5,600	21.13	3.54E-02
8,303	ND	1.00E-04 (year lower drainage layer completely silts in)
10,000	20.05	1.00E-04
38,254	18.60 (infiltration at complete degradation of the closure cap)	1.00E-04

ND = not determined

6.3 UBS Infiltration after Complete Closure Cap Degradation

The infiltration through the upper GCL at complete closure cap degradation for the upper bounding scenario and the associated time of occurrence have been determined based upon the following:

- As outlined in Section 6.1.5 at year 10,000 all layers except the erosion barrier have reached their assumed degradation endpoint. Therefore the properties of all layers except the erosion barrier will be assigned their year 10,000 values.
- As outlined in Table 4.4-2 complete degradation of the erosion barrier is assumed to result in separation and segregation of the granite stone and flowable fill with the granite stone located on top of the broken up flowable fill. As previous done for the purposes of this calculation the properties of the broken up flowable fill will be ignored. Therefore the properties of the completely degraded erosion barrier are those of the granite stone.

Appendix O provides the material property calculations based upon the above assumptions and the detailed HELP model input data and output file associated with infiltration at complete closure cap degradation through the upper GCL. This infiltration at complete closure cap degradation through the upper GCL was determined to be 18.6 inches/year in year 38,254. This worse case infiltration has been included in Table 6.2-1 for comparison purposes.

In addition, the time that the lower drainage layer completely silts in and assumes the properties of the overlying backfill has been estimated to occur in the year 8,303 (see Appendix O). This has also been included in Table 6.2-1 as input to the PA sensitivity analysis.

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7.0 SUMMARY AND CONCLUSIONS

Within Phifer (2003) closure cap degradation mechanisms and their impact upon infiltration through the closure cap developed in Phifer and Nelson (2003) have been evaluated for the proposed Mechanically Stabilized Earth (MSE) vaults developed in Winship (2003) for the base case land use scenario (i.e. institutional control to pine forest). This land use scenario is considered to be the most likely scenario. It assumes a 100-year institutional control period following final SDF closure during which the closure cap is maintained. At the end of institutional control, it is assumed that a pine forest succeeds the cap's original bamboo cover. The impact of pine forest succession, erosion, and colloidal clay migration as degradation mechanisms on the infiltration through the MSE vault closure cap has been evaluated. The primary changes caused by the degradation mechanisms that result in increased infiltration are the formation of holes in the upper geosynthetic clay liner (GCL) by pine forest succession and the reduction in the saturated hydraulic conductivity of the drainage layers due to colloidal clay migration into the layers. Holes due to root penetration at approximately 0.3 percent of the GCL area resulted in an infiltration rate as though the GCL were not there at all. A very small area of holes essentially controlled the hydraulic performance of the GCL.

As documented within this report a sensitivity analysis has been performed to bound the previous results for the MSE vault, closure cap, base case land use scenario (i.e. institutional control to pine forest) documented within Phifer 2003. The bounding sensitivity analysis includes the following two MSE vault, closure cap, land use scenarios:

- Continuous bamboo cover, and
- Institutional control to farm to pine forest.

The continuous bamboo cover land use scenario assumes that bamboo, which is shallow-rooted, is the climax species for the closure cap (i.e. pine trees will not encroach upon the bamboo). This scenario results in the least amount of infiltration through the upper hydraulic barrier layer (i.e. lower bounding scenario). The institutional control to farm to pine forest, land use scenario assumes a 100-year institutional control period following final Saltstone Disposal Facility (SDF) closure during which the closure cap is maintained. At the end of institutional control, it is assumed that the cap's original bamboo cover is removed and that corn is grown until the closure cap layers above the erosion barrier are completely eroded. After the layers above the erosion barrier are gone, it is assumed that a pine forest succeeds corn farming. This scenario results in the greatest amount of infiltration through the upper hydraulic barrier layer (i.e. upper bounding scenario). The same degradation mechanisms utilized for the base case scenario (Phifer 2003), as appropriate, have been evaluated for both the lower and upper bounding scenarios.

Table 7.0-1 and Figure 7.0-1 provide the infiltration over time for the base case scenario (i.e. institutional control to pine forest), the lower bounding scenario (i.e. continuous bamboo cover), and the upper bounding scenario (i.e. institutional control to farm to pine forest). The estimated infiltration through the upper GCL for the lower bounding, base case, and upper bounding scenarios at year 1000 were 1.75, 12.04, and 19.46 inches/year, respectively. The maximum infiltration estimated through the upper GCL within the first 10,000 years infiltration for the lower bounding, base case, and upper bounding scenarios were 6.46 inches/year at year 3,400, 14.09 inches/year at year 10,000, and 21.42 inches/year at year 3,400, respectively. The estimated infiltration through the upper GCL at complete degradation of the closure cap for the lower bounding, base case, and upper bounding scenarios were 4.75 inches/year at year 280,000, 18.12 inches/year at year 280,000, and 18.60 at approximately year 38,250.

Within the first 10,000 years the primary reason(s) for the estimated infiltration increases over time for each scenario are as follows:

- The primary reason for the lower bounding scenario (i.e. continuous bamboo cover) estimated infiltration increase through the upper GCL over time is the assumed reduction in the saturated hydraulic conductivity of the upper drainage layer due to colloidal clay migration into the layer. This silting in results in an infiltration increase from 0.36 inches/year to a maximum of 6.46 inches/year within the first 10,000 years.
- The primary reasons for the base case land use scenario (i.e. institutional control to pine forest) estimated infiltration increase through the upper GCL over time, in order of importance, are the formation of holes in the upper GCL by pine forest succession and the reduction in the saturated hydraulic conductivity of the upper drainage layer due to colloidal clay migration into the layer. These primary degradation mechanisms result in an infiltration increase from 0.36 inches/year to a maximum of 14.09 inches/year within the first 10,000 years.
- The primary reasons for the upper bounding scenario (i.e. institutional control to farm to pine forest) estimated infiltration increase through the upper GCL over time, in order of importance, are the formation of holes in the upper GCL by pine forest succession, the reduction in the saturated hydraulic conductivity of the upper drainage layer due to colloidal clay migration into the layer, the increase in the saturated hydraulic conductivity of the erosion barrier due to pine forest succession, and the erosion of the topsoil and upper backfill. These primary degradation mechanisms result in an infiltration increase from 0.36 inches/year to a maximum of 21.42 inches/year within the first 10,000 years.

Based upon the above results the following can be deduced concerning the impact of the closure cap degradation mechanisms (i.e. pine forest succession, erosion, and colloidal clay migration) on infiltration through the upper GCL:

- It is estimated that pine forest succession results in the greatest increase in infiltration through the upper GCL. An approximately 13.5-inches/year increase can be attributed to pine forest succession. It is estimated that pine forest succession produces a 7.5-inches/year increase due to the formation of holes in the upper GCL and a 6-inches/year increase due to the degradation of the erosion barrier.
- It is estimated that the reduction in the saturated hydraulic conductivity of the upper drainage layer due to colloidal clay migration into the layer results in an approximately 6 inches/year increase in infiltration through the upper GCL.
- It is estimated that erosion of the topsoil and upper backfill results in an approximately 1-inch/year increase in infiltration through the upper GCL.

Based upon this it is evident that elimination of the pine forest succession, degradation mechanism would do the most to minimize increases in the infiltration through the upper GCL over time.

In addition to infiltration over time, the saturated hydraulic conductivity of the lower drainage layer over time is an important parameter. Table 7.0-2 and Figure 7.0-2 provide the saturated hydraulic conductivity of the lower drainage layer over time for each of the scenarios. The saturated hydraulic conductivity of the lower drainage layer is assumed to reduce over time from 0.1 cm/s to 0.0001 cm/s over time due to colloidal clay migration into the layer. It is estimated that the lower drainage layer completely silts-in (i.e. has a saturated hydraulic conductivity of 0.0001 cm/s) in year 26,000 for the lower bounding scenario, in year 12,000 for the base case scenario, and in year 8,300 for the upper bounding scenario.

Table 7.0-1. Base Case, Lower Bounding, and Upper Bounding Infiltration over Time

Lower Bounding Scenario		Base Case Scenario		Upper Bounding Scenario	
Year	Infiltration [1] (in/yr)	Year	Infiltration [1] (in/yr)	Year	Infiltration [1] (in/yr)
0	0.36	0	0.36	0	0.36
100	0.41	100	0.41	100	0.43
300	0.55	300	3.05	154	0.42
550	0.80	550	7.90	300	0.56
1,000	1.75	1,000	12.04	550	1.22
1,800	5.05	1,800	13.76	602	1.37
3,400	6.46	3,400	14.03	802	16.12
5,600	6.44	5,600	14.08	1,000	19.46
10,000	6.40	10,000	14.09	1,800	21.32
280,000 [3]	4.75	96,667 [2]	14.10	3,400	21.42
		280,000 [3]	18.12	5,600	21.13
				10,000	20.05
				38,254 [3]	18.60

[1] Infiltration through upper GCL

[2] The year 96,667 is not a calculated value; it is an assumed value. It is assumed that infiltration remains at 14.10 inches/year until the upper backfill erodes to the assumed evapotranspiration zone depth of 22 inches in year 96,667. At that point it is assumed that infiltration increases linearly from 14.10 inches/year to the year 280,000 infiltration of 18.12 inches/year.

[3] Infiltration at complete degradation of the closure cap

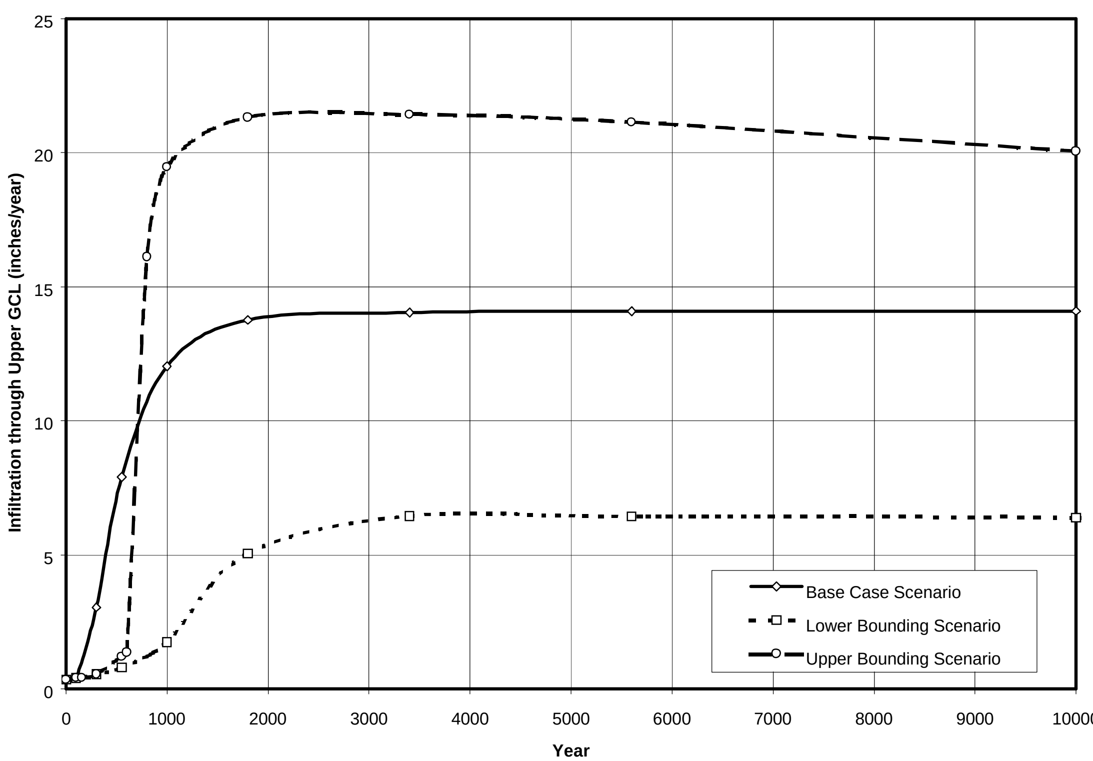

Figure 7.0-1. Base Case, Lower Bounding, and Upper Bounding Infiltration over Time

Table 7.0-2. Lower Drainage Layer Saturated Hydraulic Conductivity for the Base Case, Lower Bounding, and Upper Bounding Scenarios over Time

Lower Bounding Scenario		Base Case Scenario		Upper Bounding Scenario	
Year	K_s [1] (cm/s)	Year	K_s [1] (cm/s)	Year	K_s [1] (cm/s)
0	1.00E-01	0	1.00E-01	0	1.00E-01
100	1.00E-01	100	1.00E-01	100	1.00E-01
300	9.99E-02	300	9.98E-02	154	1.00E-01
550	9.98E-02	550	9.89E-02	300	9.99E-02
1,000	9.94E-02	1,000	9.61E-02	550	9.98E-02
1,800	9.77E-02	1,800	8.96E-02	602	9.97E-02
3,400	9.20E-02	3,400	7.56E-02	802	9.86E-02
5,600	8.30E-02	5,600	5.62E-02	1,000	9.64E-02
10,000	6.53E-02	10,000	1.74E-02	1,800	8.62E-02
26,250 [2]	1.00E-04	11,953 [2]	1.00E-04	3,400	6.47E-02
				5,600	3.54E-02
				8,303 [2]	1.00E-04

[1] Lower drainage layer saturated hydraulic conductivity
[2] This is the year that the lower drainage layer is assumed to completely silt in and the saturated hydraulic conductivity is assumed to remain at 1.00E-04 cm/s thereafter.

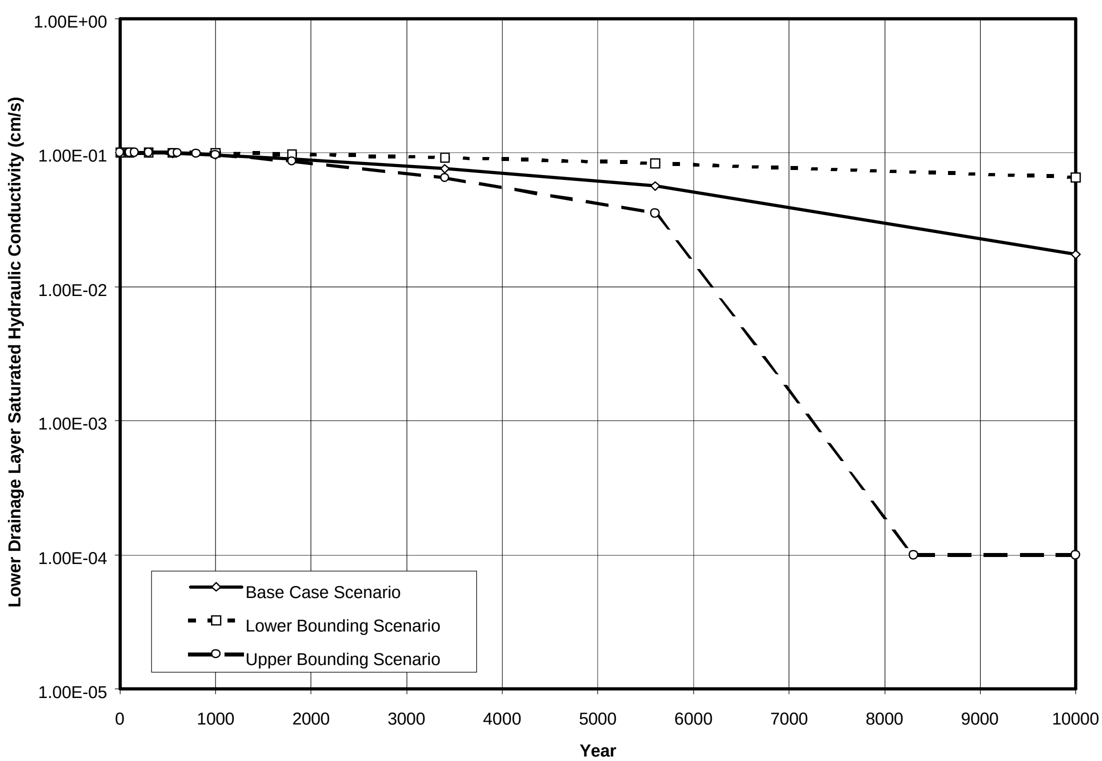

Figure 7.0-2. Lower Drainage Layer Saturated Hydraulic Conductivity for the Base Case, Lower Bounding, and Upper Bounding Scenarios over Time

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9.0 APPENDICES

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Appendix A, Augusta Synthetic Precipitation Modified with SRS Specific Average Monthly Precipitation Data over 100 Years (file name: Zprec.d4)

This appendix is in CD format due to its size. Available upon request.

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Appendix B, Augusta Synthetic Temperature Modified with SRS Specific Average Monthly Temperature Data over 100 Years (file name: Ztemp.d7)

This appendix is in CD format due to its size. Available upon request.

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Appendix C, Augusta Synthetic Solar Radiation Data over 100 Years (file name: Zsolar.d13)

This appendix is in CD format due to its size. Available upon request.

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Appendix D, Augusta Evapotranspiration Data (file name: Zevap.d11)

```
1
AUGUSTA          GEORGIA
33.22     68 323 3.5   22.    6.5  68.0 70.0 77.0 73.0
```

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Appendix E, Intact SDF MSE Vault Closure Cap (0 Years): HELP Model Input Data and Output File (output file name: ZMSEIout.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	6		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.37	0.24	0.136	0.24
5	2	12		0.38	0.08	0.013	0.08
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.38	0.08	0.013	0.08
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	1.00E-04					
5	2	1.00E-01	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	1.00E-01	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZMSEI.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZMSEIout.OUT

TIME:  14:56     DATE:  11/13/2003

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

     TITLE:  Intact SDF MSE Vault Closure Cap - 0 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =      6.00   INCHES
           POROSITY                    =      0.4000 VOL/VOL
           FIELD CAPACITY              =      0.1100 VOL/VOL
           WILTING POINT               =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     30.00   INCHES
           POROSITY                    =      0.3700 VOL/VOL
           FIELD CAPACITY              =      0.2400 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                          LAYER  3
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.0600 VOL/VOL
FIELD CAPACITY              =     0.0560 VOL/VOL
WILTING POINT               =     0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                          LAYER  4
                          --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3700 VOL/VOL
FIELD CAPACITY              =     0.2400 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                          LAYER  5
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3800 VOL/VOL
FIELD CAPACITY              =     0.0800 VOL/VOL
WILTING POINT               =     0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000     CM/SEC
SLOPE                       =     3.00   PERCENT
DRAINAGE LENGTH             =   450.0    FEET

                          LAYER  6
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.20   INCHES
POROSITY                    =     0.7500 VOL/VOL
FIELD CAPACITY              =     0.7470 VOL/VOL
WILTING POINT               =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

```
                      LAYER  7
                      --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                      LAYER  8
                      --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0800 VOL/VOL
WILTING POINT                =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000     CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET

                      LAYER  9
                      --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.500  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.320  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.524  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     28.649  INCHES
TOTAL INITIAL WATER                =     28.649  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                 0.004    0.000    0.004    0.000    0.000    0.002
                         0.027    0.091    0.016    0.006    0.002    0.001

  STD. DEVIATIONS        0.020    0.000    0.027    0.000    0.002    0.015
                         0.092    0.404    0.086    0.058    0.015    0.004

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.577    2.093    3.072    3.553    3.661    4.141
                         4.897    4.522    3.384    1.619    0.948    1.114

  STD. DEVIATIONS        0.221    0.236    0.582    0.760    1.525    1.546
                         1.588    1.378    1.039    0.606    0.207    0.206

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 2.5102   2.0619   1.9352   1.2047   0.4142   0.3121
                         0.5589   0.8185   0.7450   0.7795   0.9036   1.5056

  STD. DEVIATIONS        1.8312   1.5189   1.4896   1.0415   0.4532   0.5842
                         0.8112   1.0393   1.0279   1.0745   1.2152   1.3333

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                 0.0617   0.0514   0.0488   0.0322   0.0142   0.0105
                         0.0162   0.0224   0.0208   0.0213   0.0239   0.0381

  STD. DEVIATIONS        0.0421   0.0351   0.0336   0.0239   0.0106   0.0141
                         0.0193   0.0244   0.0241   0.0253   0.0284   0.0312

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.0511   0.0483   0.0446   0.0307   0.0106   0.0070
                         0.0123   0.0180   0.0165   0.0174   0.0205   0.0327

  STD. DEVIATIONS        0.0320   0.0336   0.0343   0.0278   0.0152   0.0131
                         0.0178   0.0224   0.0227   0.0238   0.0276   0.0281

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0051   0.0049   0.0053   0.0051   0.0049   0.0035
                         0.0036   0.0040   0.0040   0.0038   0.0036   0.0043

  STD. DEVIATIONS        0.0009   0.0001   0.0003   0.0005   0.0011   0.0019
                         0.0021   0.0020   0.0019   0.0021   0.0021   0.0019
```

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	2.1516	1.9398	1.6538	1.0666	0.3539	0.2755
	0.4775	0.6992	0.6594	0.6660	0.7977	1.2862
STD. DEVIATIONS	1.5865	1.4607	1.2739	0.9329	0.3872	0.5157
	0.6930	0.8878	0.9127	0.9179	1.0727	1.1390

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0039	0.0040	0.0034	0.0024	0.0008	0.0005
	0.0009	0.0014	0.0013	0.0013	0.0016	0.0025
STD. DEVIATIONS	0.0024	0.0028	0.0026	0.0022	0.0012	0.0010
	0.0013	0.0017	0.0018	0.0018	0.0022	0.0021

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.154	(0.4340)	10947.61	0.314
EVAPOTRANSPIRATION	34.582	(3.6251)	2464196.75	70.719
LATERAL DRAINAGE COLLECTED FROM LAYER 5	13.74952	(5.50704)	979748.062	28.11757
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.36170	(0.12899)	25773.611	0.73967
AVERAGE HEAD ON TOP OF LAYER 6	1.002	(0.403)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.30966	(0.12406)	22065.420	0.63325
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.05203	(0.00803)	3707.190	0.10639
AVERAGE HEAD ON TOP OF LAYER 9	0.002	(0.001)		
CHANGE IN WATER STORAGE	0.053	(1.9051)	3804.31	0.109

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             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      2.647       188618.8120

      DRAINAGE COLLECTED FROM LAYER  5            0.45348      32313.73240

      PERCOLATION/LEAKAGE THROUGH LAYER  6        0.018346      1307.25354

      AVERAGE HEAD ON TOP OF LAYER  6            21.373

      MAXIMUM HEAD ON TOP OF LAYER  6            31.170

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)               121.6 FEET

      DRAINAGE COLLECTED FROM LAYER  8            0.01253         892.95929

      PERCOLATION/LEAKAGE THROUGH LAYER  9        0.000195         13.90441

      AVERAGE HEAD ON TOP OF LAYER  9             0.029

      MAXIMUM HEAD ON TOP OF LAYER  9             0.055

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                 9.4 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3692

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1147

       ***  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	1.6120	0.2687
2	9.2097	0.3070
3	0.7200	0.0600
4	4.1112	0.3426
5	2.0564	0.1714
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9214	0.0801
9	0.1500	0.7500
SNOW WATER	0.000	

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Appendix F, SDF MSE Vault Closure Cap Degraded Property Value Calculations for Lower Bounding Scenario (i.e. Continuous Bamboo Cover)

The MSE vault closure cap initial (0 year) layer thickness and hydraulic property values from top to bottom are provided in Table 3.1-1. The degradation scenarios for each layer are provided in Table 4.4-1. Based upon the Table 4.4-1 degradation scenarios, the Table 3.1-1 initial SDF closure cap layer thickness and hydraulic property values have been modified to account for degradation at 100, 300, 550, 1,000, 1,800, 3,400, 5,600 and 10,000 years after closure of the SDF.

Topsoil and Upper Backfill Layer Thickness:

From Section 4.2 the soil loss in terms of depth of loss per year for the topsoil and upper backfill for a bamboo cover was estimated to be 2.0E-04 inches/year and 1.2E-04 inches/year, respectively.

Topsoil Thickness over Time Calculation:

Year	Thickness
0	6” – (0 years × 2.0E-04 inches/year) = 6”
100	6” – (100 years × 2.0E-04 inches/year) = 5.980”
300	6” – (300 years × 2.0E-04 inches/year) = 5.940”
550	6” – (550 years × 2.0E-04 inches/year) = 5.890”
1,000	6” – (1000 years × 2.0E-04 inches/year) = 5.800”
1,800	6” – (1800 years × 2.0E-04 inches/year) = 5.640”
3,400	6” – (3400 years × 2.0E-04 inches/year) = 5.320”
5,600	6” – (5600 years × 2.0E-04 inches/year) = 4.880”
10,000	6” – (10000 years × 2.0E-04 inches/year) = 4.0”

Since the topsoil does not completely erode away within the 10,000 years of interest, no reduction in the upper backfill layer occurs within this time frame.

Ground Surface Soil Texture:

The soil texture of the ground surface will change over time due to erosion of the topsoil and upper backfill layers. Soil texture is utilized in the HELP model to determine the SCS Curve Number (CN) and subsequent runoff from the closure cap. The default HELP model ground surface soil textures will be assigned based upon an equivalence between the saturated hydraulic conductivity of the material assumed to be at the ground surface and that of the default HELP model ground surface soil textures.

Default HELP Model Ground Surface Soil Textures:

Ground Surface Material	Ground Surface Material K (cm/s)	HELP Soil Texture	HELP Soil Texture K (cm/s)
Topsoil	1.0E-3	5	1.0E-3
Backfill	1.0E-4	10	1.2E-4
Erosion Barrier	3.97E-4	8	3.7E-4

Middle Backfill Layer and Upper Drainage Layer Hydraulic Properties:

It is assumed that colloidal clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the middle backfill saturated hydraulic conductivity to increase over time and that of the upper drainage layer to decrease over time.

Determine mass of clay to fill upper drainage layer void volume (0.38):

Assume clay bulk density is 1.1 g/cm^3

Look at a 1-ft^2 area of the 1-foot-thick upper drainage layer (i.e. 1 ft^3)

Void volume = 0.38×1 ft^3 = 0.38 ft^3

Clay mass per ft^3 = 1.1 $g/cm^3 \times 0.38\ ft^3 \times 2.831685E\text{-}02\ m^3/ft^3 \times 1{,}000{,}000\ cm^3/m^3$ = 11,836.3 g

Determine available clay mass in the middle backfill layer:

Assume that the middle backfill layer consists of 20% clay and 80% sand with a dry bulk density of 104-lbs/ ft^3.

Clay mass = 104 $lbs/ft^3 \times 0.20 \times 453.59$ g/lbs = 9,434.7 g/ft^3

There is not enough clay in the middle backfill layer to fill the upper drainage layer. Therefore it will be assumed that half the clay content of the middle backfill migrates into the upper drainage layer, at which point the two layers essentially become the same material and material property changes cease. Based upon this it will be assumed that the endpoint saturated hydraulic conductivity of the layers will become that of the log mid-point between the initial backfill and upper drainage layer conditions. It will also be assumed that the endpoint porosity, field capacity, and wilting point will become the arithmetic average of the backfill and upper drainage layer.

Endpoint hydraulic properties:

Intact hydraulic properties:

Hydraulic Parameter	Middle Backfill	Upper Drainage Layer
K	1.0E-04 cm/s	1.0E-01 cm/s
n	0.37	0.38
FC	0.24	0.08
WP	0.136	0.013

Endpoint saturated hydraulic conductivity:

Middle backfill: K_{MB} = 0.0001; log K_{MB} = -4

Upper drainage layer: K_{UDL} = 0.1; log K_{UDL} = -1

Log mid-point: $$\frac{Log\ K_{MB} + Log\ K_{UDL}}{2} = \frac{-1 + (-4)}{2} = -2.5$$

$K_E = 10^{-2.5}$ = 3.2E-03 cm/s

Endpoint n, FC, and WP:

n = (0.37 + 0.38)/2 = 0.375

FC = (0.24 + 0.08)/2 = 0.16

WP = (0.136 + 0.013)/2 = 0.0745

It will be assumed that the clay migrates out of the middle backfill into the upper drainage layer with the water flux containing 63 mg/L of colloidal clay. It will also be assumed that the time to achieve the endpoint conditions will be based upon the estimated water flux into the upper drainage layer and migration of half the clay content of the middle backfill layer (i.e. 9,434.7 $g/ft^3 \div 2$ = 4717.4 g/ft^3).

Determine flux of water into the upper drainage layer:

Section 3.3 intact SDF closure cap Modeling determined the following average annual flux of water into the upper drainage layer (see Appendix E):

Precipitation = 48.90 inches/year

Runoff = 0.154 inches/year

Evapotranspiration = 34.582 inches/year

Flux of water into upper drainage layer = Precipitation – (Runoff + Evapotranspiration)

Flux of water into upper drainage layer = 48.90 in/yr – (0.154 in/yr + 34.582 in/yr)

Flux of water into upper drainage layer = 14.164 in/yr

Based upon Phifer 2003 this flux of water (~14.2 inches/year) is satisfactory for the determination of the timing to achieve the endpoint conditions for the middle backfill and upper drainage layer.

Determine yearly clay migration into the upper drainage layer:

Flux into upper drainage layer = 14.2 in/yr

Colloidal clay concentration = 63 mg/L

Flux through a 1 ft^2 area = 14.2 in/yr × ft/12 in × 1 ft^2 = 1.18 ft^2/yr

Clay flux = 1.18 ft^2/yr × 63 mg/L × 2.831685E-02 m^3/ ft^3 × 1000L/ m^3 = 2,105 mg/yr = 2.1 g/yr

Determine time it takes for the 4717.4 g of clay to migrate from the middle backfill layer to the upper drainage layer:

Time = 4717.4 g ÷ 2.1 g/yr = 2,246 years

Determine middle backfill and upper drainage layer hydraulic property variation with time:

It will be assumed that the K of the middle backfill layer is increasing log linearly with time from 1.0E-04 cm/s to 3.2E-03 cm/s, until year 2,246 at which time the K becomes static. Conversely it will be assumed that the K of the upper drainage layer is decreasing log linearly with time from 1.0E-01 cm/s to 3.2E-03 cm/s, until year 2,246 at which time the K becomes static. Porosity (n), FC, and WP will be assumed to behave similarly but in an arithmetic linear manner.

Initial and End State hydraulic properties:

Hydraulic Parameter	Initial Middle Backfill	Initial Upper Drainage Layer	End State at 2,246 years
K	1.0E-04 cm/s	1.0E-01 cm/s	3.2E-03 cm/s
n	0.37	0.38	0.375
FC	0.24	0.08	0.16
WP	0.136	0.013	0.0745

Determine fraction change for each year:

Year	Fraction
0	0 ÷ 2246 = 0
100	100 ÷ 2246 = 0.0445
300	300 ÷ 2246 = 0.1336
550	550 ÷ 2246 = 0.2449
1,000	1000 ÷ 2246 = 0.4452
1,800	1800 ÷ 2246 = 0.8014
3,400	1.0
5,600	1.0
10,000	1.0

Determine variation in K, n, FC, and WP with time in the middle backfill:

Year	Fraction, F	K [1] (cm/s)	n [2]	FC [3]	WP [4]
0	0	0.0001	0.37	0.24	0.136
100	0.0445	0.00012	0.37	0.236	0.133
300	0.1336	0.00016	0.371	0.229	0.128
550	0.2449	0.00023	0.371	0.220	0.121
1,000	0.4452	0.00046	0.372	0.204	0.109
1,800	0.8014	0.0016	0.374	0.176	0.0867
3,400	1.0	0.0032	0.375	0.16	0.0745
5,600	1.0	0.0032	0.375	0.16	0.0745
10,000	1.0	0.0032	0.375	0.16	0.0745

[1] $K = 10^{[-4 + ((-2.5 - (-4))F)]} = 10^{(-4 + 1.5F)}$

[2] n = 0.37 + (0.375 – 0.37)F

[3] FC = 0.24 – (0.24 – 0.16)F

[4] WP = 0.136 – (0.136 – 0.0745)F

Determine variation in K, n, FC, and WP with time in the upper drainage layer:

Year	Fraction, F	K [1] (cm/s)	n [2]	FC [3]	WP [4]
0	0	0.1	0.38	0.08	0.013
100	0.0445	0.086	0.38	0.084	0.016
300	0.1336	0.063	0.379	0.089	0.021
550	0.2449	0.043	0.379	0.10	0.028
1,000	0.4452	0.021	0.378	0.116	0.040
1,800	0.8014	0.0063	0.376	0.144	0.062
3,400	1.0	0.0032	0.375	0.16	0.0745
5,600	1.0	0.0032	0.375	0.16	0.0745
10,000	1.0	0.0032	0.375	0.16	0.0745

[1] $K = 10^{[-1 + ((-2.5 - (-1))F)]} = 10^{(-1 - 1.5F)}$

[2] n = 0.38 - (0.38 – 0.375)F

[3] FC = 0.08 + (0.16 – 0.08)F

[4] WP = 0.013 + (0.0745 – 0.013)F

Lower Drainage Layer Hydraulic Properties:

It is assumed that colloidal clay migration from the overlying backfill is driven by the water flux through the upper GCL. This water flux driven clay migration enters into the 2-foot thick lower drainage layer and fills the lower drainage layer from the bottom up. This reduces the saturated hydraulic conductivity of the clay filled portion from 1.0E-01 to 1.0E-04 cm/s (i.e. the saturated hydraulic conductivity of the overlying backfill layer). As the thickness of the lower drainage layer filled with clay increases the overall hydraulic conductivity of the layer decreases. This is different from that assumed for the upper drainage layer since the lower drainage layer has significantly more backfill overlying it. The HELP model was run for each year with all of the previously degraded properties (see above) without degradation of the lower drainage layer in order to determine the infiltration through the upper GCL. The results are as follows:

Year	Infiltration through upper GCL (inches/year)
0	0.36170
100	0.41335
300	0.55102
550	0.80275
1,000	1.75224
1,800	5.05125
3,400	6.45544
5,600	6.44166
10,000	6.39636

It is assumed that there is a linear increase in the infiltration over time between data points.

Determine cumulative volume of water through the lower drainage layer over time:

Year	Infiltration through upper GCL (inches/year)	Time Step Infiltration [1] (inches)	Cumulative Infiltration [2] (inches)	Cumulative Volume over one ft^2 area [3] (ft^3)
0	0.36170	0	0	0
100	0.41335	38.75	38.75	3.23
300	0.55102	96.44	135.19	11.26
550	0.80227	169.16	304.35	25.36
1,000	1.75224	574.87	879.22	73.27
1,800	5.05125	2,721.40	3,600.62	300.05
3,400	6.45544	9,205.32	12,805.94	1,067.16
5,600	6.44166	14,186.81	26,992.75	2,249.4
10,000	6.39636	28,243.62	55,236.37	4,603.03

[1] Time Step Infiltration $= [I_1 \times (T_2 - T_1)] + [1/2 \times (I_2 - I_1)(T_2 - T_1)]$, where I = infiltration at time 1 or 2; T = time at time 1 or 2

[2] Cumulative Infiltration = Previous Cumulative Infiltration + Time Step Infiltration at current time step

[3] Cumulative Volume over one ft^2 area = (Cumulative Infiltration ÷ 12 in/ft) × 1 ft^2

Determine mass of clay to fill lower drainage layer void volume (0.38):

Assume clay bulk density is 1.1 g/cm^3

Look at a 1-ft^2 area of the 2-foot-thick upper drainage layer (i.e. 2 ft^3)

Void volume = 0.38 × 2 ft^3 = 0.76 ft^3

Clay mass per ft^3 = 1.1 g/cm^3 × 0.76 ft^3 × 2.831685E-02 m^3/ft^3 × 1,000,000 cm^3/m^3 = 23,672.9 g

Determine total flux of water into the lower drainage layer required to completely fill it with clay:

It will be assumed that the clay migrates out of the lower backfill into the lower drainage layer with the water flux containing 63 mg/L of colloidal clay.

$$V = \frac{23{,}672.9\ g \times 1000\ mg/g}{63\ mg/L \times 28.31685\ L/ft^3} = 13{,}269.8\ ft^3$$

Determine the mass of clay that has migrated into the lower drainage layer at the end of each time step:

Year	Mass of clay into lower drainage layer
0	0
100	3.23 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 5.76 g
300	11.26 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 20.09 g
550	25.36 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 45.24 g
1,000	73.27 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 130.71 g
1,800	300.05 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 535.28 g
3,400	1,067.16 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 1,903.77 g
5,600	2,249.4 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 4,012.84 g
10,000	4,603.03 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 8,211.63 g

Determine the fraction of the lower drainage layer filled at the end of each time step:

Year	Fraction of the lower drainage layer filled
0	0
100	5.76 g ÷ 23,672.9 g = 0.000243
300	20.09 g ÷ 23,672.9 g = 0.000849
550	45.24 g ÷ 23,672.9 g = 0.00191
1,000	130.71 g ÷ 23,672.9 g = 0.00552
1,800	535.28 g ÷ 23,672.9 g = 0.0226
3,400	1,903.77 g ÷ 23,672.9 g = 0.0804
5,600	4,012.84 g ÷ 23,672.9 g = 0.170
10,000	8,211.63 g ÷ 23,672.9 g = 0.347

The following are the hydraulic properties of the clean and clay filled portion of the lower drainage layer:

Material	Saturated Hydraulic Conductivity (cm/s)	Porosity	Field Capacity	Wilting Point
Clean	1.0E-01	0.38	0.08	0.013
Clay filled	1.0E-04	0.22 (see below)	0.21 (see below)	0.20 (see below)

Determine the porosity of the clay filled portion of the lower drainage layer:

Porosity of the clay:

Assumed clay bulk density, ρ_b = 1.1 g/cm^2

Assumed clay particle density, ρ_p = 2.6 g/cm^2

Resulting clay porosity, $n = 1 - \frac{\rho_b}{\rho_p} = 1 - \frac{1.1\ g/cm^2}{2.6\ g/cm^2} = 0.58$

Porosity of the clay filled portion = Porosity of clean portion $\times$ porosity of clay

Porosity of the clay filled portion = 0.38 $\times$ 0.58 = 0.22

Determine the field capacity and wilting point of the clay filled portion of the lower drainage layer:

Will assume that the field capacity and wilting point of the clay fill portion has the same ratio versus its porosity of 0.22 as the equivalent ratio for kaolin clay.

From WSRC 2002 the following kaolin properties are found: n = 0.56; FC = 0.55; WP = 0.50

FC = 0.22 $\times$ (0.55 ÷ 0.56) $\approx$ 0.21

WP = 0.22 $\times$ (0.50 ÷ 0.56) $\approx$ 0.20

Determine the equivalent horizontal hydraulic conductivity of the lower drainage layer over time:

The equivalent horizontal hydraulic conductivity for horizontal flow in a series of horizontal layers with different saturated hydraulic conductivities can be determined from the following equation (Freeze and Cherry 1979):

$K_h = \sum_{i=1}^{n} \frac{K_i \ d_i}{d}$, where K_h = equivalent horizontal saturated hydraulic conductivity, K_i = horizontal saturated hydraulic conductivity of i^{th} layer, d_i = thickness of i^{th} layer, d = total thickness

The fraction, F, equals d_i / d for the clay filled portion and d_i / d for the clean drainage layer material equals (1 – F), making the equation:

$$K_h = \left(K_{filled} \times F\right) + \left[K_{clean} \times (1 - F)\right]$$

Year	Equivalent K (cm/s)
0	0.1
100	(0.0001 × 0.000243) + [0.1 × (1 - 0.000243)] = 0.1
300	(0.0001 × 0.000849) + [0.1 × (1 - 0.000849)] = 0.0999
550	(0.0001 × 0.00191) + [0.1 × (1 - 0.00191)] = 0.0998
1,000	(0.0001 × 0.00552) + [0.1 × (1 - 0.00552)] = 0.0994
1,800	(0.0001 × 0.0226) + [0.1 × (1 - 0.0226)] = 0.0977
3,400	(0.0001 × 0.0804) + [0.1 × (1 - 0.0804)] = 0.0920
5,600	(0.0001 × 0.170) + [0.1 × (1 - 0.170)] = 0.0830
10,000	(0.0001 × 0.347) + [0.1 × (1 - 0.347)] = 0.0653

Determine the equivalent n, FC, and WP for the lower drainage layer over time:

In an analogous manner to that for K, the equivalent n, FC, and WP can be determined based upon the fraction filled as follows:

$$n = \left(n_{filled} \times F\right) + \left[n_{clean} \times (1 - F)\right]$$

$$FC = \left(FC_{filled} \times F\right) + \left[FC_{clean} \times (1 - F)\right]$$

$$WP = \left(WP_{filled} \times F\right) + \left[WP_{clean} \times (1 - F)\right]$$

Year	Equivalent n
0	(0.22 × 0) + [0.38 × (1 - 0)] = 0.38
100	(0.22 × 0.000243) + [0.38 × (1 - 0.000243)] = 0.38
300	(0.22 × 0.000849) + [0.38 × (1 - 0.000849)] = 0.38
550	(0.22 × 0.00191) + [0.38 × (1 - 0.00191)] = 0.38
1,000	(0.22 × 0.00552) + [0.38 × (1 - 0.00552)] = 0.379
1,800	(0.22 × 0.0226) + [0.38 × (1 - 0.0226)] = 0.376
3,400	(0.22 × 0.0804) + [0.38 × (1 - 0.0804)] = 0.367
5,600	(0.22 × 0.170) + [0.38 × (1 - 0.170)] = 0.353
10,000	(0.22 × 0.347) + [0.38 × (1 - 0.347)] = 0.324

Year	Equivalent FC
0	$(0.21 \times 0) + [0.08 \times (1 - 0)] = 0.08$
100	$(0.21 \times 0.000243) + [0.08 \times (1 - 0.000243)] = 0.08$
300	$(0.21 \times 0.000849) + [0.08 \times (1 - 0.000849)] = 0.0801$
550	$(0.21 \times 0.00191) + [0.08 \times (1 - 0.00191)] = 0.0802$
1,000	$(0.21 \times 0.00552) + [0.08 \times (1 - 0.00552)] = 0.0807$
1,800	$(0.21 \times 0.0226) + [0.08 \times (1 - 0.0226)] = 0.0829$
3,400	$(0.21 \times 0.0804) + [0.08 \times (1 - 0.0804)] = 0.0904$
5,600	$(0.21 \times 0.170) + [0.08 \times (1 - 0.170)] = 0.102$
10,000	$(0.21 \times 0.347) + [0.08 \times (1 - 0.347)] = 0.125$

Year	Equivalent WP
0	$(0.20 \times 0) + [0.013 \times (1 - 0)] = 0.013$
100	$(0.20 \times 0.000243) + [0.013 \times (1 - 0.000243)] = 0.013$
300	$(0.20 \times 0.000849) + [0.013 \times (1 - 0.000849)] = 0.0132$
550	$(0.20 \times 0.00191) + [0.013 \times (1 - 0.00191)] = 0.0134$
1,000	$(0.20 \times 0.00552) + [0.013 \times (1 - 0.00552)] = 0.0140$
1,800	$(0.20 \times 0.0226) + [0.013 \times (1 - 0.0226)] = 0.0172$
3,400	$(0.20 \times 0.0804) + [0.013 \times (1 - 0.0804)] = 0.0280$
5,600	$(0.20 \times 0.170) + [0.013 \times (1 - 0.170)] = 0.0448$
10,000	$(0.20 \times 0.347) + [0.013 \times (1 - 0.347)] = 0.0779$

Summary Lower Drainage Layer Hydraulic Properties with Time:

Year	K (cm/s)	n	FC	WP
0	0.1	0.38	0.08	0.013
100	0.1	0.38	0.08	0.013
300	0.0999	0.38	0.0801	0.0132
550	0.0998	0.38	0.0802	0.0134
1,000	0.0994	0.379	0.0807	0.0140
1,800	0.0977	0.376	0.0829	0.0172
3,400	0.0920	0.367	0.0904	0.0280
5,600	0.0830	0.353	0.102	0.0448
10,000	0.0653	0.324	0.125	0.0779

The HELP model was rerun for each time step with all of the degraded properties (see above) including that of the lower drainage layer. Infiltration through the upper GCL did not change with the addition of the degraded lower drainage layer properties. Therefore the above estimated lower drainage layer hydraulic properties over time are verified.

Infiltration through the Upper GCL after Topsoil and Upper Backfill Eroded

The infiltration through the upper GCL at complete closure cap degradation for the lower bounding scenario and the associated time of occurrence have been determined based upon the following:

- Complete closure cap degradation occurs when both the topsoil and upper backfill have eroded away.
- As outlined previously, it is assumed that the material properties of the middle backfill and upper drainage layer become the same at year 2,246 and remain constant thereafter. Therefore the middle backfill and upper drainage layer material properties will be taken as those determined at year 2,246.
- As previously demonstrated, the material properties of the lower drainage layer do not impact infiltration through the upper GCL. Completely silted in conditions will be assumed for the lower drainage layer for determination of this infiltration.

From Section 4.2 the soil loss in terms of depth of loss per year for the topsoil and upper backfill was estimated to be 2.0E-04 inches/year and 1.2E-04 inches/year, respectively.

Determine time required to completely erode the topsoil:

6” ÷ 2.0E-04 inches/year = 30,000 years

Determine time required to completely erode the upper backfill:

30” ÷ 1.2E-04 inches/year = 250,000 years

Total time required to completely erode both the topsoil and upper backfill:

30,000 years + 250,000 years = 280,000 years

Based upon the above the following are the input properties utilized for the topsoil, upper backfill, middle backfill, upper drainage layer, and lower drainage layer for determination of the year 280,000 infiltration through the upper GCL.

Summary Hydraulic Properties for determination of the infiltration through the upper GCL at 280,000 years:

Layer	Thickness (inches)	K (cm/s)	n	FC	WP
Topsoil	0	NA	NA	NA	NA
Upper Backfill	0	NA	NA	NA	NA
Middle Backfill	12	3.2E-03	0.375	0.16	0.0745
Upper Drainage Layer	12	3.2E-03	0.375	0.16	0.0745
Lower Drainage Layer	24	1.0E-04	0.37	0.24	0.136

NA = not applicable

At 280,000 years the topsoil and upper backfill are completely eroded and the erosion barrier is at the ground surface. As outlined previously default HELP model soil texture number 8 is assumed to be equivalent to the erosion barrier based upon the saturated hydraulic conductivities. This HELP model soil texture will be used to determine the CN number for determination of runoff.

The above parameter values were utilized as HELP model input to determine the infiltration through the upper GCL at 280,000 years, when both the topsoil and upper backfill are completely eroded. The detailed HELP model input data and output file associated with this infiltration at year 280,000 are provided at the end of this appendix. The infiltration through the upper GCL at year 280,000 was determined to be 4.75118 inches/year.

Year that Lower Drainage Layer Completely Silts In

After year 10,000 it will be assumed that the infiltration through the upper GCL is 6.4 inches per year (i.e. maximum infiltration through the upper GCL). From previous calculations above:

- It takes a total of 13,269.8 ft^3 of infiltrating water to completely silt in the lower drainage layer
- Through year 10,000 the infiltrating water volume was 4,603.04 ft^3

Determine water volume remaining after year 10,000 to completely silt in the lower drainage layer:

$V = 13{,}269.8\ ft^3 - 4{,}603.04\ ft^3 = 8{,}666.76\ ft^3$

Determine length of time to obtain this volume at 6.4 inches per year over a 1-ft^2 area:

$\text{Time} = 8{,}666.76\ ft^3 \div (6.4\ in/yr \times 12\ ft/in \times 1\text{-}ft^2) = 16{,}250\ \text{years}$

Determine time to completely silt in the lower drainage layer:

Time = 10,000 years + 16,250 years = 26,250 years

Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (280,000 years): HELP Model Input Data and Output File (output file name: ZLBSWout.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	8 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 71.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.06	0.056	0.052	0.056
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4	3	0.2		0.75	0.747	0.40	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.37	0.24	0.136	0.24
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.97E-04					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	3	5.00E-09					
5	1	1.00E-04					
6	2	1.00E-04	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBSW.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBSWout.OUT

TIME:  13:28     DATE:   1/14/2004

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 280,000 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     12.00   INCHES
           POROSITY                   =      0.0600 VOL/VOL
           FIELD CAPACITY             =      0.0560 VOL/VOL
           WILTING POINT              =      0.0520 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.0560 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     12.00   INCHES
           POROSITY                   =      0.3750 VOL/VOL
           FIELD CAPACITY             =      0.1600 VOL/VOL
           WILTING POINT              =      0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3750 VOL/VOL
FIELD CAPACITY              =     0.1600 VOL/VOL
WILTING POINT               =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =     3.00   PERCENT
DRAINAGE LENGTH             =   450.0    FEET

                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.20   INCHES
POROSITY                    =     0.7500 VOL/VOL
FIELD CAPACITY              =     0.7470 VOL/VOL
WILTING POINT               =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    58.57   INCHES
POROSITY                    =     0.3700 VOL/VOL
FIELD CAPACITY              =     0.2400 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    24.00   INCHES
POROSITY                    =     0.3700 VOL/VOL
FIELD CAPACITY              =     0.2400 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
SLOPE                       =    11.40   PERCENT
DRAINAGE LENGTH             =   150.0    FEET
```

```
                              LAYER  7
                              --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
      THICKNESS                  =      0.20   INCHES
      POROSITY                   =      0.7500 VOL/VOL
      FIELD CAPACITY             =      0.7470 VOL/VOL
      WILTING POINT              =      0.4000 VOL/VOL
      INITIAL SOIL WATER CONTENT =      0.7500 VOL/VOL
      EFFECTIVE SAT. HYD. COND.  =  0.499999997000E-08 CM/SEC

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

    NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
             SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A
             GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
             AND A SLOPE LENGTH OF  450. FEET.

   SCS RUNOFF CURVE NUMBER            =     71.90
   FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
   AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
   EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
   INITIAL WATER IN EVAPORATIVE ZONE  =      2.272  INCHES
   UPPER LIMIT OF EVAPORATIVE STORAGE =      4.470  INCHES
   LOWER LIMIT OF EVAPORATIVE STORAGE =      1.369  INCHES
   INITIAL SNOW WATER                 =      0.000  INCHES
   INITIAL WATER IN LAYER MATERIALS   =     24.629  INCHES
   TOTAL INITIAL WATER                =     24.629  INCHES
   TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR

               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

    NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
             AUGUSTA               GEORGIA

        STATION LATITUDE                        =  33.22 DEGREES
        MAXIMUM LEAF AREA INDEX                 =   3.50
        START OF GROWING SEASON (JULIAN DATE)   =     68
        END OF GROWING SEASON (JULIAN DATE)     =    323
        EVAPORATIVE ZONE DEPTH                  =  22.0  INCHES
        AVERAGE ANNUAL WIND SPEED               =   6.50 MPH
        AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  68.00 %
        AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  70.00 %
        AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  77.00 %
        AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  73.00 %

    NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
             COEFFICIENTS FOR    AUGUSTA             GEORGIA
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	1.271	0.651	0.859	0.092	0.088	0.115
	0.332	0.448	0.379	0.333	0.327	0.642
STD. DEVIATIONS	1.853	1.145	1.473	0.347	0.334	0.375
	0.741	1.125	0.876	0.960	0.796	1.031
EVAPOTRANSPIRATION						
TOTALS	1.646	2.122	3.124	3.058	3.012	3.768
	4.391	3.990	3.059	1.547	1.034	1.250
STD. DEVIATIONS	0.191	0.241	0.614	0.993	1.377	1.435
	1.525	1.348	1.080	0.666	0.260	0.177

```
 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.6991   0.6346   0.6647   0.5171   0.4397   0.4194
                           0.4874   0.5084   0.5031   0.5194   0.5410   0.6269

   STD. DEVIATIONS         0.1663   0.1449   0.1421   0.1106   0.1009   0.1127
                           0.1358   0.1254   0.1281   0.1659   0.1843   0.2031

 PERCOLATION/LEAKAGE THROUGH LAYER  4
 ------------------------------------
   TOTALS                  0.5148   0.4622   0.4830   0.3704   0.3155   0.3012
                           0.3510   0.3655   0.3628   0.3749   0.3912   0.4587

   STD. DEVIATIONS         0.1322   0.1114   0.1101   0.0799   0.0725   0.0809
                           0.0994   0.0917   0.0948   0.1232   0.1365   0.1542

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  0.1217   0.1148   0.1332   0.1371   0.1486   0.1425
                           0.1407   0.1333   0.1222   0.1227   0.1169   0.1215

   STD. DEVIATIONS         0.0241   0.0260   0.0342   0.0337   0.0335   0.0268
                           0.0222   0.0197   0.0177   0.0169   0.0166   0.0183

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   TOTALS                  0.2485   0.2344   0.2716   0.2791   0.3024   0.2900
                           0.2866   0.2717   0.2495   0.2506   0.2389   0.2481

   STD. DEVIATIONS         0.0484   0.0520   0.0683   0.0674   0.0670   0.0536
                           0.0444   0.0393   0.0353   0.0338   0.0331   0.0366

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

 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES               19.3304  19.0270  18.1211  14.3182  11.7689  11.6082
                          13.1135  13.6633  14.0202  14.0219  15.1354  17.2001

   STD. DEVIATIONS         5.0087   4.5875   4.1763   3.1330   2.7496   3.1696
                           3.7718   3.4770   3.7177   4.6718   5.3506   5.8492

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES                9.2267   9.5590  10.1047  10.7419  11.2712  11.1683
                          10.6730  10.1073   9.5791   9.3045   9.1634   9.2125

   STD. DEVIATIONS         1.8269   2.1831   2.5920   2.6422   2.5414   2.1011
                           1.6843   1.4907   1.3838   1.2808   1.2976   1.3878

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	5.536	(4.2083)	394483.44	11.321
EVAPOTRANSPIRATION	32.000	(3.5431)	2280228.75	65.440
LATERAL DRAINAGE COLLECTED FROM LAYER 3	6.56065	(0.86511)	467491.531	13.41643
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.75118	(0.64628)	338554.094	9.71609
AVERAGE HEAD ON TOP OF LAYER 4	15.111	(2.076)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	1.55519	(0.24069)	110818.258	3.18035
PERCOLATION/LEAKAGE THROUGH LAYER 7	3.17143	(0.48148)	225985.906	6.48552
AVERAGE HEAD ON TOP OF LAYER 7	10.009	(1.552)		
CHANGE IN WATER STORAGE	0.077	(2.2223)	5460.91	0.157

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      5.358       381824.9370

      DRAINAGE COLLECTED FROM LAYER  3            0.03085       2197.92114

      PERCOLATION/LEAKAGE THROUGH LAYER  4        0.030784      2193.54272

      AVERAGE HEAD ON TOP OF LAYER  4            36.000

      MAXIMUM HEAD ON TOP OF LAYER  4            47.656

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               152.3 FEET

      DRAINAGE COLLECTED FROM LAYER  6            0.00656        467.62650

      PERCOLATION/LEAKAGE THROUGH LAYER  7        0.013291       947.06079

      AVERAGE HEAD ON TOP OF LAYER  7            15.429

      MAXIMUM HEAD ON TOP OF LAYER  7            24.531

      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)                29.2 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2032

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0622

       ***  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	0.9491	0.0791
2	4.2708	0.3559
3	4.5000	0.3750
4	0.1500	0.7500
5	14.9780	0.2557
6	7.2945	0.3039
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix G, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (100 Years): HELP Model Input Data and Output File (output file name: ZLBS1out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.980		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.37	0.236	0.133	0.236
5	2	12		0.38	0.084	0.016	0.084
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.38	0.08	0.013	0.08
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	1.20E-04					
5	2	8.60E-02	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	1.00E-01	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS1.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS1out.OUT

TIME:   9:10     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 100 Years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                  =      5.98   INCHES
          POROSITY                   =      0.4000 VOL/VOL
          FIELD CAPACITY             =      0.1100 VOL/VOL
          WILTING POINT              =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.1100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                  =     30.00   INCHES
          POROSITY                   =      0.3700 VOL/VOL
          FIELD CAPACITY             =      0.2400 VOL/VOL
          WILTING POINT              =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT =      0.2400 VOL/VOL
          EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC
```

```
                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.0600 VOL/VOL
FIELD CAPACITY               =     0.0560 VOL/VOL
WILTING POINT                =     0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.396999996000E-03 CM/SEC

                         LAYER  4
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3700 VOL/VOL
FIELD CAPACITY               =     0.2360 VOL/VOL
WILTING POINT                =     0.1330 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2360 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC

                         LAYER  5
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3800 VOL/VOL
FIELD CAPACITY               =     0.0840 VOL/VOL
WILTING POINT                =     0.0160 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0840 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.860000029000E-01 CM/SEC
SLOPE                        =     3.00   PERCENT
DRAINAGE LENGTH              =   450.0    FEET

                         LAYER  6
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     0.20   INCHES
POROSITY                     =     0.7500 VOL/VOL
FIELD CAPACITY               =     0.7470 VOL/VOL
WILTING POINT                =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC
```

```
                    LAYER  7
                    --------

       TYPE 1 - VERTICAL PERCOLATION LAYER
           MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                    LAYER  8
                    --------

         TYPE 2 - LATERAL DRAINAGE LAYER
           MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3800 VOL/VOL
FIELD CAPACITY              =      0.0800 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000     CM/SEC
SLOPE                       =     11.40   PERCENT
DRAINAGE LENGTH             =    150.0    FEET

                    LAYER  9
                    --------

           TYPE 3 - BARRIER SOIL LINER
           MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER             =     54.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.503  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.319  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.526  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     28.647  INCHES
TOTAL INITIAL WATER                 =     28.647  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

RUNOFF

TOTALS	0.004	0.000	0.004	0.000	0.000	0.002
	0.027	0.091	0.016	0.006	0.002	0.001
STD. DEVIATIONS	0.020	0.000	0.027	0.000	0.002	0.015
	0.093	0.404	0.086	0.058	0.015	0.004

EVAPOTRANSPIRATION

TOTALS	1.577	2.093	3.072	3.553	3.657	4.141
	4.898	4.520	3.385	1.619	0.948	1.115
STD. DEVIATIONS	0.221	0.236	0.582	0.761	1.521	1.545
	1.589	1.377	1.040	0.606	0.207	0.205

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	2.4637	2.0770	1.9305	1.2378	0.4334	0.3122
	0.5454	0.8086	0.7465	0.7762	0.8953	1.4750
STD. DEVIATIONS	1.7880	1.5043	1.4526	1.0508	0.4452	0.5705
	0.7811	1.0159	1.0054	1.0565	1.1950	1.2982

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0705	0.0597	0.0558	0.0377	0.0163	0.0121
	0.0180	0.0252	0.0237	0.0243	0.0271	0.0429
STD. DEVIATIONS	0.0501	0.0418	0.0382	0.0287	0.0120	0.0156
	0.0214	0.0275	0.0276	0.0289	0.0323	0.0351

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.0570	0.0532	0.0544	0.0394	0.0137	0.0081
	0.0140	0.0206	0.0187	0.0201	0.0235	0.0377
STD. DEVIATIONS	0.0354	0.0340	0.0407	0.0385	0.0217	0.0149
	0.0199	0.0253	0.0244	0.0260	0.0305	0.0319

PERCOLATION/LEAKAGE THROUGH LAYER 9

TOTALS	0.0051	0.0049	0.0054	0.0051	0.0050	0.0039
	0.0037	0.0041	0.0040	0.0039	0.0037	0.0043
STD. DEVIATIONS	0.0009	0.0002	0.0003	0.0005	0.0009	0.0017
	0.0020	0.0020	0.0019	0.0020	0.0021	0.0019

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	2.4840	2.2841	1.9194	1.2805	0.4305	0.3204
	0.5418	0.8032	0.7723	0.7744	0.9190	1.4652
STD. DEVIATIONS	1.8885	1.7392	1.4460	1.1237	0.4423	0.5856
	0.7759	1.0092	1.0497	1.0610	1.2266	1.2896

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0043	0.0044	0.0041	0.0031	0.0010	0.0006
	0.0011	0.0016	0.0015	0.0015	0.0018	0.0029
STD. DEVIATIONS	0.0027	0.0028	0.0031	0.0030	0.0016	0.0012
	0.0015	0.0019	0.0019	0.0020	0.0024	0.0024

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****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES	CU. FEET	PERCENT
PRECIPITATION	48.90 (7.734)	3484469.2	100.00
RUNOFF	0.154 (0.4339)	10950.01	0.314
EVAPOTRANSPIRATION	34.578 (3.6236)	2463907.00	70.711
LATERAL DRAINAGE COLLECTED FROM LAYER 5	13.70162 (5.47438)	976335.062	28.01962
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.41335 (0.15024)	29453.703	0.84529
AVERAGE HEAD ON TOP OF LAYER 6	1.166 (0.472)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.36024 (0.14546)	25669.234	0.73668
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.05310 (0.00792)	3783.417	0.10858
AVERAGE HEAD ON TOP OF LAYER 9	0.002 (0.001)		
CHANGE IN WATER STORAGE	0.054 (1.9521)	3824.79	0.110

****

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

             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
    ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      2.648       188654.3750

      DRAINAGE COLLECTED FROM LAYER  5            0.39526      28164.91210

      PERCOLATION/LEAKAGE THROUGH LAYER  6        0.032853      2341.00708

      AVERAGE HEAD ON TOP OF LAYER  6            38.433

      MAXIMUM HEAD ON TOP OF LAYER  6            50.445

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)               156.8 FEET

      DRAINAGE COLLECTED FROM LAYER  8            0.01464       1042.84534

      PERCOLATION/LEAKAGE THROUGH LAYER  9        0.000199        14.20408

      AVERAGE HEAD ON TOP OF LAYER  9             0.034

      MAXIMUM HEAD ON TOP OF LAYER  9             0.071

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3691

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1148

       ***  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	1.6080	0.2689
2	8.9916	0.2997
3	0.7200	0.0600
4	4.2406	0.3534
5	2.1757	0.1813
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9215	0.0801
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix H, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (300 Years): HELP Model Input Data and Output File (output file name: ZLBS2out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.940		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.371	0.229	0.128	0.229
5	2	12		0.379	0.089	0.021	0.089
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.38	0.0801	0.0132	0.0801
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	1.60E-04					
5	2	6.30E-02	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	9.99E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS2.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS2out.OUT

TIME:  14:49     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 300 Years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =      5.94   INCHES
           POROSITY                    =      0.4000 VOL/VOL
           FIELD CAPACITY              =      0.1100 VOL/VOL
           WILTING POINT               =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     30.00   INCHES
           POROSITY                    =      0.3700 VOL/VOL
           FIELD CAPACITY              =      0.2400 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.0600 VOL/VOL
FIELD CAPACITY              =      0.0560 VOL/VOL
WILTING POINT               =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                        LAYER  4
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3710 VOL/VOL
FIELD CAPACITY              =      0.2290 VOL/VOL
WILTING POINT               =      0.1280 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2290 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.159999996000E-03 CM/SEC

                        LAYER  5
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3790 VOL/VOL
FIELD CAPACITY              =      0.0890 VOL/VOL
WILTING POINT               =      0.0210 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0890 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.630000010000E-01 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                        LAYER  6
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

```
                              LAYER  7
                              --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =     58.57   INCHES
   POROSITY                     =      0.3700 VOL/VOL
   FIELD CAPACITY               =      0.2400 VOL/VOL
   WILTING POINT                =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                              LAYER  8
                              --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =     24.00   INCHES
   POROSITY                     =      0.3800 VOL/VOL
   FIELD CAPACITY               =      0.0801 VOL/VOL
   WILTING POINT                =      0.0132 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.0801 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.998999998000E-01 CM/SEC
   SLOPE                        =     11.40   PERCENT
   DRAINAGE LENGTH              =    150.0    FEET

                              LAYER  9
                              --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =      0.20   INCHES
   POROSITY                     =      0.7500 VOL/VOL
   FIELD CAPACITY               =      0.7470 VOL/VOL
   WILTING POINT                =      0.4000 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER             =     54.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.508  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.318  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.529  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     28.621  INCHES
TOTAL INITIAL WATER                 =     28.621  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

RUNOFF

TOTALS	0.004	0.000	0.004	0.000	0.000	0.002
	0.027	0.091	0.016	0.006	0.002	0.001
STD. DEVIATIONS	0.019	0.000	0.027	0.000	0.002	0.014
	0.092	0.404	0.086	0.058	0.014	0.004

EVAPOTRANSPIRATION

TOTALS	1.577	2.094	3.075	3.555	3.655	4.138
	4.896	4.521	3.385	1.618	0.948	1.115
STD. DEVIATIONS	0.221	0.236	0.581	0.760	1.525	1.545
	1.588	1.379	1.041	0.606	0.207	0.205

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	2.3380	2.0986	1.9285	1.3079	0.4980	0.3138
	0.5201	0.7785	0.7430	0.7687	0.8730	1.3955
STD. DEVIATIONS	1.6582	1.4511	1.3519	1.0540	0.4456	0.5338
	0.7239	0.9511	0.9498	1.0111	1.1450	1.2156

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.0941	0.0827	0.0751	0.0528	0.0230	0.0157
	0.0227	0.0322	0.0312	0.0321	0.0351	0.0542
STD. DEVIATIONS	0.0790	0.0636	0.0513	0.0430	0.0160	0.0195
	0.0266	0.0356	0.0358	0.0380	0.0418	0.0445

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.0677	0.0652	0.0800	0.0624	0.0322	0.0130
	0.0180	0.0262	0.0252	0.0276	0.0295	0.0483
STD. DEVIATIONS	0.0380	0.0335	0.0621	0.0612	0.0474	0.0262
	0.0246	0.0305	0.0298	0.0363	0.0380	0.0424

PERCOLATION/LEAKAGE THROUGH LAYER 9

TOTALS	0.0051	0.0049	0.0054	0.0052	0.0053	0.0045
	0.0041	0.0042	0.0042	0.0043	0.0040	0.0044
STD. DEVIATIONS	0.0009	0.0004	0.0002	0.0005	0.0004	0.0014
	0.0018	0.0020	0.0018	0.0019	0.0019	0.0018

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	3.3788	3.2382	2.6511	1.8731	0.6753	0.4396
	0.7053	1.0640	1.0578	1.0550	1.2232	1.8923
STD. DEVIATIONS	2.9857	2.6532	1.9439	1.6851	0.6042	0.7480
	0.9816	1.3175	1.3750	1.4131	1.6044	1.6483

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0051	0.0054	0.0061	0.0049	0.0024	0.0010
	0.0014	0.0020	0.0020	0.0021	0.0023	0.0037
STD. DEVIATIONS	0.0029	0.0028	0.0047	0.0048	0.0036	0.0021
	0.0019	0.0023	0.0023	0.0028	0.0030	0.0032

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.153	(0.4340)	10931.62	0.314
EVAPOTRANSPIRATION	34.578	(3.6248)	2463907.00	70.711
LATERAL DRAINAGE COLLECTED FROM LAYER 5	13.56355	(5.37926)	966496.750	27.73727
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.55102	(0.21286)	39263.957	1.12683
AVERAGE HEAD ON TOP OF LAYER 6	1.604	(0.678)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.49539	(0.20561)	35299.797	1.01306
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.05562	(0.00756)	3963.011	0.11373
AVERAGE HEAD ON TOP OF LAYER 9	0.003	(0.001)		
CHANGE IN WATER STORAGE	0.054	(2.0574)	3871.06	0.111

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

             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                              6.87        489534.875

      RUNOFF                                     2.646       188573.8440

      DRAINAGE COLLECTED FROM LAYER  5           0.29450      20985.16410

      PERCOLATION/LEAKAGE THROUGH LAYER  6       0.040637      2895.64722

      AVERAGE HEAD ON TOP OF LAYER  6           47.587

      MAXIMUM HEAD ON TOP OF LAYER  6           60.203

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)              171.0 FEET

      DRAINAGE COLLECTED FROM LAYER  8           0.01707       1216.03259

      PERCOLATION/LEAKAGE THROUGH LAYER  9       0.000204        14.55278

      AVERAGE HEAD ON TOP OF LAYER  9            0.040

      MAXIMUM HEAD ON TOP OF LAYER  9            0.080

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                0.0 FEET

      SNOW WATER                                 2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.3688

      MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.1149

       ***  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	1.6020	0.2697
2	9.2013	0.3067
3	0.7200	0.0600
4	3.9717	0.3310
5	2.2773	0.1898
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9240	0.0802
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix I, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (550 Years): HELP Model Input Data and Output File (output file name: ZLBS3out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.890		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.371	0.220	0.121	0.220
5	2	12		0.379	0.10	0.028	0.10
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.38	0.0802	0.0134	0.0802
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	2.30E-04					
5	2	4.30E-02	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	9.98E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS3.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS3out.OUT

TIME:  10: 5     DATE:   2/11/2004

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 550 Years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =      5.89   INCHES
           POROSITY                    =      0.4000 VOL/VOL
           FIELD CAPACITY              =      0.1100 VOL/VOL
           WILTING POINT               =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     30.00   INCHES
           POROSITY                    =      0.3700 VOL/VOL
           FIELD CAPACITY              =      0.2400 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.0600 VOL/VOL
FIELD CAPACITY              =     0.0560 VOL/VOL
WILTING POINT               =     0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                        LAYER  4
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3710 VOL/VOL
FIELD CAPACITY              =     0.2200 VOL/VOL
WILTING POINT               =     0.1210 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2200 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.230000005000E-03 CM/SEC

                        LAYER  5
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3790 VOL/VOL
FIELD CAPACITY              =     0.1000 VOL/VOL
WILTING POINT               =     0.0280 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.430000015000E-01 CM/SEC
SLOPE                       =     3.00   PERCENT
DRAINAGE LENGTH             =   450.0    FEET

                        LAYER  6
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.20   INCHES
POROSITY                    =     0.7500 VOL/VOL
FIELD CAPACITY              =     0.7470 VOL/VOL
WILTING POINT               =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

```
                       LAYER  7
                       --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                       LAYER  8
                       --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0802 VOL/VOL
WILTING POINT                =      0.0134 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0802 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.997999981000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET

                       LAYER  9
                       --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.514  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.317  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.533  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     28.642  INCHES
TOTAL INITIAL WATER                =     28.642  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                  0.004    0.000    0.004    0.000    0.000    0.002
                          0.027    0.091    0.017    0.006    0.002    0.001

  STD. DEVIATIONS         0.019    0.000    0.027    0.000    0.002    0.014
                          0.092    0.405    0.086    0.058    0.014    0.004

EVAPOTRANSPIRATION
------------------
  TOTALS                  1.578    2.094    3.079    3.557    3.652    4.139
                          4.897    4.519    3.383    1.619    0.948    1.116

  STD. DEVIATIONS         0.221    0.236    0.581    0.759    1.525    1.546
                          1.589    1.381    1.040    0.605    0.207    0.205

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                  2.1396   2.0683   1.9324   1.3893   0.5976   0.3361
                          0.4900   0.7308   0.7287   0.7540   0.8439   1.2986

  STD. DEVIATIONS         1.4409   1.3054   1.2193   1.0322   0.4679   0.4810
                          0.6458   0.8569   0.8682   0.9250   1.0730   1.1106

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                  0.1345   0.1293   0.1139   0.0807   0.0366   0.0226
                          0.0305   0.0434   0.0440   0.0453   0.0489   0.0726

  STD. DEVIATIONS         0.1321   0.1276   0.0880   0.0696   0.0245   0.0253
                          0.0341   0.0478   0.0502   0.0530   0.0581   0.0589

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                  0.0822   0.0852   0.1146   0.1101   0.0798   0.0372
                          0.0262   0.0335   0.0356   0.0379   0.0398   0.0615

  STD. DEVIATIONS         0.0469   0.0421   0.0927   0.1067   0.1021   0.0731
                          0.0330   0.0349   0.0381   0.0422   0.0498   0.0545

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                  0.0051   0.0048   0.0054   0.0052   0.0054   0.0050
                          0.0049   0.0045   0.0044   0.0046   0.0044   0.0047

  STD. DEVIATIONS         0.0009   0.0007   0.0004   0.0007   0.0002   0.0007
                          0.0011   0.0017   0.0016   0.0017   0.0016   0.0016
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES                4.9100   5.1798   4.1221   2.9643   1.1873   0.6900
                            0.9734   1.4764   1.5521   1.5436   1.7459   2.5799

    STD. DEVIATIONS         5.0026   5.3145   3.3389   2.7254   0.9295   0.9875
                            1.2831   1.7908   1.9474   1.9914   2.2570   2.2064

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES                0.0062   0.0071   0.0087   0.0086   0.0061   0.0029
                            0.0020   0.0025   0.0028   0.0029   0.0031   0.0047

    STD. DEVIATIONS         0.0036   0.0035   0.0070   0.0084   0.0078   0.0057
                            0.0025   0.0027   0.0030   0.0032   0.0039   0.0041

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  48.90    (   7.734)   3484469.2     100.00

 RUNOFF                          0.153   (  0.4343)     10927.06      0.314

 EVAPOTRANSPIRATION             34.580   (  3.6259)   2464083.75     70.716

 LATERAL DRAINAGE COLLECTED     13.30920 (  5.18660)    948372.375   27.21713
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH     0.80227 (  0.35070)     57167.426    1.64064
   LAYER  6

 AVERAGE HEAD ON TOP             2.410 (    1.133)
   OF LAYER  6

 LATERAL DRAINAGE COLLECTED      0.74364 (  0.33083)     52989.637   1.52074
   FROM LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.05861 (  0.00648)      4176.500    0.11986
   LAYER  9

 AVERAGE HEAD ON TOP             0.005 (    0.002)
   OF LAYER  9

 CHANGE IN WATER STORAGE         0.055   (  2.1936)       3919.94     0.112

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

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

            PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
  ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
     PRECIPITATION                                6.87        489534.875

     RUNOFF                                       2.652       188986.2810

     DRAINAGE COLLECTED FROM LAYER  5             0.20953      14930.45610

     PERCOLATION/LEAKAGE THROUGH LAYER  6         0.051125      3643.01270

     AVERAGE HEAD ON TOP OF LAYER  6             59.920

     MAXIMUM HEAD ON TOP OF LAYER  6             73.605

     LOCATION OF MAXIMUM HEAD IN LAYER  5
           (DISTANCE FROM DRAIN)                187.8 FEET

     DRAINAGE COLLECTED FROM LAYER  8             0.02171       1546.84204

     PERCOLATION/LEAKAGE THROUGH LAYER  9         0.000214        15.21794

     AVERAGE HEAD ON TOP OF LAYER  9              0.051

     MAXIMUM HEAD ON TOP OF LAYER  9              0.100

     LOCATION OF MAXIMUM HEAD IN LAYER  8
           (DISTANCE FROM DRAIN)                  0.8 FEET

     SNOW WATER                                   2.36        168188.7190

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3691

     MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1151

      ***  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	1.5975	0.2712
2	9.1910	0.3064
3	0.7200	0.0600
4	3.8479	0.3207
5	2.5027	0.2086
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9266	0.0803
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix J, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,000 Years): HELP Model Input Data and Output File (output file name: ZLBS4out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.8		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.372	0.204	0.109	0.204
5	2	12		0.378	0.116	0.040	0.116
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.379	0.0807	0.0140	0.0807
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	4.60E-04					
5	2	2.10E-02	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	9.94E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS4.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS4out.OUT

TIME:  14:55     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 1,000 Years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =      5.80   INCHES
           POROSITY                    =      0.4000 VOL/VOL
           FIELD CAPACITY              =      0.1100 VOL/VOL
           WILTING POINT               =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     30.00   INCHES
           POROSITY                    =      0.3700 VOL/VOL
           FIELD CAPACITY              =      0.2400 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                           LAYER  3
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.0600 VOL/VOL
FIELD CAPACITY               =      0.0560 VOL/VOL
WILTING POINT                =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.396999996000E-03 CM/SEC

                           LAYER  4
                           --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3720 VOL/VOL
FIELD CAPACITY               =      0.2040 VOL/VOL
WILTING POINT                =      0.1090 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2040 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.460000010000E-03 CM/SEC

                           LAYER  5
                           --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3780 VOL/VOL
FIELD CAPACITY               =      0.1160 VOL/VOL
WILTING POINT                =      0.0400 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1160 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.209999997000E-01 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                           LAYER  6
                           --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC
```

```
                         LAYER  7
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =     58.57   INCHES
   POROSITY                     =      0.3700 VOL/VOL
   FIELD CAPACITY               =      0.2400 VOL/VOL
   WILTING POINT                =      0.1360 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                         LAYER  8
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =     24.00   INCHES
   POROSITY                     =      0.3790 VOL/VOL
   FIELD CAPACITY               =      0.0807 VOL/VOL
   WILTING POINT                =      0.0140 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.0807 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.993999988000E-01 CM/SEC
   SLOPE                        =     11.40   PERCENT
   DRAINAGE LENGTH              =    150.0    FEET

                         LAYER  9
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =      0.20   INCHES
   POROSITY                     =      0.7500 VOL/VOL
   FIELD CAPACITY               =      0.7470 VOL/VOL
   WILTING POINT                =      0.4000 VOL/VOL
   INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.526  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.314  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.540  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     28.644  INCHES
TOTAL INITIAL WATER                =     28.644  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                   0.012    0.000    0.004    0.000    0.000    0.002
                           0.027    0.092    0.016    0.006    0.002    0.001

  STD. DEVIATIONS          0.104    0.000    0.027    0.000    0.002    0.013
                           0.093    0.405    0.086    0.058    0.014    0.004

EVAPOTRANSPIRATION
------------------
  TOTALS                   1.578    2.095    3.082    3.560    3.649    4.138
                           4.895    4.520    3.384    1.619    0.949    1.116

  STD. DEVIATIONS          0.220    0.236    0.580    0.763    1.523    1.547
                           1.591    1.378    1.038    0.606    0.207    0.205

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                   1.6448   1.7169   1.8024   1.4864   0.8979   0.4949
                           0.4867   0.6368   0.6632   0.6987   0.7410   1.0747

  STD. DEVIATIONS          0.9452   0.7966   0.8238   0.8185   0.5947   0.4206
                           0.4797   0.6512   0.6542   0.7044   0.7991   0.8655

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                   0.2609   0.3021   0.2854   0.2036   0.1031   0.0582
                           0.0574   0.0758   0.0826   0.0873   0.1003   0.1355

  STD. DEVIATIONS          0.2650   0.3207   0.2736   0.1892   0.0688   0.0452
                           0.0515   0.0779   0.0956   0.1010   0.1440   0.1287

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                   0.1105   0.1277   0.2548   0.2629   0.2612   0.1961
                           0.1188   0.0678   0.0576   0.0717   0.0715   0.0885

  STD. DEVIATIONS          0.1125   0.1155   0.2835   0.2666   0.2174   0.1640
                           0.1262   0.0744   0.0475   0.0702   0.0773   0.0845

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                   0.0050   0.0046   0.0055   0.0055   0.0058   0.0055
                           0.0055   0.0054   0.0051   0.0052   0.0049   0.0051

  STD. DEVIATIONS          0.0012   0.0011   0.0009   0.0009   0.0004   0.0003
                           0.0004   0.0003   0.0007   0.0008   0.0011   0.0012
```

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	9.6996	12.3618	10.6247	7.7825	3.7120	2.0811
	1.9798	2.6776	3.0434	3.1155	3.7426	4.9498
STD. DEVIATIONS	10.0502	13.3405	10.3789	7.4141	2.6101	1.7706
	1.9516	2.9533	3.7430	3.8267	5.6371	4.8722

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0084	0.0107	0.0194	0.0207	0.0199	0.0155
	0.0091	0.0052	0.0045	0.0055	0.0056	0.0068
STD. DEVIATIONS	0.0086	0.0097	0.0216	0.0210	0.0166	0.0129
	0.0096	0.0057	0.0037	0.0054	0.0061	0.0065

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.162	(0.4445)	11558.63	0.332
EVAPOTRANSPIRATION	34.584	(3.6263)	2464362.75	70.724
LATERAL DRAINAGE COLLECTED FROM LAYER 5	12.34439	(4.38623)	879622.625	25.24409
PERCOLATION/LEAKAGE THROUGH LAYER 6	1.75224	(0.99064)	124859.273	3.58331
AVERAGE HEAD ON TOP OF LAYER 6	5.481	(3.227)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	1.68928	(0.96325)	120372.531	3.45454
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.06294	(0.00316)	4484.968	0.12871
AVERAGE HEAD ON TOP OF LAYER 9	0.011	(0.006)		
CHANGE IN WATER STORAGE	0.057	(2.6430)	4068.29	0.117

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      2.657       189349.7810

      DRAINAGE COLLECTED FROM LAYER  5            0.11176       7963.75391

      PERCOLATION/LEAKAGE THROUGH LAYER  6        0.060947      4342.92725

      AVERAGE HEAD ON TOP OF LAYER  6           71.471

      MAXIMUM HEAD ON TOP OF LAYER  6           86.212

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)              201.5 FEET

      DRAINAGE COLLECTED FROM LAYER  8            0.05388       3839.00903

      PERCOLATION/LEAKAGE THROUGH LAYER  9        0.000278        19.84088

      AVERAGE HEAD ON TOP OF LAYER  9             0.127

      MAXIMUM HEAD ON TOP OF LAYER  9             0.252

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3779

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1154

       ***  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	1.5657	0.2700
2	8.9783	0.2993
3	0.7200	0.0600
4	3.8123	0.3177
5	2.9804	0.2484
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9393	0.0808
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix K, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,800 Years): HELP Model Input Data and Output File (output file name: ZLBS5out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.640		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.374	0.176	0.0867	0.176
5	2	12		0.376	0.144	0.062	0.144
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.376	0.0829	0.0172	0.0829
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	1.60E-03					
5	2	6.30E-03	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	9.77E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS5.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS5out.OUT

TIME:  14:57     DATE:  12/11/2003

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     TITLE:  LBS Degraded MSE Vault Closure Cap - 1,800 Years

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =      5.64   INCHES
          POROSITY                     =      0.4000 VOL/VOL
          FIELD CAPACITY               =      0.1100 VOL/VOL
          WILTING POINT                =      0.0580 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.1100 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
          THICKNESS                    =     30.00   INCHES
          POROSITY                     =      0.3700 VOL/VOL
          FIELD CAPACITY               =      0.2400 VOL/VOL
          WILTING POINT                =      0.1360 VOL/VOL
          INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
          EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC
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                              LAYER  3
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.0600 VOL/VOL
FIELD CAPACITY               =      0.0560 VOL/VOL
WILTING POINT                =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.396999996000E-03 CM/SEC

                              LAYER  4
                              --------

                 TYPE 1 - VERTICAL PERCOLATION LAYER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3740 VOL/VOL
FIELD CAPACITY               =      0.1760 VOL/VOL
WILTING POINT                =      0.0867 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1760 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.159999996000E-02 CM/SEC

                              LAYER  5
                              --------

                   TYPE 2 - LATERAL DRAINAGE LAYER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3760 VOL/VOL
FIELD CAPACITY               =      0.1440 VOL/VOL
WILTING POINT                =      0.0620 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1440 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.630000001000E-02 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                              LAYER  6
                              --------

                     TYPE 3 - BARRIER SOIL LINER
                     MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC
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                       LAYER  7
                       --------

             TYPE 1 - VERTICAL PERCOLATION LAYER
                 MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =     58.57   INCHES
 POROSITY                     =      0.3700 VOL/VOL
 FIELD CAPACITY               =      0.2400 VOL/VOL
 WILTING POINT                =      0.1360 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                       LAYER  8
                       --------

               TYPE 2 - LATERAL DRAINAGE LAYER
                 MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =     24.00   INCHES
 POROSITY                     =      0.3760 VOL/VOL
 FIELD CAPACITY               =      0.0829 VOL/VOL
 WILTING POINT                =      0.0172 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.0829 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.976999998000E-01 CM/SEC
 SLOPE                        =     11.40   PERCENT
 DRAINAGE LENGTH              =    150.0    FEET

                       LAYER  9
                       --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =      0.20   INCHES
 POROSITY                     =      0.7500 VOL/VOL
 FIELD CAPACITY               =      0.7470 VOL/VOL
 WILTING POINT                =      0.4000 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.547  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.309  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.552  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     28.679  INCHES
TOTAL INITIAL WATER                =     28.679  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA AND STATION LATITUDE = 33.30 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	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

RUNOFF

TOTALS	0.124	0.072	0.102	0.000	0.000	0.002
	0.026	0.092	0.016	0.006	0.010	0.006
STD. DEVIATIONS	0.491	0.389	0.527	0.000	0.001	0.013
	0.093	0.406	0.085	0.058	0.063	0.045

EVAPOTRANSPIRATION

TOTALS	1.579	2.097	3.087	3.566	3.669	4.146
	4.893	4.519	3.390	1.618	0.948	1.115
STD. DEVIATIONS	0.219	0.234	0.584	0.758	1.516	1.540
	1.590	1.378	1.037	0.606	0.207	0.204

LATERAL DRAINAGE COLLECTED FROM LAYER 5

TOTALS	0.8475	0.8986	1.0052	0.9369	0.8403	0.6801
	0.6089	0.5825	0.5483	0.5604	0.5386	0.6537
STD. DEVIATIONS	0.3587	0.2635	0.2533	0.2462	0.2565	0.2485
	0.2469	0.2833	0.2925	0.3184	0.3378	0.3696

PERCOLATION/LEAKAGE THROUGH LAYER 6

TOTALS	0.6047	0.6857	0.7575	0.6290	0.4159	0.2881
	0.2484	0.2578	0.2450	0.2573	0.2893	0.3726
STD. DEVIATIONS	0.4816	0.4709	0.4642	0.3924	0.2430	0.1671
	0.1428	0.1988	0.2045	0.2421	0.3495	0.3609

LATERAL DRAINAGE COLLECTED FROM LAYER 8

TOTALS	0.2789	0.4035	0.6079	0.6753	0.6623	0.5074
	0.4180	0.3351	0.2848	0.2697	0.2476	0.2890
STD. DEVIATIONS	0.3428	0.4258	0.5285	0.4594	0.3733	0.2289
	0.1662	0.1448	0.1491	0.1961	0.2280	0.3300

PERCOLATION/LEAKAGE THROUGH LAYER 9

TOTALS	0.0051	0.0050	0.0061	0.0063	0.0066	0.0061
	0.0061	0.0059	0.0056	0.0057	0.0055	0.0057
STD. DEVIATIONS	0.0017	0.0016	0.0016	0.0012	0.0008	0.0005
	0.0005	0.0005	0.0005	0.0008	0.0007	0.0010

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES              22.7387  28.3245  28.5346  24.4540  15.5748  11.0924
                           9.2256   9.5782   9.4041   9.5604  11.1402  13.9346

    STD. DEVIATIONS       18.2684  19.5820  17.6081  15.3822   9.2174   6.5515
                           5.4173   7.5401   8.0160   9.1831  13.6987  13.6904

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES               0.0217   0.0344   0.0472   0.0542   0.0514   0.0407
                           0.0325   0.0260   0.0228   0.0209   0.0199   0.0224

    STD. DEVIATIONS        0.0266   0.0364   0.0410   0.0368   0.0290   0.0184
                           0.0129   0.0112   0.0120   0.0152   0.0183   0.0256

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     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
--------------------------------------------------------------------------------
                                     INCHES          CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                  48.90    (   7.734)    3484469.2     100.00

 RUNOFF                          0.457   (  0.9444)     32559.99       0.934

 EVAPOTRANSPIRATION             34.626   (  3.6406)   2467356.75      70.810

 LATERAL DRAINAGE COLLECTED      8.70105 (  2.16949)   620009.875   17.79352
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH     5.05125 (  2.34617)   359936.500   10.32974
   LAYER  6

 AVERAGE HEAD ON TOP            16.130 (    7.591)
   OF LAYER  6

 LATERAL DRAINAGE COLLECTED      4.97956 (  2.26762)   354828.156   10.18313
   FROM LAYER  8

 PERCOLATION/LEAKAGE THROUGH     0.06975 (  0.00476)     4969.981     0.14263
   LAYER  9

 AVERAGE HEAD ON TOP             0.033 (    0.015)
   OF LAYER  9

 CHANGE IN WATER STORAGE         0.067   (  3.7668)      4744.57       0.136

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             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
  ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      2.662       189714.1560

      DRAINAGE COLLECTED FROM LAYER  5            0.04469       3184.31494

      PERCOLATION/LEAKAGE THROUGH LAYER  6        0.061091      4353.16406

      AVERAGE HEAD ON TOP OF LAYER  6            71.640

      MAXIMUM HEAD ON TOP OF LAYER  6            86.396

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)               201.7 FEET

      DRAINAGE COLLECTED FROM LAYER  8            0.06161       4390.11670

      PERCOLATION/LEAKAGE THROUGH LAYER  9        0.000296        21.10303

      AVERAGE HEAD ON TOP OF LAYER  9             0.148

      MAXIMUM HEAD ON TOP OF LAYER  9             0.295

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3777

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1160

       ***  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	1.5516	0.2751
2	8.9333	0.2978
3	0.7200	0.0600
4	3.2987	0.2749
5	4.2930	0.3578
6	0.1500	0.7500
7	14.2484	0.2433
8	1.9922	0.0830
9	0.1500	0.7500
SNOW WATER	0.000	

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Appendix L, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (3,400 Years): HELP Model Input Data and Output File (output file name: ZLBS6out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.320		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.375	0.16	0.0745	0.16
5	2	12		0.375	0.16	0.0745	0.16
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.367	0.0904	0.0280	0.0904
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	3.20E-03					
5	2	3.20E-03	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	9.20E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS6.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS6out.OUT

TIME:  15: 0     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 3,400 Years

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

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

                                   LAYER  1
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =      5.32   INCHES
           POROSITY                   =      0.4000 VOL/VOL
           FIELD CAPACITY             =      0.1100 VOL/VOL
           WILTING POINT              =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                    TYPE 1 - VERTICAL PERCOLATION LAYER
                        MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     30.00   INCHES
           POROSITY                   =      0.3700 VOL/VOL
           FIELD CAPACITY             =      0.2400 VOL/VOL
           WILTING POINT              =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC
```

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                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.0600 VOL/VOL
FIELD CAPACITY              =      0.0560 VOL/VOL
WILTING POINT               =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                        LAYER  4
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3750 VOL/VOL
FIELD CAPACITY              =      0.1600 VOL/VOL
WILTING POINT               =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC

                        LAYER  5
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3750 VOL/VOL
FIELD CAPACITY              =      0.1600 VOL/VOL
WILTING POINT               =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                        LAYER  6
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

```
                        LAYER  7
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     58.57   INCHES
  POROSITY                     =      0.3700 VOL/VOL
  FIELD CAPACITY               =      0.2400 VOL/VOL
  WILTING POINT                =      0.1360 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                        LAYER  8
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =     24.00   INCHES
  POROSITY                     =      0.3670 VOL/VOL
  FIELD CAPACITY               =      0.0904 VOL/VOL
  WILTING POINT                =      0.0280 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.0904 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.920000002000E-01 CM/SEC
  SLOPE                        =     11.40   PERCENT
  DRAINAGE LENGTH              =    150.0    FEET

                        LAYER  9
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =      0.20   INCHES
  POROSITY                     =      0.7500 VOL/VOL
  FIELD CAPACITY               =      0.7470 VOL/VOL
  WILTING POINT                =      0.4000 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER             =     54.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      4.588  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      8.300  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      2.577  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     28.824  INCHES
TOTAL INITIAL WATER                 =     28.824  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR AUGUSTA GEORGIA AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                 0.189    0.100    0.143    0.004    0.000    0.001
                         0.027    0.097    0.016    0.011    0.027    0.014

  STD. DEVIATIONS        0.673    0.479    0.667    0.045    0.003    0.010
                         0.095    0.432    0.085    0.071    0.155    0.098

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.580    2.099    3.102    3.578    3.662    4.148
                         4.894    4.513    3.390    1.617    0.948    1.117

  STD. DEVIATIONS        0.217    0.232    0.571    0.772    1.509    1.535
                         1.591    1.378    1.038    0.606    0.208    0.204

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.7061   0.7367   0.8269   0.7617   0.6572   0.5233
                         0.4857   0.4785   0.4540   0.4635   0.4519   0.5515

  STD. DEVIATIONS        0.3023   0.2301   0.2274   0.2180   0.2081   0.1769
                         0.1797   0.2126   0.2210   0.2388   0.2626   0.2969

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                 0.7497   0.8052   0.8989   0.7431   0.5188   0.3884
                         0.3586   0.3771   0.3527   0.3638   0.3939   0.5051

  STD. DEVIATIONS        0.5002   0.4625   0.4578   0.3925   0.2465   0.1705
                         0.1638   0.2393   0.2291   0.2635   0.3650   0.3957

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.4184   0.5602   0.7668   0.8250   0.7772   0.5795
                         0.4829   0.4148   0.3865   0.3884   0.3664   0.4091

  STD. DEVIATIONS        0.3823   0.4734   0.5376   0.4609   0.3666   0.2308
                         0.1663   0.1512   0.1852   0.2098   0.2339   0.3463

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0057   0.0055   0.0067   0.0068   0.0070   0.0064
                         0.0063   0.0061   0.0059   0.0061   0.0058   0.0060

  STD. DEVIATIONS        0.0014   0.0016   0.0016   0.0012   0.0008   0.0005
                         0.0004   0.0005   0.0005   0.0006   0.0007   0.0009
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES             28.2410  33.2948  33.8990  28.9293  19.4818  15.0244
                         13.4043  14.1063  13.6250  13.6019  15.2386  18.9590

    STD. DEVIATIONS      18.9748  19.2312  17.3660  15.3861   9.3492   6.6842
                          6.2147   9.0772   8.9794   9.9972  14.3057  15.0098

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES              0.0345   0.0507   0.0632   0.0703   0.0641   0.0494
                          0.0398   0.0342   0.0329   0.0320   0.0312   0.0337

    STD. DEVIATIONS       0.0315   0.0429   0.0443   0.0393   0.0302   0.0197
                          0.0137   0.0125   0.0158   0.0173   0.0199   0.0285

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                      INCHES           CU. FEET       PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                    48.90    (   7.734)    3484469.2     100.00

 RUNOFF                            0.630   (  1.1808)     44884.09      1.288

 EVAPOTRANSPIRATION               34.647   (  3.6413)   2468838.50     70.853

 LATERAL DRAINAGE COLLECTED        7.09687 (  1.76355)   505701.156   14.51300
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH       6.45544 (  2.45320)   459994.594    13.20128
   LAYER  6

 AVERAGE HEAD ON TOP              20.650 (    7.927)
   OF LAYER  6

 LATERAL DRAINAGE COLLECTED        6.37531 (  2.36287)   454284.781   13.03742
   FROM LAYER  8

 PERCOLATION/LEAKAGE THROUGH       0.07418 (  0.00536)     5285.910    0.15170
   LAYER  9

 AVERAGE HEAD ON TOP               0.045 (    0.017)
   OF LAYER  9

 CHANGE IN WATER STORAGE           0.077   (  3.8107)      5475.16      0.157

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

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

            PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                               (INCHES)      (CU. FT.)
                                              ----------    -------------
      PRECIPITATION                             6.87        489534.875

      RUNOFF                                    2.665       189900.2810

      DRAINAGE COLLECTED FROM LAYER  5          0.03708       2642.50122

      PERCOLATION/LEAKAGE THROUGH LAYER  6      0.060819      4333.77344

      AVERAGE HEAD ON TOP OF LAYER  6          71.320

      MAXIMUM HEAD ON TOP OF LAYER  6          86.046

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)             201.3 FEET

      DRAINAGE COLLECTED FROM LAYER  8          0.06125       4364.23340

      PERCOLATION/LEAKAGE THROUGH LAYER  9      0.000303        21.60339

      AVERAGE HEAD ON TOP OF LAYER  9           0.157

      MAXIMUM HEAD ON TOP OF LAYER  9           0.310

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)               0.0 FEET

      SNOW WATER                                2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3773

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1171

       ***  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 100

LAYER	(INCHES)	(VOL/VOL)
1	1.4523	0.2730
2	8.9073	0.2969
3	0.7200	0.0600
4	3.8066	0.3172
5	4.5000	0.3750
6	0.1500	0.7500
7	14.6459	0.2501
8	2.1751	0.0906
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix M, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (5,600 Years): HELP Model Input Data and Output File (output file name: ZLBS7out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	4.880		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.375	0.16	0.0745	0.16
5	2	12		0.375	0.16	0.0745	0.16
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.353	0.102	0.0448	0.102
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	3.20E-03					
5	2	3.20E-03	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	8.30E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS7.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS7out.OUT

TIME:  15: 8     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 5,600 Years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =      4.88   INCHES
           POROSITY                    =      0.4000 VOL/VOL
           FIELD CAPACITY              =      0.1100 VOL/VOL
           WILTING POINT               =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     30.00   INCHES
           POROSITY                    =      0.3700 VOL/VOL
           FIELD CAPACITY              =      0.2400 VOL/VOL
           WILTING POINT               =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                    LAYER  3
                    --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.0600 VOL/VOL
FIELD CAPACITY              =      0.0560 VOL/VOL
WILTING POINT               =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.396999996000E-03 CM/SEC

                    LAYER  4
                    --------

         TYPE 1 - VERTICAL PERCOLATION LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3750 VOL/VOL
FIELD CAPACITY              =      0.1600 VOL/VOL
WILTING POINT               =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC

                    LAYER  5
                    --------

           TYPE 2 - LATERAL DRAINAGE LAYER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3750 VOL/VOL
FIELD CAPACITY              =      0.1600 VOL/VOL
WILTING POINT               =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                    LAYER  6
                    --------

             TYPE 3 - BARRIER SOIL LINER
             MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC
```

```
                         LAYER  7
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                         LAYER  8
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3530 VOL/VOL
FIELD CAPACITY               =      0.1020 VOL/VOL
WILTING POINT                =      0.0448 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1020 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.829999968000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET

                         LAYER  9
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.646  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.286  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.611  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     29.054  INCHES
TOTAL INITIAL WATER                =     29.054  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                  0.199     0.104     0.146     0.005     0.000     0.001
                          0.028     0.098     0.017     0.011     0.029     0.014

  STD. DEVIATIONS         0.695     0.489     0.677     0.052     0.002     0.009
                          0.100     0.439     0.084     0.074     0.167     0.101

EVAPOTRANSPIRATION
------------------
  TOTALS                  1.582     2.102     3.113     3.587     3.646     4.143
                          4.892     4.511     3.390     1.615     0.949     1.119

  STD. DEVIATIONS         0.216     0.231     0.569     0.781     1.507     1.531
                          1.590     1.378     1.040     0.605     0.209     0.202

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                  0.7063    0.7361    0.8265    0.7595    0.6533    0.5203
                          0.4842    0.4777    0.4534    0.4639    0.4518    0.5529

  STD. DEVIATIONS         0.3008    0.2294    0.2269    0.2185    0.2080    0.1763
                          0.1797    0.2131    0.2218    0.2402    0.2624    0.2965

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                  0.7488    0.8038    0.8968    0.7385    0.5134    0.3868
                          0.3586    0.3767    0.3524    0.3664    0.3938    0.5057

  STD. DEVIATIONS         0.4978    0.4592    0.4533    0.3883    0.2423    0.1701
                          0.1663    0.2394    0.2293    0.2676    0.3641    0.3937

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                  0.4021    0.5292    0.7519    0.8185    0.7929    0.5999
                          0.4972    0.4223    0.3855    0.3881    0.3652    0.4071

  STD. DEVIATIONS         0.3726    0.4574    0.5398    0.4611    0.3740    0.2382
                          0.1718    0.1527    0.1810    0.2105    0.2328    0.3431

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                  0.0058    0.0056    0.0068    0.0070    0.0072    0.0065
                          0.0064    0.0062    0.0060    0.0061    0.0059    0.0061

  STD. DEVIATIONS         0.0015    0.0017    0.0017    0.0013    0.0009    0.0006
                          0.0005    0.0006    0.0005    0.0007    0.0007    0.0010
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES              28.2053  33.2354  33.8176  28.7483  19.2768  14.9615
                          13.4026  14.0891  13.6130  13.7003  15.2351  18.9832

    STD. DEVIATIONS       18.8840  19.0935  17.1958  15.2203   9.1923   6.6687
                           6.3077   9.0808   8.9881  10.1493  14.2708  14.9333

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES               0.0367   0.0531   0.0687   0.0773   0.0725   0.0566
                           0.0454   0.0386   0.0364   0.0355   0.0345   0.0372

    STD. DEVIATIONS        0.0340   0.0460   0.0493   0.0435   0.0342   0.0225
                           0.0157   0.0140   0.0171   0.0192   0.0220   0.0314

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
------------------------------------------------------------------------------
                                      INCHES           CU. FEET      PERCENT
                                  -------------------  -------------  ---------
 PRECIPITATION                    48.90    (   7.734)    3484469.2     100.00

 RUNOFF                            0.653   (  1.2111)      46552.36      1.336

 EVAPOTRANSPIRATION               34.649   (  3.6322)    2468960.50     70.856

 LATERAL DRAINAGE COLLECTED        7.08591 (  1.76126)    504920.219   14.49059
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH       6.44166 (  2.44030)    459012.531    13.17310
   LAYER  6

 AVERAGE HEAD ON TOP              20.606 (    7.885)
   OF LAYER  6

 LATERAL DRAINAGE COLLECTED        6.35997 (  2.34966)    453192.062   13.00606
   FROM LAYER  8

 PERCOLATION/LEAKAGE THROUGH       0.07568 (  0.00583)      5392.924     0.15477
   LAYER  9

 AVERAGE HEAD ON TOP               0.049 (    0.018)
   OF LAYER  9

 CHANGE IN WATER STORAGE           0.076   (  3.8352)       5451.10      0.156

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

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                               ----------    -------------
      PRECIPITATION                                6.87        489534.875

      RUNOFF                                       2.694       191971.8440

      DRAINAGE COLLECTED FROM LAYER  5             0.03685       2625.91138

      PERCOLATION/LEAKAGE THROUGH LAYER  6         0.060445      4307.11182

      AVERAGE HEAD ON TOP OF LAYER  6             70.880

      MAXIMUM HEAD ON TOP OF LAYER  6             85.565

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)                200.8 FEET

      DRAINAGE COLLECTED FROM LAYER  8             0.06089       4338.53662

      PERCOLATION/LEAKAGE THROUGH LAYER  9         0.000317        22.56991

      AVERAGE HEAD ON TOP OF LAYER  9              0.172

      MAXIMUM HEAD ON TOP OF LAYER  9              0.343

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)                  0.0 FEET

      SNOW WATER                                   2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.3767

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.1187

       ***  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 100

LAYER	(INCHES)	(VOL/VOL)
1	1.4151	0.2900
2	9.0114	0.3004
3	0.6720	0.0560
4	3.7003	0.3084
5	4.5000	0.3750
6	0.1500	0.7500
7	14.6508	0.2501
8	2.4539	0.1022
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix N, Lower Bounding Scenario Degraded SDF MSE Vault Closure Cap (10,000 Years): HELP Model Input Data and Output File (output file name: ZLBS8out.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	4.0		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.375	0.16	0.0745	0.16
5	2	12		0.375	0.16	0.0745	0.16
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.324	0.125	0.0779	0.125
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	3.20E-03					
5	2	3.20E-03	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	6.53E-02	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZLBS8.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZLBS8out.OUT

TIME:  15:12     DATE:  12/11/2003

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

     TITLE:  LBS Degraded MSE Vault Closure Cap - 10,000 Years

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

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

                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =      4.00   INCHES
           POROSITY                   =      0.4000 VOL/VOL
           FIELD CAPACITY             =      0.1100 VOL/VOL
           WILTING POINT              =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     30.00   INCHES
           POROSITY                   =      0.3700 VOL/VOL
           FIELD CAPACITY             =      0.2400 VOL/VOL
           WILTING POINT              =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                            LAYER  3
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.0600 VOL/VOL
FIELD CAPACITY                =      0.0560 VOL/VOL
WILTING POINT                 =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.396999996000E-03 CM/SEC

                            LAYER  4
                            --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.3750 VOL/VOL
FIELD CAPACITY                =      0.1600 VOL/VOL
WILTING POINT                 =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.319999992000E-02 CM/SEC

                            LAYER  5
                            --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =     12.00   INCHES
POROSITY                      =      0.3750 VOL/VOL
FIELD CAPACITY                =      0.1600 VOL/VOL
WILTING POINT                 =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.319999992000E-02 CM/SEC
SLOPE                         =      3.00   PERCENT
DRAINAGE LENGTH               =    450.0    FEET

                            LAYER  6
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                     =      0.20   INCHES
POROSITY                      =      0.7500 VOL/VOL
FIELD CAPACITY                =      0.7470 VOL/VOL
WILTING POINT                 =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT    =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.     =  0.499999997000E-08 CM/SEC
```

```
                    LAYER  7
                    --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                    LAYER  8
                    --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3240 VOL/VOL
FIELD CAPACITY              =      0.1250 VOL/VOL
WILTING POINT               =      0.0779 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1250 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.653000027000E-01 CM/SEC
SLOPE                       =     11.40   PERCENT
DRAINAGE LENGTH             =    150.0    FEET

                    LAYER  9
                    --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.760  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.260  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.680  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     29.509  INCHES
TOTAL INITIAL WATER                =     29.509  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                 0.219    0.114    0.156    0.007    0.000    0.003
                         0.035    0.109    0.019    0.017    0.033    0.016

  STD. DEVIATIONS        0.739    0.514    0.696    0.066    0.003    0.018
                         0.119    0.464    0.089    0.098    0.188    0.115

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.584    2.108    3.140    3.612    3.609    4.134
                         4.884    4.501    3.380    1.616    0.950    1.120

  STD. DEVIATIONS        0.215    0.228    0.564    0.782    1.515    1.533
                         1.589    1.384    1.041    0.605    0.210    0.203

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 0.7082   0.7352   0.8236   0.7552   0.6466   0.5160
                         0.4821   0.4779   0.4540   0.4640   0.4523   0.5537

  STD. DEVIATIONS        0.2980   0.2269   0.2258   0.2175   0.2065   0.1756
                         0.1805   0.2132   0.2211   0.2408   0.2613   0.2968

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                 0.7491   0.7978   0.8870   0.7266   0.5032   0.3823
                         0.3560   0.3762   0.3522   0.3677   0.3929   0.5054

  STD. DEVIATIONS        0.4923   0.4514   0.4462   0.3795   0.2321   0.1673
                         0.1627   0.2382   0.2268   0.2690   0.3590   0.3908

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.4173   0.5182   0.7265   0.7998   0.7744   0.5897
                         0.4941   0.4211   0.3873   0.3888   0.3704   0.4195

  STD. DEVIATIONS        0.3557   0.4362   0.5367   0.4572   0.3722   0.2297
                         0.1645   0.1459   0.1761   0.2009   0.2239   0.3274

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0064   0.0061   0.0072   0.0074   0.0076   0.0069
                         0.0067   0.0065   0.0062   0.0064   0.0062   0.0065

  STD. DEVIATIONS        0.0012   0.0015   0.0019   0.0015   0.0013   0.0009
                         0.0008   0.0007   0.0006   0.0006   0.0007   0.0010
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  6
  -------------------------------------
    AVERAGES              28.2173  32.9866  33.4489  28.2828  18.8872  14.7858
                          13.3038  14.0691  13.6039  13.7477  15.2020  18.9731

    STD. DEVIATIONS       18.6747  18.7677  16.9263  14.8758   8.8037   6.5536
                           6.1715   9.0357   8.8889  10.2054  14.0708  14.8230

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES               0.0485   0.0661   0.0844   0.0960   0.0899   0.0708
                           0.0574   0.0489   0.0465   0.0452   0.0445   0.0487

    STD. DEVIATIONS        0.0413   0.0558   0.0623   0.0549   0.0432   0.0276
                           0.0191   0.0169   0.0211   0.0233   0.0269   0.0380

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

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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
----------------------------------------------------------------------------
                                      INCHES           CU. FEET      PERCENT
                                 -------------------  -------------  ---------
 PRECIPITATION                   48.90    (   7.734)   3484469.2     100.00

 RUNOFF                           0.727   (  1.2877)     51799.17      1.487

 EVAPOTRANSPIRATION              34.638   (  3.6111)   2468202.50     70.834

 LATERAL DRAINAGE COLLECTED       7.06888 (  1.74841)   503706.125   14.45575
   FROM LAYER  5

 PERCOLATION/LEAKAGE THROUGH      6.39636 (  2.39499)   455784.531    13.08046
   LAYER  6

 AVERAGE HEAD ON TOP             20.459 (    7.737)
   OF LAYER  6

 LATERAL DRAINAGE COLLECTED       6.30706 (  2.29410)   449421.781   12.89785
   FROM LAYER  8

 PERCOLATION/LEAKAGE THROUGH      0.08019 (  0.00749)     5714.427    0.16400
   LAYER  9

 AVERAGE HEAD ON TOP              0.062 (    0.023)
   OF LAYER  9

 CHANGE IN WATER STORAGE          0.079   (  3.8209)      5626.00      0.161

****************************************************************************
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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.87	489534.875
RUNOFF	2.802	199632.0160
DRAINAGE COLLECTED FROM LAYER 5	0.03639	2592.87378
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.059697	4253.78760
AVERAGE HEAD ON TOP OF LAYER 6	70.000	
MAXIMUM HEAD ON TOP OF LAYER 6	84.603	
LOCATION OF MAXIMUM HEAD IN LAYER 5 (DISTANCE FROM DRAIN)	199.8 FEET	
DRAINAGE COLLECTED FROM LAYER 8	0.06027	4294.41650
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.000355	25.26759
AVERAGE HEAD ON TOP OF LAYER 9	0.217	
MAXIMUM HEAD ON TOP OF LAYER 9	0.429	
LOCATION OF MAXIMUM HEAD IN LAYER 8 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.36	168188.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3755	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1218	

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	1.1692	0.2923
2	9.0112	0.3004
3	0.6720	0.0560
4	3.7853	0.3154
5	4.5000	0.3750
6	0.1500	0.7500
7	14.6568	0.2502
8	3.3096	0.1379
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix O, SDF MSE Vault Closure Cap Degraded Property Value Calculations for Upper Bounding Scenario (i.e. Institutional Control to Farm to Pine Forest)

The MSE vault closure cap initial (0 year) layer thickness and hydraulic property values from top to bottom are provided in Table 3.1-1. The degradation scenarios for each layer are provided in Table 4.4-2. Based upon the Table 4.4-2 degradation scenarios, the Table 3.1-1 initial SDF closure cap layer thickness and hydraulic property values have been modified to account for degradation at 100, 154, 300, 550, 602, 802, 1,000, 1,800, 3,400, 5,600 and 10,000 years after closure of the SDF.

Topsoil and Upper Backfill Layer Thickness:

From Section 4.2 the soil loss in terms of depth of loss per year for the topsoil was estimated to be 2.0E-04 inches/year with bamboo and 0.11 inches/year with corn. For the backfill it was estimated to be 1.2E-04 inches/year with bamboo and 0.067 inches/year with corn.

Topsoil / Upper Backfill Thickness Over Time Calculation:

Year	Vegetation	Topsoil / Upper Backfill Thickness
0	bamboo	6” – (0 years × 2.0E-04 inches/year) = 6” / 30”
100	bamboo	6” – (100 years × 2.0E-04 inches/year) = 5.980” / 30”
How long does it take for the topsoil to be completely eroded away with corn which is assumed to be planted immediately after the 100 year institutional control period has ended: 5.980” ÷ 0.11 inches/year = 54 years 100 years + 54 years = 154 years		
154	corn	0” / 30”
How long does it take for the upper backfill to be completely eroded away with corn which is assumed to be planted immediately after the 100 year institutional control period has ended: 30” ÷ 0.067 inches/year = 448 years 154 years + 448 years = 602 years		
300	corn	0” / 30” – ((300 years – 154 years) × 0.067 inches/year) = 20.218”
550	corn	0” / 30” – ((550 years – 154 years) × 0.067 inches/year) = 3.468”
602	corn	0” / 0”
802	pine trees	0” / 0”
1,000	pine trees	0” / 0”
1,800	pine trees	0” / 0”
3,400	pine trees	0” / 0”
5,600	pine trees	0” / 0”
10,000	pine trees	0” / 0”

Erosion Barrier Hydraulic Properties:

As outlined in Phifer and Nelson 2003, the erosion barrier is assumed to consist of a one foot thick layer of 2-inch to 6-inch granite stone whose voids are filled with a Controlled Low Strength Material (CLSM) or flowable fill. Maintenance during the institutional control period and farming practices during corn farming prevent degradation of the erosion control barrier. Subsequent to the institutional control period and corn farming, pine forest succession will result in root penetration through the erosion control barrier. This does not impact its ability to function as an erosion barrier. For this scenario pine forest succession occurs after all of the topsoil and upper backfill have been completely eroded, therefore the upper backfill is not available to fill holes in the erosion barrier after the roots decompose. However it will be assumed that root penetration breaks up the flowable fill and separates it from the granite stone. After the root decomposes it will be assumed that segregation of the granite stone and broken up flowable fill occurs, resulting in the flowable fill at the bottom of the hole and the granite stone at the top. For the purposes of this calculation the properties of the broken up flowable fill will be ignored. Therefore will assume that the degraded barrier consists of intact erosion barrier with holes filled with the granite stone.

The following are the assumed properties of the intact erosion barrier and granite stone:

Material	K	N	FC	WP
Intact erosion barrier [1]	3.97E-04	0.06	0.056	0.052
Granite stone [2]	3.0E-01	0.397	0.032	0.013

[1] Phifer and Nelson 2003
[2] USEPA 1994a and USEPA 1994b

From Section 4.1 the following assumptions relative to pine forest succession that impact the erosion barrier hydraulic properties were made:

- 200 years after the end of farming it is assumed that the entire cap is dominated by pine (i.e. 400 mature trees per acre).
- Complete turnover of the 400 mature trees per acre occurs every 100 years (in a staggered manner).
- There are 400 mature trees per acre with 4 roots to 6 feet and 1 root to 12 feet. The roots are 3 inches in diameter at a depth of 1 foot and 0.25 inches in diameter at either 6 or 12 feet, whichever is applicable.

Area of holes in erosion barrier due to root penetration:

Average Erosion Barrier Depth after topsoil and upper backfill completely eroded (see Table 3.1-1):

Average depth = ½(12”) = 6” ≈ 0.5’

Root Diameter for 4-6’ roots at 0.5’:

3” diameter at 1’ depth and 0.25” at 6’

$$(3''-0.25'')/(6'-1') = 0.55''/\,ft$$

Diameter = 3” + (0.5’ × 0.55”/ft) = 3.275”

Area of for 4-6’ roots at 0.5’:

Area = $4 \times \frac{1}{4}\pi D^2 = \pi D^2 = \pi(3.275'')^2 = 33.7\ in^2$

Root Diameter for 1-12’ root at 0.5’:

3” diameter at 1’ depth and 0.25” at 12’

$$(3''-0.25'')/(12'-1') = 0.25''/\,ft$$

Diameter = 3” + (0.5’ × 0.25”/ft] = 3.125”

Area of for 1-12’ roots at 0.5’:

Area = $\frac{1}{4}\pi D^2 = \frac{1}{4}\pi(3.125'')^2 = 7.7\ in^2$

Total area of holes in erosion barrier per tree:

Total area = $33.7\ in^2 + 7.7\ in^2 = 41.4\ in^2 \times ft^2/144\ in^2 \approx 0.29\ ft^2$/tree

Total area of holes per acre per 100 years:

400 trees/acre/100 years

Total area = $0.29\ ft^2$/tree × 400 trees/acre/100 years = $116\ ft^2$/ acre/100 years

Year	Vegetation	Area of holes in erosion barrier / acre
0	Bamboo	0
100	Bamboo	0
154	Corn	0
300	Corn	0
550	Corn	0
602	Corn	0
802 [1]	Pine trees	116 ft^2/ acre
1,000	Pine trees	116 ft^2/ acre + [(1000 yrs – 802 yrs) × 116 ft^2/ acre/100 years] = 346 ft^2/ acre
1,800	Pine trees	116 ft^2/ acre + [(1800 yrs – 802 yrs) × 116 ft^2/ acre/100 years] = 1274 ft^2/ acre
3,400	Pine trees	116 ft^2/ acre + [(3400 yrs – 802 yrs) × 116 ft^2/ acre/100 years] = 3130 ft^2/ acre
5,600	Pine trees	116 ft^2/ acre + [(5600 yrs – 802 yrs) × 116 ft^2/ acre/100 years] = 5682 ft^2/ acre
10,000	Pine trees	116 ft^2/ acre + [(10000 yrs – 802 yrs) × 116 ft^2/ acre/100 years] = 10786 ft^2/ acre

[1] 200 years after corn farming ceases (i.e. at year 802) it is assumed that the entire cap is covered with pine (i.e. 400 mature trees per acre). It is assumed that each "generation" of roots becomes instantaneous voids at the 100-year turnover period.

Year	Vegetation	Fraction (f) of erosion barrier area comprising holes
0	Bamboo	0 ÷ 43560 ft^2/ acre = 0
100	Bamboo	0 ÷ 43560 ft^2/ acre = 0
154	Corn	0 ÷ 43560 ft^2/ acre = 0
300	Corn	0 ÷ 43560 ft^2/ acre = 0
550	Corn	0 ÷ 43560 ft^2/ acre = 0
602	Corn	0 ÷ 43560 ft^2/ acre = 0
802	Pine trees	116 ft^2/ acre ÷ 43560 ft^2/ acre = 0.00266
1,000	Pine trees	346 ft^2/ acre ÷ 43560 ft^2/ acre = 0.00794
1,800	Pine trees	1274 ft^2/ acre ÷ 43560 ft^2/ acre = 0.0292
3,400	Pine trees	3130 ft^2/ acre ÷ 43560 ft^2/ acre = 0.0718
5,600	Pine trees	5682 ft^2/ acre ÷ 43560 ft^2/ acre = 0.130
10,000	Pine trees	10786 ft^2/ acre ÷ 43560 ft^2/ acre = 0.248

The equivalent horizontal hydraulic conductivity for horizontal flow in a series of horizontal layers with different saturated hydraulic conductivities can be determined from the following equation (Freeze and Cherry 1979):

$$K_h = \sum_{i=1}^{n} \frac{K_i \ d_i}{d}$$

, where K_h = equivalent horizontal saturated hydraulic conductivity, K_i = horizontal saturated hydraulic conductivity of i^{th} layer, d_i = thickness of i^{th} layer, d = total thickness

In a similar manner the equivalent vertical hydraulic conductivity for vertical flow in a horizontal zone containing areas of materials with different saturated hydraulic conductivities can be determined based upon an area proportionality as follows:

$$K_v = \sum_{i=1}^{n} \frac{K_i \ A_i}{A}$$

, where K_v = equivalent vertical saturated hydraulic conductivity, K_i = vertical saturated hydraulic conductivity of i^{th} layer, A_i = Area of i^{th} layer, A = total area

The following are the input saturated hydraulic conductivities (see above):

Intact erosion barrier = 3.97E-04 cm/s

Granite stone = 3.0E-01 cm/s

The fraction (F) provided above is equivalent to A_i/A for the granite stone that is assumed to fill the holes in the erosion barrier and one minus the fraction (1 – F) is equivalent to A_i/A for the for the intact erosion barrier, making the equation:

$K_v = (3.0E\text{-}01 \times F) + (3.97E\text{-}04 \times (1 - F))$

Year	K_v
0	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
100	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
154	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
300	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
550	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
602	(3.0E-01 cm/s × 0) + (3.97E-04 cm/s × (1 – 0)) = 3.97E-04 cm/s
802	(3.0E-01 cm/s × 0.00266) + (3.97E-04 cm/s × (1 – 0.00266)) = 1.2E-03 cm/s
1,000	(3.0E-01 cm/s × 0.00794) + (3.97E-04 cm/s × (1 – 0.00794)) = 2.8E-03 cm/s
1,800	(3.0E-01 cm/s × 0.0292) + (3.97E-04 cm/s × (1 – 0.0292)) = 9.1E-03 cm/s
3,400	(3.0E-01 cm/s × 0.0718) + (3.97E-04 cm/s × (1 – 0.0718)) = 2.2E-02 cm/s
5,600	(3.0E-01 cm/s × 0.130) + (3.97E-04 cm/s × (1 – 0.130)) = 3.9E-02 cm/s
10,000	(3.0E-01 cm/s × 0.248) + (3.97E-04 cm/s × (1 – 0.248)) = 7.5E-02 cm/s

In an analogous manner the equivalent porosity (n), field capacity (FC), and wilting point (WP) can be determined based upon an area proportionality as follows:

$$n = \sum_{i=1}^{n} n_i \ A_i$$

$$FC = \sum_{i=1}^{n} FC_i \ A_i$$

$$WP = \sum_{i=1}^{n} WP_i \ A_i$$

The following are the input properties (see above):

Material	Porosity	Field Capacity	Wilting Point
Erosion Barrier	0.06	0.056	0.052
Granite Stone	0.397	0.032	0.013

Year	n
0	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
100	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
154	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
300	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
550	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
602	$(0.397 \times 0) + (0.06 \times (1 - 0)) = 0.06$
802	$(0.397 \times 0.00266) + (0.06 \times (1 - 0.00266)) = 0.061$
1,000	$(0.397 \times 0.00794) + (0.06 \times (1 - 0.00794)) = 0.063$
1,800	$(0.397 \times 0.0292) + (0.06 \times (1 - 0.0292)) = 0.070$
3,400	$(0.397 \times 0.0718) + (0.06 \times (1 - 0.0718)) = 0.084$
5,600	$(0.397 \times 0.130) + (0.06 \times (1 - 0.130)) = 0.104$
10,000	$(0.397 \times 0.248) + (0.06 \times (1 - 0.248)) = 0.144$

Year	FC
0	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
100	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
154	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
300	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
550	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
602	$(0.032 \times 0) + (0.056 \times (1 - 0)) = 0.056$
802	$(0.032 \times 0.00266) + (0.056 \times (1 - 0.00266)) = 0.0559$
1,000	$(0.032 \times 0.00794) + (0.056 \times (1 - 0.00794)) = 0.0558$
1,800	$(0.032 \times 0.0292) + (0.056 \times (1 - 0.0292)) = 0.0553$
3,400	$(0.032 \times 0.0718) + (0.056 \times (1 - 0.0718)) = 0.0543$
5,600	$(0.032 \times 0.130) + (0.056 \times (1 - 0.130)) = 0.0529$
10,000	$(0.032 \times 0.248) + (0.056 \times (1 - 0.248)) = 0.050$

Year	WP
0	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
100	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
154	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
300	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
550	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
602	$(0.013 \times 0) + (0.052 \times (1 - 0)) = 0.052$
802	$(0.013 \times 0.00266) + (0.052 \times (1 - 0.00266)) = 0.0519$
1,000	$(0.013 \times 0.00794) + (0.052 \times (1 - 0.00794)) = 0.0517$
1,800	$(0.013 \times 0.0292) + (0.052 \times (1 - 0.0292)) = 0.0509$
3,400	$(0.013 \times 0.0718) + (0.052 \times (1 - 0.0718)) = 0.0492$
5,600	$(0.013 \times 0.130) + (0.052 \times (1 - 0.130)) = 0.0469$
10,000	$(0.013 \times 0.248) + (0.052 \times (1 - 0.248)) = 0.0423$

Summary Erosion Barrier Hydraulic Properties with Time:

Year	K_v	n	FC	WP
0	3.97E-04 cm/s	0.06	0.056	0.052
100	3.97E-04 cm/s	0.06	0.056	0.052
154	3.97E-04 cm/s	0.06	0.056	0.052
300	3.97E-04 cm/s	0.06	0.056	0.052
550	3.97E-04 cm/s	0.06	0.056	0.052
602	3.97E-04 cm/s	0.06	0.056	0.052
802	1.2E-03 cm/s	0.061	0.0559	0.0519
1,000	2.8E-03 cm/s	0.063	0.0558	0.0517
1,800	9.1E-03 cm/s	0.070	0.0553	0.0509
3,400	2.2E-02 cm/s	0.084	0.0543	0.0492
5,600	3.9E-02 cm/s	0.104	0.0529	0.0469
10,000	7.5E-02 cm/s	0.144	0.050	0.0423

Ground Surface Soil Texture:

The soil texture of the ground surface will change over time due to erosion of the topsoil and upper backfill layers and the degradation of the erosion barrier. Soil texture is utilized in the HELP model to determine the SCS Curve Number (CN) and subsequent runoff from the closure cap. The default HELP model ground surface soil textures will be assigned based upon an equivalence between the saturated hydraulic conductivity of the material assumed to be at the ground surface and that of the default HELP model ground surface soil textures.

Default HELP Model Ground Surface Soil Textures:

Year	Ground Surface Material	Ground Surface Material K (cm/s)	HELP Soil Texture	HELP Soil Texture K (cm/s)
0	Topsoil	1.0E-3	5	1.0E-3
100	Topsoil	1.0E-3	5	1.0E-3
154	Backfill	1.0E-4	10	1.2E-4
300	Backfill	1.0E-4	10	1.2E-4
550	Backfill	1.0E-4	10	1.2E-4
602	Erosion Barrier	3.97E-4	8	3.7E-4
802	Erosion Barrier	1.2E-3	5	1.0E-3
1000	Erosion Barrier	2.8E-3	3	3.1E-3
1800	Erosion Barrier	9.1E-3	1	1.0E-2
3400	Erosion Barrier	2.2E-2	1	1.0E-2
5600	Erosion Barrier	3.9E-2	1	1.0E-2
10000	Erosion Barrier	7.5E-2	1	1.0E-2

Upper GCL Holes:

Maintenance during the institutional control period and farming practices during corn farming prevent degradation of the upper GCL. Subsequent to the institutional control period and corn farming after all of the topsoil and upper backfill have been completely eroded, pine forest succession will result in root penetration through the GCL. This allows the overlying drainage layer to fill the holes after the roots decompose. The holes in the GCL essentially act as direct conduits from the upper drainage layer to the lower backfill layer. When saturated conditions occur in the drainage layer after major precipitation events, cones of depression are created around the holes in the GCL with a radius of influence much greater than the radius of the hole. This means that a small area of GCL holes can greatly reduce the lateral flow of water in the drainage layer and increase the vertical flow into the lower backfill.

From Section 4.1 the following assumptions were made relative to the succession of bamboo by a pine forest that result in root penetration into the upper GCL:

- 200 years after the end of farming it is assumed that the entire cap is dominated by pine (i.e. 400 mature trees per acre).
- Complete turnover of the 400 mature trees per acre occurs every 100 years (in a staggered manner).
- There are 400 mature trees per acre with 4 roots to 6 feet and 1 root to 12 feet. The roots are 3 inches in diameter at a depth of 1 foot and 0.25 inches in diameter at either 6 or 12 feet, whichever is applicable.

Area of holes in upper GCL due to root penetration:

Upper GCL Depth (see Table 3.1-1) = 12” + 12” + 12” = 36” = 3’

Root Diameter for 4-6’ roots at 3’:

3” diameter at 1’ depth and 0.25” at 6’

$$(3''-0.25'')/(6'-1') = 0.55''/\,ft$$

Diameter = 0.25” + [(6’ – 3’) × 0.55”/ft] = 1.9”

Area of for 4-6’ roots at 3’:

Area = $4 \times \frac{1}{4}\pi D^2 = \pi D^2 = \pi(1.9'')^2 = 11.3\ in^2$

Root Diameter for 1-12’ root at 3’:

3” diameter at 1’ depth and 0.25” at 12’

$$(3''-0.25'')/(12'-1') = 0.25''/\,ft$$

Diameter = 0.25” + [(12’ – 3’) × 0.25”/ft] = 2.5”

Area of for 1-12’ root at 3’:

Area = $\frac{1}{4}\pi D^2 = \frac{1}{4}\pi(2.5'')^2 = 4.91\ in^2$

Total area of holes in erosion barrier per tree:

Total area = $11.3\ in^2 + 4.91\ in^2 = 16.21\ in^2 \times ft^2/144\ in^2 \approx 0.11\ ft^2$/tree

Total area of holes per acre per 100 years:

400 trees/acre/100 years

Total area = 0.11 ft^2/tree × 400 trees/acre/100 years = 44 ft^2/ acre/100 years

Year	Vegetation	Area of holes in upper GCL / acre due to root penetration
0	Bamboo	0
100	Bamboo	0
154	Corn	0
300	Corn	0
550	Corn	0
602	Corn	0
802[1]	Pine trees	44 ft^2/ acre
1,000	Pine trees	44 ft^2/ acre + [(1000 yrs – 802 yrs) × 44 ft^2/ acre/100 years = 131 ft^2/ acre
1,800	Pine trees	44 ft^2/ acre + [(1800 yrs – 802 yrs) × 44 ft^2/ acre/100 years = 483 ft^2/ acre
3,400	Pine trees	44 ft^2/ acre + [(3400 yrs – 802 yrs) × 44 ft^2/ acre/100 years = 1187 ft^2/ acre
5,600	Pine trees	44 ft^2/ acre + [(5600 yrs – 802 yrs) × 44 ft^2/ acre/100 years = 2155 ft^2/ acre
10,000	Pine trees	44 ft^2/ acre + [(10000 yrs – 802 yrs) × 44 ft^2/ acre/100 years = 4091 ft^2/ acre

[1] 200 years after corn farming ceases (i.e. at year 802) it is assumed that the entire cap is covered with pine (i.e. 400 mature trees per acre)

Number of one-square-centimeter holes in upper GCL per acre due to root penetration (each HELP model installation defect for a flexible membrane liner (FML) is assumed to be one square centimeter):

1 cm^2 = 0.001076391 ft^2 so 0.001076391 ft^2/installation defect

Year	Percent of GCL area degraded due to root penetration
0	0
100	0
154	0
300	0
550	0
602	0
802	(44 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 0.10
1,000	(131 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 0.30
1,800	(483 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 1.11
3,400	(1187 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 2.72
5,600	(2155 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 4.95
10,000	(4091 ft^2/ acre ÷ 43560 ft^2/ acre) × 100 = 9.39

Year	# of installation defects in upper GCL / acre due to root penetration
0	0
100	0
154	0
300	0
550	0
602	0
802	44 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 40,877
1,000	131 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 121,703
1,800	483 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 448,722
3,400	1187 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 1,102,759
5,600	2155 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 2,002,060
10,000	4091 ft^2/ acre ÷ 0.001076391 ft^2/installation defect = 3,800,664

The number of installation defects that can entered into the HELP model is limited to a maximum of 999,999. Therefore the number of installation defects calculated above for years 3,400, 5,600, and 10,000 can not be entered. As outlined in Phifer 2003 the upper GCL becomes ineffective as a barrier layer when holes comprise 0.29 percent of the layer’s area. Therefore for determination of the flux at years 3,400, 5,600, and 10,000, the GCL will be assigned as a barrier soil liner with the same material properties as the overlying upper drainage layer.

Year	HELP Model Layer Type	# of installation defects
0	3	NA
100	3	NA
154	3	NA
300	3	NA
550	3	NA
602	3	NA
802	4	40,877
1,000	4	121,703
1,800	4	448,722
3,400	3	NA
5,600	3	NA
10,000	3	NA

Middle Backfill Layer and Upper Drainage Layer Hydraulic Properties:

It is assumed that colloidal clay migration from the 1-foot-thick middle backfill to the underlying 1-foot-thick upper drainage layer causes the middle backfill saturated hydraulic conductivity to increase over time and that of the upper drainage layer to decrease over time.

Determine mass of clay to fill upper drainage layer void volume (0.38):

Assume clay bulk density is 1.1 g/cm^3

Look at a 1-ft^2 area of the 1-foot-thick upper drainage layer (i.e. 1 ft^3)

Void volume = 0.38 $\times$ 1 ft^3 = 0.38 ft^3

Clay mass per ft^3 = 1.1 g/cm^3 $\times$ 0.38 ft^3 $\times$ 2.831685E-02 m^3/ft^3 $\times$ 1,000,000 cm^3/m^3 = 11,836.3 g

Determine available clay mass in the middle backfill layer:

Assume that the middle backfill layer consists of 20% clay and 80% sand with a dry bulk density of 104-lbs/ft^3.

Clay mass = 104 lbs/ft^3 $\times$ 0.20 $\times$ 453.59 g/lbs = 9,434.7 g/ft^3

There is not enough clay in the middle backfill layer to fill the upper drainage layer. Therefore it will be assumed that half the clay content of the middle backfill migrates into the upper drainage layer, at which point the two layers essentially become the same material and material property changes cease. Based upon this it will be assumed that the endpoint saturated hydraulic conductivity of the layers will become that of the log mid-point between the initial backfill and upper drainage layer conditions. It will also be assumed that the endpoint porosity, field capacity, and wilting point will become the arithmetic average of the backfill and upper drainage layer.

Endpoint hydraulic properties:

Intact hydraulic properties:

Hydraulic Parameter	Middle Backfill	Upper Drainage Layer
K	1.0E-04 cm/s	1.0E-01 cm/s
n	0.37	0.38
FC	0.24	0.08
WP	0.136	0.013

Endpoint saturated hydraulic conductivity:

Middle backfill: K_{MB} = 0.0001; log K_{MB} = -4

Upper drainage layer: K_{UDL} = 0.1; log K_{UDL} = -1

Log mid-point: $$\frac{Log\ K_{MB} + Log\ K_{UDL}}{2} = \frac{-1 + (-4)}{2} = -2.5$$

$K_E = 10^{-2.5}$ = 3.2E-03 cm/s

Endpoint n, FC, and WP:

n = (0.37 + 0.38)/2 = 0.375

FC = (0.24 + 0.08)/2 = 0.16

WP = (0.136 + 0.013)/2 = 0.0745

It will be assumed that the clay migrates out of the middle backfill into the upper drainage layer with the water flux containing 63 mg/L of colloidal clay. It will also be assumed that the time to achieve the endpoint conditions will be based upon the estimated water flux into the upper drainage layer and migration of half the clay content of the middle backfill layer (i.e. 9,434.7 g/ft^3 ÷ 2 = 4717.4 g/ft^3).

Determine flux of water into the upper drainage layer:

Section 3.4 intact SDF closure cap Modeling determined the following average annual flux of water into the upper drainage layer (see Appendix E):

Precipitation = 48.90 inches/year

Runoff = 0.154 inches/year

Evapotranspiration = 34.582 inches/year

Flux of water into upper drainage layer = Precipitation – (Runoff + Evapotranspiration)

Flux of water into upper drainage layer = 48.90 in/yr – (0.154 in/yr + 34.582 in/yr)

Flux of water into upper drainage layer = 14.164 in/yr

The above flux is based upon the best-case cap conditions. Therefore, a water flux into the upper drainage layer that is calculated close to the anticipated time when the endpoint properties are reached is needed. Within Phifer 2003 the endpoint properties were reached in year 2246 based upon a water flux into the upper drainage layer of ~14.2 in/yr. Higher water fluxes into the upper drainage layer are anticipated for this scenario for latter times, which should result the endpoint being reached sooner. Therefore will determine the flux based upon the preliminary 1,800 year conditions as follows:

- The topsoil and upper backfill are completely eroded away at year 1,800 year (see above).
- 1,800 year erosion barrier conditions with K = 9.1E-03 cm/s; n = 0.070; FC = 0.0553; WP = 0.0509 (see above).
- 1,800 HELP model soil texture class of 1 (see above).
- Middle backfill and upper drainage layer at end state conditions with K = 3.2E-03 cm/s; n = 0.375; FC = 0.16; WP = 0.0745 (see above). In Phifer 2003 for the base case scenario the end state conditions were determined to occur at year 2246, therefore end state conditions at year 1,800 should be a reasonable assumption for this scenario.
- Upper GCL as a flexible membrane liner (layer type #4) 448,722 installation defects (see above).
- Lower drainage layer with intact backfill properties (used since 1,800 year conditions not yet determined).
- The detailed HELP model input data and output file associated with the preliminary 1,800-year conditions is provided at the end of this appendix. The following are the pertinent values extracted from the output file:

  Precipitation = 48.90 inches/year

  Runoff = 0.000 inches/year

  Evapotranspiration = 27.492 inches/year

  Flux of water into upper drainage layer = Precipitation – (Runoff + Evapotranspiration)

  Flux of water into upper drainage layer = 48.90 in/yr – (0.000 in/yr + 27.492 in/yr)

  Flux of water into upper drainage layer = 21.408 in/yr

Will take the average of the initial and 1,800 years fluxes as the water flux into the upper drainage layer for determination of the middle backfill and upper drainage layer properties over time:

Average flux into upper drainage layer = (14.164 in/yr + 21.408 in/yr) / 2 = 17.786 in/yr

Determine yearly clay migration into the upper drainage layer:

Flux into upper drainage layer ≈ 17.8 in/yr

Colloidal clay concentration = 63 mg/L

Flux through a 1 ft^2 area = 17.8 in/yr × ft/12 in × 1 ft^2 = 1.48 ft^2/yr

Clay flux = 1.48 ft^2/yr × 63 mg/L × 2.831685E-02 m^3/ ft^3 × 1000L/ m^3 = 2,640 mg/yr = 2.64 g/yr

Determine time it takes for the 4717.4 g of clay to migrate from the middle backfill layer to the upper drainage layer:

Time = 4717.4 g ÷ 2.64 g/yr = 1,787 years

Determine middle backfill and upper drainage layer hydraulic property variation with time:

It will be assumed that the K of the middle backfill layer is increasing log linearly with time from 1.0E-04 cm/s to 3.2E-03 cm/s, until year 1,787 at which time the K becomes static. Conversely it will be assumed that the K of the upper drainage layer is decreasing log linearly with time from 1.0E-01 cm/s to 3.2E-03 cm/s, until year 1,787 at which time the K becomes static. Porosity (n), FC, and WP will be assumed to behave similarly but in an arithmetic linear manner.

Initial and End State hydraulic properties:

Hydraulic Parameter	Initial Middle Backfill	Initial Upper Drainage Layer	End State at 1,787 years
K	1.0E-04 cm/s	1.0E-01 cm/s	3.2E-03 cm/s
n	0.37	0.38	0.375
FC	0.24	0.08	0.16
WP	0.136	0.013	0.0745

Determine fraction change for each year:

Year	Fraction
0	0 ÷ 1787 = 0
100	100 ÷ 1787 = 0.056
154	154 ÷ 1787 = 0.0862
300	300 ÷ 1787 = 0.168
550	550 ÷ 1787 = 0.308
602	602 ÷ 1787 = 0.337
802	802 ÷ 1787 = 0.449
1,000	1000 ÷ 1787 = 0.560
1,800	1.0
3,400	1.0
5,600	1.0
10,000	1.0

Determine variation in K, n, FC, and WP with time in the middle backfill:

Year	Fraction, F	K [1] (cm/s)	n [2]	FC [3]	WP [4]
0	0	0.0001	0.37	0.24	0.136
100	0.056	0.00012	0.37	0.236	0.132
154	0.0862	0.00014	0.37	0.233	0.131
300	0.168	0.00018	0.371	0.226	0.126
550	0.308	0.00029	0.372	0.215	0.117
602	0.337	0.00032	0.372	0.213	0.115
802	0.449	0.00047	0.372	0.204	0.108
1,000	0.560	0.00069	0.373	0.195	0.102
1,800	1.0	0.0032	0.375	0.16	0.0745
3,400	1.0	0.0032	0.375	0.16	0.0745
5,600	1.0	0.0032	0.375	0.16	0.0745
10,000	1.0	0.0032	0.375	0.16	0.0745

[1] $K = 10^{[-4 + ((-2.5 - (-4))F)]} = 10^{(-4 + 1.5F)}$

[2] n = 0.37 + (0.375 – 0.37)F

[3] FC = 0.24 – (0.24 – 0.16)F

[4] WP = 0.136 – (0.136 – 0.0745)F

Determine variation in K, n, FC, and WP with time in the upper drainage layer:

Year	Fraction, F	K [1] (cm/s)	n [2]	FC [3]	WP [4]
0	0	0.1	0.38	0.08	0.013
100	0.056	0.082	0.38	0.084	0.0164
154	0.0862	0.074	0.38	0.087	0.0183
300	0.168	0.056	0.379	0.093	0.0233
550	0.308	0.034	0.378	0.105	0.0319
602	0.337	0.031	0.378	0.107	0.0337
802	0.449	0.021	0.378	0.116	0.0406
1,000	0.560	0.014	0.377	0.125	0.0474
1,800	1.0	0.0032	0.375	0.16	0.0745
3,400	1.0	0.0032	0.375	0.16	0.0745
5,600	1.0	0.0032	0.375	0.16	0.0745
10,000	1.0	0.0032	0.375	0.16	0.0745

[1] $K = 10^{[-1 + ((-2.5 - (-1))F)]} = 10^{(-1 - 1.5F)}$

[2] n = 0.38 – (0.38 – 0.375)F

[3] FC = 0.08 + (0.16 – 0.08)F

[4] WP = 0.013 + (0.0745 – 0.013)F

Lower Drainage Layer Hydraulic Properties:

It is assumed that colloidal clay migration from the minimum 5-foot-thick overlying backfill into the 2-foot-thick lower drainage layer is driven by the water flux through the upper GCL. This water flux driven clay migration enters into the lower drainage layer and fills the lower drainage layer from the bottom up. This reduces the saturated hydraulic conductivity of the clay-filled portion from 1.0E-01 to 1.0E-04 cm/s (i.e. to the saturated hydraulic conductivity of the overlying backfill), while the conductivity of the clean portion remains at 1.0E-01 cm/s. As the thickness of the lower drainage layer filled with clay increases, the equivalent hydraulic conductivity of the entire layer decreases. This is different from that assumed for the upper drainage layer since the lower drainage layer has significantly more backfill overlying it. The HELP model was run for each year with all of the previously degraded properties (see above) without degradation of the lower drainage layer in order to determine the infiltration through the upper GCL. The results are as follows:

Year	Infiltration through upper GCL (inches/year)
0	0.36170
100	0.43127
154	0.42058
300	0.56138
550	1.21999
602	1.37415
802	16.11727
1,000	19.46389
1,800	21.31867
3,400	21.42358
5,600	21.13124
10,000	20.05366

It is assumed that there is a linear change in the infiltration over time between data points.

Determine cumulative volume of water through the lower drainage layer over time:

Year	Infiltration through upper GCL (inches/year)	Time Step Infiltration [1] (inches)	Cumulative Infiltration [2] (inches)	Cumulative Volume over one ft^2 area [3] (ft^3)
0	0.36170	0	0	0
100	0.43127	39.648	39.648	3.304
154	0.42058	23.000	62.648	5.221
300	0.56138	71.683	134.331	11.194
550	1.21999	222.671	357.002	29.750
602	1.37415	67.448	424.450	35.371
802	16.11727	1,749.142	2,173.592	181.133
1,000	19.46389	3,522.535	5,696.127	474.677
1,800	21.31867	16,313.024	22,009.151	1,834.096
3,400	21.42358	34,193.800	56,202.951	4,683.579
5,600	21.13124	46,810.302	103,013.253	8,584.438
10,000	20.05366	90,606.780	193,620.033	16,135.003

[1] Time Step Infiltration $=[I_1 \times (T_2 - T_1)] + [1/2 \times (I_2 - I_1)(T_2 - T_1)]$, where I = infiltration at time 1 or 2; T = time at time 1 or 2

[2] Cumulative Infiltration = Previous cumulative Infiltration + Time Step Infiltration at current time step

[3] Cumulative Volume over one ft^2 area = (Cumulative Infiltration $\div$ 12 in/ft) $\times$ 1 ft^2

Determine mass of clay to fill lower drainage layer void volume (0.38):

Assume clay bulk density is 1.1 g/cm^3

Look at a 1-ft^2 area of the 2-foot-thick upper drainage layer (i.e. 2 ft^3)

Void volume = 0.38 $\times$ 2 ft^3 = 0.76 ft^3

Clay mass per ft^3 = 1.1 g/cm^3 $\times$ 0.76 ft^3 $\times$ 2.831685E-02 m^3/ft^3 $\times$ 1,000,000 cm^3/m^3 = 23,672.9 g

Determine total flux of water into the lower drainage layer required to completely fill it with clay:

It will be assumed that the clay migrates out of the lower backfill into the lower drainage layer with the water flux containing 63 mg/L of colloidal clay.

$$V = \frac{23{,}672.9\ g \times 1000\ mg/g}{63\ mg/L \times 28.31685\ L/\ ft^3} = 13{,}269.8\ ft^3$$

Determine the mass of clay that has migrated into the lower drainage layer at the end of each time step:

Year	Mass of clay into lower drainage layer
0	0
100	3.3 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 5.9 g
154	5.2 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 9.3 g
300	11.2 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 20.0 g
550	29.75 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 53.1 g
602	35.4 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 63.2 g
802	181.1 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 323.1 g
1,000	474.7 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 846.8 g
1,800	1,834.1 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 3,272.0 g
3,400	4,683.6 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 8,355.4 g
5,600	8,584.4 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 15,314.3 g
10,000	16,135.0 $ft^3 \times$ 63 mg/L $\times$ 28.31685 L/ $ft^3 \times$ g/1000 mg = 28,784.2 g

Determine the fraction of the lower drainage layer filled at the end of each time step:

Year	Fraction of the lower drainage layer filled
0	0
100	5.9 g ÷ 23,672.9 g = 0.000249
154	9.3 g ÷ 23,672.9 g = 0.000393
300	20.0 g ÷ 23,672.9 g = 0.000845
550	53.1 g ÷ 23,672.9 g = 0.00224
602	63.2 g ÷ 23,672.9 g = 0.00267
802	323.1 g ÷ 23,672.9 g = 0.0136
1,000	846.8 g ÷ 23,672.9 g = 0.0358
1,800	3,272.0 g ÷ 23,672.9 g = 0.138
3,400	8,355.4 g ÷ 23,672.9 g = 0.353
5,600	15,314.3 g ÷ 23,672.9 g = 0.647
10,000	28,784.2 g ÷ 23,672.9 g = 1.216 (the fraction can not be greater than 1.0; this indicates that the lower drainage layer is completely fill prior to year 10,000)

The following are the hydraulic properties of the clean and clay filled portion of the lower drainage layer:

Material	Saturated Hydraulic Conductivity (cm/s)	Porosity	Field Capacity	Wilting Point
Clean	1.0E-01	0.38	0.08	0.013
Clay filled	1.0E-04	0.22 (see below)	0.21 (see below)	0.20 (see below)

Determine the porosity of the clay filled portion of the lower drainage layer:

Porosity of the clay:

Assumed clay bulk density, ρ_b = 1.1 g/cm^2

Assumed clay particle density, ρ_p = 2.6 g/cm^2

Resulting clay porosity, $n = 1 - \frac{\rho_b}{\rho_p} = 1 - \frac{1.1\ g/cm^2}{2.6\ g/cm^2} = 0.58$

Porosity of the clay filled portion = Porosity of clean portion × porosity of clay

Porosity of the clay filled portion = 0.38 × 0.58 = 0.22

Determine the field capacity and wilting point of the clay filled portion of the lower drainage layer:

Will assume that the field capacity and wilting point of the clay fill portion has the same ratio versus its porosity of 0.22 as the equivalent ratio for kaolin clay.

From WSRC 2002 the following kaolin properties are found: n = 0.56; FC = 0.55; WP = 0.50

FC = 0.22 × (0.55 ÷ 0.56) ≈ 0.21

WP = 0.22 × (0.50 ÷ 0.56) ≈ 0.20

Determine the equivalent horizontal hydraulic conductivity of the lower drainage layer over time:

The equivalent horizontal hydraulic conductivity for horizontal flow in a series of horizontal layers with different saturated hydraulic conductivities can be determined from the following equation (Freeze and Cherry 1979):

$$K_h = \sum_{i=1}^{n} \frac{K_i \; d_i}{d}$$

, where K_h = equivalent horizontal saturated hydraulic conductivity, K_i = horizontal saturated hydraulic conductivity of i^{th} layer, d_i = thickness of i^{th} layer, d = total thickness

The fraction, F, equals d_i/d for the clay filled portion and d_i/d for the clean drainage layer material equals (1 – F), making the equation:

$$K_h = \left(K_{filled} \times F\right) + \left[K_{clean} \times (1 - F)\right]$$

Year	Equivalent K (cm/s)
0	0.1
100	(0.0001 × 0.000249) + [0.1 × (1 – 0.000249)] = 0.1
154	(0.0001 × 0.000393) + [0.1 × (1 – 0.000393)] = 0.1
300	(0.0001 × 0.000845) + [0.1 × (1 – 0.000845)] = 0.0999
550	(0.0001 × 0.00224) + [0.1 × (1 – 0.00224)] = 0.0998
602	(0.0001 × 0.00267) + [0.1 × (1 – 0.00267)] = 0.0997
802	(0.0001 × 0.0136) + [0.1 × (1 – 0.0136)] = 0.986
1,000	(0.0001 × 0.0358) + [0.1 × (1 – 0.0358)] = 0.0964
1,800	(0.0001 × 0.138) + [0.1 × (1 – 0.138)] = 0.0862
3,400	(0.0001 × 0.353) + [0.1 × (1 – 0.353)] = 0.0647
5,600	(0.0001 × 0.647) + [0.1 × (1 – 0.647)] = 0.0354
10,000	(0.0001 × 1.0) + [0.1 × (1 – 1.0)] = 0.0001

Determine the equivalent n, FC, and WP for the lower drainage layer over time:

In an analogous manner to that for K, the equivalent n, FC, and WP can be determined based upon the fraction filled as follows:

$$n = \left(n_{filled} \times F\right) + \left[n_{clean} \times (1 - F)\right]$$

$$FC = \left(FC_{filled} \times F\right) + \left[FC_{clean} \times (1 - F)\right]$$

$$WP = \left(WP_{filled} \times F\right) + \left[WP_{clean} \times (1 - F)\right]$$

Year	Equivalent n
0	(0.22 × 0) + [0.38 × (1 - 0)] = 0.38
100	(0.22 × 0.000249) + [0.38 × (1 – 0.000249)] = 0.38
154	(0.22 × 0.000393) + [0.38 × (1 – 0.000393)] = 0.38
300	(0.22 × 0.000845) + [0.38 × (1 – 0.000845)] = 0.38
550	(0.22 × 0.00224) + [0.38 × (1 – 0.00224)] = 0.38
602	(0.22 × 0.00267) + [0.38 × (1 – 0.00267)] = 0.38
802	(0.22 × 0.0136) + [0.38 × (1 – 0.0136)] = 0.378
1,000	(0.22 × 0.0358) + [0.38 × (1 – 0.0358)] = 0.374
1,800	(0.22 × 0.138) + [0.38 × (1 – 0.138)] = 0.358
3,400	(0.22 × 0.353) + [0.38 × (1 – 0.353)] = 0.324
5,600	(0.22 × 0.647) + [0.38 × (1 – 0.647)] = 0.276
10,000	(0.22 × 1.0) + [0.38 × (1 – 1.0)] = 0.22

Year	Equivalent FC
0	(0.21 × 0) + [0.08 × (1 - 0)] = 0.08
100	(0.21 × 0.000249) + [0.08 × (1 - 0.000249)] = 0.08
154	(0.21 × 0.000393) + [0.08 × (1 - 0.000393)] = 0.08
300	(0.21 × 0.000845) + [0.08 × (1 - 0.000845)] = 0.08
550	(0.21 × 0.00224) + [0.08 × (1 - 0.00224)] = 0.0803
602	(0.21 × 0.00267) + [0.08 × (1 - 0.00267)] = 0.0803
802	(0.21 × 0.0136) + [0.08 × (1 - 0.0136)] = 0.0818
1,000	(0.21 × 0.0358) + [0.08 × (1 - 0.0358)] = 0.0846
1,800	(0.21 × 0.138) + [0.08 × (1 - 0.138)] = 0.0979
3,400	(0.21 × 0.353) + [0.08 × (1 - 0.353)] = 0.126
5,600	(0.21 × 0.647) + [0.08 × (1 - 0.647)] = 0.164
10,000	(0.21 × 1.0) + [0.08 × (1 – 1.0)] = 0.21

Year	Equivalent WP
0	(0.20 × 0) + [0.013 × (1 - 0)] = 0.013
100	(0.20 × 0.000249) + [0.013 × (1 - 0.000249)] = 0.013
154	(0.20 × 0.000393) + [0.013 × (1 - 0.000393)] = 0.0131
300	(0.20 × 0.000845) + [0.013 × (1 - 0.000845)] = 0.0132
550	(0.20 × 0.00224) + [0.013 × (1 - 0.00224)] = 0.0134
602	(0.20 × 0.00267) + [0.013 × (1 - 0.00267)] = 0.0135
802	(0.20 × 0.0136) + [0.013 × (1 - 0.0136)] = 0.0155
1,000	(0.20 × 0.0358) + [0.013 × (1 - 0.0358)] = 0.0197
1,800	(0.20 × 0.138) + [0.013 × (1 - 0.138)] = 0.0388
3,400	(0.20 × 0.353) + [0.013 × (1 - 0.353)] = 0.0790
5,600	(0.20 × 0.647) + [0.013 × (1 - 0.647)] = 0.134
10,000	(0.20 × 0.) + [0.013 × (1 - 0.)] = 0.20

Summary Lower Drainage Layer Hydraulic Properties with Time:

Year	K (cm/s)	n	FC	WP
0	0.1	0.38	0.08	0.013
100	0.1	0.38	0.08	0.013
154	0.1	0.38	0.08	0.0131
300	0.0999	0.38	0.08	0.0132
550	0.0998	0.38	0.0803	0.0134
602	0.0997	0.38	0.0803	0.0135
802	0.0986	0.378	0.0818	0.0155
1,000	0.0964	0.374	0.0846	0.0197
1,800	0.0862	0.358	0.0979	0.0388
3,400	0.0647	0.324	0.126	0.0790
5,600	0.0354	0.276	0.164	0.134
10,000	0.0001	0.22	0.21	0.20

The HELP model was rerun for each time step with all of the degraded properties (see above) including that of the lower drainage layer. Infiltration through the upper GCL did not change with the addition of the degraded lower drainage layer properties. Therefore the above estimated lower drainage layer hydraulic properties over time are verified.

Infiltration through the Upper GCL at Complete Degradation

The infiltration through the upper GCL at complete degradation and the associated time of occurrence have been determined based upon the following:

- As outlined above at year 10,000 all layers except the erosion barrier have reached their assumed degradation endpoint. Therefore the properties of all layers except the erosion barrier will be assigned their year 10,000 values.
- As outlined in Table 4.4-2 complete degradation of the erosion barrier is assumed to result in separation and segregation of the granite stone and flowable fill with the granite stone located on top of the broken up flowable fill. As previous done for the purposes of this calculation the properties of the broken up flowable fill will be ignored. Therefore the properties of the completely degraded erosion barrier are those of the granite stone as shown below:

Material	Saturated Hydraulic Conductivity (cm/s)	Porosity	Field Capacity	Wilting Point
Completely Degraded Erosion Barrier (i.e. Granite Stone)	3.0E-01	0.397	0.032	0.013

The above parameter values for the completely degraded erosion barrier (i.e. granite stone) replaced the previous year 10,000 HELP run to determine infiltration at complete degradation. The detailed HELP model input data and output file associated with this completely degraded case are provided at the end of this appendix. The infiltration through the upper GCL at complete degradation was determined to be 18.59674 inches/year.

Determine time required for complete degradation of the erosion barrier:

Complete degradation of the erosion barrier will occur after pine trees have completely penetrated the entire area.

From previous erosion barrier calculations:

$$116 \text{ ft}^2\text{/ acre} + [(X - 802 \text{ yrs}) \times 116 \text{ ft}^2\text{/ acre/100 years}] = 43{,}560 \text{ ft}^2\text{/ acre}$$

$$(X - 802 \text{ yrs}) \times 116 \text{ ft}^2\text{/ acre/100 years} = 43{,}444 \text{ ft}^2\text{/ acre}$$

X – 802 yrs = 37,452 yrs

X = 38,254 yrs

Year that Lower Drainage Layer Completely Silts In

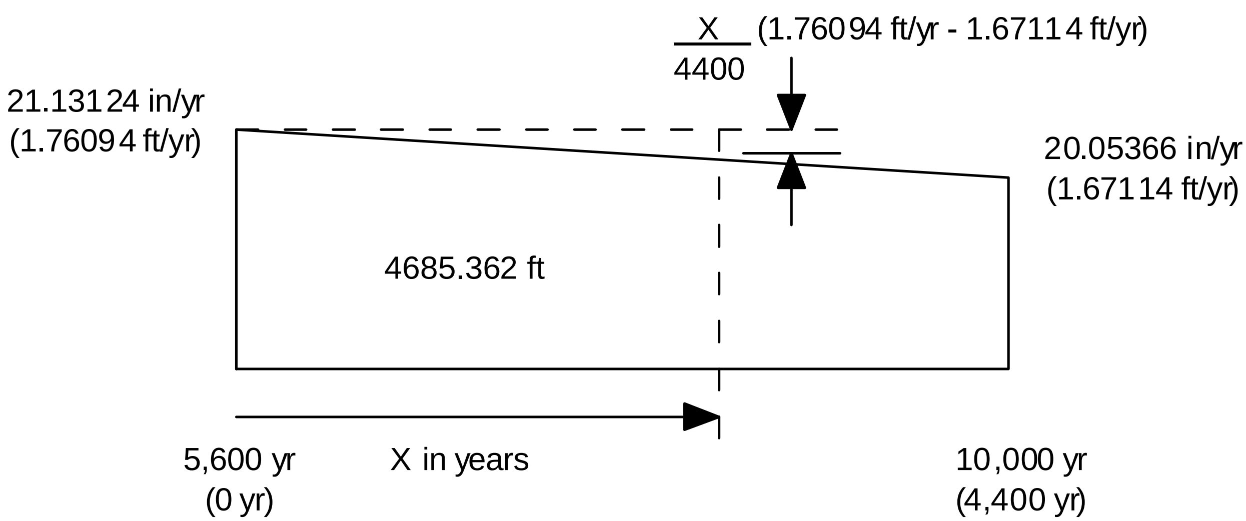
From previous calculations above the following were determined:

- It takes a total of 13,269.8 ft^3 of infiltrating water to completely silt in the lower drainage layer.
- The lower drainage layer completely silts in between year 5,600 and 10,000.
- Through year 5,600 the infiltrating water volume was 8,584.438 ft^3.
- At year 5,600 the infiltration through the upper GCL was 21.13124 inches/year, and at year 10,000 it was 20.05366 inches/year.
- It is assumed that infiltration varies linearly between year 5,600 and year 10,000.

Determine water volume remaining after year 5,600 to completely silt in the lower drainage layer:

V = 13,269.8 ft^3 – 8,584.438 ft^3 = 4,685.362 ft^3

Determine time to completely silt in the lower drainage layer:



$$1.76094\ ft/yr\ X - \frac{1}{2}X\left[\frac{X}{4{,}400\ yr}\left(1.76094\ ft/yr - 1.67114\ ft/yr\right)\right] = 4{,}685.362\ ft$$

$$1.76094\ ft/yr\ X - 1.02E-5\ ft/yr^2\ X^2 = 4{,}685.362\ ft$$

Determine X:

X	4,685.362
3,000	5,191.02
2,500	4,338.6
2,700	4,680.18
2,703	4,685.3 (close enough!)

Year lower drainage layer completely silts in:

Year = 5,600 + 2,703 = 8,303

At year 8,803 the lower drainage layer completely silts in and has the following properties: saturated hydraulic conductivity = 1.0E-04 cm/s; porosity = 0.22; field capacity = 0.21; wilting point = 0.20.

Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (Preliminary 1,800 Years): HELP Model Input Data and Output Files (output file name: ZUBSP18o.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 in
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.90	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	4 (flexible membrane liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.070	0.0553	0.0509	0.0553
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4 *	4	0.2		0.75	0.747	0.040	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.38	0.08	0.013	0.08
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data is missing from the table.

* The input porosity, field capacity, and wilting point values of the upper GCL are ignored by the HELP model, since the upper GCL is designated as an geomembrane in order for the HELP model to take into account the holes produced by root penetration.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	9.1E-03					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	4	5.00E-09					
5	1	1.00E-04					
6	2	1.00E-01	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	4	0	448,722	1	
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data is missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSP18.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSP18o.OUT

TIME:  10:57     DATE:   1/ 9/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - Preliminary 1,800 yrs

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.0700 VOL/VOL
           FIELD CAPACITY              =     0.0553 VOL/VOL
           WILTING POINT               =     0.0509 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.0553 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.910000037000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.3750 VOL/VOL
           FIELD CAPACITY              =     0.1600 VOL/VOL
           WILTING POINT               =     0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3750 VOL/VOL
FIELD CAPACITY              =      0.1600 VOL/VOL
WILTING POINT               =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   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.   =  0.499999997000E-08 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    = 448722.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  1 - PERFECT

                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3800 VOL/VOL
FIELD CAPACITY              =      0.0800 VOL/VOL
WILTING POINT               =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.100000001000     CM/SEC
SLOPE                       =     11.40   PERCENT
DRAINAGE LENGTH             =    150.0    FEET
```

```
                      LAYER  7
                      --------

           TYPE 3 - BARRIER SOIL LINER
           MATERIAL TEXTURE NUMBER   0
 THICKNESS                   =     0.20   INCHES
 POROSITY                    =     0.7500 VOL/VOL
 FIELD CAPACITY              =     0.7470 VOL/VOL
 WILTING POINT               =     0.4000 VOL/VOL
 INITIAL SOIL WATER CONTENT  =     0.7500 VOL/VOL
 EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =    26.90
FRACTION OF AREA ALLOWING RUNOFF   =   100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =    19.630  ACRES
EVAPORATIVE ZONE DEPTH             =    22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =     2.264  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =     4.590  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =     1.356  INCHES
INITIAL SNOW WATER                 =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =    20.630  INCHES
TOTAL INITIAL WATER                =    20.630  INCHES
TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR

          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          AUGUSTA               GEORGIA

     STATION LATITUDE                        =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   3.50
     START OF GROWING SEASON (JULIAN DATE)   =     68
     END OF GROWING SEASON (JULIAN DATE)     =    323
     EVAPORATIVE ZONE DEPTH                  =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  73.00 %

 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    AUGUSTA             GEORGIA
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.533	1.848	2.491	2.259	2.667	3.342
	3.735	3.302	2.593	1.394	1.079	1.249
STD. DEVIATIONS	0.293	0.300	0.645	0.744	1.019	1.215
	1.151	1.059	0.903	0.614	0.322	0.226

LATERAL DRAINAGE COLLECTED FROM LAYER 3

TOTALS	0.0108	0.0062	0.0084	0.0026	0.0036	0.0052
	0.0074	0.0075	0.0065	0.0050	0.0054	0.0072
STD. DEVIATIONS	0.0074	0.0052	0.0067	0.0028	0.0049	0.0051
	0.0064	0.0080	0.0065	0.0061	0.0052	0.0059

PERCOLATION/LEAKAGE THROUGH LAYER 4

TOTALS	3.0512	1.7476	2.3858	0.7227	1.0296	1.4571
	2.1022	2.0406	1.8313	1.4116	1.5195	2.0197
STD. DEVIATIONS	2.0978	1.4638	1.8930	0.7843	1.3935	1.4405
	1.8048	1.9848	1.8437	1.7074	1.4556	1.6787

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	2.5956	2.1551	2.2481	1.6060	1.0289	1.1417
	1.8238	2.0841	1.8564	1.6368	1.3646	1.6380
STD. DEVIATIONS	1.9272	1.5168	1.6230	1.0743	0.8091	1.0756
	1.4530	1.7694	1.4302	1.3590	1.2418	1.2948

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	0.0102	0.0090	0.0097	0.0082	0.0072	0.0069
	0.0084	0.0091	0.0087	0.0083	0.0075	0.0080
STD. DEVIATIONS	0.0041	0.0032	0.0033	0.0023	0.0017	0.0027
	0.0036	0.0039	0.0030	0.0031	0.0028	0.0032

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.2885	0.1810	0.2256	0.0705	0.0973	0.1424
	0.1988	0.2001	0.1790	0.1336	0.1484	0.1909
STD. DEVIATIONS	0.1985	0.1519	0.1791	0.0766	0.1318	0.1408
	0.1708	0.2119	0.1803	0.1619	0.1423	0.1588

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	0.1969	0.1792	0.1705	0.1259	0.0780	0.0895
	0.1383	0.1581	0.1455	0.1241	0.1069	0.1242
STD. DEVIATIONS	0.1462	0.1263	0.1231	0.0842	0.0614	0.0843
	0.1102	0.1342	0.1121	0.1031	0.0973	0.0982

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	27.492	(2.7375)	1959003.12	56.221
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.07578	(0.02295)	5399.602	0.15496
PERCOLATION/LEAKAGE THROUGH LAYER 4	21.31867	(6.36277)	1519102.370	43.59638
AVERAGE HEAD ON TOP OF LAYER 4	0.171	(0.052)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	21.17908	(6.39207)	1509155.370	43.31091
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.10113	(0.01490)	7206.182	0.20681
AVERAGE HEAD ON TOP OF LAYER 7	0.136	(0.041)		
CHANGE IN WATER STORAGE	0.052	(1.8590)	3704.81	0.106

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             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  3            0.02213       1576.94116

      PERCOLATION/LEAKAGE THROUGH LAYER  4        3.401600    242387.45300

      AVERAGE HEAD ON TOP OF LAYER  4            17.964

      MAXIMUM HEAD ON TOP OF LAYER  4            27.399

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)               113.1 FEET

      DRAINAGE COLLECTED FROM LAYER  6            1.77993     126832.40600

      PERCOLATION/LEAKAGE THROUGH LAYER  7        0.003729       265.69943

      AVERAGE HEAD ON TOP OF LAYER  7             4.185

      MAXIMUM HEAD ON TOP OF LAYER  7             7.565

      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)                12.7 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.1959

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0616

       ***  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	0.8162	0.0680
2	2.4742	0.2062
3	2.5665	0.2139
4	0.0000	0.0000
5	17.8803	0.3053
6	1.9425	0.0809
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (38,254 Years): HELP Model Input Data and Output File (output file name: ZUBSD12o.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.397	0.032	0.013	0.032
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4	3	0.2		0.375	0.16	0.0745	0.375
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.22	0.21	0.20	0.21
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.00E-01					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	3	3.20E-03					
5	1	1.00E-04					
6	2	1.00E-04	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD12.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD12o.OUT

TIME:  16: 8     DATE:   2/ 9/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 38,254 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.3970 VOL/VOL
           FIELD CAPACITY              =     0.0320 VOL/VOL
           WILTING POINT               =     0.0130 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.0320 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.300000012000     CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.3750 VOL/VOL
           FIELD CAPACITY              =     0.1600 VOL/VOL
           WILTING POINT               =     0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     12.00   INCHES
POROSITY                   =      0.3750 VOL/VOL
FIELD CAPACITY             =      0.1600 VOL/VOL
WILTING POINT              =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.319999992000E-02 CM/SEC
SLOPE                      =      3.00   PERCENT
DRAINAGE LENGTH            =    450.0    FEET

                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.3750 VOL/VOL
FIELD CAPACITY             =      0.1600 VOL/VOL
WILTING POINT              =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.3750 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.319999992000E-02 CM/SEC

                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     58.57   INCHES
POROSITY                   =      0.3700 VOL/VOL
FIELD CAPACITY             =      0.2400 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.2200 VOL/VOL
FIELD CAPACITY             =      0.2100 VOL/VOL
WILTING POINT              =      0.2000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2100 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC
SLOPE                      =     11.40   PERCENT
DRAINAGE LENGTH            =    150.0    FEET
```

```
                           LAYER  7
                           --------

                 TYPE 3 - BARRIER SOIL LINER
                 MATERIAL TEXTURE NUMBER   0
  THICKNESS                   =      0.20   INCHES
  POROSITY                    =      0.7500 VOL/VOL
  FIELD CAPACITY              =      0.7470 VOL/VOL
  WILTING POINT               =      0.4000 VOL/VOL
  INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     26.90
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      1.984  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.514  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      0.901  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     23.546  INCHES
TOTAL INITIAL WATER                =     23.546  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR

            EVAPOTRANSPIRATION AND WEATHER DATA
            -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          AUGUSTA               GEORGIA

     STATION LATITUDE                         =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   3.50
     START OF GROWING SEASON (JULIAN DATE)    =     68
     END OF GROWING SEASON (JULIAN DATE)      =    323
     EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %

 NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
          COEFFICIENTS FOR    AUGUSTA             GEORGIA
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.645	2.060	2.823	2.715	2.955	3.623
	4.143	3.684	2.854	1.490	1.031	1.267
STD. DEVIATIONS	0.237	0.285	0.686	0.819	1.241	1.356
	1.351	1.199	0.977	0.629	0.262	0.182

```
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                 2.9510   1.6175   2.0985   0.5246   0.7190   1.0807
                         1.7117   1.6609   1.5355   1.2406   1.4540   2.0028

  STD. DEVIATIONS        2.1257   1.4928   1.8893   0.7271   1.2286   1.2965
                         1.6165   1.9208   1.7769   1.6397   1.4920   1.6936

LATERAL DRAINAGE COLLECTED FROM LAYER  6
----------------------------------------
  TOTALS                 0.5891   0.6215   0.6790   0.6232   0.5102   0.4146
                         0.4172   0.4755   0.4824   0.4936   0.4489   0.4834

  STD. DEVIATIONS        0.3052   0.2573   0.2660   0.2568   0.2296   0.2164
                         0.2364   0.2720   0.2427   0.2586   0.2700   0.2850

PERCOLATION/LEAKAGE THROUGH LAYER  7
------------------------------------
  TOTALS                 1.1548   1.2145   1.3285   1.2239   1.0136   0.8274
                         0.8323   0.9424   0.9569   0.9789   0.8891   0.9562

  STD. DEVIATIONS        0.5759   0.4739   0.4919   0.4766   0.4371   0.4194
                         0.4610   0.5249   0.4666   0.4952   0.5137   0.5461

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

DAILY AVERAGE HEAD ON TOP OF LAYER  4
-------------------------------------
  AVERAGES               0.0452   0.0249   0.0296   0.0081   0.0096   0.0159
                         0.0240   0.0221   0.0186   0.0181   0.0223   0.0274

  STD. DEVIATIONS        0.0382   0.0251   0.0316   0.0129   0.0177   0.0213
                         0.0261   0.0270   0.0233   0.0297   0.0278   0.0265

DAILY AVERAGE HEAD ON TOP OF LAYER  7
-------------------------------------
  AVERAGES              43.6097  50.3192  50.1942  47.7751  38.2504  32.2369
                        31.3769  35.5542  37.3121  36.9337  34.6518  36.0772

  STD. DEVIATIONS       21.8427  19.6512  18.6593  18.6803  16.5818  16.4323
                        17.4825  19.9018  18.2875  18.7808  20.1343  20.7074

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	30.290	(3.0661)	2158378.25	61.943
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00002	(0.00001)	1.422	0.00004
PERCOLATION/LEAKAGE THROUGH LAYER 4	18.59674	(6.32641)	1325146.250	38.03008
AVERAGE HEAD ON TOP OF LAYER 4	0.022	(0.008)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	6.23846	(1.96206)	444533.625	12.75757
PERCOLATION/LEAKAGE THROUGH LAYER 7	12.31864	(3.71703)	877787.937	25.19144
AVERAGE HEAD ON TOP OF LAYER 7	39.524	(11.963)		
CHANGE IN WATER STORAGE	0.053	(3.0163)	3768.12	0.108

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.87	489534.875
RUNOFF	0.000	0.0000
DRAINAGE COLLECTED FROM LAYER 3	0.00001	0.62330
PERCOLATION/LEAKAGE THROUGH LAYER 4	4.176939	297635.71900
AVERAGE HEAD ON TOP OF LAYER 4	2.578	
MAXIMUM HEAD ON TOP OF LAYER 4	0.013	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	39.4 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.03765	2682.47388
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.070386	5015.48437
AVERAGE HEAD ON TOP OF LAYER 7	82.570	
MAXIMUM HEAD ON TOP OF LAYER 7	101.074	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	63.2 FEET	
SNOW WATER	2.36	168188.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2400	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0410	

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	1.4229	0.1186
2	2.2049	0.1837
3	1.9200	0.1600
4	0.0750	0.3750
5	17.8738	0.3052
6	5.1872	0.2161
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

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Appendix P, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (100 Years): HELP Model Input Data and Output File (output file name: ZUBSD1ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Topsoil	1	1 (vertical percolation layer)
Upper Backfill	2	1 (vertical percolation layer)
Erosion Barrier	3	1 (vertical percolation layer)
Middle Backfill	4	1 (vertical percolation layer)
Upper Drainage Layer	5	2 (lateral drainage layer)
Upper GCL	6	3 (barrier soil liner)
Lower Backfill	7	1 (vertical percolation layer)
Lower Drainage Layer	8	2 (lateral drainage layer)
Lower GCL	9	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	5.980		0.4	0.11	0.058	0.11
2	1	30		0.37	0.24	0.136	0.24
3	1	12		0.06	0.056	0.052	0.056
4	1	12		0.37	0.236	0.132	0.236
5	2	12		0.38	0.084	0.0164	0.084
6	3	0.2		0.75	0.747	0.40	0.75
7	1	58.57		0.37	0.24	0.136	0.24
8	2	24		0.38	0.08	0.013	0.08
9	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-03					
2	1	1.00E-04					
3	1	3.97E-04					
4	1	1.20E-04					
5	2	8.20E-02	450	3			
6	3	5.00E-09					
7	1	1.00E-04					
8	2	1.00E-01	150	11.4			
9	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	1				
5	2				
6	3				
7	1				
8	2				
9	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD1.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD1ou.OUT

TIME:  14:10     DATE:   1/12/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 100 years

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

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

                                   LAYER  1
                                   --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   0
           THICKNESS                 =      5.98   INCHES
           POROSITY                  =      0.4000 VOL/VOL
           FIELD CAPACITY            =      0.1100 VOL/VOL
           WILTING POINT             =      0.0580 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.1100 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.100000005000E-02 CM/SEC

                                   LAYER  2
                                   --------

                  TYPE 1 - VERTICAL PERCOLATION LAYER
                      MATERIAL TEXTURE NUMBER   0
           THICKNESS                 =     30.00   INCHES
           POROSITY                  =      0.3700 VOL/VOL
           FIELD CAPACITY            =      0.2400 VOL/VOL
           WILTING POINT             =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT  =    0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                         LAYER  3
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.0600 VOL/VOL
FIELD CAPACITY               =      0.0560 VOL/VOL
WILTING POINT                =      0.0520 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0560 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.396999996000E-03 CM/SEC

                         LAYER  4
                         --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2360 VOL/VOL
WILTING POINT                =      0.1320 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2360 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.119999997000E-03 CM/SEC

                         LAYER  5
                         --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0840 VOL/VOL
WILTING POINT                =      0.0164 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0840 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.820000023000E-01 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                         LAYER  6
                         --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC
```

```
                     LAYER  7
                     --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     58.57   INCHES
POROSITY                   =      0.3700 VOL/VOL
FIELD CAPACITY             =      0.2400 VOL/VOL
WILTING POINT              =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC

                     LAYER  8
                     --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.3800 VOL/VOL
FIELD CAPACITY             =      0.0800 VOL/VOL
WILTING POINT              =      0.0130 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.100000001000     CM/SEC
SLOPE                      =     11.40   PERCENT
DRAINAGE LENGTH            =    150.0    FEET

                     LAYER  9
                     --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.7500 VOL/VOL
FIELD CAPACITY             =      0.7470 VOL/VOL
WILTING POINT              =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     54.40
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.503  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.319  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.526  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     28.647  INCHES
TOTAL INITIAL WATER                =     28.647  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
------
  TOTALS                 0.004    0.000    0.004    0.000    0.000    0.002
                         0.027    0.091    0.016    0.006    0.002    0.001

  STD. DEVIATIONS        0.020    0.000    0.027    0.000    0.002    0.015
                         0.093    0.404    0.086    0.058    0.015    0.004

EVAPOTRANSPIRATION
------------------
  TOTALS                 1.577    2.093    3.072    3.553    3.657    4.141
                         4.898    4.520    3.385    1.619    0.948    1.115

  STD. DEVIATIONS        0.221    0.236    0.582    0.761    1.521    1.545
                         1.589    1.377    1.040    0.606    0.207    0.205

LATERAL DRAINAGE COLLECTED FROM LAYER  5
----------------------------------------
  TOTALS                 2.4473   2.0838   1.9296   1.2481   0.4364   0.3120
                         0.5422   0.8056   0.7456   0.7750   0.8928   1.4653

  STD. DEVIATIONS        1.7695   1.4993   1.4379   1.0556   0.4450   0.5670
                         0.7744   1.0088   0.9990   1.0513   1.1885   1.2857

PERCOLATION/LEAKAGE THROUGH LAYER  6
------------------------------------
  TOTALS                 0.0736   0.0626   0.0583   0.0397   0.0170   0.0126
                         0.0186   0.0262   0.0247   0.0253   0.0282   0.0445

  STD. DEVIATIONS        0.0531   0.0439   0.0397   0.0307   0.0125   0.0162
                         0.0222   0.0286   0.0288   0.0301   0.0336   0.0364

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.0588   0.0548   0.0579   0.0421   0.0155   0.0085
                         0.0146   0.0214   0.0195   0.0213   0.0242   0.0394

  STD. DEVIATIONS        0.0362   0.0336   0.0426   0.0421   0.0247   0.0155
                         0.0206   0.0261   0.0248   0.0274   0.0312   0.0332

PERCOLATION/LEAKAGE THROUGH LAYER  9
------------------------------------
  TOTALS                 0.0051   0.0049   0.0054   0.0051   0.0050   0.0040
                         0.0038   0.0041   0.0040   0.0040   0.0038   0.0043

  STD. DEVIATIONS        0.0009   0.0002   0.0003   0.0005   0.0009   0.0017
                         0.0020   0.0020   0.0019   0.0020   0.0021   0.0019
```

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 6

AVERAGES	2.6013	2.4050	2.0133	1.3575	0.4546	0.3359
	0.5649	0.8393	0.8101	0.8108	0.9611	1.5265
STD. DEVIATIONS	2.0034	1.8262	1.5053	1.2013	0.4636	0.6104
	0.8067	1.0510	1.0972	1.1069	1.2795	1.3395

DAILY AVERAGE HEAD ON TOP OF LAYER 9

AVERAGES	0.0045	0.0046	0.0044	0.0033	0.0012	0.0007
	0.0011	0.0016	0.0015	0.0016	0.0019	0.0030
STD. DEVIATIONS	0.0027	0.0028	0.0032	0.0033	0.0019	0.0012
	0.0016	0.0020	0.0019	0.0021	0.0024	0.0025

****

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.154	(0.4339)	10950.01	0.314
EVAPOTRANSPIRATION	34.578	(3.6236)	2463907.00	70.711
LATERAL DRAINAGE COLLECTED FROM LAYER 5	13.68366	(5.46188)	975054.875	27.98288
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.43127	(0.15765)	30730.955	0.88194
AVERAGE HEAD ON TOP OF LAYER 6	1.223	(0.497)		
LATERAL DRAINAGE COLLECTED FROM LAYER 8	0.37786	(0.15286)	26925.406	0.77273
PERCOLATION/LEAKAGE THROUGH LAYER 9	0.05339	(0.00788)	3804.487	0.10918
AVERAGE HEAD ON TOP OF LAYER 9	0.002	(0.001)		
CHANGE IN WATER STORAGE	0.054	(1.9679)	3827.47	0.110

****

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

            PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                             6.87        489534.875

      RUNOFF                                    2.648       188654.3750

      DRAINAGE COLLECTED FROM LAYER  5          0.37728      26883.74800

      PERCOLATION/LEAKAGE THROUGH LAYER  6      0.033315      2373.92480

      AVERAGE HEAD ON TOP OF LAYER  6          38.977

      MAXIMUM HEAD ON TOP OF LAYER  6          51.035

      LOCATION OF MAXIMUM HEAD IN LAYER  5
            (DISTANCE FROM DRAIN)             157.7 FEET

      DRAINAGE COLLECTED FROM LAYER  8          0.01501       1069.88452

      PERCOLATION/LEAKAGE THROUGH LAYER  9      0.000200        14.25814

      AVERAGE HEAD ON TOP OF LAYER  9           0.035

      MAXIMUM HEAD ON TOP OF LAYER  9           0.073

      LOCATION OF MAXIMUM HEAD IN LAYER  8
            (DISTANCE FROM DRAIN)               0.0 FEET

      SNOW WATER                                2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.3691

      MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.1148

       ***  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	1.6080	0.2689
2	8.9916	0.2997
3	0.7200	0.0600
4	4.2368	0.3531
5	2.1832	0.1819
6	0.1500	0.7500
7	14.0568	0.2400
8	1.9215	0.0801
9	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix Q, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (154 Years): HELP Model Input Data and Output File (output file name: ZUBSD2ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	10 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 80.1	

Layer	Layer Number	Layer Type
Upper Backfill	1	1 (vertical percolation layer)
Erosion Barrier	2	1 (vertical percolation layer)
Middle Backfill	3	1 (vertical percolation layer)
Upper Drainage Layer	4	2 (lateral drainage layer)
Upper GCL	5	3 (barrier soil liner)
Lower Backfill	6	1 (vertical percolation layer)
Lower Drainage Layer	7	2 (lateral drainage layer)
Lower GCL	8	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	30		0.37	0.24	0.136	0.24
2	1	12		0.06	0.056	0.052	0.056
3	1	12		0.37	0.233	0.131	0.233
4	2	12		0.38	0.087	0.0183	0.087
5	3	0.2		0.75	0.747	0.40	0.75
6	1	58.57		0.37	0.24	0.136	0.24
7	2	24		0.38	0.08	0.0131	0.08
8	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-04					
2	1	3.97E-04					
3	1	1.40E-04					
4	2	7.40E-02	450	3			
5	3	5.00E-09					
6	1	1.00E-04					
7	2	1.00E-01	150	11.4			
8	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	2				
5	3				
6	1				
7	2				
8	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD2.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD2ou.OUT

TIME:  13:38     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 154 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    30.00   INCHES
           POROSITY                   =     0.3700 VOL/VOL
           FIELD CAPACITY             =     0.2400 VOL/VOL
           WILTING POINT              =     0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    12.00   INCHES
           POROSITY                   =     0.0600 VOL/VOL
           FIELD CAPACITY             =     0.0560 VOL/VOL
           WILTING POINT              =     0.0520 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.0560 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.396999996000E-03 CM/SEC
```

```
                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2330 VOL/VOL
WILTING POINT               =      0.1310 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2330 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.140000004000E-03 CM/SEC

                        LAYER  4
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3800 VOL/VOL
FIELD CAPACITY              =      0.0870 VOL/VOL
WILTING POINT               =      0.0183 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0870 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.740000010000E-01 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                        LAYER  5
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

                        LAYER  6
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                         LAYER  7
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0800 VOL/VOL
WILTING POINT                =      0.0131 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.100000001000     CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET

                         LAYER  8
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     80.10
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      5.280  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      8.140  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.992  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     27.989  INCHES
TOTAL INITIAL WATER                =     27.989  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
 ------
   TOTALS                  0.230    0.087    0.178    0.024    0.077    0.143
                           0.291    0.361    0.211    0.144    0.096    0.111

   STD. DEVIATIONS         0.341    0.178    0.312    0.081    0.183    0.254
                           0.425    0.716    0.403    0.331    0.227    0.191

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                  1.595    2.128    3.237    3.622    3.388    4.096
                           4.863    4.449    3.320    1.611    0.951    1.130

   STD. DEVIATIONS         0.211    0.217    0.523    0.842    1.515    1.531
                           1.595    1.384    1.061    0.623    0.225    0.201

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                  2.2963   1.9286   1.7335   1.0582   0.3039   0.2517
                           0.4476   0.5892   0.5929   0.6475   0.8246   1.4170

   STD. DEVIATIONS         1.5435   1.3489   1.2928   0.9441   0.3547   0.4610
                           0.6451   0.7477   0.8434   0.8876   1.0578   1.1919

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                  0.0751   0.0638   0.0580   0.0373   0.0141   0.0113
                           0.0172   0.0219   0.0220   0.0236   0.0288   0.0475

   STD. DEVIATIONS         0.0478   0.0422   0.0394   0.0289   0.0112   0.0149
                           0.0206   0.0237   0.0264   0.0280   0.0332   0.0373

 LATERAL DRAINAGE COLLECTED FROM LAYER  7
 ----------------------------------------
   TOTALS                  0.0624   0.0573   0.0562   0.0394   0.0111   0.0076
                           0.0135   0.0176   0.0176   0.0197   0.0240   0.0414

   STD. DEVIATIONS         0.0357   0.0343   0.0396   0.0381   0.0176   0.0140
                           0.0194   0.0220   0.0249   0.0270   0.0298   0.0339

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                  0.0052   0.0049   0.0054   0.0051   0.0048   0.0036
                           0.0036   0.0040   0.0040   0.0039   0.0037   0.0044

   STD. DEVIATIONS         0.0008   0.0003   0.0001   0.0003   0.0011   0.0018
                           0.0021   0.0020   0.0018   0.0021   0.0021   0.0018
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES               2.6586   2.4524   2.0023   1.2634   0.3509   0.3002
                           0.5167   0.6802   0.7072   0.7474   0.9836   1.6358

    STD. DEVIATIONS        1.8039   1.7532   1.4946   1.1301   0.4094   0.5500
                           0.7447   0.8632   1.0061   1.0247   1.2618   1.3759

  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES               0.0047   0.0048   0.0043   0.0031   0.0008   0.0006
                           0.0010   0.0013   0.0014   0.0015   0.0019   0.0031

    STD. DEVIATIONS        0.0027   0.0028   0.0030   0.0030   0.0013   0.0011
                           0.0015   0.0017   0.0019   0.0020   0.0023   0.0026

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

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

    AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                      INCHES            CU. FEET       PERCENT
                                 -------------------  -------------   ---------
 PRECIPITATION                     48.90    (   7.734)    3484469.2     100.00

 RUNOFF                             1.953   (  1.2038)     139173.55     3.994

 EVAPOTRANSPIRATION                34.391   (  3.5912)    2450586.25    70.329

 LATERAL DRAINAGE COLLECTED        12.09099 (  4.72285)    861566.687   24.72591
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH        0.42058 (  0.14847)     29969.580    0.86009
   LAYER  5

 AVERAGE HEAD ON TOP                1.192 (    0.467)
   OF LAYER  5

 LATERAL DRAINAGE COLLECTED         0.36785 (  0.14403)     26211.666   0.75224
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH        0.05272 (  0.00812)      3756.311    0.10780
   LAYER  8

 AVERAGE HEAD ON TOP                0.002 (    0.001)
   OF LAYER  8

 CHANGE IN WATER STORAGE            0.045   (  1.7733)      3174.83      0.091

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

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      3.729       265714.0000

      DRAINAGE COLLECTED FROM LAYER  4            0.33581      23928.91800

      PERCOLATION/LEAKAGE THROUGH LAYER  5        0.018371      1309.04749

      AVERAGE HEAD ON TOP OF LAYER  5            21.403

      MAXIMUM HEAD ON TOP OF LAYER  5            31.206

      LOCATION OF MAXIMUM HEAD IN LAYER  4
            (DISTANCE FROM DRAIN)               121.6 FEET

      DRAINAGE COLLECTED FROM LAYER  7            0.01387        988.50873

      PERCOLATION/LEAKAGE THROUGH LAYER  8        0.000198        14.09545

      AVERAGE HEAD ON TOP OF LAYER  8             0.033

      MAXIMUM HEAD ON TOP OF LAYER  8             0.065

      LOCATION OF MAXIMUM HEAD IN LAYER  7
            (DISTANCE FROM DRAIN)                 0.0 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.3479

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.1360

       ***  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	8.7843	0.2928
2	0.6720	0.0560
3	3.6450	0.3038
4	3.0638	0.2553
5	0.1500	0.7500
6	14.0568	0.2400
7	1.9223	0.0801
8	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix R, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (300 Years): HELP Model Input Data and Output File (output file name: ZUBSD3ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	10 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 80.1	

Layer	Layer Number	Layer Type
Upper Backfill	1	1 (vertical percolation layer)
Erosion Barrier	2	1 (vertical percolation layer)
Middle Backfill	3	1 (vertical percolation layer)
Upper Drainage Layer	4	2 (lateral drainage layer)
Upper GCL	5	3 (barrier soil liner)
Lower Backfill	6	1 (vertical percolation layer)
Lower Drainage Layer	7	2 (lateral drainage layer)
Lower GCL	8	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	20.218		0.37	0.24	0.136	0.24
2	1	12		0.06	0.056	0.052	0.056
3	1	12		0.371	0.226	0.126	0.226
4	2	12		0.379	0.093	0.0233	0.093
5	3	0.2		0.75	0.747	0.40	0.75
6	1	58.57		0.37	0.24	0.136	0.24
7	2	24		0.38	0.08	0.0132	0.08
8	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-04					
2	1	3.97E-04					
3	1	1.80E-04					
4	2	5.60E-02	450	3			
5	3	5.00E-09					
6	1	1.00E-04					
7	2	9.99E-02	150	11.4			
8	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	2				
5	3				
6	1				
7	2				
8	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD3.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD3ou.OUT

TIME:  13:42     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 300 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    20.22   INCHES
           POROSITY                   =     0.3700 VOL/VOL
           FIELD CAPACITY             =     0.2400 VOL/VOL
           WILTING POINT              =     0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    12.00   INCHES
           POROSITY                   =     0.0600 VOL/VOL
           FIELD CAPACITY             =     0.0560 VOL/VOL
           WILTING POINT              =     0.0520 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.0560 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.396999996000E-03 CM/SEC
```

```
                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3710 VOL/VOL
FIELD CAPACITY              =      0.2260 VOL/VOL
WILTING POINT               =      0.1260 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2260 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.180000003000E-03 CM/SEC

                        LAYER  4
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3790 VOL/VOL
FIELD CAPACITY              =      0.0930 VOL/VOL
WILTING POINT               =      0.0233 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0930 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.560000017000E-01 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                        LAYER  5
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   INCHES
POROSITY                    =      0.7500 VOL/VOL
FIELD CAPACITY              =      0.7470 VOL/VOL
WILTING POINT               =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.499999997000E-08 CM/SEC

                        LAYER  6
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
```

```
                          LAYER  7
                          --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    24.00   INCHES
POROSITY                     =     0.3800 VOL/VOL
FIELD CAPACITY               =     0.0800 VOL/VOL
WILTING POINT                =     0.0132 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.0800 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.998999998000E-01 CM/SEC
SLOPE                        =    11.40   PERCENT
DRAINAGE LENGTH              =   150.0    FEET

                          LAYER  8
                          --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     0.20   INCHES
POROSITY                     =     0.7500 VOL/VOL
FIELD CAPACITY               =     0.7470 VOL/VOL
WILTING POINT                =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     80.10
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      4.952  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      7.588  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      2.842  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     25.629  INCHES
TOTAL INITIAL WATER                =     25.629  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
 ------
   TOTALS                   0.231    0.086    0.177    0.024    0.077    0.143
                            0.291    0.361    0.211    0.144    0.096    0.111

   STD. DEVIATIONS          0.342    0.178    0.310    0.081    0.184    0.255
                            0.427    0.716    0.403    0.330    0.226    0.192

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                   1.612    2.139    3.242    3.495    3.292    4.043
                            4.791    4.373    3.269    1.592    0.959    1.148

   STD. DEVIATIONS          0.211    0.215    0.534    0.898    1.478    1.512
                            1.574    1.371    1.051    0.637    0.230    0.200

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                   2.2735   1.8902   1.7018   1.0030   0.3272   0.3113
                            0.5343   0.6563   0.6542   0.7026   0.8841   1.4480

   STD. DEVIATIONS          1.4394   1.2978   1.2490   0.9080   0.3709   0.4838
                            0.6752   0.7577   0.8370   0.8988   1.0346   1.1357

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                   0.0990   0.0823   0.0741   0.0457   0.0184   0.0173
                            0.0263   0.0313   0.0311   0.0330   0.0399   0.0630

   STD. DEVIATIONS          0.0653   0.0580   0.0515   0.0378   0.0149   0.0196
                            0.0275   0.0308   0.0339   0.0367   0.0422   0.0463

 LATERAL DRAINAGE COLLECTED FROM LAYER  7
 ----------------------------------------
   TOTALS                   0.0746   0.0676   0.0781   0.0572   0.0243   0.0131
                            0.0212   0.0255   0.0247   0.0284   0.0325   0.0548

   STD. DEVIATIONS          0.0356   0.0352   0.0563   0.0620   0.0394   0.0204
                            0.0267   0.0284   0.0291   0.0356   0.0353   0.0415

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                   0.0053   0.0049   0.0054   0.0052   0.0053   0.0048
                            0.0048   0.0049   0.0048   0.0048   0.0044   0.0048

   STD. DEVIATIONS          0.0006   0.0003   0.0001   0.0002   0.0002   0.0008
                            0.0010   0.0011   0.0010   0.0012   0.0015   0.0014
```

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES                3.5600   3.2229   2.6118   1.5926   0.4992   0.4907
                            0.8150   1.0016   1.0312   1.0741   1.3936   2.2090

    STD. DEVIATIONS         2.4719   2.4125   1.9524   1.4814   0.5657   0.7626
                            1.0300   1.1572   1.3194   1.3772   1.6309   1.7325

  DAILY AVERAGE HEAD ON TOP OF LAYER  8
  -------------------------------------
    AVERAGES                0.0057   0.0056   0.0059   0.0045   0.0018   0.0010
                            0.0016   0.0019   0.0019   0.0022   0.0025   0.0042

    STD. DEVIATIONS         0.0027   0.0029   0.0043   0.0049   0.0030   0.0016
                            0.0020   0.0022   0.0023   0.0027   0.0028   0.0032

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                          INCHES            CU. FEET      PERCENT
                                    -------------------  -------------  ---------
 PRECIPITATION                      48.90    (   7.734)   3484469.2     100.00

 RUNOFF                              1.953   (  1.2009)    139192.66      3.995

 EVAPOTRANSPIRATION                 33.956   (  3.5509)   2419606.25     69.440

 LATERAL DRAINAGE COLLECTED         12.38653 (  4.71636)   882625.750   25.33028
   FROM LAYER  4

 PERCOLATION/LEAKAGE THROUGH         0.56138 (  0.19807)    40002.363    1.14802
   LAYER  5

 AVERAGE HEAD ON TOP                 1.625 (    0.635)
   OF LAYER  5

 LATERAL DRAINAGE COLLECTED          0.50194 (  0.19286)    35766.445    1.02645
   FROM LAYER  7

 PERCOLATION/LEAKAGE THROUGH         0.05940 (  0.00465)     4232.409    0.12146
   LAYER  8

 AVERAGE HEAD ON TOP                 0.003 (    0.001)
   OF LAYER  8

 CHANGE IN WATER STORAGE             0.043   (  1.7258)      3045.79      0.087

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

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.87	489534.875
RUNOFF	3.725	265455.3750
DRAINAGE COLLECTED FROM LAYER 4	0.25747	18346.30660
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.032847	2340.56616
AVERAGE HEAD ON TOP OF LAYER 5	38.426	
MAXIMUM HEAD ON TOP OF LAYER 5	50.278	
LOCATION OF MAXIMUM HEAD IN LAYER 4 (DISTANCE FROM DRAIN)	156.5 FEET	
DRAINAGE COLLECTED FROM LAYER 7	0.01678	1195.40491
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.000204	14.51149
AVERAGE HEAD ON TOP OF LAYER 8	0.039	
MAXIMUM HEAD ON TOP OF LAYER 8	0.078	
LOCATION OF MAXIMUM HEAD IN LAYER 7 (DISTANCE FROM DRAIN)	0.0 FEET	
SNOW WATER	2.36	168188.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.3215	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.1292	

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	5.4079	0.2675
2	0.8921	0.0743
3	3.7346	0.3112
4	3.5871	0.2989
5	0.1500	0.7500
6	14.0595	0.2400
7	1.9222	0.0801
8	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix S, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (550 Years): HELP Model Input Data and Output File (output file name: ZUBSD4ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	10 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 80.1	

Layer	Layer Number	Layer Type
Upper Backfill	1	1 (vertical percolation layer)
Erosion Barrier	2	1 (vertical percolation layer)
Middle Backfill	3	1 (vertical percolation layer)
Upper Drainage Layer	4	2 (lateral drainage layer)
Upper GCL	5	3 (barrier soil liner)
Lower Backfill	6	1 (vertical percolation layer)
Lower Drainage Layer	7	2 (lateral drainage layer)
Lower GCL	8	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	3.468		0.37	0.24	0.136	0.24
2	1	12		0.06	0.056	0.052	0.056
3	1	12		0.372	0.215	0.117	0.215
4	2	12		0.378	0.105	0.0319	0.105
5	3	0.2		0.75	0.747	0.40	0.75
6	1	58.57		0.37	0.24	0.136	0.24
7	2	24		0.38	0.0803	0.0134	0.0803
8	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.00E-04					
2	1	3.97E-04					
3	1	2.90E-04					
4	2	3.40E-02	450	3			
5	3	5.00E-09					
6	1	1.00E-04					
7	2	9.98E-02	150	11.4			
8	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	1				
4	2				
5	3				
6	1				
7	2				
8	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD4.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD4ou.OUT

TIME:  13:53     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 550 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =      3.47   INCHES
           POROSITY                   =      0.3700 VOL/VOL
           FIELD CAPACITY             =      0.2400 VOL/VOL
           WILTING POINT              =      0.1360 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.2400 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-04 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =     12.00   INCHES
           POROSITY                   =      0.0600 VOL/VOL
           FIELD CAPACITY             =      0.0560 VOL/VOL
           WILTING POINT              =      0.0520 VOL/VOL
           INITIAL SOIL WATER CONTENT =      0.0560 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.396999996000E-03 CM/SEC
```

```
                        LAYER  3
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3720 VOL/VOL
FIELD CAPACITY               =     0.2150 VOL/VOL
WILTING POINT                =     0.1170 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2150 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.289999996000E-03 CM/SEC

                        LAYER  4
                        --------

                TYPE 2 - LATERAL DRAINAGE LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3780 VOL/VOL
FIELD CAPACITY               =     0.1050 VOL/VOL
WILTING POINT                =     0.0319 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.1050 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.340000018000E-01 CM/SEC
SLOPE                        =     3.00   PERCENT
DRAINAGE LENGTH              =   450.0    FEET

                        LAYER  5
                        --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     0.20   INCHES
POROSITY                     =     0.7500 VOL/VOL
FIELD CAPACITY               =     0.7470 VOL/VOL
WILTING POINT                =     0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

                        LAYER  6
                        --------

              TYPE 1 - VERTICAL PERCOLATION LAYER
                  MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    58.57   INCHES
POROSITY                     =     0.3700 VOL/VOL
FIELD CAPACITY               =     0.2400 VOL/VOL
WILTING POINT                =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC
```

```
                         LAYER  7
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0803 VOL/VOL
WILTING POINT                =      0.0134 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0803 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.997999981000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET

                         LAYER  8
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
           SOIL DATA BASE USING SOIL TEXTURE #10 WITH A
           GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
           AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     80.10
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.909  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      4.433  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.860  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     21.628  INCHES
TOTAL INITIAL WATER                =     21.628  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
AUGUSTA GEORGIA

STATION LATITUDE	=	33.22 DEGREES
MAXIMUM LEAF AREA INDEX	=	3.50
START OF GROWING SEASON (JULIAN DATE)	=	68
END OF GROWING SEASON (JULIAN DATE)	=	323
EVAPORATIVE ZONE DEPTH	=	22.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	6.50 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	70.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	77.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	73.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90

```
RUNOFF
 ------
   TOTALS                0.192    0.084    0.144    0.021    0.072    0.125
                         0.267    0.333    0.181    0.123    0.063    0.068

   STD. DEVIATIONS       0.429    0.246    0.311    0.072    0.162    0.219
                         0.378    0.670    0.362    0.316    0.162    0.138

 EVAPOTRANSPIRATION
 ------------------
   TOTALS                1.681    2.097    2.865    2.406    2.802    3.438
                         3.898    3.454    2.698    1.466    1.068    1.298

   STD. DEVIATIONS       0.228    0.294    0.738    0.909    1.126    1.312
                         1.269    1.166    0.950    0.679    0.282    0.203

 LATERAL DRAINAGE COLLECTED FROM LAYER  4
 ----------------------------------------
   TOTALS                2.1202   1.8138   1.7760   1.2001   0.7499   0.9084
                         1.3365   1.4961   1.3923   1.2466   1.2125   1.5414

   STD. DEVIATIONS       1.1708   1.1039   1.0639   0.8652   0.6453   0.7220
                         0.9105   0.9416   0.8999   1.0017   0.9693   0.9844

 PERCOLATION/LEAKAGE THROUGH LAYER  5
 ------------------------------------
   TOTALS                0.1595   0.1349   0.1310   0.0858   0.0550   0.0654
                         0.0942   0.1066   0.0999   0.0904   0.0883   0.1090

   STD. DEVIATIONS       0.1091   0.0999   0.0905   0.0605   0.0429   0.0483
                         0.0611   0.0677   0.0659   0.0729   0.0725   0.0684

 LATERAL DRAINAGE COLLECTED FROM LAYER  7
 ----------------------------------------
   TOTALS                0.1088   0.0975   0.1294   0.1274   0.1065   0.0765
                         0.0763   0.0852   0.0864   0.0878   0.0821   0.0924

   STD. DEVIATIONS       0.0636   0.0553   0.0790   0.1025   0.1050   0.0774
                         0.0490   0.0434   0.0495   0.0607   0.0612   0.0632

 PERCOLATION/LEAKAGE THROUGH LAYER  8
 ------------------------------------
   TOTALS                0.0053   0.0048   0.0055   0.0053   0.0055   0.0053
                         0.0054   0.0054   0.0052   0.0054   0.0052   0.0054

   STD. DEVIATIONS       0.0006   0.0006   0.0004   0.0003   0.0002   0.0002
                         0.0002   0.0003   0.0004   0.0005   0.0003   0.0002
```

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 5

AVERAGES	5.8522	5.4113	4.7682	3.1614	1.8873	2.3646
	3.3727	3.8440	3.7151	3.2328	3.2608	3.9337
STD. DEVIATIONS	4.1391	4.1516	3.4339	2.3734	1.6279	1.8951
	2.3196	2.5676	2.5839	2.7640	2.8427	2.5945

DAILY AVERAGE HEAD ON TOP OF LAYER 8

AVERAGES	0.0083	0.0081	0.0098	0.0100	0.0081	0.0060
	0.0058	0.0065	0.0068	0.0067	0.0064	0.0070
STD. DEVIATIONS	0.0048	0.0046	0.0060	0.0080	0.0080	0.0061
	0.0037	0.0033	0.0039	0.0046	0.0048	0.0048

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	1.674	(1.1207)	119312.50	3.424
EVAPOTRANSPIRATION	29.172	(2.9357)	2078691.75	59.656
LATERAL DRAINAGE COLLECTED FROM LAYER 4	16.79392	(5.06796)	1196682.870	34.34333
PERCOLATION/LEAKAGE THROUGH LAYER 5	1.21999	(0.38499)	86932.844	2.49487
AVERAGE HEAD ON TOP OF LAYER 5	3.734	(1.244)		
LATERAL DRAINAGE COLLECTED FROM LAYER 7	1.15625	(0.35664)	82390.602	2.36451
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.06366	(0.00121)	4536.280	0.13019
AVERAGE HEAD ON TOP OF LAYER 8	0.007	(0.002)		
CHANGE IN WATER STORAGE	0.040	(1.7923)	2855.07	0.082

****

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

            PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
  ------------------------------------------------------------------------
                                                 (INCHES)      (CU. FT.)
                                                ----------   -------------
     PRECIPITATION                                6.87        489534.875

     RUNOFF                                       3.631       258749.8590

     DRAINAGE COLLECTED FROM LAYER  4             0.15807      11263.81930

     PERCOLATION/LEAKAGE THROUGH LAYER  5         0.033553      2390.87256

     AVERAGE HEAD ON TOP OF LAYER  5             39.256

     MAXIMUM HEAD ON TOP OF LAYER  5             51.171

     LOCATION OF MAXIMUM HEAD IN LAYER  4
           (DISTANCE FROM DRAIN)                157.9 FEET

     DRAINAGE COLLECTED FROM LAYER  7             0.01737       1237.79187

     PERCOLATION/LEAKAGE THROUGH LAYER  8         0.000205        14.59881

     AVERAGE HEAD ON TOP OF LAYER  8              0.041

     MAXIMUM HEAD ON TOP OF LAYER  8              0.084

     LOCATION OF MAXIMUM HEAD IN LAYER  7
           (DISTANCE FROM DRAIN)                  0.0 FEET

     SNOW WATER                                   2.36        168188.7190

     MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.2015

     MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0845

      ***  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	0.8942	0.2578
2	0.7993	0.0666
3	3.1131	0.2594
4	4.5360	0.3780
5	0.1500	0.7500
6	14.0638	0.2401
7	1.9286	0.0804
8	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix T, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (602 Years): HELP Model Input Data and Output File (output file name: ZUBSD5ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	8 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 71.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.06	0.056	0.052	0.056
2	1	12		0.372	0.213	0.115	0.213
3	2	12		0.378	0.107	0.0337	0.107
4	3	0.2		0.75	0.747	0.40	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.38	0.0803	0.0135	0.0803
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.97E-04					
2	1	3.20E-04					
3	2	3.10E-02	450	3			
4	3	5.00E-09					
5	1	1.00E-04					
6	2	9.97E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD5.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD5ou.OUT

TIME:  14: 0     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 602 years

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

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

                                   LAYER  1
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.0600 VOL/VOL
           FIELD CAPACITY               =     0.0560 VOL/VOL
           WILTING POINT                =     0.0520 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.0560 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.396999996000E-03 CM/SEC

                                   LAYER  2
                                   --------

                      TYPE 1 - VERTICAL PERCOLATION LAYER
                          MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.3720 VOL/VOL
           FIELD CAPACITY               =     0.2130 VOL/VOL
           WILTING POINT                =     0.1150 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.2130 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.319999992000E-03 CM/SEC
```

```
                         LAYER  3
                         --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3780 VOL/VOL
FIELD CAPACITY               =      0.1070 VOL/VOL
WILTING POINT                =      0.0337 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1070 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.309999995000E-01 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                         LAYER  4
                         --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

                         LAYER  5
                         --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                         LAYER  6
                         --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3800 VOL/VOL
FIELD CAPACITY               =      0.0803 VOL/VOL
WILTING POINT                =      0.0135 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0803 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.996999964000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET
```

```
                            LAYER  7
                            --------

                  TYPE 3 - BARRIER SOIL LINER
                  MATERIAL TEXTURE NUMBER   0
    THICKNESS                    =      0.20   INCHES
    POROSITY                     =      0.7500 VOL/VOL
    FIELD CAPACITY               =      0.7470 VOL/VOL
    WILTING POINT                =      0.4000 VOL/VOL
    INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
    EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 8 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

 SCS RUNOFF CURVE NUMBER             =     71.90
 FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
 EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE   =      2.802  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.440  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.774  INCHES
 INITIAL SNOW WATER                  =      0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS    =     20.796  INCHES
 TOTAL INITIAL WATER                 =     20.796  INCHES
 TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR

             EVAPOTRANSPIRATION AND WEATHER DATA
             -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA               GEORGIA

      STATION LATITUDE                         =  33.22 DEGREES
      MAXIMUM LEAF AREA INDEX                  =   3.50
      START OF GROWING SEASON (JULIAN DATE)    =     68
      END OF GROWING SEASON (JULIAN DATE)      =    323
      EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
      AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.161	0.069	0.092	0.003	0.011	0.022
	0.078	0.154	0.082	0.049	0.032	0.010
STD. DEVIATIONS	0.562	0.347	0.377	0.017	0.042	0.061
	0.182	0.517	0.351	0.301	0.148	0.046
EVAPOTRANSPIRATION						
TOTALS	1.652	2.095	2.878	2.482	2.872	3.546
	3.979	3.557	2.740	1.472	1.052	1.274
STD. DEVIATIONS	0.223	0.279	0.718	0.929	1.184	1.353
	1.295	1.189	0.961	0.674	0.274	0.193

```
 LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                 2.1452   1.8435   1.8081   1.1962   0.7402   0.8998
                           1.3499   1.5439   1.4473   1.2928   1.2685   1.5860

    STD. DEVIATIONS        1.1233   1.0668   1.0407   0.8585   0.6646   0.7492
                           0.9321   0.9897   0.9184   1.0140   0.9760   1.0000

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 0.1795   0.1499   0.1462   0.0937   0.0595   0.0711
                           0.1052   0.1228   0.1145   0.1040   0.1025   0.1253

    STD. DEVIATIONS        0.1160   0.1014   0.0960   0.0667   0.0496   0.0562
                           0.0714   0.0822   0.0753   0.0861   0.0841   0.0821

  LATERAL DRAINAGE COLLECTED FROM LAYER  6
  ----------------------------------------
    TOTALS                 0.1153   0.1068   0.1487   0.1476   0.1273   0.0851
                           0.0808   0.0893   0.0959   0.1076   0.0994   0.1067

    STD. DEVIATIONS        0.0718   0.0628   0.0876   0.1128   0.1174   0.0863
                           0.0553   0.0501   0.0570   0.0794   0.0719   0.0758

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    TOTALS                 0.0052   0.0048   0.0055   0.0054   0.0055   0.0053
                           0.0054   0.0053   0.0052   0.0054   0.0052   0.0054

    STD. DEVIATIONS        0.0009   0.0006   0.0004   0.0003   0.0002   0.0002
                           0.0003   0.0006   0.0007   0.0006   0.0004   0.0004

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES               6.6097   6.0338   5.3468   3.4717   2.0567   2.5883
                           3.7906   4.4596   4.2917   3.7471   3.8162   4.5531

    STD. DEVIATIONS        4.3961   4.2118   3.6413   2.6149   1.8810   2.2030
                           2.7065   3.1156   2.9477   3.2623   3.2952   3.1154

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES               0.0088   0.0089   0.0113   0.0116   0.0097   0.0067
                           0.0061   0.0068   0.0075   0.0082   0.0078   0.0081

    STD. DEVIATIONS        0.0055   0.0053   0.0067   0.0089   0.0089   0.0068
                           0.0042   0.0038   0.0045   0.0060   0.0057   0.0058

*******************************************************************************
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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.764	(0.9983)	54414.64	1.562
EVAPOTRANSPIRATION	29.600	(2.9900)	2109233.00	60.532
LATERAL DRAINAGE COLLECTED FROM LAYER 3	17.12147	(5.19863)	1220022.500	35.01315
PERCOLATION/LEAKAGE THROUGH LAYER 4	1.37415	(0.44696)	97917.969	2.81013
AVERAGE HEAD ON TOP OF LAYER 4	4.230	(1.442)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	1.31049	(0.40512)	93381.766	2.67994
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.06352	(0.00198)	4526.362	0.12990
AVERAGE HEAD ON TOP OF LAYER 7	0.008	(0.003)		
CHANGE IN WATER STORAGE	0.041	(1.8707)	2890.97	0.083

****

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.87	489534.875
RUNOFF	3.519	250773.2190
DRAINAGE COLLECTED FROM LAYER 3	0.14393	10256.28910
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.030784	2193.54272
AVERAGE HEAD ON TOP OF LAYER 4	36.000	
MAXIMUM HEAD ON TOP OF LAYER 4	47.656	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	152.3 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.01739	1239.02258
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.000205	14.60376
AVERAGE HEAD ON TOP OF LAYER 7	0.041	
MAXIMUM HEAD ON TOP OF LAYER 7	0.078	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	5.2 FEET	
SNOW WATER	2.36	168188.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2018	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0806	

*** 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	0.7980	0.0665
2	3.2212	0.2684
3	4.5360	0.3780
4	0.1500	0.7500
5	14.0695	0.2402
6	1.9283	0.0803
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix U, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (802 Years): HELP Model Input Data and Output File (output file name: ZUBSD6ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	5 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 54.4	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	4 (geomembrane liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.061	0.059	0.0519	0.059
2	1	12		0.372	0.204	0.108	0.204
3	2	12		0.378	0.116	0.0406	0.116
4 *	4	0.2		0.75	0.747	0.40	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.378	0.0818	0.0155	0.0818
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The input porosity, field capacity, and wilting point values of the upper GCL are ignored by the HELP model, since the upper GCL is designated as an geomembrane in order for the HELP model to take into account the holes produced by root penetration.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	1.20E-03					
2	1	4.70E-04					
3	2	2.10E-02	450	3			
4	4	5.00E-09					
5	1	1.00E-04					
6	2	9.86E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	4	0	40,877	1	
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD6.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD6ou.OUT

TIME:  14: 2     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 802 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.0610 VOL/VOL
           FIELD CAPACITY               =     0.0590 VOL/VOL
           WILTING POINT                =     0.0519 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.0590 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.120000006000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.3720 VOL/VOL
           FIELD CAPACITY               =     0.2040 VOL/VOL
           WILTING POINT                =     0.1080 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.2040 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.469999999000E-03 CM/SEC
```

```
                       LAYER  3
                       --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     12.00   INCHES
POROSITY                    =      0.3780 VOL/VOL
FIELD CAPACITY              =      0.1160 VOL/VOL
WILTING POINT               =      0.0406 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.1160 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.209999997000E-01 CM/SEC
SLOPE                       =      3.00   PERCENT
DRAINAGE LENGTH             =    450.0    FEET

                       LAYER  4
                       --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =      0.20   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.   =  0.499999997000E-08 CM/SEC
FML PINHOLE DENSITY         =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =  40877.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  1 - PERFECT

                       LAYER  5
                       --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     58.57   INCHES
POROSITY                    =      0.3700 VOL/VOL
FIELD CAPACITY              =      0.2400 VOL/VOL
WILTING POINT               =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                       LAYER  6
                       --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     24.00   INCHES
POROSITY                    =      0.3780 VOL/VOL
FIELD CAPACITY              =      0.0818 VOL/VOL
WILTING POINT               =      0.0155 VOL/VOL
INITIAL SOIL WATER CONTENT  =      0.0818 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.986000001000E-01 CM/SEC
SLOPE                       =     11.40   PERCENT
DRAINAGE LENGTH             =    150.0    FEET
```

```
                    LAYER  7
                    --------

          TYPE 3 - BARRIER SOIL LINER
          MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 5 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER             =     54.40
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.748  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.452  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.703  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     20.718  INCHES
TOTAL INITIAL WATER                 =     20.718  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR

          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA               GEORGIA

     STATION LATITUDE                           =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                    =   3.50
     START OF GROWING SEASON (JULIAN DATE)      =     68
     END OF GROWING SEASON (JULIAN DATE)        =    323
     EVAPORATIVE ZONE DEPTH                     =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                  =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY      =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY      =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY      =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY      =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.031	0.002	0.006	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.002	0.189	0.017	0.055	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.584	1.951	2.649	2.426	2.784	3.457
	3.865	3.464	2.702	1.454	1.105	1.281
STD. DEVIATIONS	0.270	0.294	0.649	0.774	1.083	1.279
	1.205	1.125	0.934	0.637	0.316	0.205

```
 LATERAL DRAINAGE COLLECTED FROM LAYER  3
  ----------------------------------------
    TOTALS                 0.5647   0.3776   0.4326   0.1885   0.1588   0.2448
                           0.3709   0.3800   0.3364   0.2718   0.2850   0.3798

    STD. DEVIATIONS        0.3742   0.2982   0.3383   0.1913   0.2212   0.2347
                           0.3075   0.3179   0.3075   0.3007   0.2639   0.2820

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
    TOTALS                 2.2772   1.5210   1.7431   0.7586   0.6393   0.9848
                           1.4945   1.5553   1.3635   1.1064   1.1482   1.5253

    STD. DEVIATIONS        1.5280   1.2145   1.3727   0.7687   0.8877   0.9441
                           1.2445   1.3491   1.2729   1.2537   1.0692   1.1319

  LATERAL DRAINAGE COLLECTED FROM LAYER  6
  ----------------------------------------
    TOTALS                 1.7592   1.8681   1.6771   1.5063   0.8715   0.7715
                           1.0464   1.5153   1.3806   1.3645   1.1043   1.1461

    STD. DEVIATIONS        1.4343   1.2836   1.0709   0.9687   0.4896   0.6680
                           0.8377   1.2075   0.9939   1.0005   0.9407   0.9090

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
    TOTALS                 0.0083   0.0084   0.0085   0.0081   0.0069   0.0061
                           0.0064   0.0078   0.0076   0.0077   0.0069   0.0070

    STD. DEVIATIONS        0.0034   0.0028   0.0023   0.0020   0.0013   0.0019
                           0.0026   0.0030   0.0023   0.0025   0.0023   0.0024

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
    AVERAGES               2.3071   1.6893   1.7657   0.7931   0.6461   1.0302
                           1.5134   1.5752   1.4268   1.1199   1.2015   1.5450

    STD. DEVIATIONS        1.5487   1.3497   1.3914   0.8057   0.9001   0.9890
                           1.2617   1.3675   1.3333   1.2710   1.1200   1.1474

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES               0.1353   0.1576   0.1290   0.1197   0.0670   0.0613
                           0.0805   0.1166   0.1097   0.1050   0.0878   0.0882

    STD. DEVIATIONS        0.1103   0.1084   0.0824   0.0770   0.0377   0.0531
                           0.0644   0.0929   0.0790   0.0770   0.0748   0.0699

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

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.038	(0.1965)	2740.38	0.079
EVAPOTRANSPIRATION	28.723	(2.8346)	2046702.00	58.738
LATERAL DRAINAGE COLLECTED FROM LAYER 3	3.99102	(1.25187)	284387.844	8.16158
PERCOLATION/LEAKAGE THROUGH LAYER 4	16.11727	(5.09535)	1148466.750	32.95959
AVERAGE HEAD ON TOP OF LAYER 4	1.384	(0.438)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	16.01076	(4.97200)	1140877.120	32.74178
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.08980	(0.01248)	6399.206	0.18365
AVERAGE HEAD ON TOP OF LAYER 7	0.105	(0.033)		
CHANGE IN WATER STORAGE	0.047	(2.1262)	3362.64	0.097

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

             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
    ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------   -------------
       PRECIPITATION                               6.87        489534.875

       RUNOFF                                      1.385        98725.5234

       DRAINAGE COLLECTED FROM LAYER  3            0.09975       7108.17578

       PERCOLATION/LEAKAGE THROUGH LAYER  4        0.933570     66523.31250

       AVERAGE HEAD ON TOP OF LAYER  4            29.325

       MAXIMUM HEAD ON TOP OF LAYER  4            40.406

       LOCATION OF MAXIMUM HEAD IN LAYER  3
             (DISTANCE FROM DRAIN)               139.9 FEET

       DRAINAGE COLLECTED FROM LAYER  6            0.59060      42084.27730

       PERCOLATION/LEAKAGE THROUGH LAYER  7        0.001368        97.45431

       AVERAGE HEAD ON TOP OF LAYER  7             1.408

       MAXIMUM HEAD ON TOP OF LAYER  7             2.687

       LOCATION OF MAXIMUM HEAD IN LAYER  6
             (DISTANCE FROM DRAIN)                 5.0 FEET

       SNOW WATER                                  2.36        168188.7190

       MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.2024

       MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0774

        ***  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	0.7932	0.0661
2	2.6548	0.2212
3	4.1493	0.3458
4	0.0000	0.0000
5	15.7171	0.2683
6	1.9726	0.0822
7	0.1500	0.7500
SNOW WATER	0.000	

****
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Appendix V, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,000 Years): HELP Model Input Data and Output File (output file name: ZUBSD7ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	3 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 46.6	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	4 (geomembrane liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.063	0.0558	0.0517	0.0558
2	1	12		0.373	0.195	0.102	0.195
3	2	12		0.377	0.125	0.0474	0.125
4 *	4	0.2		0.75	0.747	0.40	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.374	0.0846	0.0197	0.0846
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.
* The input porosity, field capacity, and wilting point values of the upper GCL are ignored by the HELP model, since the upper GCL is designated as an geomembrane in order for the HELP model to take into account the holes produced by root penetration.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	2.80E-03					
2	1	6.90E-04					
3	2	1.40E-02	450	3			
4	4	5.00E-09					
5	1	1.00E-04					
6	2	9.64E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	4	0	121,703	1	
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD7.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD7ou.OUT

TIME:  14: 7     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 1,000 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    12.00   INCHES
           POROSITY                   =     0.0630 VOL/VOL
           FIELD CAPACITY             =     0.0558 VOL/VOL
           WILTING POINT              =     0.0517 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.0558 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.279999990000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                  =    12.00   INCHES
           POROSITY                   =     0.3730 VOL/VOL
           FIELD CAPACITY             =     0.1950 VOL/VOL
           WILTING POINT              =     0.1020 VOL/VOL
           INITIAL SOIL WATER CONTENT =     0.1950 VOL/VOL
           EFFECTIVE SAT. HYD. COND.  =  0.690000015000E-03 CM/SEC
```

```
                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3770 VOL/VOL
FIELD CAPACITY               =      0.1250 VOL/VOL
WILTING POINT                =      0.0474 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1250 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.140000004000E-01 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   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.    =  0.499999997000E-08 CM/SEC
FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     = 121703.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  1 - PERFECT

                         LAYER  5
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                         LAYER  6
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3740 VOL/VOL
FIELD CAPACITY               =      0.0846 VOL/VOL
WILTING POINT                =      0.0197 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0846 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.964000002000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET
```

```
                    LAYER  7
                    --------

          TYPE 3 - BARRIER SOIL LINER
          MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 3 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER             =     46.60
FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.620  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.486  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.640  INCHES
INITIAL SNOW WATER                  =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     20.747  INCHES
TOTAL INITIAL WATER                 =     20.747  INCHES
TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR

          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA               GEORGIA

     STATION LATITUDE                         =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   3.50
     START OF GROWING SEASON (JULIAN DATE)    =     68
     END OF GROWING SEASON (JULIAN DATE)      =    323
     EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.016	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.108	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.560	1.908	2.564	2.331	2.752	3.435
	3.843	3.445	2.680	1.432	1.085	1.261
STD. DEVIATIONS	0.284	0.306	0.679	0.776	1.048	1.266
	1.190	1.111	0.921	0.628	0.321	0.215

```
 LATERAL DRAINAGE COLLECTED FROM LAYER  3
 ----------------------------------------
   TOTALS                  0.1591   0.0963   0.1224   0.0422   0.0508   0.0715
                           0.1046   0.1020   0.0921   0.0742   0.0793   0.1075

   STD. DEVIATIONS         0.1083   0.0794   0.0982   0.0458   0.0697   0.0701
                           0.0916   0.0954   0.0941   0.0887   0.0754   0.0848

  PERCOLATION/LEAKAGE THROUGH LAYER  4
  ------------------------------------
   TOTALS                  2.8051   1.6978   2.1573   0.7456   0.8955   1.2598
                           1.8439   1.8287   1.6240   1.3140   1.3973   1.8949

   STD. DEVIATIONS         1.9112   1.3971   1.7294   0.8067   1.2268   1.2351
                           1.6183   1.7622   1.6595   1.5871   1.3296   1.4924

  LATERAL DRAINAGE COLLECTED FROM LAYER  6
  ----------------------------------------
   TOTALS                  2.3210   2.1014   2.0537   1.6187   0.9418   0.9990
                           1.5182   1.8522   1.6550   1.5295   1.2744   1.4739

   STD. DEVIATIONS         1.7721   1.4986   1.4568   1.0790   0.6680   0.9729
                           1.2097   1.5345   1.2871   1.2451   1.1581   1.2035

  PERCOLATION/LEAKAGE THROUGH LAYER  7
  ------------------------------------
   TOTALS                  0.0097   0.0090   0.0094   0.0084   0.0071   0.0067
                           0.0077   0.0087   0.0083   0.0081   0.0073   0.0077

   STD. DEVIATIONS         0.0041   0.0033   0.0032   0.0023   0.0015   0.0025
                           0.0033   0.0037   0.0029   0.0030   0.0028   0.0031

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

  DAILY AVERAGE HEAD ON TOP OF LAYER  4
  -------------------------------------
   AVERAGES                0.9716   0.6445   0.7471   0.2663   0.3099   0.4506
                           0.6385   0.6331   0.5809   0.4549   0.5000   0.6562

   STD. DEVIATIONS         0.6624   0.5308   0.5994   0.2889   0.4250   0.4423
                           0.5608   0.6107   0.5943   0.5499   0.4761   0.5173

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
   AVERAGES                0.1826   0.1813   0.1616   0.1316   0.0741   0.0812
                           0.1194   0.1457   0.1345   0.1203   0.1036   0.1160

   STD. DEVIATIONS         0.1394   0.1294   0.1146   0.0877   0.0526   0.0791
                           0.0952   0.1207   0.1046   0.0980   0.0941   0.0947

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET       PERCENT
                               -------------------  --------------  ---------
 PRECIPITATION                 48.90    (   7.734)   3484469.2     100.00

 RUNOFF                         0.016   (  0.1078)      1143.22      0.033

 EVAPOTRANSPIRATION            28.295   (  2.7952)   2016190.25     57.862

 LATERAL DRAINAGE COLLECTED     1.10213 (  0.33837)    78534.008    2.25383
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH   19.46389 (  5.99995)  1386936.620    39.80339
   LAYER  4

 AVERAGE HEAD ON TOP            0.571 (    0.176)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED    19.33876 (  5.95606)  1378019.750   39.54748
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH    0.09811 (  0.01463)     6991.046     0.20063
   LAYER  7

 AVERAGE HEAD ON TOP            0.129 (    0.040)
   OF LAYER  7

 CHANGE IN WATER STORAGE        0.050   (  2.0018)      3591.10      0.103
*******************************************************************************
```

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	6.87	489534.875
RUNOFF	0.980	69863.4219
DRAINAGE COLLECTED FROM LAYER 3	0.06879	4901.85645
PERCOLATION/LEAKAGE THROUGH LAYER 4	2.165414	154300.68700
AVERAGE HEAD ON TOP OF LAYER 4	23.259	
MAXIMUM HEAD ON TOP OF LAYER 4	34.250	
LOCATION OF MAXIMUM HEAD IN LAYER 3 (DISTANCE FROM DRAIN)	128.0 FEET	
DRAINAGE COLLECTED FROM LAYER 6	0.98597	70257.18750
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.002215	157.83235
AVERAGE HEAD ON TOP OF LAYER 7	2.405	
MAXIMUM HEAD ON TOP OF LAYER 7	4.489	
LOCATION OF MAXIMUM HEAD IN LAYER 6 (DISTANCE FROM DRAIN)	8.2 FEET	
SNOW WATER	2.36	168188.7190
MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.2039	
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0746	

*** 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 100

LAYER	(INCHES)	(VOL/VOL)
1	0.7954	0.0663
2	2.7523	0.2294
3	3.2982	0.2748
4	0.0000	0.0000
5	16.7511	0.2860
6	2.0395	0.0850
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix W, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (1,800 Years): HELP Model Input Data and Output File (output file name: ZUBSD8ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	4 (geomembrane liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.070	0.0553	0.0509	0.0553
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4 *	4	0.2		0.75	0.747	0.40	0.75
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.358	0.0979	0.0388	0.0979
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The input porosity, field capacity, and wilting point values of the upper GCL are ignored by the HELP model, since the upper GCL is designated as an geomembrane in order for the HELP model to take into account the holes produced by root penetration.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	9.10E-03					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	4	5.00E-09					
5	1	1.00E-04					
6	2	8.62E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	4	0	448,722	1	
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD8.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD8ou.OUT

TIME:  14:10     DATE:   1/13/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 1,800 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.0700 VOL/VOL
           FIELD CAPACITY               =     0.0553 VOL/VOL
           WILTING POINT                =     0.0509 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.0553 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.910000037000E-02 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                    =    12.00   INCHES
           POROSITY                     =     0.3750 VOL/VOL
           FIELD CAPACITY               =     0.1600 VOL/VOL
           WILTING POINT                =     0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT   =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.319999992000E-02 CM/SEC
```

```
                         LAYER  3
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     12.00   INCHES
POROSITY                     =      0.3750 VOL/VOL
FIELD CAPACITY               =      0.1600 VOL/VOL
WILTING POINT                =      0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.319999992000E-02 CM/SEC
SLOPE                        =      3.00   PERCENT
DRAINAGE LENGTH              =    450.0    FEET

                         LAYER  4
                         --------

             TYPE 4 - FLEXIBLE MEMBRANE LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   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.    =  0.499999997000E-08 CM/SEC
FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     = 448722.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  1 - PERFECT

                         LAYER  5
                         --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     58.57   INCHES
POROSITY                     =      0.3700 VOL/VOL
FIELD CAPACITY               =      0.2400 VOL/VOL
WILTING POINT                =      0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                         LAYER  6
                         --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.3580 VOL/VOL
FIELD CAPACITY               =      0.0979 VOL/VOL
WILTING POINT                =      0.0388 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0979 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.861999989000E-01 CM/SEC
SLOPE                        =     11.40   PERCENT
DRAINAGE LENGTH              =    150.0    FEET
```

```
                         LAYER  7
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
 THICKNESS                    =      0.20   INCHES
 POROSITY                     =      0.7500 VOL/VOL
 FIELD CAPACITY               =      0.7470 VOL/VOL
 WILTING POINT                =      0.4000 VOL/VOL
 INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
 EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     26.90
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.264  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      4.590  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.356  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     21.060  INCHES
TOTAL INITIAL WATER                =     21.060  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR

           EVAPOTRANSPIRATION AND WEATHER DATA
           -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA              GEORGIA

     STATION LATITUDE                         =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   3.50
     START OF GROWING SEASON (JULIAN DATE)    =     68
     END OF GROWING SEASON (JULIAN DATE)      =    323
     EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.533	1.848	2.491	2.259	2.667	3.342
	3.735	3.302	2.593	1.394	1.079	1.249
STD. DEVIATIONS	0.293	0.300	0.645	0.744	1.019	1.215
	1.151	1.059	0.903	0.614	0.322	0.226

```
   LATERAL DRAINAGE COLLECTED FROM LAYER  3
   ----------------------------------------
     TOTALS                  0.0108   0.0062   0.0084   0.0026   0.0036   0.0052
                             0.0074   0.0075   0.0065   0.0050   0.0054   0.0072

     STD. DEVIATIONS         0.0074   0.0052   0.0067   0.0028   0.0049   0.0051
                             0.0064   0.0080   0.0065   0.0061   0.0052   0.0059

   PERCOLATION/LEAKAGE THROUGH LAYER  4
   ------------------------------------
     TOTALS                  3.0512   1.7476   2.3858   0.7227   1.0296   1.4571
                             2.1022   2.0406   1.8313   1.4116   1.5195   2.0197

     STD. DEVIATIONS         2.0978   1.4638   1.8930   0.7843   1.3935   1.4405
                             1.8048   1.9848   1.8437   1.7074   1.4556   1.6787

   LATERAL DRAINAGE COLLECTED FROM LAYER  6
   ----------------------------------------
     TOTALS                  2.5536   2.1825   2.2402   1.6574   1.0316   1.1275
                             1.7972   2.0915   1.8523   1.6568   1.3644   1.6171

     STD. DEVIATIONS         1.9086   1.5207   1.5988   1.0939   0.7808   1.0859
                             1.4237   1.7540   1.4075   1.3401   1.2384   1.2753

   PERCOLATION/LEAKAGE THROUGH LAYER  7
   ------------------------------------
     TOTALS                  0.0110   0.0098   0.0104   0.0089   0.0075   0.0072
                             0.0089   0.0098   0.0092   0.0089   0.0079   0.0085

     STD. DEVIATIONS         0.0047   0.0036   0.0038   0.0027   0.0019   0.0031
                             0.0040   0.0045   0.0034   0.0034   0.0032   0.0035

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

   DAILY AVERAGE HEAD ON TOP OF LAYER  4
   -------------------------------------
     AVERAGES                0.2885   0.1810   0.2256   0.0705   0.0973   0.1424
                             0.1988   0.2001   0.1790   0.1336   0.1484   0.1909

     STD. DEVIATIONS         0.1985   0.1519   0.1791   0.0766   0.1318   0.1408
                             0.1708   0.2119   0.1803   0.1619   0.1423   0.1588

   DAILY AVERAGE HEAD ON TOP OF LAYER  7
   -------------------------------------
     AVERAGES                0.2247   0.2106   0.1971   0.1507   0.0908   0.1025
                             0.1581   0.1840   0.1684   0.1458   0.1241   0.1423

     STD. DEVIATIONS         0.1679   0.1469   0.1407   0.0995   0.0687   0.0987
                             0.1253   0.1543   0.1280   0.1179   0.1126   0.1122

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

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

     AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                     INCHES            CU. FEET      PERCENT
                               -------------------  -------------  ---------
 PRECIPITATION                 48.90    (   7.734)   3484469.2     100.00

 RUNOFF                         0.000   (  0.0000)        0.00       0.000

 EVAPOTRANSPIRATION            27.492   (  2.7375)   1959003.12     56.221

 LATERAL DRAINAGE COLLECTED     0.07578 (  0.02295)     5399.602    0.15496
   FROM LAYER  3

 PERCOLATION/LEAKAGE THROUGH   21.31867 (  6.36277)  1519102.370    43.59638
   LAYER  4

 AVERAGE HEAD ON TOP            0.171 (    0.052)
   OF LAYER  4

 LATERAL DRAINAGE COLLECTED    21.17214 (  6.37298)  1508660.870   43.29672
   FROM LAYER  6

 PERCOLATION/LEAKAGE THROUGH    0.10798 (  0.01688)     7694.309     0.22082
   LAYER  7

 AVERAGE HEAD ON TOP            0.158 (    0.048)
   OF LAYER  7

 CHANGE IN WATER STORAGE        0.052   (  1.9127)      3711.20      0.107
*******************************************************************************
```

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
  ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------   -------------
    PRECIPITATION                                  6.87       489534.875

    RUNOFF                                         0.000           0.0000

    DRAINAGE COLLECTED FROM LAYER  3               0.02213      1576.94116

    PERCOLATION/LEAKAGE THROUGH LAYER  4           3.401600   242387.45300

    AVERAGE HEAD ON TOP OF LAYER  4               17.964

    MAXIMUM HEAD ON TOP OF LAYER  4               27.399

    LOCATION OF MAXIMUM HEAD IN LAYER  3
          (DISTANCE FROM DRAIN)                  113.1 FEET

    DRAINAGE COLLECTED FROM LAYER  6               1.72149    122668.17200

    PERCOLATION/LEAKAGE THROUGH LAYER  7           0.004163      296.63727

    AVERAGE HEAD ON TOP OF LAYER  7                4.695

    MAXIMUM HEAD ON TOP OF LAYER  7                8.419

    LOCATION OF MAXIMUM HEAD IN LAYER  6
          (DISTANCE FROM DRAIN)                   13.8 FEET

    SNOW WATER                                     2.36       168188.7190

    MAXIMUM VEG. SOIL WATER (VOL/VOL)                      0.1959

    MINIMUM VEG. SOIL WATER (VOL/VOL)                      0.0616

     ***  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	0.8162	0.0680
2	2.4742	0.2062
3	2.5665	0.2139
4	0.0000	0.0000
5	17.8803	0.3053
6	2.3810	0.0992
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix X, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (3,400 Years): HELP Model Input Data and Output File (output file name: ZUBSD9ou.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.084	0.0543	0.0492	0.0543
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4	3	0.2		0.375	0.16	0.0745	0.375
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.324	0.126	0.0790	0.126
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	2.20E-02					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	3	3.20E-03					
5	1	1.00E-04					
6	2	6.47E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
******************************************************************************
******************************************************************************
**                                                                          **
**                                                                          **
**              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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD9.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD9ou.OUT

TIME:  16:21     DATE:   2/ 9/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 3,400 years

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

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

                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.0840 VOL/VOL
           FIELD CAPACITY              =     0.0543 VOL/VOL
           WILTING POINT               =     0.0492 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.0543 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.219999999000E-01 CM/SEC

                                  LAYER  2
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.3750 VOL/VOL
           FIELD CAPACITY              =     0.1600 VOL/VOL
           WILTING POINT               =     0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    12.00   INCHES
POROSITY                     =     0.3750 VOL/VOL
FIELD CAPACITY               =     0.1600 VOL/VOL
WILTING POINT                =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.319999992000E-02 CM/SEC
SLOPE                        =     3.00   PERCENT
DRAINAGE LENGTH              =   450.0    FEET

                        LAYER  4
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =     0.20   INCHES
POROSITY                     =     0.3750 VOL/VOL
FIELD CAPACITY               =     0.1600 VOL/VOL
WILTING POINT                =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.3750 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.319999992000E-02 CM/SEC

                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    58.57   INCHES
POROSITY                     =     0.3700 VOL/VOL
FIELD CAPACITY               =     0.2400 VOL/VOL
WILTING POINT                =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER   0
THICKNESS                    =    24.00   INCHES
POROSITY                     =     0.3240 VOL/VOL
FIELD CAPACITY               =     0.1260 VOL/VOL
WILTING POINT                =     0.0790 VOL/VOL
INITIAL SOIL WATER CONTENT   =     0.1260 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.647000000000E-01 CM/SEC
SLOPE                        =    11.40   PERCENT
DRAINAGE LENGTH              =   150.0    FEET
```

```
                    LAYER  7
                    --------

          TYPE 3 - BARRIER SOIL LINER
          MATERIAL TEXTURE NUMBER   0
THICKNESS                    =      0.20   INCHES
POROSITY                     =      0.7500 VOL/VOL
FIELD CAPACITY               =      0.7470 VOL/VOL
WILTING POINT                =      0.4000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     26.90
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =      2.252  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =      4.758  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE =      1.335  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS   =     21.797  INCHES
TOTAL INITIAL WATER                =     21.797  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR

         EVAPOTRANSPIRATION AND WEATHER DATA
         -----------------------------------

NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA              GEORGIA

     STATION LATITUDE                          =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                   =   3.50
     START OF GROWING SEASON (JULIAN DATE)     =     68
     END OF GROWING SEASON (JULIAN DATE)       =    323
     EVAPORATIVE ZONE DEPTH                    =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                 =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY     =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY     =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY     =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY     =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.526	1.853	2.479	2.282	2.698	3.334
	3.739	3.292	2.580	1.386	1.055	1.247
STD. DEVIATIONS	0.281	0.305	0.637	0.734	1.051	1.207
	1.165	1.054	0.894	0.606	0.311	0.218

```
 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                 3.0795   1.7500   2.4184   0.6934   0.9936   1.4985
                          2.1156   2.0484   1.8259   1.4336   1.5242   2.0425

   STD. DEVIATIONS        2.1241   1.5193   1.9330   0.7578   1.3707   1.4961
                          1.8446   2.0089   1.8271   1.7159   1.4725   1.6994

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                 2.5807   2.1593   2.2623   1.6326   1.0453   1.1434
                          1.7990   2.0776   1.8699   1.6549   1.3869   1.6361

   STD. DEVIATIONS        1.9494   1.5073   1.6332   1.0596   0.7973   1.0450
                          1.4402   1.7426   1.4120   1.3360   1.2182   1.2751

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   TOTALS                 0.0131   0.0114   0.0122   0.0101   0.0084   0.0086
                          0.0107   0.0116   0.0108   0.0103   0.0093   0.0101

   STD. DEVIATIONS        0.0062   0.0047   0.0051   0.0033   0.0025   0.0033
                          0.0045   0.0055   0.0044   0.0042   0.0038   0.0041

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

 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES               0.0446   0.0272   0.0334   0.0101   0.0125   0.0224
                          0.0263   0.0287   0.0270   0.0185   0.0226   0.0284

   STD. DEVIATIONS        0.0359   0.0283   0.0320   0.0132   0.0192   0.0249
                          0.0284   0.0355   0.0308   0.0229   0.0261   0.0256

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES               0.3025   0.2775   0.2652   0.1977   0.1225   0.1385
                          0.2109   0.2435   0.2265   0.1940   0.1680   0.1918

   STD. DEVIATIONS        0.2285   0.1939   0.1914   0.1284   0.0935   0.1266
                          0.1688   0.2043   0.1710   0.1566   0.1476   0.1495

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	27.471	(2.7402)	1957474.75	56.177
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00002	(0.00001)	1.677	0.00005
PERCOLATION/LEAKAGE THROUGH LAYER 4	21.42358	(6.40759)	1526578.120	43.81092
AVERAGE HEAD ON TOP OF LAYER 4	0.025	(0.008)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	21.24801	(6.40753)	1514067.250	43.45188
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.12671	(0.02043)	9028.894	0.25912
AVERAGE HEAD ON TOP OF LAYER 7	0.212	(0.064)		
CHANGE IN WATER STORAGE	0.055	(1.9035)	3896.46	0.112

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

             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
    ------------------------------------------------------------------------
                                                  (INCHES)      (CU. FT.)
                                                 ----------   -------------
      PRECIPITATION                                6.87        489534.875

      RUNOFF                                       0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  3             0.00001          0.53023

      PERCOLATION/LEAKAGE THROUGH LAYER  4         5.288364    376832.43700

      AVERAGE HEAD ON TOP OF LAYER  4              2.776

      MAXIMUM HEAD ON TOP OF LAYER  4              0.012

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

      DRAINAGE COLLECTED FROM LAYER  6             2.12129     151156.32800

      PERCOLATION/LEAKAGE THROUGH LAYER  7         0.006725       479.21652

      AVERAGE HEAD ON TOP OF LAYER  7              7.708

      MAXIMUM HEAD ON TOP OF LAYER  7             13.261

      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)                 19.3 FEET

      SNOW WATER                                   2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                    0.1617

      MINIMUM VEG. SOIL WATER (VOL/VOL)                    0.0607

       ***  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	0.8775	0.0731
2	2.2755	0.1896
3	1.9200	0.1600
4	0.0750	0.3750
5	18.5832	0.3173
6	3.3844	0.1410
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix Y, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (5,600 Years): HELP Model Input Data and Output File (output file name: ZUBSD10o.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.104	0.0529	0.0469	0.0529
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4	3	0.2		0.375	0.16	0.0745	0.375
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.276	0.164	0.134	0.164
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	3.90E-02					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	3	3.20E-03					
5	1	1.00E-04					
6	2	3.54E-02	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD10.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD10o.OUT

TIME:   9:53     DATE:   2/11/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 5,600 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.1040 VOL/VOL
           FIELD CAPACITY              =     0.0529 VOL/VOL
           WILTING POINT               =     0.0469 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.0529 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.390000008000E-01 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =    12.00   INCHES
           POROSITY                    =     0.3750 VOL/VOL
           FIELD CAPACITY              =     0.1600 VOL/VOL
           WILTING POINT               =     0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3750 VOL/VOL
FIELD CAPACITY              =     0.1600 VOL/VOL
WILTING POINT               =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =     3.00   PERCENT
DRAINAGE LENGTH             =   450.0    FEET

                        LAYER  4
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.20   INCHES
POROSITY                    =     0.3750 VOL/VOL
FIELD CAPACITY              =     0.1600 VOL/VOL
WILTING POINT               =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.3750 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC

                        LAYER  5
                        --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    58.57   INCHES
POROSITY                    =     0.3700 VOL/VOL
FIELD CAPACITY              =     0.2400 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    24.00   INCHES
POROSITY                    =     0.2760 VOL/VOL
FIELD CAPACITY              =     0.1640 VOL/VOL
WILTING POINT               =     0.1340 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1640 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.353999995000E-01 CM/SEC
SLOPE                       =    11.40   PERCENT
DRAINAGE LENGTH             =   150.0    FEET
```

```
                              LAYER  7
                              --------

                    TYPE 3 - BARRIER SOIL LINER
                    MATERIAL TEXTURE NUMBER   0
  THICKNESS                    =      0.20   INCHES
  POROSITY                     =      0.7500 VOL/VOL
  FIELD CAPACITY               =      0.7470 VOL/VOL
  WILTING POINT                =      0.4000 VOL/VOL
  INITIAL SOIL WATER CONTENT   =      0.7500 VOL/VOL
  EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

 NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
          SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
          GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
          AND A SLOPE LENGTH OF  450. FEET.

SCS RUNOFF CURVE NUMBER            =     26.90
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
EVAPORATIVE ZONE DEPTH             =     22.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE   =      2.235  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE  =      4.998  INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.308  INCHES
INITIAL SNOW WATER                 =      0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =     22.693  INCHES
TOTAL INITIAL WATER                =     22.693  INCHES
TOTAL SUBSURFACE INFLOW            =      0.00   INCHES/YEAR

               EVAPOTRANSPIRATION AND WEATHER DATA
               -----------------------------------

 NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
          AUGUSTA              GEORGIA

     STATION LATITUDE                         =  33.22 DEGREES
     MAXIMUM LEAF AREA INDEX                  =   3.50
     START OF GROWING SEASON (JULIAN DATE)    =     68
     END OF GROWING SEASON (JULIAN DATE)      =    323
     EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
     AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 DEGREES

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 100

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.552	1.901	2.514	2.338	2.740	3.354
	3.756	3.305	2.609	1.399	1.041	1.249
STD. DEVIATIONS	0.282	0.299	0.633	0.757	1.082	1.229
	1.170	1.081	0.894	0.604	0.291	0.210

```
 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                  3.0476   1.7224   2.3844   0.6803   0.9666   1.4297
                           2.0996   2.0526   1.7938   1.4017   1.5138   2.0388

   STD. DEVIATIONS         2.1362   1.4842   1.9591   0.7621   1.3798   1.4819
                           1.8388   2.0183   1.8568   1.6957   1.4708   1.6996

 LATERAL DRAINAGE COLLECTED FROM LAYER  6
 ----------------------------------------
   TOTALS                  2.5804   2.1134   2.2429   1.5738   1.0200   1.1036
                           1.7592   2.0828   1.8197   1.6138   1.3541   1.6445

   STD. DEVIATIONS         1.9666   1.5155   1.6294   1.0640   0.7936   1.0363
                           1.4611   1.7751   1.3895   1.3488   1.2126   1.3003

 PERCOLATION/LEAKAGE THROUGH LAYER  7
 ------------------------------------
   TOTALS                  0.0197   0.0167   0.0179   0.0139   0.0110   0.0113
                           0.0151   0.0169   0.0153   0.0143   0.0127   0.0144

   STD. DEVIATIONS         0.0113   0.0087   0.0093   0.0061   0.0045   0.0059
                           0.0083   0.0101   0.0079   0.0077   0.0069   0.0075

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

 DAILY AVERAGE HEAD ON TOP OF LAYER  4
 -------------------------------------
   AVERAGES                0.0440   0.0288   0.0330   0.0095   0.0144   0.0184
                           0.0275   0.0249   0.0261   0.0183   0.0213   0.0306

   STD. DEVIATIONS         0.0353   0.0261   0.0359   0.0107   0.0226   0.0211
                           0.0298   0.0287   0.0341   0.0256   0.0230   0.0295

 DAILY AVERAGE HEAD ON TOP OF LAYER  7
 -------------------------------------
   AVERAGES                0.5528   0.4965   0.4805   0.3484   0.2185   0.2443
                           0.3769   0.4462   0.4028   0.3458   0.2998   0.3523

   STD. DEVIATIONS         0.4213   0.3566   0.3491   0.2356   0.1700   0.2294
                           0.3130   0.3803   0.3076   0.2890   0.2684   0.2786

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

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	27.756	(2.7635)	1977837.50	56.762
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00002	(0.00001)	1.710	0.00005
PERCOLATION/LEAKAGE THROUGH LAYER 4	21.13124	(6.44700)	1505746.620	43.21309
AVERAGE HEAD ON TOP OF LAYER 4	0.025	(0.009)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	20.90792	(6.42289)	1489833.870	42.75641
PERCOLATION/LEAKAGE THROUGH LAYER 7	0.17926	(0.03686)	12773.592	0.36659
AVERAGE HEAD ON TOP OF LAYER 7	0.380	(0.117)		
CHANGE IN WATER STORAGE	0.056	(1.8648)	4022.33	0.115

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             PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                                (INCHES)      (CU. FT.)
                                               ----------   -------------
      PRECIPITATION                               6.87        489534.875

      RUNOFF                                      0.000            0.0000

      DRAINAGE COLLECTED FROM LAYER  3            0.00001          0.57965

      PERCOLATION/LEAKAGE THROUGH LAYER  4        3.774003    268923.71900

      AVERAGE HEAD ON TOP OF LAYER  4             2.143

      MAXIMUM HEAD ON TOP OF LAYER  4             0.013

      LOCATION OF MAXIMUM HEAD IN LAYER  3
            (DISTANCE FROM DRAIN)                23.2 FEET

      DRAINAGE COLLECTED FROM LAYER  6            2.19062     156097.14100

      PERCOLATION/LEAKAGE THROUGH LAYER  7        0.012542       893.73029

      AVERAGE HEAD ON TOP OF LAYER  7            14.549

      MAXIMUM HEAD ON TOP OF LAYER  7            23.311

      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)                28.3 FEET

      SNOW WATER                                  2.36        168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                   0.1658

      MINIMUM VEG. SOIL WATER (VOL/VOL)                   0.0594

       ***  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	0.9601	0.0800
2	2.2836	0.1903
3	2.4705	0.2059
4	0.0750	0.3750
5	18.0053	0.3074
6	4.3929	0.1830
7	0.1500	0.7500
SNOW WATER	0.000	

****
****

Appendix Z, Upper Bounding Scenario Degraded SDF MSE Vault Closure Cap (10,000 Years): HELP Model Input Data and Output File (output file name: ZUBSD11o.OUT)

Input Data:

Input Parameter (HELP Model Query)	Generic Input Parameter Value
Landfill area =	19.63 acres
Percent of area where runoff is possible =	100%
Do you want to specify initial moisture storage? (Y/N)	Y
Amount of water or snow on surface =	0 inches
CN Input Parameter (HELP Model Query)	CN Input Parameter Value
Slope =	3 %
Slope length =	450 ft
Soil Texture =	1 (HELP model default soil texture)
Vegetation =	4 (i.e., a good stand of grass)
HELP Model Computed Curve Number = 26.9	

Layer	Layer Number	Layer Type
Erosion Barrier	1	1 (vertical percolation layer)
Middle Backfill	2	1 (vertical percolation layer)
Upper Drainage Layer	3	2 (lateral drainage layer)
Upper GCL	4	3 (barrier soil liner)
Lower Backfill	5	1 (vertical percolation layer)
Lower Drainage Layer	6	2 (lateral drainage layer)
Lower GCL	7	3 (barrier soil liner)

	Layer Type	Layer Thickness (in)	Soil Texture No.	Total Porosity (Vol/Vol)	Field Capacity (Vol/Vol)	Wilting Point (Vol/Vol)	Initial Moisture (Vol/Vol)
1	1	12		0.144	0.050	0.0423	0.050
2	1	12		0.375	0.16	0.0745	0.16
3	2	12		0.375	0.16	0.0745	0.16
4	3	0.2		0.375	0.16	0.0745	0.375
5	1	58.57		0.37	0.24	0.136	0.24
6	2	24		0.22	0.21	0.20	0.21
7	3	0.2		0.75	0.747	0.40	0.75

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

Input Data (continued):

	Layer Type	Sat. Hyd. Conductivity * (cm/sec)	Drainage Length (ft)	Drain Slope (%)	Leachate Recirc. (%)	Recirc. to Layer (#)	Subsurface Inflow (in/yr)
1	1	7.50E-02					
2	1	3.20E-03					
3	2	3.20E-03	450	3			
4	3	3.20E-03					
5	1	1.00E-04					
6	2	1.00E-04	150	11.4			
7	3	5.00E-09					

	Layer Type	Geomembrane Pinhole Density (#/acre)	Geomembrane Instal. Defects (#/acre)	Geomembrane Placement Quality	Geotextile Transmissivity (cm^2/sec)
1	1				
2	1				
3	2				
4	3				
5	1				
6	2				
7	3				

The lack of values in the table for particular parameters in particular layers denotes that no HELP model input was required for that parameter in that layer. No data are missing from the table.

* The HELP model output often produces an increased number of significant digits for the Effective Saturated Hydraulic Conductivity over that of the actual input

```
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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:    D:\HELP3\Hweather\ZPREC.D4
TEMPERATURE DATA FILE:      D:\HELP3\Hweather\ZTEMP.D7
SOLAR RADIATION DATA FILE:  D:\HELP3\Hweather\ZSOLAR.D13
EVAPOTRANSPIRATION DATA:    D:\HELP3\Hweather\ZEVAP.D11
SOIL AND DESIGN DATA FILE:  D:\HELP3\Hsdfmse\ZUBSD11.D10
OUTPUT DATA FILE:           D:\HELP3\Hsdfmse\ZUBSD11o.OUT

TIME:   9:58     DATE:   2/11/2004

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

     TITLE:  UBS Degraded MSE Vault Closure Cap - 10,000 years

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

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

                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.1440 VOL/VOL
           FIELD CAPACITY              =      0.0500 VOL/VOL
           WILTING POINT               =      0.0423 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.0500 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.750000030000E-01 CM/SEC

                                   LAYER  2
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER   0
           THICKNESS                   =     12.00   INCHES
           POROSITY                    =      0.3750 VOL/VOL
           FIELD CAPACITY              =      0.1600 VOL/VOL
           WILTING POINT               =      0.0745 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.1600 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
```

```
                        LAYER  3
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    12.00   INCHES
POROSITY                    =     0.3750 VOL/VOL
FIELD CAPACITY              =     0.1600 VOL/VOL
WILTING POINT               =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.1600 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC
SLOPE                       =     3.00   PERCENT
DRAINAGE LENGTH             =   450.0    FEET

                        LAYER  4
                        --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =     0.20   INCHES
POROSITY                    =     0.3750 VOL/VOL
FIELD CAPACITY              =     0.1600 VOL/VOL
WILTING POINT               =     0.0745 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.3750 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.319999992000E-02 CM/SEC

                        LAYER  5
                        --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    58.57   INCHES
POROSITY                    =     0.3700 VOL/VOL
FIELD CAPACITY              =     0.2400 VOL/VOL
WILTING POINT               =     0.1360 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2400 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC

                        LAYER  6
                        --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER   0
THICKNESS                   =    24.00   INCHES
POROSITY                    =     0.2200 VOL/VOL
FIELD CAPACITY              =     0.2100 VOL/VOL
WILTING POINT               =     0.2000 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.2100 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC
SLOPE                       =    11.40   PERCENT
DRAINAGE LENGTH             =   150.0    FEET
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                         LAYER  7
                         --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER   0
   THICKNESS                    =     0.20   INCHES
   POROSITY                     =     0.7500 VOL/VOL
   FIELD CAPACITY               =     0.7470 VOL/VOL
   WILTING POINT                =     0.4000 VOL/VOL
   INITIAL SOIL WATER CONTENT   =     0.7500 VOL/VOL
   EFFECTIVE SAT. HYD. COND.    =  0.499999997000E-08 CM/SEC

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

  NOTE:  SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM DEFAULT
         SOIL DATA BASE USING SOIL TEXTURE # 1 WITH A
         GOOD STAND OF GRASS, A SURFACE SLOPE OF  3.%
         AND A SLOPE LENGTH OF  450. FEET.

 SCS RUNOFF CURVE NUMBER             =     26.90
 FRACTION OF AREA ALLOWING RUNOFF    =    100.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE  =     19.630  ACRES
 EVAPORATIVE ZONE DEPTH              =     22.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE   =      2.200  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE  =      5.478  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE  =      1.253  INCHES
 INITIAL SNOW WATER                  =      0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS    =     23.762  INCHES
 TOTAL INITIAL WATER                 =     23.762  INCHES
 TOTAL SUBSURFACE INFLOW             =      0.00   INCHES/YEAR

          EVAPOTRANSPIRATION AND WEATHER DATA
          -----------------------------------

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         AUGUSTA              GEORGIA

      STATION LATITUDE                         =  33.22 DEGREES
      MAXIMUM LEAF AREA INDEX                  =   3.50
      START OF GROWING SEASON (JULIAN DATE)    =     68
      END OF GROWING SEASON (JULIAN DATE)      =    323
      EVAPORATIVE ZONE DEPTH                   =  22.0  INCHES
      AVERAGE ANNUAL WIND SPEED                =   6.50 MPH
      AVERAGE 1ST QUARTER RELATIVE HUMIDITY    =  68.00 %
      AVERAGE 2ND QUARTER RELATIVE HUMIDITY    =  70.00 %
      AVERAGE 3RD QUARTER RELATIVE HUMIDITY    =  77.00 %
      AVERAGE 4TH QUARTER RELATIVE HUMIDITY    =  73.00 %
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NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
4.38	3.95	4.68	2.91	3.56	4.99
5.43	5.41	3.93	3.12	2.96	3.45

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
46.30	50.00	57.20	64.30	72.10	78.40
81.60	80.30	75.20	65.10	56.70	48.80

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR AUGUSTA GEORGIA
AND STATION LATITUDE = 33.30 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	4.56	3.57	4.76	2.74	3.60	4.97
	5.81	5.32	4.41	2.99	2.75	3.41
STD. DEVIATIONS	2.44	1.60	2.47	1.31	2.12	2.60
	2.83	2.95	2.54	2.28	1.72	1.90
RUNOFF						
TOTALS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
STD. DEVIATIONS	0.000	0.000	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000
EVAPOTRANSPIRATION						
TOTALS	1.603	1.982	2.647	2.496	2.850	3.465
	3.926	3.444	2.711	1.427	1.034	1.248
STD. DEVIATIONS	0.274	0.289	0.662	0.780	1.172	1.282
	1.271	1.131	0.938	0.621	0.283	0.207

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	3.0360	1.6629	2.2625	0.6128	0.8417	1.2964
	1.9344	1.9023	1.6896	1.3447	1.4465	2.0238
STD. DEVIATIONS	2.1295	1.5215	1.9195	0.7182	1.3150	1.4168
	1.7582	1.9775	1.7861	1.6770	1.4752	1.6978

LATERAL DRAINAGE COLLECTED FROM LAYER 6

TOTALS	0.6172	0.6376	0.7047	0.6478	0.5428	0.4570
	0.4763	0.5382	0.5468	0.5502	0.4971	0.5225
STD. DEVIATIONS	0.2997	0.2523	0.2622	0.2575	0.2307	0.2204
	0.2463	0.2794	0.2450	0.2597	0.2649	0.2778

PERCOLATION/LEAKAGE THROUGH LAYER 7

TOTALS	1.2083	1.2448	1.3764	1.2694	1.0765	0.9097
	0.9467	1.0622	1.0801	1.0874	0.9831	1.0320
STD. DEVIATIONS	0.5623	0.4635	0.4824	0.4756	0.4364	0.4234
	0.4758	0.5336	0.4657	0.4923	0.5018	0.5288

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 4

AVERAGES	0.0454	0.0246	0.0299	0.0085	0.0104	0.0188
	0.0239	0.0242	0.0234	0.0183	0.0193	0.0327
STD. DEVIATIONS	0.0366	0.0252	0.0338	0.0128	0.0198	0.0230
	0.0226	0.0295	0.0287	0.0263	0.0235	0.0311

DAILY AVERAGE HEAD ON TOP OF LAYER 7

AVERAGES	45.6372	51.5823	52.0127	49.5576	40.6339	35.4604
	35.7117	40.0956	42.1399	41.0525	38.3359	38.9516
STD. DEVIATIONS	21.3258	19.2214	18.2994	18.6430	16.5548	16.5915
	18.0489	20.2354	18.2515	18.6704	19.6669	20.0545

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 100

	INCHES		CU. FEET	PERCENT
PRECIPITATION	48.90	(7.734)	3484469.2	100.00
RUNOFF	0.000	(0.0000)	0.00	0.000
EVAPOTRANSPIRATION	28.832	(2.9518)	2054464.25	58.961
LATERAL DRAINAGE COLLECTED FROM LAYER 3	0.00002	(0.00001)	1.605	0.00005
PERCOLATION/LEAKAGE THROUGH LAYER 4	20.05366	(6.38813)	1428961.500	41.00945
AVERAGE HEAD ON TOP OF LAYER 4	0.023	(0.008)		
LATERAL DRAINAGE COLLECTED FROM LAYER 6	6.73828	(1.97717)	480149.156	13.77969
PERCOLATION/LEAKAGE THROUGH LAYER 7	13.27656	(3.72127)	946046.312	27.15037
AVERAGE HEAD ON TOP OF LAYER 7	42.598	(11.974)		
CHANGE IN WATER STORAGE	0.053	(3.0144)	3808.61	0.109

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              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                              (INCHES)      (CU. FT.)
                                             ----------   -------------
      PRECIPITATION                            6.87       489534.875

      RUNOFF                                   0.000           0.0000

      DRAINAGE COLLECTED FROM LAYER  3         0.00001         0.55582

      PERCOLATION/LEAKAGE THROUGH LAYER  4     3.645235   259748.15600

      AVERAGE HEAD ON TOP OF LAYER  4          2.729

      MAXIMUM HEAD ON TOP OF LAYER  4          0.013

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

      DRAINAGE COLLECTED FROM LAYER  6         0.03765      2682.47388

      PERCOLATION/LEAKAGE THROUGH LAYER  7     0.070386     5015.48437

      AVERAGE HEAD ON TOP OF LAYER  7         82.570

      MAXIMUM HEAD ON TOP OF LAYER  7        101.074

      LOCATION OF MAXIMUM HEAD IN LAYER  6
            (DISTANCE FROM DRAIN)             63.2 FEET

      SNOW WATER                               2.36       168188.7190

      MAXIMUM VEG. SOIL WATER (VOL/VOL)                0.1752

      MINIMUM VEG. SOIL WATER (VOL/VOL)                0.0569

       ***  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            1.1711         0.0976

                       2            2.2645         0.1887

                       3            2.4673         0.2056

                       4            0.0750         0.3750

                       5           17.7770         0.3035

                       6            5.2018         0.2167

                       7            0.1500         0.7500

                   SNOW WATER       0.000

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