APPENDIX I

EVALUATION OF HYDRAULIC PERFORMANCE FOR SCA DESIGN

GEOSYNTEC CONSULTANTS

COMPUTATION COVER SHEET

Client: Honeywell **Project:** Onondaga Lake SCA Design **Project/Proposal #:** GJ4299 **Task #:** 18

TITLE OF COMPUTATIONS **EVALUTION OF HYDRAULIC PERFORMANCE FOR SCA DESIGN**

COMPUTATIONS BY:

Signature [signature] 1/12/2010 DATE

Printed Name and Title: Joseph Sura, Staff Engineer

ASSUMPTIONS AND PROCEDURES CHECKED BY:
(Peer Reviewer)

Signature R. Kulasingam [signature] 1/12/2010 DATE

Printed Name and Title: R. Kulasingam, Project Engineer

COMPUTATIONS CHECKED BY:

Signature Fan Zhu [signature] 1/12/2010 DATE

Printed Name and Title: Fan Zhu, Staff Engineer

COMPUTATIONS BACKCHECKED BY:
(Originator)

Signature [signature] 1/12/2010 DATE

Printed Name and Title: Joseph Sura, Staff Engineer

APPROVED BY:
(PM or Designate)

Signature [signature] 12 JAN 2010 DATE

Printed Name and Title: Jay Beech, Principal

STATE OF NEW YORK JOHN F. BEECH LICENSED PROFESSIONAL ENGINEER No. 066337

APPROVAL NOTES: ____________________

REVISIONS (Number and initial all revisions)

NO.	SHEET	DATE	BY	CHECKED BY	APPROVAL

Written by:	Joseph Sura	Date:	11/23/2009	Reviewed by:	Fan Zhu / R. Kulasingam	Date:	12/2/2009
Client:	Honeywell	Project:	Onondaga Lake SCA Final Design	Project/ Proposal No.:	GJ4299	Task No.:	18

EVALUATION OF HYDRAULIC PERFORMANCE FOR SCA DESIGN

INTRODUCTION

This package was prepared in support of the design of the Sediment Consolidation Area (SCA) for the Onondaga Lake Bottom Site, which will be constructed on Wastebed 13 (WB-13). This package presents an analysis of hydraulic performance of the SCA, which will contain geotextile tubes (geo-tubes) filled with dredge material from Onondaga Lake. The analysis presented in this package has three main objectives:

1. Evaluate the infiltration rate through the final cover system. The infiltration rate through the cover system is needed to calculate the amount of liquid to be pumped through the base liner liquid management system (LMS) after closure of the SCA.
2. Evaluate the liquid head above the liner system. It should be noted that the maximum liquid head acting on the base liner system will be limited to 12 inches per New York State Department of Environmental Conservation (NYSDEC) regulations.
3. Determine the liquid head on the cover system of the SCA top and side slopes. The liquid head on the cover system of the SCA side slopes is required to analyze the veneer stability of the final cover system. More details regarding the veneer stability analysis are provided in the calculation package titled "Final Cover Veneer Stability Analyses for SCA Design" (Appendix L of the SCA Final Design).

In addition, calculations were performed to estimate the amount of consolidation water that could potentially be squeezed out of the foundation Solvay waste (SOLW) due to the SCA loading. The estimated amount of consolidation water was compared with the estimated reduction in infiltration of precipitation into WB-13 due to the installation of the SCA liner system. Calculations were also performed to compare the efficiencies of the proposed liner and NYSDEC Part 360 liner systems with regards to protection of groundwater quality.

METHODOLOGY

The calculations in this package were performed using the "Hydraulic Evaluation of Landfill Performance" (HELP) software, Version 3.07 developed by the U.S. Environmental Protection Agency. The HELP model is a quasi two-dimensional hydrologic model of water movement across, into, through, and out of landfills. The model accepts weather, soil, and design data and accounts for the effects of surface storage, snowmelt, runoff, infiltration, evapotranspiration, vegetative growth, lateral drainage, and leakage through liners [Schroeder, 1994]. The amount of consolidation water was estimated using methods that are consistent with the calculation package titled "Settlement Analyses for SCA" (Appendix H of the SCA Final Design).

INPUT PARAMETERS

The HELP software accepts parameters for layer type, hydraulic conductivity *K* for each layer, drainage path length, slope, moisture storage values, and climate. The SCA was modeled as shown in Figure 1, which provides a typical cross section. Specific properties of the eight different layers of materials are included in Table 1 and are discussed further below. It is noted that the HELP default parameters were used to select the total porosity, field capacity, and wilting point of each layer, however, the hydraulic conductivity was modified to better represent expected or potentially critical conditions.

SCA Geometry and Cover

The current design of the side slopes of the SCA is based on a 20-ft offset between geo-tubes. Each geo-tube layer is expected to be approximately 6-ft thick. This results in side slopes of 20 horizontal:6 vertical (i.e., 30% slopes) and a slope angle β=16.7 degrees. The drainage path length along the side slopes is 100 ft. The overall final cover slope on the top of the SCA is approximately 0.5% towards the low points near the sump areas. The longest possible drainage path is shown in Figure 2, which is approximately 1500 ft in length.

The current design of the SCA final cover consists of the following layers, from top to bottom, as shown in Figures 3A and 3B for the top and side slopes, respectively:

- Vegetative soil layer;
- Protective soil layer;
- Geocomposite drainage layer (SCA side slopes only);
- Geomembrane (GM) liner; and
- Leveling layer.

The proposed vegetative soil layer has a thickness of 6 in and was modeled as a sandy silt (ML) with a hydraulic conductivity of $1.0x10^{-4}$ cm/s. The protective soil layer has a thickness of 24 in and is assumed to be a sandy clay (SC) material with a hydraulic conductivity of $1.0x10^{-5}$ cm/s.

The geocomposite drainage layer will only be included in the side slopes of the SCA to reduce the liquid head on the cover and improve the final cover veneer stability. For purposes of this analysis, a 200 mil geocomposite with a minimum measured hydraulic conductivity of 10 cm/s is recommended. After the use of reduction factors to account for creep (1.2), delayed intrusion (1.1), degradation (1.2), particulate clogging (1.2), chemical clogging (1.2), biological clogging (1.3) and a general safety factor of 2.5, the design hydraulic conductivity is considered to be 1.33 cm/s.

The cover GM was modeled using the HELP model parameters for a low density polyethylene (LDPE) liner, which is available in the HELP database. It is noted that changing the type of GM to other materials, such as ethylene-propylene diene monomer (EPDM) or high density polyethylene (HDPE), which are also available in the HELP database, did not affect the calculated values. It was assumed to contain one hole per acre and have good contact with the soil layer below, both of which can typically be achieved during construction. The holes in the GM were assumed to be 0.16 in^2, following the recommendations of Giroud and Bonaparte [1989].

A leveling layer was assumed to smooth post-settlement contours and maintain positive drainage. The decision on the material to be used in the leveling layer will be determined based on available material sources during operations. Therefore, a sensitivity analysis has been performed to model the impact of using either a SC material of the same type as the protective soil layer (i.e., hydraulic conductivity of 10^{-5} cm/s) or a granular material with hydraulic conductivity of 1.0 cm/s that is likely to be available if particle separation is performed on the dredged material. It is noted that the thickness of the leveling layer may vary, based on surface water requirements and the amount of separated material available for disposal. Based on sensitivity analyses, a thickness of 6 inches was selected for modeling.

Geo-tubes and Dredge Material

The geo-tubes above the gravel drainage layer were modeled as three separate layers, from bottom to top: (i) a layer for the dredge material; (ii) a small intermediate layer; and (iii) a geotextile layer for the top layer of geo-tubes. The 30-ft thick dredge material was modeled with properties similar to a low plasticity silt (ML). A hydraulic conductivity of $K_{DREDGE} = 1.0x10^{-5}$ cm/s was used to represent the dredged material. Laboratory test results on the material to be dredged, which consists mostly of Solvay waste (SOLW) from the In-Lake Waste Deposit (ILWD) of Onondaga Lake, indicate that the hydraulic conductivity of the dredge material (K_{DREDGE}) may vary from approximately $K_{DREDGE}=10^{-5}$ cm/s to $K_{DREDGE}=10^{-6}$ cm/s. As discussed in subsequent sections, sensitivity analyses were performed to evaluate the effect of K_{DREDGE} on the infiltration rate and the head on the liner.

The intermediate layer above the dredge material was modeled as a vertical percolation layer of 60-mil thickness of dredge material. This layer is necessary due to modeling restrictions within the HELP program, which does not allow the placement of a barrier soil layer underlying another barrier soil layer.

The geotextile layer represents the interface between the geo-tubes and dredge material. As the liquid flows through the cover system to reach the top geo-tube/dredge material interface, it will experience preferential flow patterns. As shown in Figure 4, the liquid can pass through the geotextile material itself or through the open area filled with dredge material. Therefore, this layer was modeled using a combined equivalent hydraulic conductivity K_{EQ}, calculated using Equation 1 below, as discussed by Das [2005].

$$K_{EQ} = K_{DREDGE} \text{ x } A_{DREDGE} + K_{GT} \text{ x } A_{GT} \qquad \text{(Eq.1)}$$

where:

K_{EQ} = Equivalent hydraulic conductivity

K_{DREDGE} = Hydraulic conductivity of dredge material

A_{DREDGE} = Cross-sectional area of dredge material, measured as percent open area of the geotextile

K_{GT} = Hydraulic conductivity of woven geotextile

A_{GT} = Cross-sectional area covered by woven geotextile material and calculated as 100% - A_{DREDGE}

The percent open area was assumed to be 4% based on the standard typical minimum value for a woven geotextile [TC Mirafi, 2000]. A sensitivity analysis on the equivalent hydraulic conductivity resulting from different values of K_{GT} was performed and is shown in Figure 5. As described on Figure 5, a value of $K_{EQ} = 4.0\text{x}10^{-7}$ cm/s was selected based on this analysis.

Liner System

The SCA liner system consists of the following layers from top to bottom:

- Gravel drainage layer;
- Nonwoven geotextile cushion;
- Geomembrane (GM) liner; and
- Low permeability soil layer.

The proposed gravel drainage layer has an average thickness of 2 ft and a minimum thickness of 1 ft. It was modeled conservatively as a 1-ft thick layer. This drainage layer will be sloped towards the sumps to allow gravity drainage. Based on the predicted grading of the underlying low permeability soil layer 30 years after closure, the gravel drainage layer was modeled with a slope of 1% and a drainage path length of 1500 ft, as shown in Figure 6. A sensitivity analysis using a slope of 0.5% for the gravel drainage layer was also performed. The assumed hydraulic conductivity of the gravel is 10 cm/s based on available material sources. Sensitivity analyses were performed to evaluate the effect of K_{GRAVEL} ranging from 5 cm/s to 15 cm/s, based on a range in values for other potentially available gravel types.

A nonwoven (NW) geotextile (GT) cushion will be placed between the gravel drainage layer and GM for protection. This NW GT layer was not included in the HELP model.

The GM was modeled using the HELP model parameters for a low density polyethylene (LDPE) liner, which is available in the HELP database. It is noted that changing the type of GM to other materials, such as ethylene-propylene diene monomer (EPDM) or high density polyethylene (HDPE), which are also available in the HELP database, did not affect the calculated values. The GM was assumed to contain one hole per acre and have good contact with the soil layer below, both of which can typically be achieved during construction. The holes in the GM were assumed to be 0.16 in^2, following the recommendations of Giroud and Bonaparte [1989].

The low permeability soil layer has a proposed minimum thickness of 1 ft. The top 6 inches of this layer is required to have a hydraulic conductivity of K=10^{-6} cm/s or lower, per agreement with NYSDEC. The bottom part of this layer was modeled with a hydraulic conductivity of K=10^{-5} cm/s.

Climate Data

The data for precipitation, temperature, humidity, and solar radiation were modeled using the HELP software synthetic data generation function for Syracuse, New York for a 100-year modeling period. This generation uses recorded mean monthly data for Syracuse, shown in Table 2, to stochastically generate daily data with approximately the same statistical characteristics as the historic data. The precipitation data was manually adjusted to account for the design storm event of a 25-year, 24-hour rainfall. The rainfall corresponding to the design storm event was selected to be 4.4 inches based on recommendations from the Natural Resources Conservation Service [1986], as shown in Figure 7. The evaporative zone depth, which is the maximum depth from which water may be removed by evapotranspiration, was assumed to be 30 inches, corresponding to the total thickness of the topsoil and the protective soil layer in the final cover system. For this analysis, it is assumed that a good stand of grass will be established on the final cover system; therefore, the leaf area index (i.e., the dimensionless ratio of leaf area of active vegetation to the nominal surface area) of 3.5 was selected. If willows are planted above the GM, less infiltration will result; therefore, that case is not analyzed herein. Values of the climate parameters are shown in Table 3.

CASES ANALYZED

Table 4 provides a summary of the cases evaluated, which includes a Base Case (top and side slopes) and a sensitivity analysis on the parameters K_{DREDGE}, K_{GRAVEL}, and $K_{LEVELING}$. Case 1, as compared to the Base Case (top), was used to evaluate the effect of uncertainty in the hydraulic conductivity of the dredge material. Cases 2A and 2B, as compared to the Base Case (top), were used to evaluate the effect of the gravel drainage layer hydraulic conductivity on liquid production and the liquid head on the geomembrane liner. Case 3, as compared to the Base Case (top), was used to evaluate the effect of a clayey soil (i.e., SC soil, $K_{LEVELING}$=1.0x10^{-5} cm/s) in the leveling layer as compared to granular soil (i.e., $K_{LEVELING}$=1.0 cm/s) in the leveling layer.

For analysis of the SCA side slopes, the Base Case parameters were used with a geocomposite added to the final cover, as discussed previously. This case is referred to as Base (side slopes) in Table 4.

Finally, HELP modeling was also performed to demonstrate the efficiency of the SCA with the proposed composite liner system as compared to the efficiency of the SCA with a prescribed Part 360 liner. The Part 360 prescribed liner system used for comparison is summarized in Table 5.

RESULTS OF ANALYSIS

The results of the HELP Model analyses are summarized in Table 6. HELP Output files for the Base Case on the SCA top (run I_1A) and SCA side slopes (run III_1A) are included in Attachment 1.

The effect of uncertainty in the hydraulic conductivity of the dredge material was studied by comparing the results of Case 1 with the Base Case (top). Increasing the hydraulic conductivity of the dredge material did not significantly affect calculated peak daily or average annual values of liquid head on the cover and liner system or liquid production. Therefore, it is recommended that a value of $K_{DREDGE}= 10^{-5}$ cm/s be used for design purposes.

When compared to the Base Case on the top (K_{GRAVEL}=10 cm/s), changing the gravel hydraulic conductivity (i.e., Cases 2A and 2B) did not significantly affect calculated peak daily or average annual values of liquid head on the cover and liner system or liquid production. Therefore, it is recommended that a value of K_{GRAVEL}=10 cm/s be used for design purposes.

Changing the material used in the leveling layer (i.e., Base Case [top] compared to Case 3) did not affect the calculated peak daily or average annual values of liquid head on the cover and liner system or liquid production. Therefore, based on the results of the HELP analysis, use of either the SC soil or a granular material (or any other soil with K values in between $1.0x10^{-5}$ cm/s and 1 cm/s) is considered to be acceptable from a hydraulic performance standpoint.

The results of the consolidation water and infiltration reduction calculations are presented in Table 7. These calculations were performed on an annual average basis during the SCA operational period using reasonable assumptions regarding liner construction and geo-tube filling phasing. Key assumptions are presented as footnotes in Table 7. During the four years of operation, total amounts of consolidation water due to filling of the SCA and infiltration reduction due to installation of the liner were calculated to be 189 and 162 million gallons, respectively. Considering the complicated nature of nonlinear field processes such as consolidation and infiltration and the use of idealized simple models to perform the estimates, the total amount of consolidation water and reduction in infiltration are considered to be comparable over a four year operational period. The current capacity of the existing liquid collection system and its ability to handle a potential increase in flow will be further evaluated as part of the closure of WB-9 through WB-15.

The equivalency calculations summarized in Table 8 indicate that the SCA with both the proposed liner and the NYSDEC Part 360 liner have liner efficiencies of greater than 99.99%. Therefore, it can be demonstrated that the proposed system will effectively protect groundwater quality.

SUMMARY AND CONCLUSIONS

This package presents the analyses of the hydraulic performance of the proposed SCA using the HELP model. The evaluation presented in this package has three main objectives: (i) evaluate the infiltration rate through the proposed final cover system; (ii) evaluate the liquid head above the liner system; and (iii) evaluate the liquid head above the GM in the cover system on the top and side slopes of the SCA. Analysis of the SCA top and side slopes indicates that the calculated liquid head on the liner satisfies the NYSDEC requirement of 1 ft or less on the liner system. The calculated annual average liquid rate was approximately 0.4 gallons per minute. The maximum and average calculated liquid heads in the cover system on the SCA side slopes during the peak day were 0.030 inches (0.003 ft) and 0.020 inches (0.002 ft), respectively.

In addition, the calculations performed to estimate the amount of consolidation water indicate that the amount of water squeezed out over the four year operational period is the same order of magnitude as the reduction in infiltration that will occur due to liner system installation. The capacity of the existing liquid collection system is currently being evaluated as part of the WB-9 through WB-15 closure.

The equivalency calculations indicate that the efficiency of the proposed SCA with its composite liner system is comparable to the efficiency of the SCA with a Part 360 liner. Therefore, it can be demonstrated that the proposed SCA liner will effectively protect groundwater quality at the site.

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Tables

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

Table 1: Material Properties of Layers within SCA System

Layer	Description[1]	Layer Type[2]	HELP Default[3]	HELP USCS Name	Thickness (in)	K (cm/s)
1	Topsoil	1	8	ML	6	1.0E-04
2	Protective Layer	2	13	SC	24	1.0E-05
3	Geomembrane	4	36	LDPE	0.06	4.0E-13[4]
4	Leveling Layer	1	21 / 13	Gravel / SC	6[5]	1.0 / 1.0E-05
5	Geo-tube with Dredge Filter Cake	3	20	Drainage Net	0.06	4.0E-07[6]
6	Dredge material[7]	1	22	ML	0.06	1.0E-05[8]
7	Dredge material	3	22	ML	360	1.0E-05[8]
8	Gravel Drainage	2	21	Gravel	12	10[9]
9	Geomembrane	4	36	LDPE	0.06	4.0E-13[4]
10	Low Permeability Soil (Top 6")	3	24	SC	6	1.0E-06
11	Low Permeability Soil (Bottom 6")	1	13	SC	6	1.0E-05

Notes:

1. This is a general description of each layer.
2. The following layer types are available in the HELP model: 1=Vertical Percolation, 2=Lateral Drainage, 3=Barrier Soil Liner, 4=Geomembrane Liner (GM).
3. This is the HELP default soil texture number. It is noted that the hydraulic conductivity of each layer may be changed from the HELP default to better represent expected or potentially critical conditions. All input parameters can be found in the HELP output files provided in Attachment 1.
4. This layer is modeled as LDPE GM, using typical values from the HELP database. Selection of a different GM type will not affect the results significantly.
5. The leveling layer thickness may vary based on surface water requirements and the amount of separated material available for disposal. Based on sensitivity analyses discussed in the package, a thickness of 6 inches was selected for modeling.
6. This was calculated using the percent Open Area, as discussed in the package.
7. This layer is identical to the 360 inch (30 ft) layer of dredge material, but is modeled as a vertical percolation layer. This is necessary due to modeling restrictions within the HELP program.
8. The value shown here is the base parameter, used in cases labeled “A”. This value was changed to $K=1.0\times10^{-6}$ cm/s in cases labeled “B” to evaluate sensitivity.
9. The assumed hydraulic conductivity of the gravel is 10 cm/s, based on potentially available material.
10. It is noted that layers 8 through 11 compose the proposed liner system.

11. It is noted that for the side slope case (S_III_1A), a 200 mil geocomposite drainage layer was added between layers 2 and 3. This layer was modeled as the HELP default soil texture 20 (i.e., drainage net) and a design hydraulic conductivity of 1.33 cm/s, which corresponds to a measured laboratory hydraulic conductivity of 10 cm/s.

Table 2: Normal Mean Precipitation and Temperature Data for Syracuse, NY

Month	Precipitation (in)	Temperature (°F)
January	2.61	22.80
February	2.65	24.00
March	3.11	33.30
April	3.34	46.10
May	3.16	57.00
June	3.63	66.30
July	3.76	70.90
August	3.77	69.30
September	3.29	62.10
October	3.14	51.30
November	3.45	40.60
December	3.20	28.30

Note:

These are the default normal mean monthly values of precipitation and temperature for Syracuse, NY, available in the HELP software.

Table 3: Climate Parameters for Syracuse, NY and Other Parameters for the SCA Final Cover (HELP Default Values Unless Stated Otherwise)

Parameter	Value	Units
Fraction of Area allowing Runoff	100%	percent of total area
Evaporative Zone Depth	30	Inches
Latitude	43.07	Degrees
Maximum Leaf Area Index	3.5[3]	--
Start of Growing Season (date)	124[4]	--
End of Growing Season (date)	284[4]	--
Planar Area[1]	1	Acre
Average Annual Wind Speed	9.7	miles/hr
Average 1st Quarter Relative Humidity	72%	--
Average 2nd Quarter Relative Humidity	68%	--
Average 3rd Quarter Relative Humidity	75%	--
Average 4th Quarter Relative Humidity	76%	--
Peak Daily Rainfall, 25-year, 24-hour storm event[2]	4.40	Inches

Notes:

1. The area was modeled as one acre to produce values on a per-acre basis. This was multiplied by the total number of acres to calculate total flow rates over the entire area of the SCA. The total area of the SCA was assumed to be approximately 70 acres.
2. Value from National Resources Conservation Service data shown in Figure 7.
3. This value corresponds to a good stand of grass on top of the final cover.
4. These dates correspond to May 4 through October 11.

Table 4: Cases Evaluated

Case	Run ID[1]	Variable	Description of Variable	K_{DREDGE} (cm/s)	K_{GRAVEL} (cm/s)	$K_{LEVELING}$ (cm/s)
Base Top[2]	**I_1A**	N/A	Base case using parameters from Table 1	1.0E-05	10	1
1	**I_1B**	K_{DREDGE}	Hydraulic conductivity of dredge material	1.0E-06	10	1
2A	**I_2A**	K_{GRAVEL}	Hydraulic conductivity of gravel drainage layer	1.0E-05	5	1
2B	**I_2B**	K_{GRAVEL}	Hydraulic conductivity of gravel drainage layer	1.0E-05	15	1
3	**II_1A**	$K_{LEVELING}$	Material to be used for leveling layer (SC or granular)	1.0E-05	10	1.0E-05
Base Side Slopes[3]	**S_III_1A**	N/A	Base case using parameters from Table 1	1.0E-05	10	1

Note:

1. The Run ID corresponds to the case listed in Table 6.
2. This is the base case for comparison. The parameters used are the base parameters shown in Table 1, and the leveling layer is considered to be granular material.
3. This is the base case for the side slopes. The parameters used are the base parameters shown in Table 1, with the modifications described in Note 11 of Table 1.

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

Table 5: Part 360 Prescribed Liner System

Layer	Description[1]	Layer Type[2]	HELP Default[3]	HELP USCS Name	Thickness (in)	K (cm/s)
8[4]	Granular Drainage	2	1	SP	24	0.01[5]
9	Geomembrane	4	36	LDPE	0.06	4.0E-13[6]
10	Compacted Clay	3	29	CH	6	1.0E-07[5]
11	Structural Fill	1	10	SC	12	1.0E-04[7]
12	Granular Drainage	2	1	SP	12	0.01[5]
13	Geomembrane	4	36	LDPE	0.06	4.0E-13[6]
14	Compacted Clay	3	29	CH	24	1.0E-07[5]

Notes:

1. This is a general description of each layer.
2. The following layer types are available in the HELP model: 1=Vertical Percolation, 2=Lateral Drainage, 3=Barrier Soil Liner, 4=Geomembrane Liner (GM).
3. This is the HELP default soil texture number. It is noted that the hydraulic conductivity of each layer may be changed from the HELP default to better represent expected or potentially critical conditions.
4. Layers 1 through 7 represent the final cover system and geo-tubes. Therefore, they are modeled identically as in the base case. Details of these layers are shown on Table 1. Layers 8 through 14 compose the Part 360 prescribed liner system, as compared to Layers 8 through 11 in Table 1 that represent the proposed liner system.
5. Required values per NYSDEC Part 360 regulations.
6. This layer is modeled as LDPE GM, using typical values from the HELP database. It is noted that the regulations do not specify a GM material. Selection of a different GM type will not affect the results significantly.
7. This hydraulic conductivity value is assumed based on the type of material.

Table 6: Results of HELP Modeling for the SCA

Case	Run ID	Curve Number	K_{DREDGE} (cm/s)	K_{GRAVEL} (cm/s)	$K_{LEVELING}$ (cm/s)	Peak Daily Values					Average Annual Values				
						H_{AVG} (in) cover	H_{MAX} (in) liner	H_{AVG} (in) liner	Liquid (ft^3/ad)	Liquid (gal/min)	H_{AVG} (in) liner	Liquid (ft^3/ac-yr)	Liquid (gal/ac-day)	Liquid (gal/ac)	Liquid (gal/min)
Base Top	**I_1A**	68.2	1.0E-05	10	1	30.0	0.0	0.0	2.6	0.9	0.0	366.0	7.5	525.0	0.4
1	**I_1B**	68.2	1.0E-06	10	1	30.0	0.0	0.0	2.6	0.9	0.0	366.0	7.5	525.0	0.4
2A	**I_2A**	68.2	1.0E-05	5	1	30.0	0.0	0.0	2.6	0.9	0.0	366.0	7.5	525.0	0.4
2B	**I_2B**	68.2	1.0E-05	15	1	30.0	0.0	0.0	2.6	0.9	0.0	366.0	7.5	525.0	0.4
3	**II_1A**	68.2	1.0E-05	10	1.0E-05	30.0	0.0	0.0	2.6	0.9	0.0	366.0	7.5	525.0	0.4
Base Side Slopes	**S_III_1A**	76.1	1.0E-05	10	1	0.02	0.0	0.0	13.1	4.8	0.0	403.5	8.3	578.8	0.4

Notes:

1. The curve number is calculated by HELP based on model inputs.
1. Selected maximum precipitation for a single day is 4.4 inches, based on the National Resources Conservation Service [1986] recommendations for a 25 year, 24 hour storm event.
2. SCA is assumed to have a total acreage of 70 acres.
3. This table uses a drainage path length of 1500 ft and slope of approximately 0.5% for the final cover top area and a drainage path length of 1500 ft and slope of 1% for the gravel drainage layer.
4. The HELP Output file for the base case, I_1A, is included in Attachment 1.
5. Case S_III_1A represents the SCA side slopes and is modeled with a final cover drainage path length of 100 ft and slope of 30%. It is noted that the gravel drainage layer is modeled with a drainage path length of 1500 ft and slope of 1%. The HELP Output file for this case is included in Attachment 1.

Table 7: Results of Consolidation Water and Reduction in Infiltration Rate Calculations

Year	SCA Footprint at End of Each Phase (ac)[1]	New SCA Footprint in Each Year (ac)	Total Lined SCA Area at End of Each Phase (ac)[2]	Additional Lined Area (ac)[3]	Infiltration Cut-off (million gallons)		Consolidation Squeezed Water (million gallons)				
					Assuming 40" Infiltration Each Year[4]	Assuming 0.5 x 40" Infiltration Each Year[5]	Estimated Average Geo-tube Height (ft)[6]	Estimated Average Total Thickness of Gravel Drainage Layer and Liner (ft)[7]	Estimated Total Equivalent Soil Thickness (ft)[8]	Estimated Average Settlement (ft)[9]	Estimated Consolidation Squeezed Water in Each Year (million gallons)[10]
0	--	--	15	10	14	7	--	--	--	--	--
1	30	30	40	10	54	27	18	5	18.1	5.4	53
2	50	20	61	10	77	39	22	5	20.7	6.2	48
3	72	22	72	10	89	45	23	5	21.3	6.4	49
4	72	0	72	10	89	45	30	5	26.8	8.0	38
Total Estimated Infiltration Cut-off in 4+ years (million gallons)					323	**162**	Total Estimated Consolidation Squeezed Water in 4 years (million gallons)				**189**

Notes:

1. The SCA footprint is measured from the outside toe of the perimeter berm.
2. Assuming half of the new SCA footprint will be lined in advance during the previous year.
3. Additional lined area for basins, and water treatment and pre-processing facilities.
4. The infiltration cut-off volume equals 40 inches of annual average rainfall multiplied by the total lined area at the end of each year. In year 0, only half a year for the infiltration cut-off was assumed.
5. Assuming 50% for evapotranspiration based on the analysis presented in the HELP calculations.
6. To estimate the average geo-tube height for calculating loads for settlements, a 25% decrease of the available footprint was considered to account for the SCA perimeter berm, the 10-ft gap between geo-tubes and the berm, and the 20-ft offset distance for geo-tube stacking. This assumption is considered reasonable based on the calculation of an average geo-tube height of 30 ft for year 4.
7. These thicknesses are based on the calculations presented in the package titled "Volume Calculations for SCA Design".
8. Assuming a unit weight of 120 pcf for liner and gravel and 86 pcf for dredge material. The total thickness was converted to an equivalent thickness of soil with a unit weight of 120 pcf.
9. Using a rule of thumb: 10 ft soil causes approximately 3 ft of settlement in SOLW (based on test plot results). The total calculated average settlement of 8 feet in the 4th year is consistent with the results of detailed settlement calculations presented in the calculation package titled "Settlement Analyses for SCA" in the Final SCA Design.
10. The Solvay waste above the groundwater table was conservatively assumed to be fully saturated in the calculation. Primary consolidation time was assumed to be less than one year, thus resulting in all calculated consolidation water for a given year being squeezed out within that year.

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

Table 8: Results of Liner Equivalency Calculations

Run ID	**Liner Type**	**Peak Daily Values**			**Average Annual Values**		
		Precipitation (in/ac-day)	Leakage (in/ac-day)	Efficiency (%)	Precipitation (in/ac)	Leakage (in/ac)	Efficiency (%)
I_1A	Proposed	4.40	0.000314	99.9929%	39.20	0.00340	99.9913%
360_Soil	Part 360 - Double-liner with soils	4.40	0.000000	100.0000%	39.20	0.00001	100.0000%

Notes:

1. The analyses presented in the table use a drainage path length of 1500 ft and slope of 0.5% for the final cover and a drainage path length of 1500 ft and slope of 1% for the drainage layer in the liner.
2. The proposed liner system (Base Case [top], run I_1A) is described in Table 1. The prescribed NYSDEC Part 360 liner is described in Table 5.
3. The efficiency of the liner is calculated using the formula:

$$Efficiency = 100\% - \frac{Leakage}{\Pr ecipitation}.$$

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Figures

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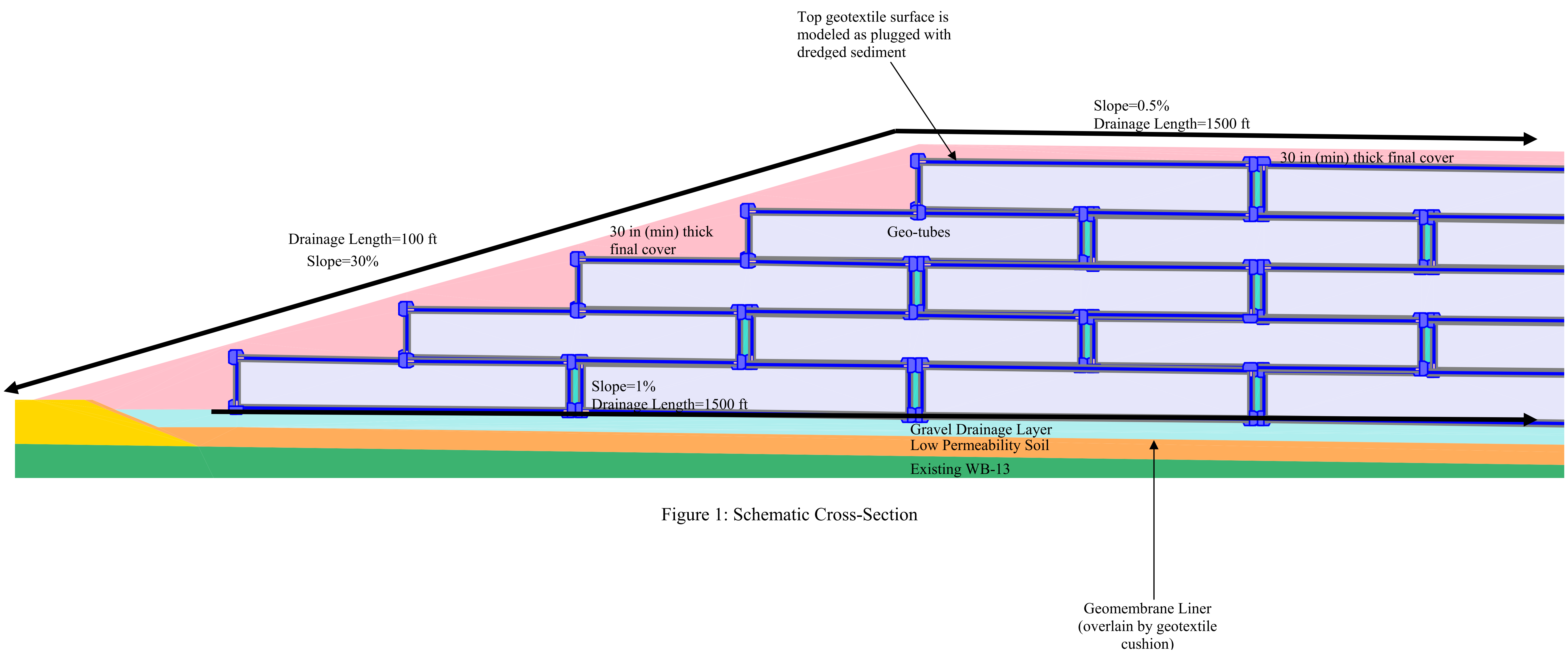

Figure 1: Schematic Cross-Section

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Client: Honeywell Project: Onondaga Lake SCA Final Design Project/ Proposal No.: GJ4299 Task No.: 18

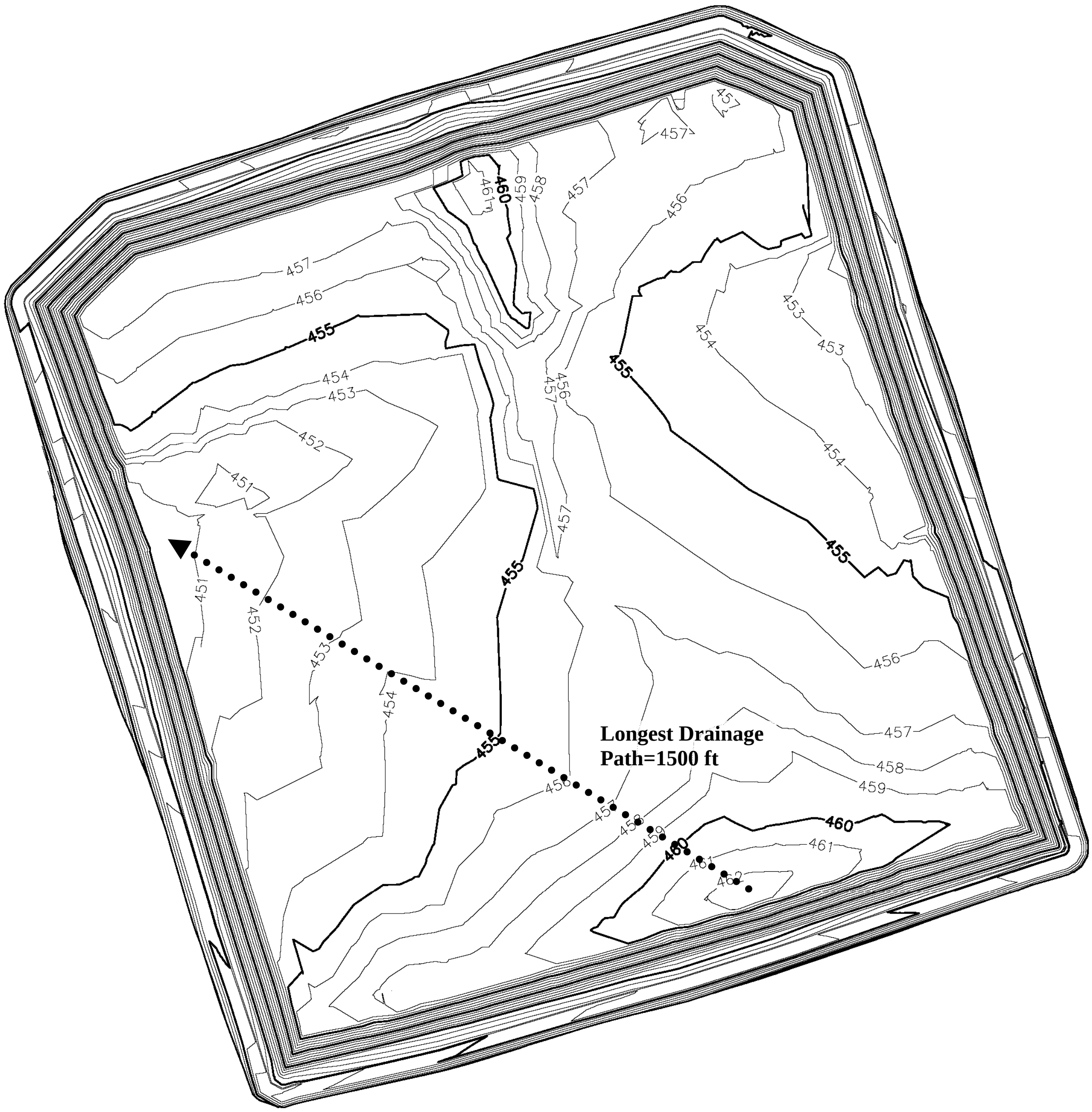

Figure 2: Design Top of Final Cover

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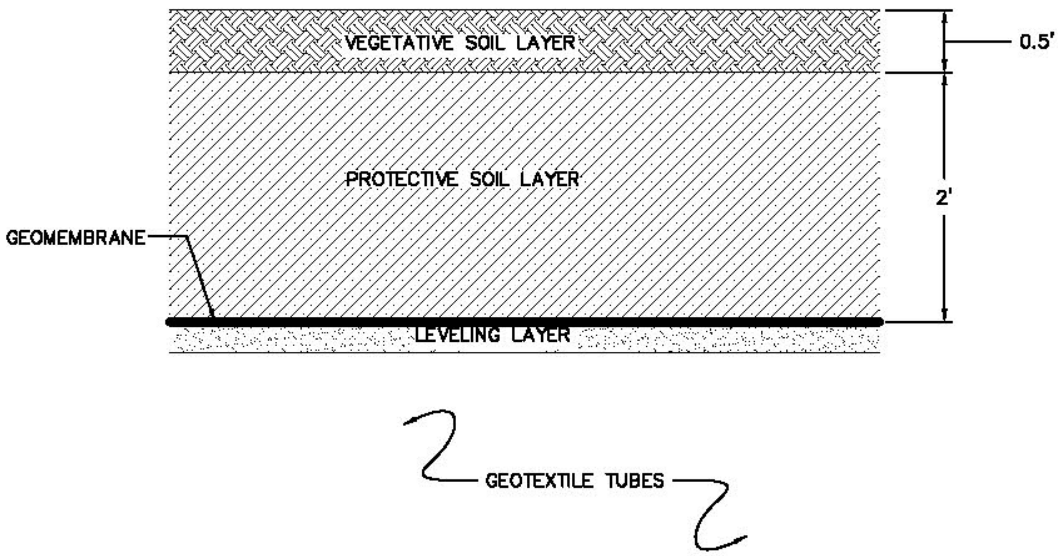


Figure 3A: Section View of Final Cover (SCA top)

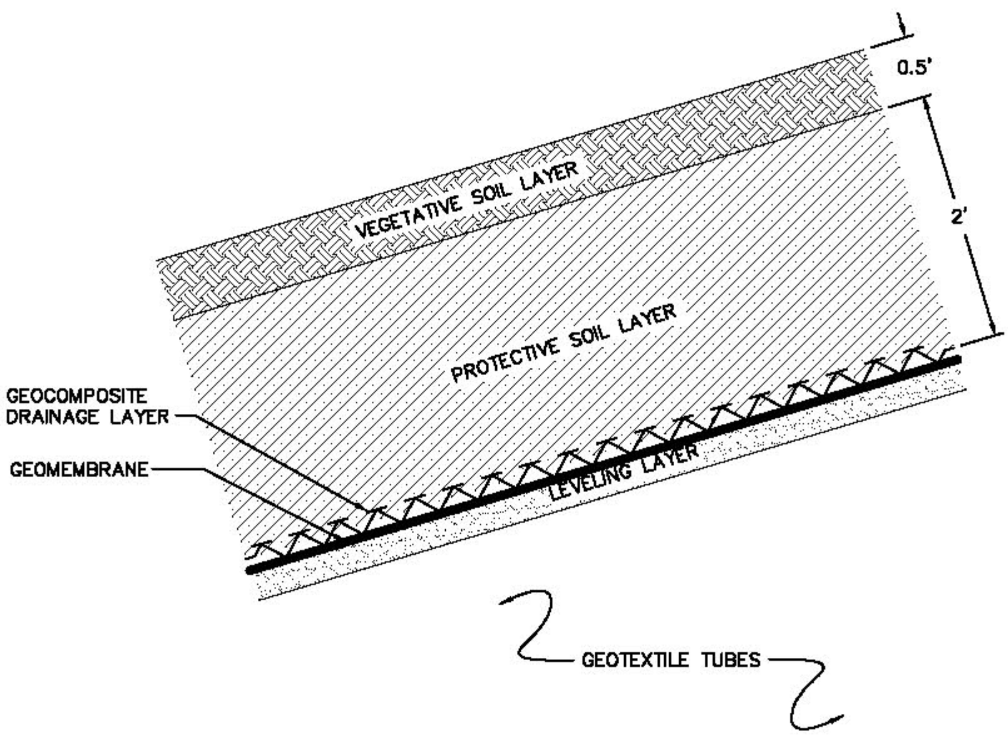
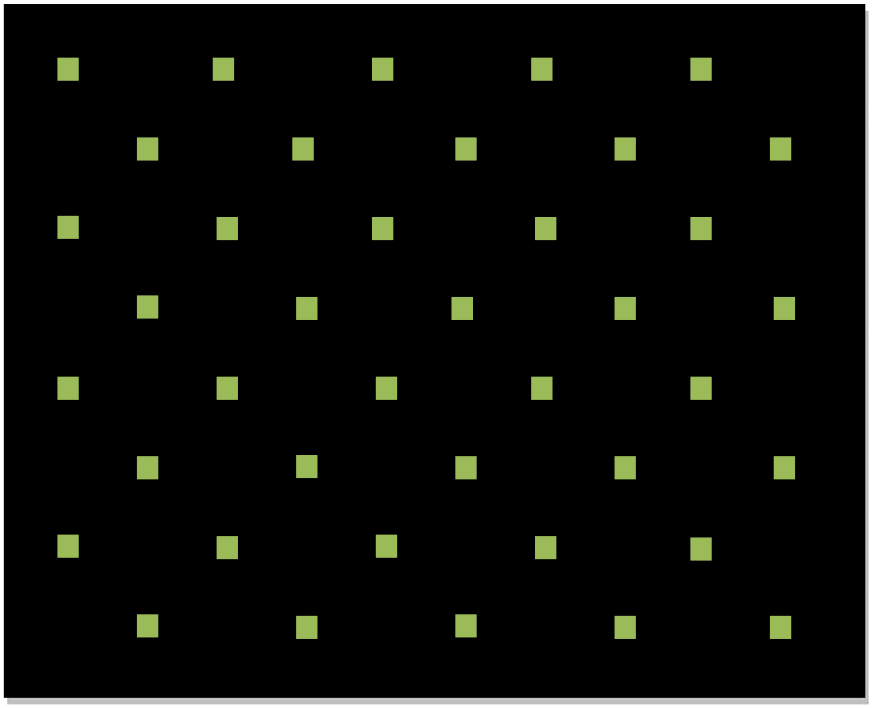


Figure 3B: Section View of Final Cover (SCA side slopes)



*K*DREDGE (green)
*K*GT (black)

Figure 4: Conceptual View of Geo-tube/Dredge Material Layer Equivalent Hydraulic Conductivity

Notes:

1. This figure illustrates the modeling of the geo-tube/dredge material layer equivalent hydraulic conductivity.
2. The open area of the geo-tubes (assumed to be 4% of total area) is covered with dredge filter cake material, as shown. Therefore, the hydraulic conductivity of the geo-tubes/dredge material interface layer was modeled as a liner with equivalent hydraulic conductivity.

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Client:	Honeywell	Project:	Onondaga Lake SCA Final Design	Project/ Proposal No.:	GJ4299	Task No.:	18

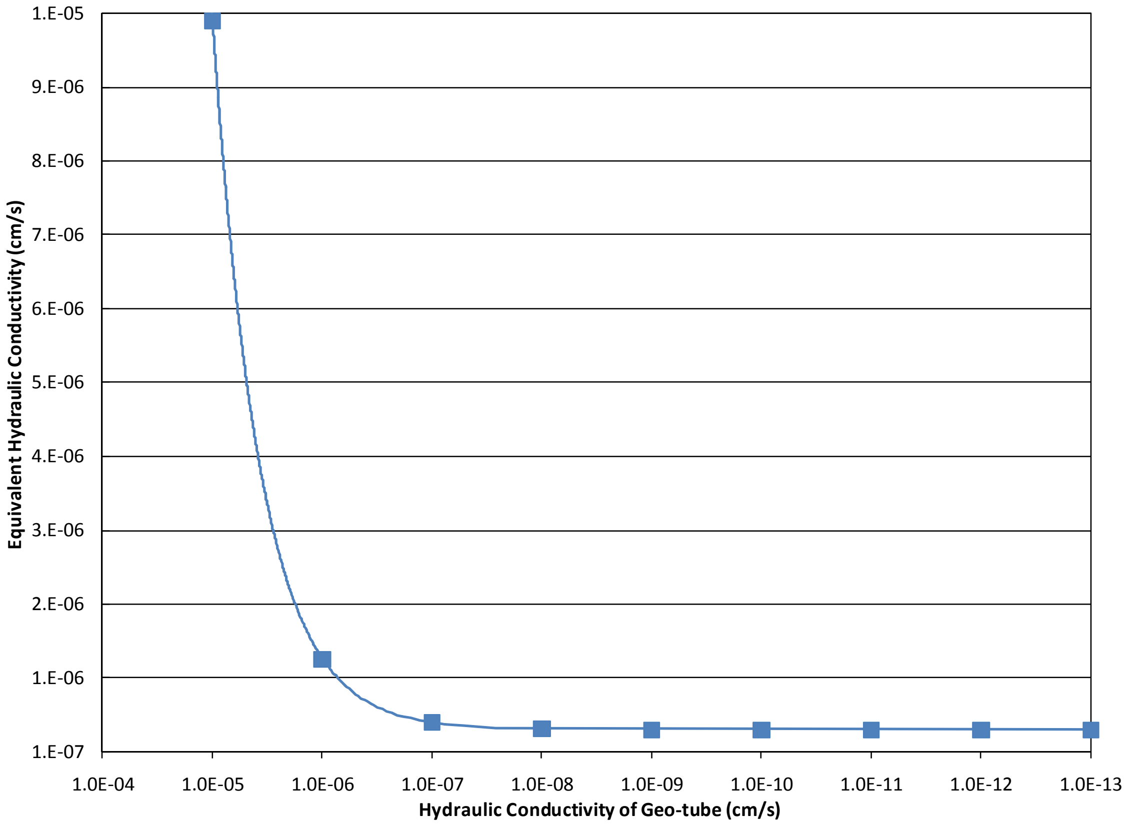

Figure 5: Sensitivity of Dredge Material/Geo-tube Equivalent Hydraulic Conductivity to the Hydraulic Conductivity of the Geo-tube Material

Notes:

1. This figure shows the equivalent hydraulic conductivity of Layer 5, the top of geo-tubes with open areas plugged with dredge material.
2. The actual fabric of a woven geotextile was assumed to have a hydraulic conductivity of 10^{-8} cm/s or less.
3. The calculations were performed using a hydraulic conductivity of $1.0x10^{-5}$ cm/s for the dredge material.
4. Based on the assumed $K_{GT}=10^{-8}$ cm/s, a K_{EQ} value of $4x10^{-7}$ cm/s has been assumed for the analyses.

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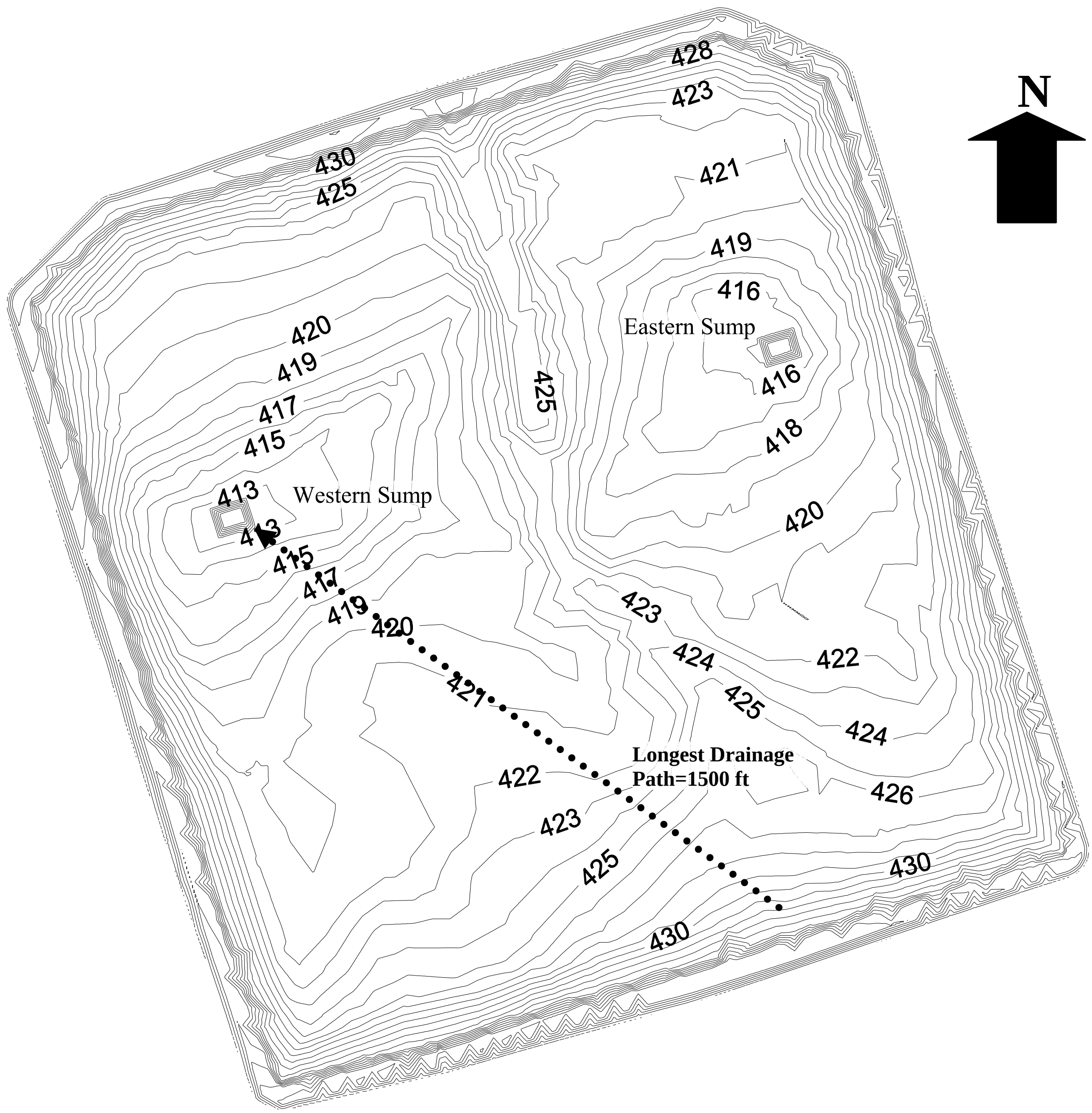

Figure 6: Top of Low Permeability Soil Liner Grades - 30 Years after Closure

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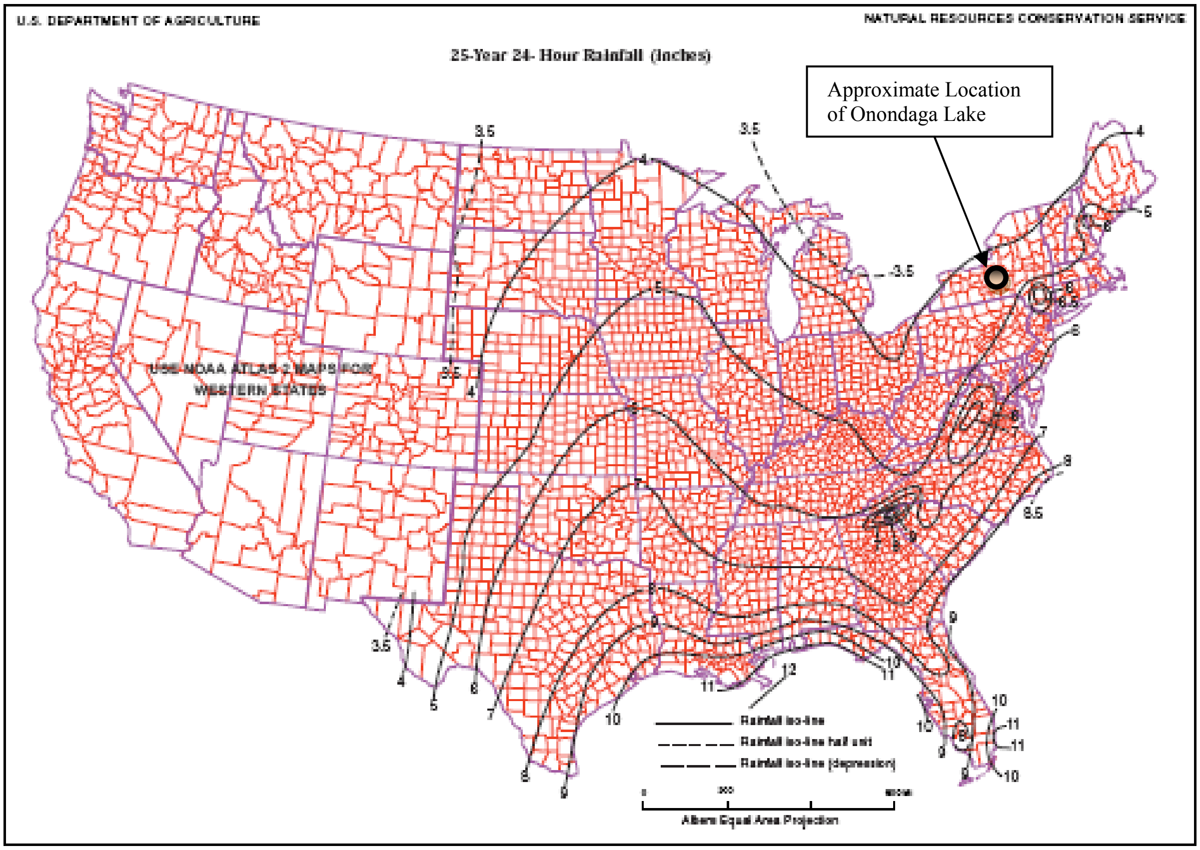

Figure 7: NRCS Map for Calculation of 25-year, 24-hour Storm Event [NRCS, 1986]

Note:

The value selected for the model is 4.40 inches, based on the approximate location of Onondaga Lake.

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Attachment 1: HELP Output Files

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Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

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


PRECIPITATION DATA FILE:     C:\PROGRA~1\HELP\OLPRECIP.D4
TEMPERATURE DATA FILE:       C:\PROGRA~1\HELP\OLTEMP.D7
SOLAR RADIATION DATA FILE:   C:\PROGRA~1\HELP\OLSOLAR.D13
EVAPOTRANSPIRATION DATA:     C:\PROGRA~1\HELP\OL_LAI35.D11
SOIL AND DESIGN DATA FILE:   C:\PROGRA~1\HELP\I__1A.D10
OUTPUT DATA FILE:            C:\PROGRA~1\HELP\I__1A.OUT


TIME:  13:38     DATE:  12/ 9/2009


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

     TITLE:  Onondaga Lake SCA - Final Design

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


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


                                  LAYER  1
                                  --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER 108
           THICKNESS                    =      6.00   INCHES
           POROSITY                     =      0.4630 VOL/VOL
           FIELD CAPACITY               =      0.2320 VOL/VOL
           WILTING POINT                =      0.1160 VOL/VOL
           INITIAL SOIL WATER CONTENT   =      0.4586 VOL/VOL
           EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-04 CM/SEC


                                  LAYER  2
                                  --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

```
              MATERIAL TEXTURE NUMBER 113
THICKNESS                    =     24.00   INCHES
POROSITY                     =      0.4300 VOL/VOL
FIELD CAPACITY               =      0.3210 VOL/VOL
WILTING POINT                =      0.2210 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4310 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC
SLOPE                        =      0.51   PERCENT
DRAINAGE LENGTH              =   1500.0    FEET


                        LAYER  3
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD


                        LAYER  4
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER 221
THICKNESS                    =      6.00   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.    =   1.00000000000     CM/SEC


                        LAYER  5
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER 120
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.400000005000E-06 CM/SEC


                        LAYER  6
```

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Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

```
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER 122
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.4190 VOL/VOL
FIELD CAPACITY               =      0.3070 VOL/VOL
WILTING POINT                =      0.1800 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3070 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                        LAYER  7
                        --------

              TYPE 3 - BARRIER SOIL LINER
              MATERIAL TEXTURE NUMBER 122
THICKNESS                    =    360.00   INCHES
POROSITY                     =      0.4190 VOL/VOL
FIELD CAPACITY               =      0.3070 VOL/VOL
WILTING POINT                =      0.1800 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4190 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                        LAYER  8
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER 121
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.    =   10.0000000000     CM/SEC
SLOPE                        =      1.00   PERCENT
DRAINAGE LENGTH              =   1500.0    FEET


                        LAYER  9
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.0000 VOL/VOL
FIELD CAPACITY               =      0.0000 VOL/VOL
WILTING POINT                =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY          =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS     =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY        =  3 - GOOD
```

```
                         LAYER 10
                         --------

                TYPE 3 - BARRIER SOIL LINER
                MATERIAL TEXTURE NUMBER 124
   THICKNESS                  =     6.00   INCHES
   POROSITY                   =     0.3650 VOL/VOL
   FIELD CAPACITY             =     0.3050 VOL/VOL
   WILTING POINT              =     0.2020 VOL/VOL
   INITIAL SOIL WATER CONTENT =     0.3650 VOL/VOL
   EFFECTIVE SAT. HYD. COND.  =  0.999999997000E-06 CM/SEC


                         LAYER 11
                         --------

            TYPE 1 - VERTICAL PERCOLATION LAYER
                MATERIAL TEXTURE NUMBER 113
   THICKNESS                  =     6.00   INCHES
   POROSITY                   =     0.4300 VOL/VOL
   FIELD CAPACITY             =     0.3210 VOL/VOL
   WILTING POINT              =     0.2210 VOL/VOL
   INITIAL SOIL WATER CONTENT =     0.3049 VOL/VOL
   EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-05 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  1.%
         AND A SLOPE LENGTH OF 1500. FEET.

 SCS RUNOFF CURVE NUMBER            =    68.20
 FRACTION OF AREA ALLOWING RUNOFF   =   100.0    PERCENT
 AREA PROJECTED ON HORIZONTAL PLANE =     1.000  ACRES
 EVAPORATIVE ZONE DEPTH             =    30.0    INCHES
 INITIAL WATER IN EVAPORATIVE ZONE  =    13.096  INCHES
 UPPER LIMIT OF EVAPORATIVE STORAGE =    13.098  INCHES
 LOWER LIMIT OF EVAPORATIVE STORAGE =     6.000  INCHES
 INITIAL SNOW WATER                 =     0.000  INCHES
 INITIAL WATER IN LAYER MATERIALS   =   168.601  INCHES
 TOTAL INITIAL WATER                =   168.601  INCHES
 TOTAL SUBSURFACE INFLOW            =     0.00   INCHES/YEAR


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

  NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SYRACUSE              NEW YORK
```

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```
STATION LATITUDE                       =  43.07 DEGREES
MAXIMUM LEAF AREA INDEX                =   3.50
START OF GROWING SEASON (JULIAN DATE)  =    124
END OF GROWING SEASON (JULIAN DATE)    =    284
EVAPORATIVE ZONE DEPTH                 =  30.0  INCHES
AVERAGE ANNUAL WIND SPEED              =   9.70 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY  =  72.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY  =  68.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY  =  75.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY  =  76.00 %
```

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SYRACUSE NEW YORK

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.61	2.65	3.11	3.34	3.16	3.63
3.76	3.77	3.29	3.14	3.45	3.20

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SYRACUSE NEW YORK

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.80	24.00	33.30	46.10	57.00	66.30
70.90	69.30	62.10	51.30	40.60	28.30

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING COEFFICIENTS FOR SYRACUSE NEW YORK AND STATION LATITUDE = 43.07 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	2.59	2.72	3.16	3.27	3.09	3.71
	3.87	3.95	3.27	2.95	3.40	3.22
STD. DEVIATIONS	0.70	0.96	1.19	1.19	1.31	1.57
	1.67	1.76	1.60	1.16	1.19	0.76
RUNOFF						

```
------
  TOTALS                 0.840    1.708    5.121    2.038    0.493    0.312
                         0.056    0.019    0.027    0.158    0.770    1.251

  STD. DEVIATIONS        0.941    1.678    2.481    1.397    0.690    0.666
                         0.419    0.152    0.165    0.473    1.120    1.084

EVAPOTRANSPIRATION
------------------
  TOTALS                 0.491    0.407    0.480    1.806    2.889    5.480
                         6.166    4.126    2.211    1.045    0.710    0.497

  STD. DEVIATIONS        0.080    0.077    0.169    0.691    0.799    0.644
                         0.755    1.297    0.674    0.154    0.135    0.109

LATERAL DRAINAGE COLLECTED FROM LAYER  2
----------------------------------------
  TOTALS                 0.0000   0.0000   0.0000   0.0002   0.0003   0.0002
                         0.0001   0.0000   0.0000   0.0001   0.0002   0.0002

  STD. DEVIATIONS        0.0000   0.0000   0.0000   0.0001   0.0000   0.0000
                         0.0000   0.0000   0.0001   0.0001   0.0002   0.0002

PERCOLATION/LEAKAGE THROUGH LAYER  3
------------------------------------
  TOTALS                 0.0052   0.0043   0.0052   0.0129   0.0194   0.0150
                         0.0069   0.0024   0.0021   0.0046   0.0100   0.0128

  STD. DEVIATIONS        0.0019   0.0011   0.0018   0.0046   0.0006   0.0014
                         0.0034   0.0037   0.0044   0.0071   0.0084   0.0065

PERCOLATION/LEAKAGE THROUGH LAYER  5
------------------------------------
  TOTALS                 0.0052   0.0043   0.0052   0.0129   0.0194   0.0150
                         0.0069   0.0024   0.0021   0.0046   0.0100   0.0128

  STD. DEVIATIONS        0.0019   0.0011   0.0018   0.0046   0.0006   0.0014
                         0.0034   0.0037   0.0044   0.0071   0.0084   0.0065

PERCOLATION/LEAKAGE THROUGH LAYER  7
------------------------------------
  TOTALS                 0.0052   0.0043   0.0052   0.0129   0.0194   0.0150
                         0.0069   0.0024   0.0021   0.0046   0.0100   0.0128

  STD. DEVIATIONS        0.0019   0.0011   0.0018   0.0046   0.0006   0.0014
                         0.0034   0.0037   0.0044   0.0071   0.0084   0.0065

LATERAL DRAINAGE COLLECTED FROM LAYER  8
----------------------------------------
  TOTALS                 0.0052   0.0043   0.0051   0.0125   0.0194   0.0153
                         0.0071   0.0024   0.0020   0.0045   0.0097   0.0131

  STD. DEVIATIONS        0.0020   0.0011   0.0017   0.0047   0.0006   0.0014
                         0.0034   0.0037   0.0044   0.0070   0.0084   0.0066

PERCOLATION/LEAKAGE THROUGH LAYER 10
------------------------------------
  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 11
  ------------------------------------
    TOTALS                   0.0004   0.0004   0.0004   0.0004   0.0004   0.0003
                             0.0003   0.0001   0.0001   0.0001   0.0002   0.0003

    STD. DEVIATIONS          0.0011   0.0009   0.0009   0.0008   0.0008   0.0007
                             0.0006   0.0003   0.0003   0.0003   0.0006   0.0006


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


  DAILY AVERAGE HEAD ON TOP OF LAYER  3
  -------------------------------------
    AVERAGES                 5.1671   4.5585   5.1793  17.5567  26.9031  21.4400
                             8.4427   2.6768   2.6671   6.0991  13.9574  16.9021

    STD. DEVIATIONS          2.5364   1.2677   2.2985   7.1492   0.7459   2.1231
                             5.0019   4.8488   6.1433   9.8299  12.0795   9.2454

  DAILY AVERAGE HEAD ON TOP OF LAYER  5
  -------------------------------------
    AVERAGES                 0.0001   0.0001   0.0001   0.0001   0.0002   0.0002
                             0.0001   0.0000   0.0000   0.0001   0.0001   0.0001

    STD. DEVIATIONS          0.0000   0.0000   0.0000   0.0001   0.0000   0.0000
                             0.0000   0.0000   0.0001   0.0001   0.0001   0.0001

  DAILY AVERAGE HEAD ON TOP OF LAYER  7
  -------------------------------------
    AVERAGES                 0.0002   0.0002   0.0002   0.0005   0.0007   0.0006
                             0.0002   0.0001   0.0001   0.0002   0.0004   0.0005

    STD. DEVIATIONS          0.0001   0.0000   0.0001   0.0002   0.0000   0.0001
                             0.0001   0.0001   0.0002   0.0003   0.0003   0.0002

  DAILY AVERAGE HEAD ON TOP OF LAYER  9
  -------------------------------------
    AVERAGES                 0.0004   0.0004   0.0004   0.0011   0.0017   0.0013
                             0.0006   0.0002   0.0002   0.0004   0.0009   0.0011

    STD. DEVIATIONS          0.0002   0.0001   0.0001   0.0004   0.0000   0.0001
                             0.0003   0.0003   0.0004   0.0006   0.0007   0.0006

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


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

   AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS    1 THROUGH  100
-------------------------------------------------------------------------------
                                    INCHES           CU. FEET       PERCENT
                              -------------------  -------------   ---------
 PRECIPITATION                 39.20    (   4.823)     142279.7     100.00

 RUNOFF                        12.794   (  3.3907)      46441.28     32.641

 EVAPOTRANSPIRATION            26.309   (  2.2364)      95501.46     67.122
```

```
  LATERAL DRAINAGE COLLECTED      0.00145 (  0.00054)        5.246    0.00369
    FROM LAYER  2

  PERCOLATION/LEAKAGE THROUGH     0.10082 (  0.02666)      365.966     0.25722
    LAYER  3

  AVERAGE HEAD ON TOP            10.962 (    3.116)
    OF LAYER  3

  PERCOLATION/LEAKAGE THROUGH     0.10082 (  0.02666)      365.966     0.25722
    LAYER  5

  AVERAGE HEAD ON TOP             0.000 (    0.000)
    OF LAYER  5

  PERCOLATION/LEAKAGE THROUGH     0.10082 (  0.02666)      365.966     0.25722
    LAYER  7

  AVERAGE HEAD ON TOP             0.000 (    0.000)
    OF LAYER  7

  LATERAL DRAINAGE COLLECTED      0.10081 (  0.02665)      365.952    0.25721
    FROM LAYER  8

  PERCOLATION/LEAKAGE THROUGH     0.00001 (  0.00000)        0.020     0.00001
    LAYER 10

  AVERAGE HEAD ON TOP             0.001 (    0.000)
    OF LAYER  9

  PERCOLATION/LEAKAGE THROUGH     0.00340 (  0.00747)       12.332     0.00867
    LAYER 11

  CHANGE IN WATER STORAGE        -0.013   (  1.5171)       -46.59     -0.033
*******************************************************************************

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

              PEAK DAILY VALUES FOR YEARS    1 THROUGH  100
   ------------------------------------------------------------------------
                                              (INCHES)     (CU. FT.)
                                             ----------  -------------
       PRECIPITATION                            4.40        15972.000

       RUNOFF                                   4.342       15759.7656

       DRAINAGE COLLECTED FROM LAYER  2         0.00002         0.06081

       PERCOLATION/LEAKAGE THROUGH LAYER  3     0.000703        2.55133

       AVERAGE HEAD ON TOP OF LAYER  3         30.000

       MAXIMUM HEAD ON TOP OF LAYER  3         37.397

       LOCATION OF MAXIMUM HEAD IN LAYER  2
             (DISTANCE FROM DRAIN)            596.4 FEET

       PERCOLATION/LEAKAGE THROUGH LAYER  5     0.000703        2.55133

       AVERAGE HEAD ON TOP OF LAYER  5          0.000
```

```
PERCOLATION/LEAKAGE THROUGH LAYER  7       0.000703         2.55133

AVERAGE HEAD ON TOP OF LAYER  7            0.001

DRAINAGE COLLECTED FROM LAYER  8           0.00070          2.55124

PERCOLATION/LEAKAGE THROUGH LAYER 10       0.000000         0.00009

AVERAGE HEAD ON TOP OF LAYER  9            0.002

MAXIMUM HEAD ON TOP OF LAYER  9            0.004

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

PERCOLATION/LEAKAGE THROUGH LAYER 11       0.000314         1.14110

SNOW WATER                                 9.62         34911.7891


MAXIMUM VEG. SOIL WATER (VOL/VOL)                  0.4366

MINIMUM VEG. SOIL WATER (VOL/VOL)                  0.2000

 ***  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.

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

Written by:	Joseph Sura	Date:	11/23/2009	Reviewed by:	Fan Zhu / R. Kulasingam	Date:	12/2/2009
Client:	Honeywell	Project:	Onondaga Lake SCA Final Design	Project/ Proposal No.:	GJ4299	Task No.:	18

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

                 FINAL WATER STORAGE AT END OF YEAR  100
    ----------------------------------------------------------------------
                  LAYER        (INCHES)       (VOL/VOL)
                  -----        --------       ---------
                    1            2.7516         0.4586

                    2            9.3544         0.3898

                    3            0.0000         0.0000

                    4            0.1920         0.0320

                    5            0.0510         0.8500

                    6            0.0184         0.3070

                    7          150.8400         0.4190

                    8            0.3840         0.0320

                    9            0.0000         0.0000

                   10            2.1900         0.3650

                   11            1.4902         0.2484

                SNOW WATER       0.046

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

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


PRECIPITATION DATA FILE:    C:\PROGRA~1\HELP\OLPRECIP.D4
TEMPERATURE DATA FILE:      C:\PROGRA~1\HELP\OLTEMP.D7
SOLAR RADIATION DATA FILE:  C:\PROGRA~1\HELP\OLSOLAR.D13
EVAPOTRANSPIRATION DATA:    C:\PROGRA~1\HELP\OL_LAI35.D11
SOIL AND DESIGN DATA FILE:  C:\PROGRA~1\HELP\S_III1A.D10
OUTPUT DATA FILE:           C:\PROGRA~1\HELP\S_III1A.OUT


TIME:  13:47     DATE:  12/ 9/2009


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

     TITLE:  Onondaga Lake SCA - Final Design

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


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


                                   LAYER  1
                                   --------

                     TYPE 1 - VERTICAL PERCOLATION LAYER
                         MATERIAL TEXTURE NUMBER 108
           THICKNESS                  =      6.00   INCHES
           POROSITY                   =      0.4630 VOL/VOL
           FIELD CAPACITY             =      0.2320 VOL/VOL
           WILTING POINT              =      0.1160 VOL/VOL
           INITIAL SOIL WATER CONTENT  =      0.4567 VOL/VOL
           EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-04 CM/SEC


                                   LAYER  2
                                   --------

                       TYPE 2 - LATERAL DRAINAGE LAYER
```

```
              MATERIAL TEXTURE NUMBER 113
THICKNESS                  =     24.00   INCHES
POROSITY                   =      0.4300 VOL/VOL
FIELD CAPACITY             =      0.3210 VOL/VOL
WILTING POINT              =      0.2210 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.4057 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.999999975000E-05 CM/SEC


                        LAYER  3
                        --------

            TYPE 2 - LATERAL DRAINAGE LAYER
              MATERIAL TEXTURE NUMBER 220
THICKNESS                  =      0.20   INCHES
POROSITY                   =      0.8500 VOL/VOL
FIELD CAPACITY             =      0.0100 VOL/VOL
WILTING POINT              =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0100 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =   1.33000004000     CM/SEC
SLOPE                      =     30.00   PERCENT
DRAINAGE LENGTH            =    100.0    FEET


                        LAYER  4
                        --------

            TYPE 4 - FLEXIBLE MEMBRANE LINER
              MATERIAL TEXTURE NUMBER  36
THICKNESS                  =      0.06   INCHES
POROSITY                   =      0.0000 VOL/VOL
FIELD CAPACITY             =      0.0000 VOL/VOL
WILTING POINT              =      0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT =      0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.  =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY        =      0.00   HOLES/ACRE
FML INSTALLATION DEFECTS   =      1.00   HOLES/ACRE
FML PLACEMENT QUALITY      =  3 - GOOD


                        LAYER  5
                        --------

          TYPE 1 - VERTICAL PERCOLATION LAYER
              MATERIAL TEXTURE NUMBER 221
THICKNESS                  =      6.00   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.  =   1.00000000000     CM/SEC


                        LAYER  6
```

```
                          --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER 120
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.8500 VOL/VOL
FIELD CAPACITY               =      0.0100 VOL/VOL
WILTING POINT                =      0.0050 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.8500 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.400000005000E-06 CM/SEC


                          LAYER  7
                          --------

           TYPE 1 - VERTICAL PERCOLATION LAYER
               MATERIAL TEXTURE NUMBER 122
THICKNESS                    =      0.06   INCHES
POROSITY                     =      0.4190 VOL/VOL
FIELD CAPACITY               =      0.3070 VOL/VOL
WILTING POINT                =      0.1800 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.3070 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                          LAYER  8
                          --------

               TYPE 3 - BARRIER SOIL LINER
               MATERIAL TEXTURE NUMBER 122
THICKNESS                    =    360.00   INCHES
POROSITY                     =      0.4190 VOL/VOL
FIELD CAPACITY               =      0.3070 VOL/VOL
WILTING POINT                =      0.1800 VOL/VOL
INITIAL SOIL WATER CONTENT   =      0.4190 VOL/VOL
EFFECTIVE SAT. HYD. COND.    =  0.999999975000E-05 CM/SEC


                          LAYER  9
                          --------

             TYPE 2 - LATERAL DRAINAGE LAYER
               MATERIAL TEXTURE NUMBER 121
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.    =   10.0000000000     CM/SEC
SLOPE                        =      1.00   PERCENT
DRAINAGE LENGTH              =   1500.0    FEET


                          LAYER 10
```

```
                    --------

          TYPE 4 - FLEXIBLE MEMBRANE LINER
            MATERIAL TEXTURE NUMBER  36
THICKNESS                   =     0.06   INCHES
POROSITY                    =     0.0000 VOL/VOL
FIELD CAPACITY              =     0.0000 VOL/VOL
WILTING POINT               =     0.0000 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.0000 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.399999993000E-12 CM/SEC
FML PINHOLE DENSITY         =     0.00   HOLES/ACRE
FML INSTALLATION DEFECTS    =     1.00   HOLES/ACRE
FML PLACEMENT QUALITY       =  3 - GOOD


                    LAYER 11
                    --------

            TYPE 3 - BARRIER SOIL LINER
            MATERIAL TEXTURE NUMBER 124
THICKNESS                   =     6.00   INCHES
POROSITY                    =     0.3650 VOL/VOL
FIELD CAPACITY              =     0.3050 VOL/VOL
WILTING POINT               =     0.2020 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.3650 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999997000E-06 CM/SEC


                    LAYER 12
                    --------

        TYPE 1 - VERTICAL PERCOLATION LAYER
            MATERIAL TEXTURE NUMBER 113
THICKNESS                   =     6.00   INCHES
POROSITY                    =     0.4300 VOL/VOL
FIELD CAPACITY              =     0.3210 VOL/VOL
WILTING POINT               =     0.2210 VOL/VOL
INITIAL SOIL WATER CONTENT  =     0.3038 VOL/VOL
EFFECTIVE SAT. HYD. COND.   =  0.999999975000E-05 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 30.%
         AND A SLOPE LENGTH OF  100. FEET.

SCS RUNOFF CURVE NUMBER            =     76.10
FRACTION OF AREA ALLOWING RUNOFF   =    100.0    PERCENT
AREA PROJECTED ON HORIZONTAL PLANE =      1.000  ACRES
EVAPORATIVE ZONE DEPTH             =     30.0    INCHES
INITIAL WATER IN EVAPORATIVE ZONE  =     12.477  INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE =     13.098  INCHES
```

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

```
LOWER LIMIT OF EVAPORATIVE STORAGE  =     6.000  INCHES
INITIAL SNOW WATER                  =     0.000  INCHES
INITIAL WATER IN LAYER MATERIALS    =   167.977  INCHES
TOTAL INITIAL WATER                 =   167.977  INCHES
TOTAL SUBSURFACE INFLOW             =     0.00   INCHES/YEAR
```

EVAPOTRANSPIRATION AND WEATHER DATA

```
NOTE:  EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
         SYRACUSE              NEW YORK

     STATION LATITUDE                        =  43.07 DEGREES
     MAXIMUM LEAF AREA INDEX                 =   3.50
     START OF GROWING SEASON (JULIAN DATE)   =    124
     END OF GROWING SEASON (JULIAN DATE)     =    284
     EVAPORATIVE ZONE DEPTH                  =  30.0  INCHES
     AVERAGE ANNUAL WIND SPEED               =   9.70 MPH
     AVERAGE 1ST QUARTER RELATIVE HUMIDITY   =  72.00 %
     AVERAGE 2ND QUARTER RELATIVE HUMIDITY   =  68.00 %
     AVERAGE 3RD QUARTER RELATIVE HUMIDITY   =  75.00 %
     AVERAGE 4TH QUARTER RELATIVE HUMIDITY   =  76.00 %


NOTE:  PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    SYRACUSE            NEW YORK
```

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.61	2.65	3.11	3.34	3.16	3.63
3.76	3.77	3.29	3.14	3.45	3.20

```
NOTE:  TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    SYRACUSE            NEW YORK
```

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
22.80	24.00	33.30	46.10	57.00	66.30
70.90	69.30	62.10	51.30	40.60	28.30

```
NOTE:  SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
         COEFFICIENTS FOR    SYRACUSE            NEW YORK
           AND STATION LATITUDE  =  43.07 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	2.59	2.72	3.16	3.27	3.09	3.71
	3.87	3.95	3.27	2.95	3.40	3.22
STD. DEVIATIONS	0.70	0.96	1.19	1.19	1.31	1.57
	1.67	1.76	1.60	1.16	1.19	0.76
RUNOFF						
TOTALS	0.497	1.349	4.738	1.504	0.063	0.094
	0.038	0.037	0.071	0.048	0.080	0.259
STD. DEVIATIONS	0.697	1.446	2.349	1.452	0.208	0.310
	0.224	0.147	0.214	0.155	0.213	0.487
EVAPOTRANSPIRATION						
TOTALS	0.491	0.407	0.479	1.824	2.916	5.443
	4.723	3.571	2.156	1.070	0.725	0.498
STD. DEVIATIONS	0.080	0.077	0.168	0.702	0.812	0.668
	1.357	1.206	0.670	0.183	0.141	0.111
LATERAL DRAINAGE COLLECTED FROM LAYER 3						
TOTALS	0.0459	0.0000	0.1598	1.8128	0.8908	0.3306
	0.0782	0.0232	0.0449	0.3348	1.0917	1.1946
STD. DEVIATIONS	0.1518	0.0000	0.4555	0.7230	0.6554	0.3481
	0.1773	0.1174	0.1629	0.6606	1.0613	0.9642
PERCOLATION/LEAKAGE THROUGH LAYER 4						
TOTALS	0.0008	0.0000	0.0017	0.0247	0.0222	0.0121
	0.0025	0.0006	0.0013	0.0063	0.0183	0.0205
STD. DEVIATIONS	0.0029	0.0000	0.0051	0.0103	0.0076	0.0059
	0.0041	0.0028	0.0043	0.0115	0.0156	0.0136
PERCOLATION/LEAKAGE THROUGH LAYER 6						
TOTALS	0.0008	0.0000	0.0017	0.0247	0.0222	0.0121
	0.0025	0.0006	0.0013	0.0063	0.0183	0.0205
STD. DEVIATIONS	0.0029	0.0000	0.0051	0.0103	0.0076	0.0059
	0.0041	0.0028	0.0043	0.0115	0.0156	0.0136
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0008	0.0000	0.0017	0.0247	0.0222	0.0121
	0.0025	0.0006	0.0013	0.0063	0.0183	0.0205
STD. DEVIATIONS	0.0029	0.0000	0.0051	0.0103	0.0076	0.0059
	0.0041	0.0028	0.0043	0.0115	0.0156	0.0136

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

```
LATERAL DRAINAGE COLLECTED FROM LAYER  9
----------------------------------------
  TOTALS                  0.0010   0.0000   0.0015   0.0238   0.0228   0.0123
                          0.0027   0.0006   0.0013   0.0061   0.0177   0.0213

  STD. DEVIATIONS         0.0033   0.0000   0.0046   0.0108   0.0078   0.0059
                          0.0042   0.0028   0.0043   0.0112   0.0155   0.0137

PERCOLATION/LEAKAGE THROUGH LAYER 11
------------------------------------
  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 12
------------------------------------
  TOTALS                  0.0000   0.0000   0.0000   0.0003   0.0005   0.0005
                          0.0004   0.0003   0.0003   0.0002   0.0003   0.0004

  STD. DEVIATIONS         0.0001   0.0000   0.0000   0.0006   0.0010   0.0009
                          0.0006   0.0007   0.0007   0.0005   0.0006   0.0006


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


DAILY AVERAGE HEAD ON TOP OF LAYER  4
-------------------------------------
  AVERAGES                0.0001   0.0000   0.0003   0.0036   0.0018   0.0007
                          0.0002   0.0000   0.0001   0.0006   0.0022   0.0023

  STD. DEVIATIONS         0.0003   0.0000   0.0009   0.0015   0.0013   0.0007
                          0.0003   0.0002   0.0003   0.0013   0.0021   0.0019

DAILY AVERAGE HEAD ON TOP OF LAYER  6
-------------------------------------
  AVERAGES                0.0000   0.0000   0.0000   0.0003   0.0002   0.0001
                          0.0000   0.0000   0.0000   0.0001   0.0002   0.0002

  STD. DEVIATIONS         0.0000   0.0000   0.0001   0.0001   0.0001   0.0001
                          0.0000   0.0000   0.0000   0.0001   0.0002   0.0002

DAILY AVERAGE HEAD ON TOP OF LAYER  8
-------------------------------------
  AVERAGES                0.0000   0.0000   0.0001   0.0009   0.0008   0.0004
                          0.0001   0.0000   0.0000   0.0002   0.0007   0.0007

  STD. DEVIATIONS         0.0001   0.0000   0.0002   0.0004   0.0003   0.0002
                          0.0001   0.0001   0.0002   0.0004   0.0006   0.0005

DAILY AVERAGE HEAD ON TOP OF LAYER 10
-------------------------------------
  AVERAGES                0.0001   0.0000   0.0001   0.0021   0.0019   0.0011
                          0.0002   0.0001   0.0001   0.0005   0.0016   0.0018

  STD. DEVIATIONS         0.0003   0.0000   0.0004   0.0010   0.0007   0.0005
                          0.0004   0.0002   0.0004   0.0010   0.0014   0.0012
```

****

****

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	39.20 (4.823)	142279.7	100.00
RUNOFF	8.779 (2.3674)	31868.48	22.398
EVAPOTRANSPIRATION	24.302 (2.5984)	88217.59	62.003
LATERAL DRAINAGE COLLECTED FROM LAYER 3	6.00731 (2.22963)	21806.545	15.32654
PERCOLATION/LEAKAGE THROUGH LAYER 4	0.11115 (0.03784)	403.480	0.28358
AVERAGE HEAD ON TOP OF LAYER 4	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 6	0.11115 (0.03784)	403.480	0.28358
AVERAGE HEAD ON TOP OF LAYER 6	0.000 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.11115 (0.03784)	403.480	0.28358
AVERAGE HEAD ON TOP OF LAYER 8	0.000 (0.000)		
LATERAL DRAINAGE COLLECTED FROM LAYER 9	0.11115 (0.03780)	403.465	0.28357
PERCOLATION/LEAKAGE THROUGH LAYER 11	0.00000 (0.00000)	0.015	0.00001
AVERAGE HEAD ON TOP OF LAYER 10	0.001 (0.000)		
PERCOLATION/LEAKAGE THROUGH LAYER 12	0.00307 (0.00595)	11.137	0.00783
CHANGE IN WATER STORAGE	-0.008 (1.3026)	-27.54	-0.019

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 100

	(INCHES)	(CU. FT.)
PRECIPITATION	4.40	15972.000
RUNOFF	4.194	15225.1016

```
DRAINAGE COLLECTED FROM LAYER  3          0.34412       1249.16895

PERCOLATION/LEAKAGE THROUGH LAYER  4      0.004427        16.06958

AVERAGE HEAD ON TOP OF LAYER  4           0.020

MAXIMUM HEAD ON TOP OF LAYER  4           0.030

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

PERCOLATION/LEAKAGE THROUGH LAYER  6      0.004427        16.06958

AVERAGE HEAD ON TOP OF LAYER  6           0.002

PERCOLATION/LEAKAGE THROUGH LAYER  8      0.004427        16.06958

AVERAGE HEAD ON TOP OF LAYER  8           0.005

DRAINAGE COLLECTED FROM LAYER  9          0.00361         13.08806

PERCOLATION/LEAKAGE THROUGH LAYER 11      0.000000         0.00022

AVERAGE HEAD ON TOP OF LAYER 10           0.010

MAXIMUM HEAD ON TOP OF LAYER 10           0.019

LOCATION OF MAXIMUM HEAD IN LAYER  9
      (DISTANCE FROM DRAIN)               0.0 FEET

PERCOLATION/LEAKAGE THROUGH LAYER 12      0.000289         1.04834

SNOW WATER                                9.62         34911.7891


MAXIMUM VEG. SOIL WATER (VOL/VOL)                 0.4355

MINIMUM VEG. SOIL WATER (VOL/VOL)                 0.2000

 ***  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            2.7516         0.4586

                2            9.2275         0.3845

                3            0.0020         0.0100
```

Written by: **Joseph Sura** Date: **11/23/2009** Reviewed by: **Fan Zhu / R. Kulasingam** Date: **12/2/2009**

Client: **Honeywell** Project: **Onondaga Lake SCA Final Design** Project/ Proposal No.: **GJ4299** Task No.: **18**

4	0.0000	0.0000
5	0.1920	0.0320
6	0.0510	0.8500
7	0.0184	0.3070
8	150.8400	0.4190
9	0.3840	0.0320
10	0.0000	0.0000
11	2.1900	0.3650
12	1.5163	0.2527
SNOW WATER	0.046	

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