Appendix B

Infiltration Testing Summary Report and HELP Model Results – 2016

Contents:

Infiltration Testing Summary Report

HELP Model Results

Infiltration Testing Summary Report

Soil and Land Use Technology, Inc. (SaLUT-TLB)
530 McCormick Drive, Suite S • Glen Burnie, MD 21061 (443) 577-1600
www.SaLUTinc.com

November 20, 2015

Ms. Laura Jo Oakes, PE
EA Engineering, Science and Technology, Inc.
225 Schilling Circle, Suite 400
Hunt Valley, MD 21031

Re: Gude Landfill Double Ring Infiltration Testing
Montgomery County, MD.
SaLUT Summary Report

Dear Ms. Oakes,

In accordance with our proposal dated October 15, 2015, Soil and Land Use Technology, Inc. (SaLUT) has completed the double ring infiltration testing at the Gude Landfill located in Montgomery County, Maryland as shown in Figure A-1 in Appendix A. The purpose of this testing was to evaluate the infiltration rate in the top two (2) feet of the existing soil cover. The specific scope of our services on this project consisted of preparing the surface at six (6) test locations, installing double rings below the surface, providing water and obtaining water level readings for up to 8 hours, and submitting our findings in a summary report.

The field exploration consisted of six (6) double ring infiltration tests, conducted on November 5, 2015 through November 10, 2015. A test location plan showing all six (6) test locations and a sketch of each individual location is included in Appendix A. The ground surface at each test location was prepared by clearing away any grass or vegetation using a skid loader. The infiltration test locations were located just outside of previously disturbed areas as observed by new growth of grass and straw mulch, and as shown on test location sketch in Appendix A. Approximate dimensions from the existing well and edge of the access road are shown on the location sketches. After the ground surface was prepared, the double infiltration test rings were installed at each location to a maximum depth of 6-inches below the ground surface. The diameter of the inner and outer rings were 12-inches and 24-inches, respectfully. Several double ring infiltration test were conducted simultaneously at various locations. Water was brought to the site and was manually added during the infiltration test using a graduated cylinder. Water level readings were recorded at 15 minute intervals for the first hour, 30 minute intervals for the second hour and one hour intervals for the following 6 hours, totaling 8 hours. All six (6) double ring infiltration test were terminated after 8 hours. After the test was completed, the double rings were removed from the test locations.

The incremental infiltration velocity was calculated for the inner ring and annular space in accordance with ASTM D 3385. Results of the infiltration testing are summarized in Table-1. The infiltration test logs are included in Appendix B.

Table 1: Average Incremental Infiltration Velocity		
Test Location	**Inner Ring ($V_{IR, AVG}$) (in/hr)**	**Annular Space ($V_{A, AVG}$) (in/hr)**
I-1	0.34	0.35
I-2	0	0.13
I-3	0.04	0.19
I-4	0	0
I-5	0.41	0.67
I-6	0.44	0.59

As requested, the vertical hydraulic conductivity was estimated from the double ring infiltration test data. Per ASTM D 3385, the double-ring infiltration test method "cannot be used directly to determine the hydraulic conductivity of the soil." Therefore, assuming a constant-rate-test method and unit hydraulic gradient, the vertical hydraulic conductivity was estimated by dividing the flow rate by the area of the inner ring. Table 2 below summarizes the vertical hydraulic gradient for the average flow rate at each test location.

Table 2: Estimated Vertical Hydraulic Conductivity			
Test Location	**Average Flow Rate (in^3/min)**	**K_{est} (in/min)**	**K_{est} (cm/s)**
I - 1	0.65	5.74E-3	2.43E-4
I - 2	0.00	0	0
I - 3	0.07	6.35E-4	2.69E-5
I - 4	0.00	0	0
I - 5	0.78	6.88E-3	2.91E-4
I - 6	0.84	7.39E-3	3.13E-4

We appreciate the opportunity working with you and if you have any questions, please contact us.

Soil and Land Use Technology Inc.

Edward H. Dalton, PE
Vice President

Appendix A

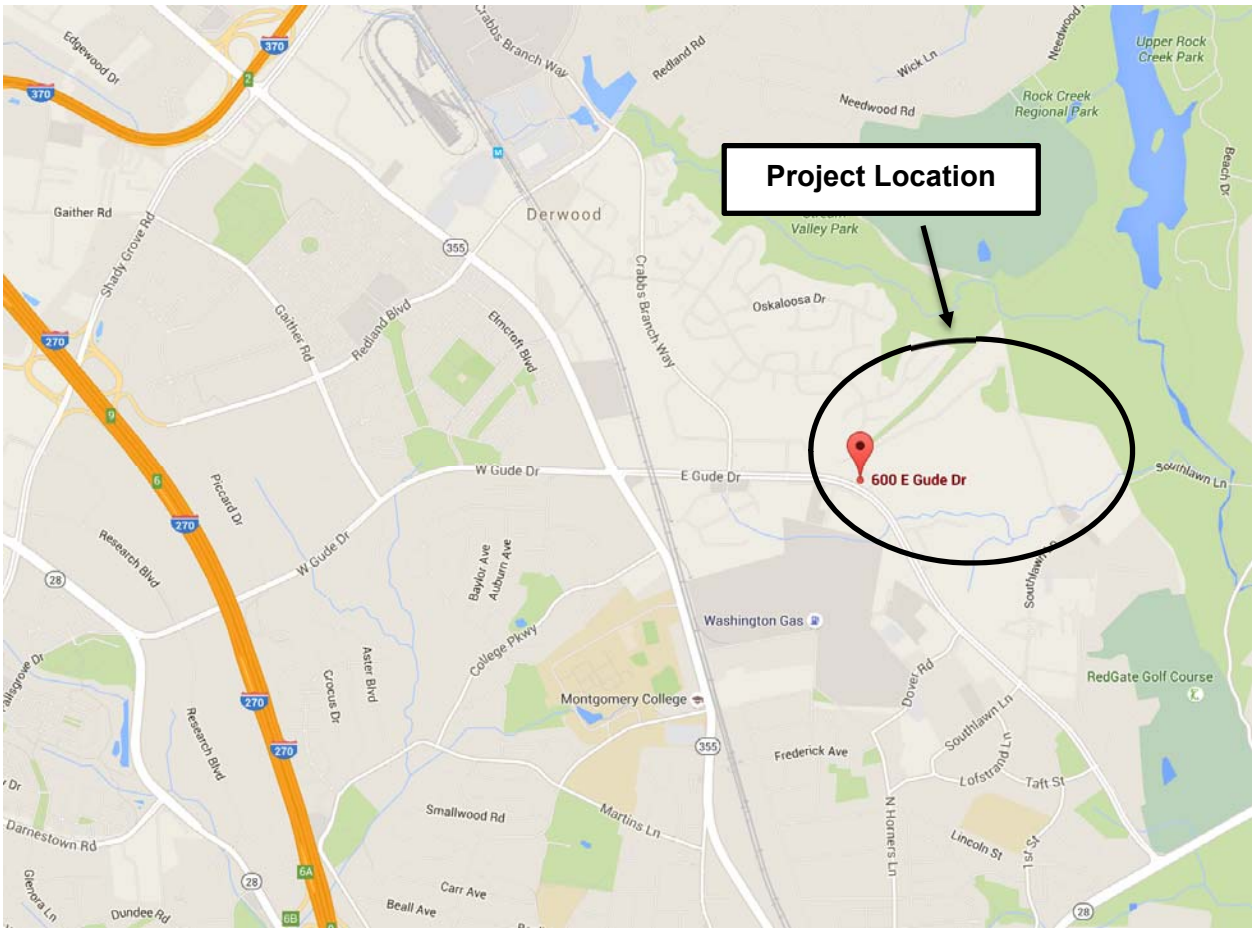
Contents:

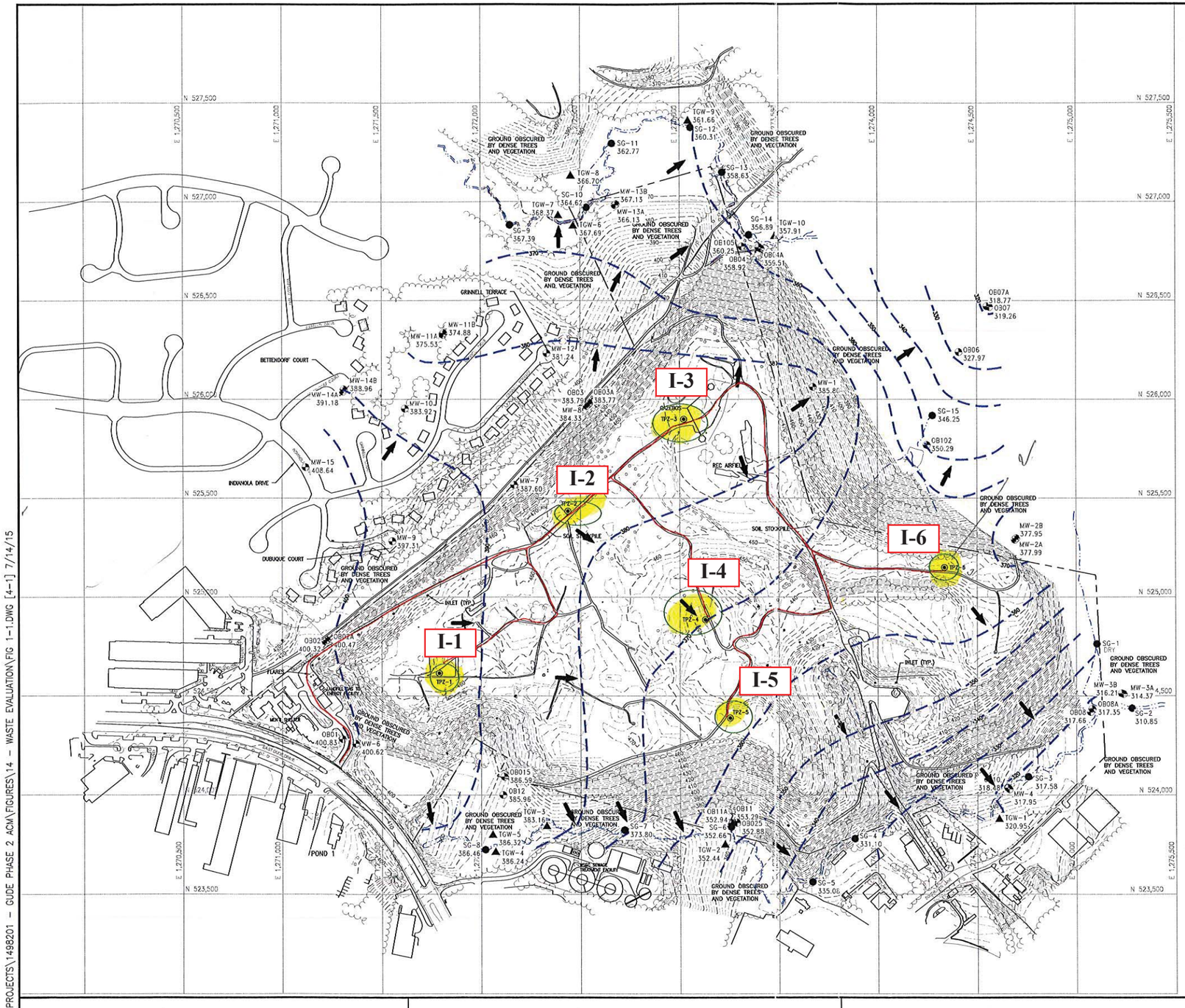
Project Location Map

Infiltration Test Location Plan

Infiltration Test Location Sketch

Figure A-1: Project Location Map





N

NOTES:

1. TOPOGRAPHY COMPILED BY APPLIED MAPPING SOLUTIONS, INC. USING PHOTOGRAMMETRIC METHODS WITH PHOTOGRAPHY DATED 06/24/09 AND SUPPLEMENTED WITH FIELD SURVEY PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., OCTOBER 2009.
2. SURVEY OF STREAMS TAKEN FROM 2007 PHOTOGRAMMETRY BY AXIS GEOSPATIAL, LLC.
3. HORIZONTAL DATUM IS NORTH AMERICAN DATUM OF 1983/91 (NAD-83/91). COORDINATE SYSTEM IS MARYLAND STATE PLANE, U.S. SURVEY FEET. VERTICAL DATUM IS NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD-88) WITH ELEVATIONS SHOWN IN FEET.
4. TOPOGRAPHY IS APPROXIMATE IN AREAS NOTED "GROUND OBSCURED BY DENSE TREES AND VEGETATION".
5. FIELD SURVEY OF MW-14A, MW-14B, & MW-15, TEMPORARY GROUNDWATER MONITORING LOCATIONS, AND STREAM GAUGE LOCATIONS PERFORMED BY C.C. JOHNSON & MALHOTRA, P.C., AUGUST 2011.
6. GROUNDWATER ELEVATION DATA FOR OB102 (350.19') NOT USED IN CONTOURING BECAUSE IT IS INCONSISTENT WITH SURROUNDING DATA.

LEGEND

- 400 — 10-FT ELEVATION CONTOUR
- 2-FT ELEVATION CONTOUR
- PROPERTY BOUNDARY
- STREAM
- GROUNDWATER CONTOUR INTERVAL (10 FEET)
- SG-X — TEMPORARY STREAM GAUGE LOCATION (2011)
- MW-X — EXISTING GROUNDWATER MONITORING WELL
- TGW-X — TEMPORARY GROUNDWATER MONITORING LOCATION (2011)
- 318.40 — GROUNDWATER ELEVATION (FT. MSL.)
- INFERRED GROUNDWATER FLOW
- TPZ-X — TEMPORARY PIEZOMETER LOCATION
- APPROVED ROUTES OF TRAVEL FOR DRILL RIG

250 125 0 250 500
GRAPHIC SCALE IN FEET

FILE PATH: Q:\PROJECTS\14982O1 - GUDE PHASE 2 ACM\FIGURES\14 - WASTE EVALUATION\FIG 1-1.DWG [4-1] 7/14/15

EA ENGINEERING, SCIENCE, AND TECHNOLOGY

GUDE LANDFILL
ASSESSMENT OF CORRECTIVE MEASURES
MONTGOMERY COUNTY, MARYLAND

FIGURE A-2
Infiltration Test Location Plan

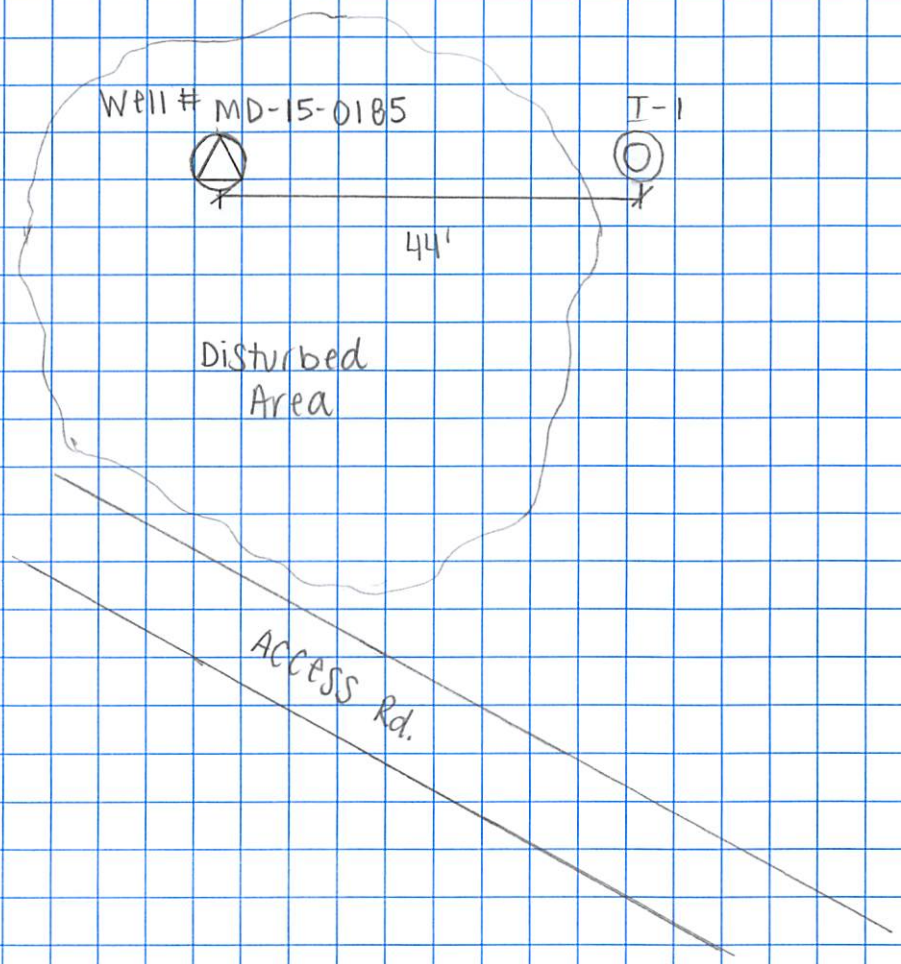
DESIGNED BY	DRAWN BY	DATE	PROJECT NO.
PL/LJO	TJP	JULY 2015	14982.01
CHECKED BY	PROJECT MGR.	DRAWING NO.	FIGURE
PC	JK	–	A-2

Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Dude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 1 of 4
Calculated By: DMO Date: 11/19/15
Checked By: _____ Date: _____
Subject: Infiltration Test Location Sketch

1:20 scale

Location I-1



Legend:
- : Well
- : Double-ring Infiltration Test Location
- : Disturbed Area
- : Locust Tree

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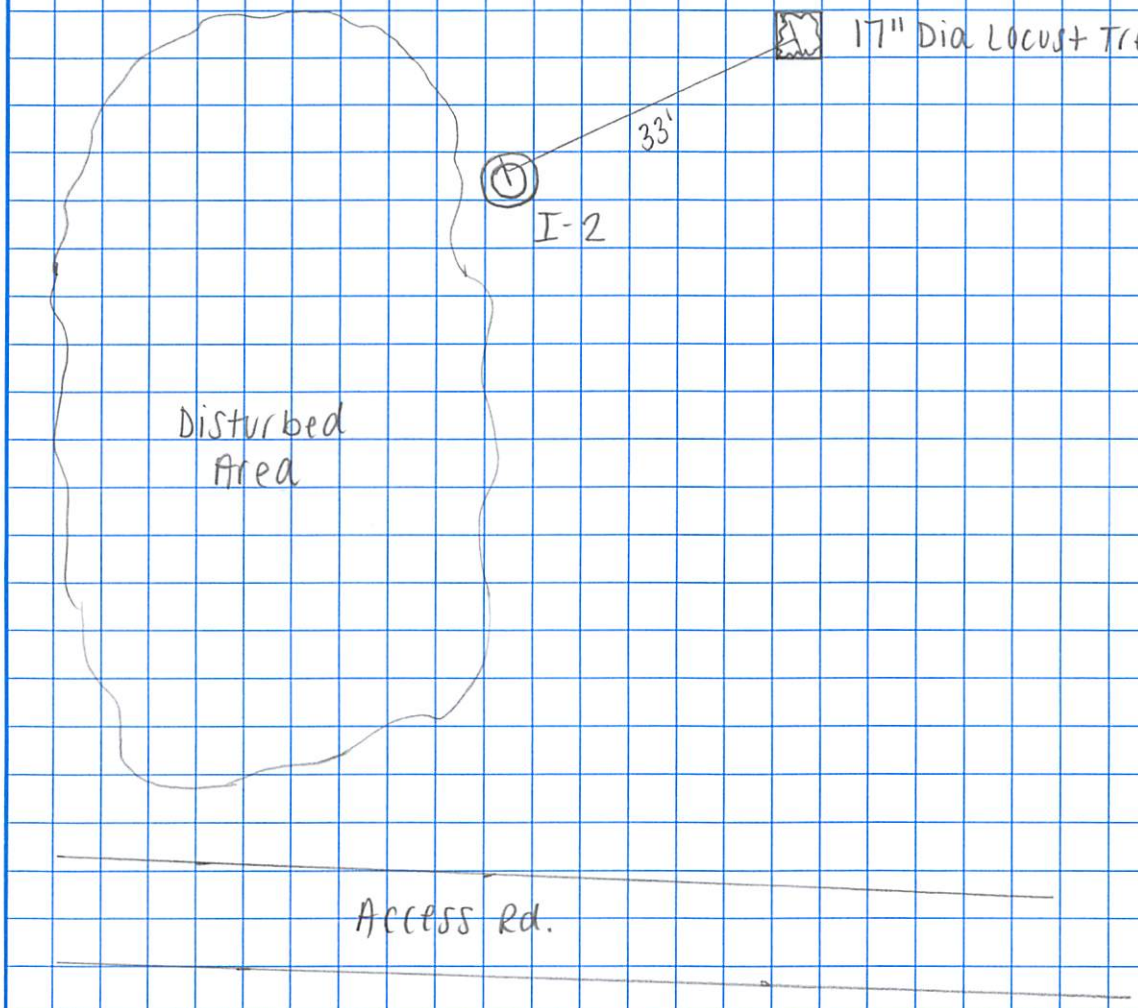
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 2 of 4
Calculated By: OMD Date: 11/19/15
Checked By: _____ Date: _____
Subject: Infiltration Test Location Sketch

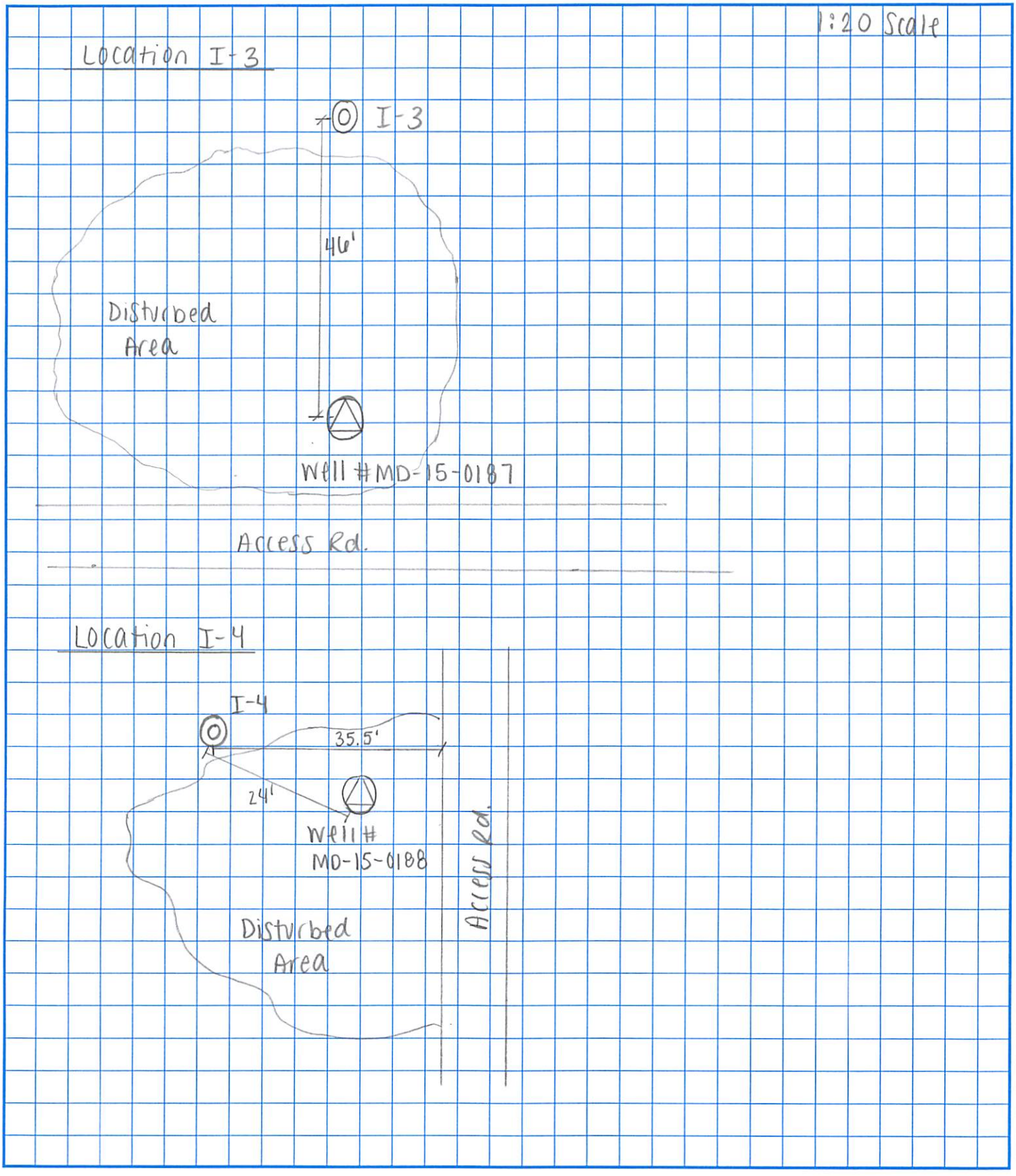
1:20 Scale

Location I-2



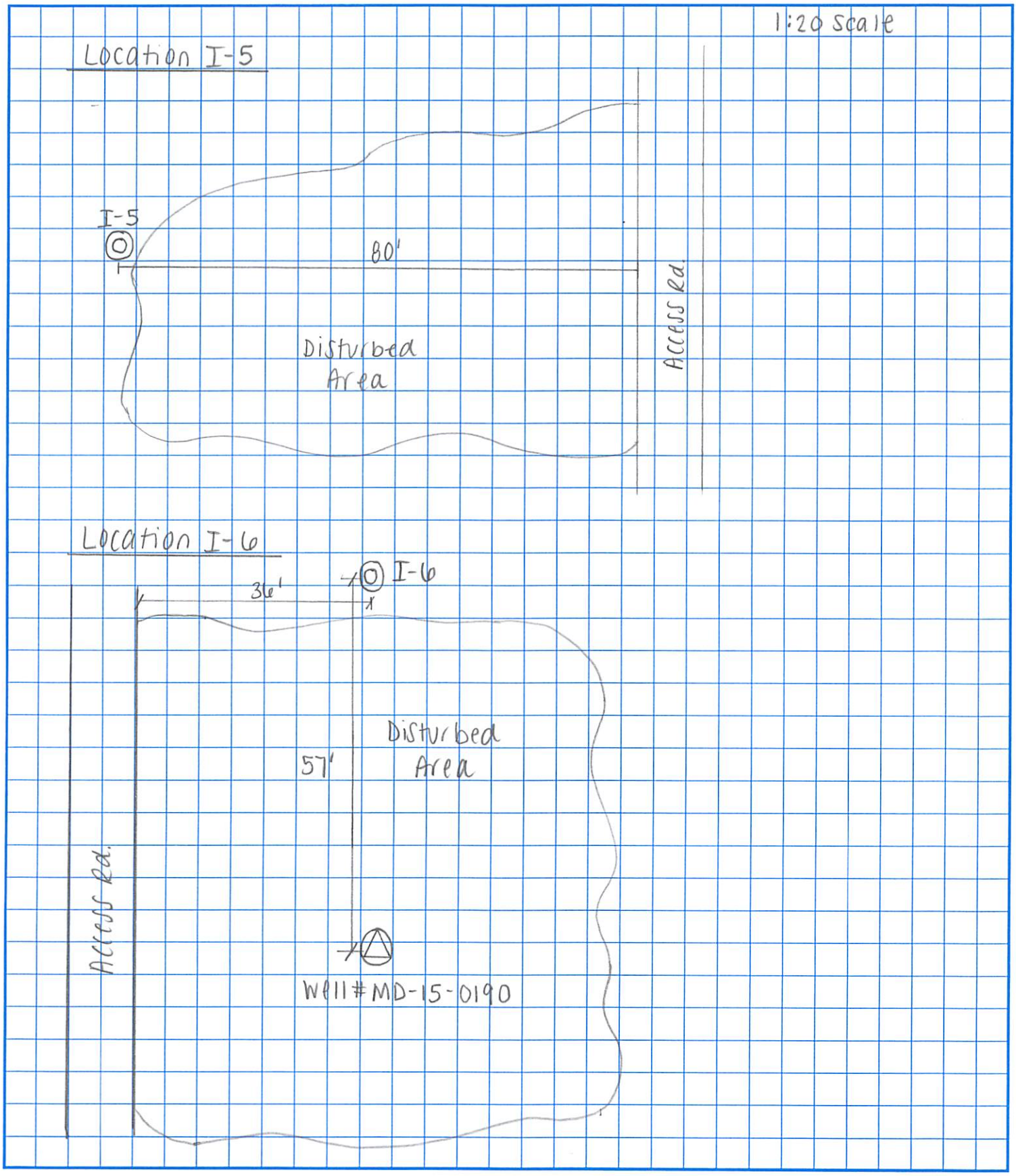
Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 Sheet No. 3 of 4
Calculated By: DMD Date: 11/19/15
Checked By: _____ Date: _____
Subject: Infiltration Test Location Sketch



Soil and Land Use Technology Inc. (SaLUT)
Geotechnical Engineers
530 McCormick Drive, Suite S
Glen Burnie, MD. 21061
443-577-1600

Job: Gude Landfill Double-Ring Infiltrometer
Job No: 15-00047 **Sheet No.** 4 **of** 4
Calculated By: OMD **Date:** 11/19/15
Checked By: _____ **Date:** _____
Subject: Infiltration Test Location Sketch



Appendix B

Contents:

Infiltration Test Logs

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

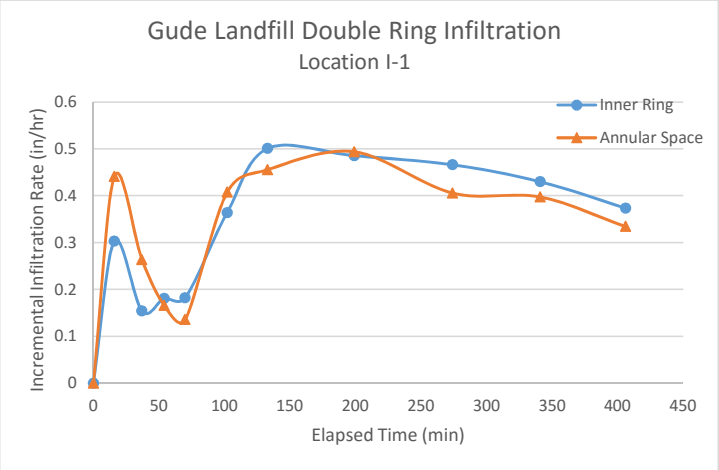
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 4 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 3 Location: I-1

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/5/2015	8:34 AM	0	0	0					65	0	0
2	11/5/2015	8:50 AM	16	16	0.27	150	9.15	650	39.67	65	0.30	0.44
3	11/5/2015	9:11 AM	21	37	0.35	100	6.10	510	31.12	65	0.15	0.26
4	11/5/2015	9:28 AM	17	54	0.28	95	5.80	260	15.87	65	0.18	0.17
5	11/5/2015	9:44 AM	16	70	0.27	90	5.49	200	12.20	65	0.18	0.14
6	11/5/2015	10:16 AM	32	102	0.53	360	21.97	1200	73.23	65	0.36	0.41
7	11/5/2015	10:47 AM	31	133	0.52	480	29.29	1300	79.33	65	0.50	0.46
8	11/5/2015	11:53 AM	66	199	1.10	990	60.41	3000	183.07	65	0.49	0.49
9	11/5/2015	1:08 PM	75	274	1.25	1080	65.91	2800	170.87	65	0.47	0.41
10	11/5/2015	2:15 PM	67	341	1.12	890	54.31	2450	149.51	65	0.43	0.40
11	11/5/2015	3:20 PM	65	406	1.08	750	45.77	2000	122.05	65	0.37	0.33
Average											0.34	0.35



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
V_{IR} = inner ring incremental infiltration velocity (in/hr)
ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

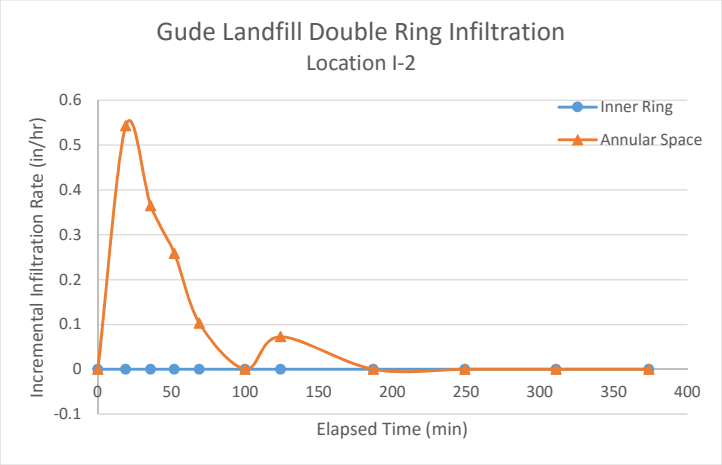
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 5.5 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 1 Location: I-2

Reading No.	Date	Time	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/10/2015	7:56 AM	0	0	0					59	0	0
2	11/10/2015	8:15 AM	19	19	0.32	0	0.00	950	57.97	59	0.00	0.54
3	11/10/2015	8:32 AM	17	36	0.28	0	0.00	570	34.78	59	0.00	0.36
4	11/10/2015	8:48 AM	16	52	0.27	0	0.00	380	23.19	59	0.00	0.26
5	11/10/2015	9:05 AM	17	69	0.28	0	0.00	160	9.76	59	0.00	0.10
6	11/10/2015	9:36 AM	31	100	0.52	0	0.00	0	0.00	55	0.00	0.00
7	11/10/2015	10:00 AM	24	124	0.40	0	0.00	160	9.76	55	0.00	0.07
8	11/10/2015	11:03 AM	63	187	1.05	0	0.00	0	0.00	55	0.00	0.00
9	11/10/2015	12:05 PM	62	249	1.03	0	0.00	0	0.00	55	0.00	0.00
10	11/10/2015	1:07 PM	62	311	1.03	0	0.00	0	0.00	55	0.00	0.00
11	11/10/2015	2:10 PM	63	374	1.05	0	0.00	0	0.00	55	0.00	0.00
Average											0.00	0.13



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
V_{IR} = inner ring incremental infiltration velocity (in/hr)
ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Wade

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

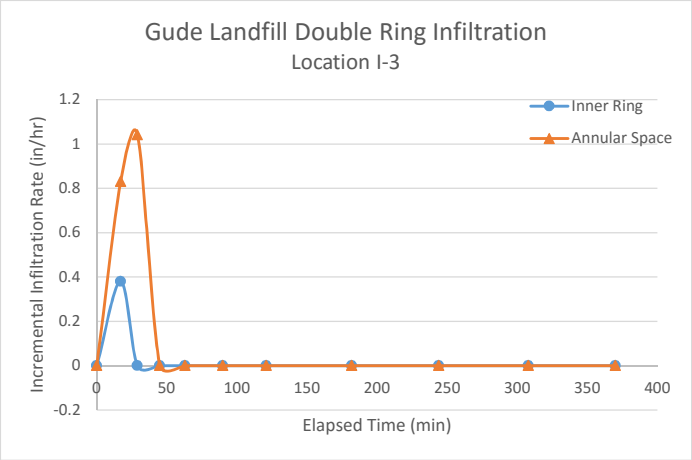
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 6 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 2 Location: I-3

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/10/2015	8:05 AM	0	0	0					59	0	0
2	11/10/2015	8:22 AM	17	17	0.28	200	12.20	1300	79.33	59	0.38	0.83
3	11/10/2015	8:34 AM	12	29	0.20	0	0.00	1150	70.18	59	0.00	1.04
4	11/10/2015	8:50 AM	16	45	0.27	0	0.00	0	0.00	59	0.00	0.00
5	11/10/2015	9:08 AM	18	63	0.30	0	0.00	0	0.00	59	0.00	0.00
6	11/10/2015	9:35 AM	27	90	0.45	0	0.00	0	0.00	55	0.00	0.00
7	11/10/2015	10:06 AM	31	121	0.52	0	0.00	0	0.00	55	0.00	0.00
8	11/10/2015	11:07 AM	61	182	1.02	0	0.00	0	0.00	55	0.00	0.00
9	11/10/2015	12:09 PM	62	244	1.03	0	0.00	0	0.00	55	0.00	0.00
10	11/10/2015	1:13 PM	64	308	1.07	0	0.00	0	0.00	55	0.00	0.00
11	11/10/2015	2:15 PM	62	370	1.03	0	0.00	0	0.00	55	0.00	0.00
Average											0.04	0.19



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
V_{IR} = inner ring incremental infiltration velocity (in/hr)
ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double-Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Terry

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

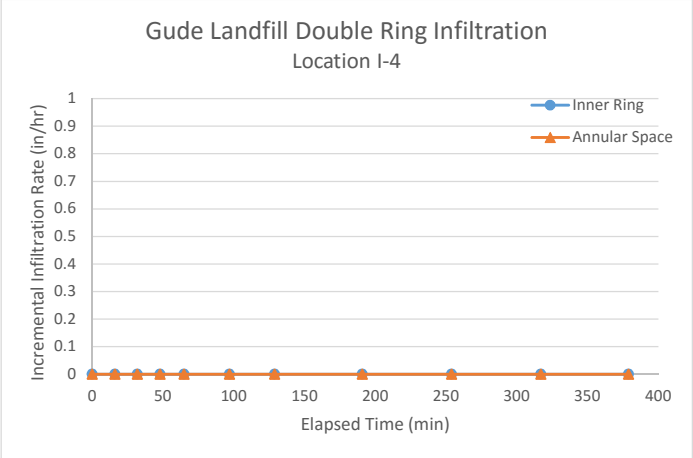
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 6 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 3 Location: I-4

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/7/2015	9:16 AM	0	0	0					67	0	0
2	11/7/2015	9:32 AM	16	16	0.27	0	0.00	0	0.00	67	0.00	0.00
3	11/7/2015	9:48 AM	16	32	0.27	0	0.00	0	0.00	67	0.00	0.00
4	11/7/2015	10:04 AM	16	48	0.27	0	0.00	0	0.00	67	0.00	0.00
5	11/7/2015	10:21 AM	17	65	0.28	0	0.00	0	0.00	67	0.00	0.00
6	11/7/2015	10:53 AM	32	97	0.53	0	0.00	0	0.00	67	0.00	0.00
7	11/7/2015	11:25 AM	32	129	0.53	0	0.00	0	0.00	65	0.00	0.00
8	11/7/2015	12:27 PM	62	191	1.03	0	0.00	0	0.00	60	0.00	0.00
9	11/7/2015	1:30 PM	63	254	1.05	0	0.00	0	0.00	60	0.00	0.00
10	11/7/2015	2:33 PM	63	317	1.05	0	0.00	0	0.00	60	0.00	0.00
11	11/7/2015	3:35 PM	62	379	1.03	0	0.00	0	0.00	60	0.00	0.00
Average											0.00	0.00



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
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ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

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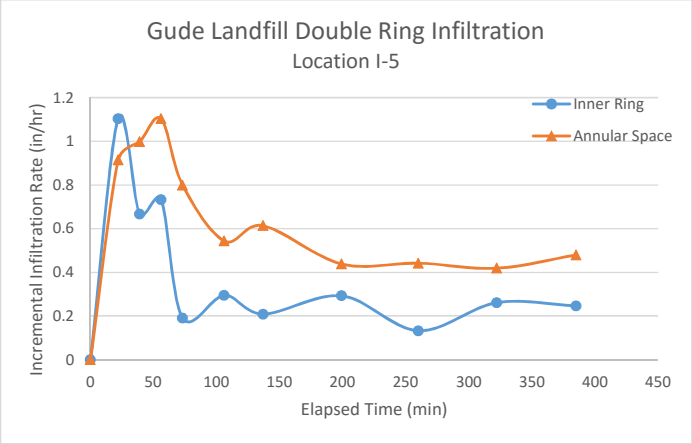
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 3.75 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 2 Location: I-5

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/7/2015	9:13 AM	0	0	0					67	0	0
2	11/7/2015	9:35 AM	22	22	0.37	750	45.77	1850	112.89	67	1.10	0.91
3	11/7/2015	9:52 AM	17	39	0.28	350	21.36	1560	95.20	67	0.67	1.00
4	11/7/2015	10:09 AM	17	56	0.28	385	23.49	1725	105.27	67	0.73	1.10
5	11/7/2015	10:26 AM	17	73	0.28	185	6.10	1250	76.28	67	0.19	0.80
6	11/7/2015	10:59 AM	33	106	0.55	300	18.31	1650	100.69	63	0.29	0.54
7	11/7/2015	11:30 AM	31	137	0.52	200	12.20	1750	106.79	63	0.21	0.61
8	11/7/2015	12:32 PM	62	199	1.03	560	34.17	2500	152.56	60	0.29	0.44
9	11/7/2015	1:33 PM	61	260	1.02	250	15.26	2480	151.34	60	0.13	0.44
10	11/7/2015	2:35 PM	62	322	1.03	500	30.51	2390	145.85	60	0.26	0.42
11	11/7/2015	3:38 PM	63	385	1.05	480	29.29	2780	169.65	60	0.25	0.48
Average											0.41	0.67



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
V_{IR} = inner ring incremental infiltration velocity (in/hr)
ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

Project: Gude Landfill Double- Ring Infiltration Testing
Location: 600 Gude Drive, Rockville MD
Tested By: Dan and Terry

Job No: 15-00047
Client: EA Engineering
Contact: Laura Oakes

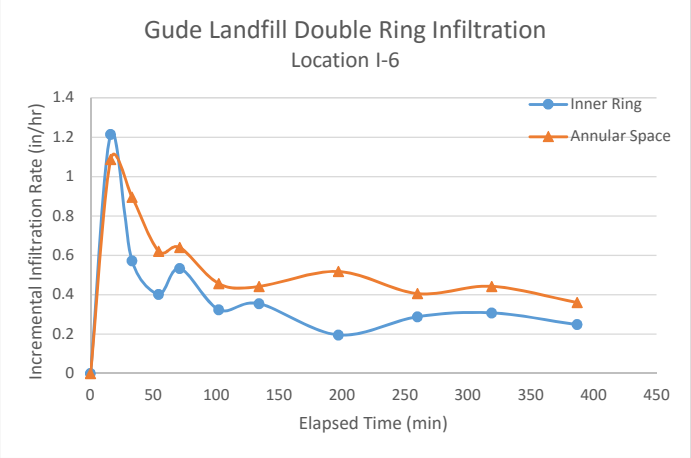
Inner Ring Diameter = 12 in
Outer Ring Diameter = 24 in
Ring Thickness = 0.125 in

Depth of Water = 8 in
Embedment Depth of Rings = 5 in

A_{IR} = 113.1 in^2
A_A = 336.9 in^2

Ring No. : 1 Location: I-6

Reading No.	Date	Time (24 hr)	Elapsed Time, Δt (min)	Elapsed Time, total (min)	Elapsed Time, Δt (hr)	Flow/ Water Added: Inner Ring, ΔV_{IR} (mL)	Flow/ Water Added: Inner Ring, ΔV_{IR} (in^3)	Flow/ Water Added: Annular Space, ΔV_A (mL)	Flow/ Water Added: Annular Space, ΔV_A (in^3)	Water Temp (°F)	V_{IR} (in/hr)	V_A (in/hr)
1	11/7/2015	9:03 AM	0	0	0					67	0	0
2	11/7/2015	9:19 AM	16	16	0.27	600	36.61	1600	97.64	67	1.21	1.09
3	11/7/2015	9:36 AM	17	33	0.28	300	18.31	1400	85.43	67	0.57	0.89
4	11/7/2015	9:57 AM	21	54	0.35	260	15.87	1200	73.23	67	0.40	0.62
5	11/7/2015	10:14 AM	17	71	0.28	280	17.09	1000	61.02	67	0.53	0.64
6	11/7/2015	10:45 AM	31	102	0.52	310	18.92	1300	79.33	63	0.32	0.46
7	11/7/2015	11:17 AM	32	134	0.53	350	21.36	1300	79.33	63	0.35	0.44
8	11/7/2015	12:20 PM	63	197	1.05	380	23.19	3000	183.07	60	0.20	0.52
9	11/7/2015	1:23 PM	63	260	1.05	560	34.17	2350	143.41	60	0.29	0.41
10	11/7/2015	2:22 PM	59	319	0.98	560	34.17	2400	146.46	60	0.31	0.44
11	11/7/2015	3:30 PM	68	387	1.13	520	31.73	2250	137.30	60	0.25	0.36
Average											0.44	0.59



$$V_{IR} = \frac{\Delta V_{IR}}{A_{IR} * \Delta t}$$

where:
V_{IR} = inner ring incremental infiltration velocity (in/hr)
ΔV_{IR} = volume of liquid used during time interval to maintain constant head in the inner ring (in^3)
A_{IR} = internal area of inner ring (in^2)
Δt = time interval (hr)

$$A_{IR} = \pi * 6^2$$

$$V_A = \frac{\Delta V_A}{A_A * \Delta t}$$

where:
V_A = annular space incremental infiltration velocity (in/hr)
ΔV_A = volume of liquid used during time interval to maintain constant head in the annualar space between the two rings (in^3)
A_A = area of annular space between the rings (in^2)
Δt = time interval (hr)

$$A_A = \pi * (12^2 - (6 + 0.0625)^2)$$

*Note: need to take into account thickness of rings when computing area of annular space between the rings

HELP Model Results

Project	Gude Landfill – Assessment of Corrective Measures	Project No.	14982.01.0012
Subject	Average Annual Leachate Infiltration	Sheet No.	1 of 2
		Drawing No.	
Computed by	BTT Date 4/8/16	Checked by	Date 4/8/16

REFERENCES:

EA Engineering, Science, and Technology, Inc., PBC (EA). 2015. *Waste Evaluation: Temporary Piezometer Installation Summary, Gude Landfill, Montgomery County, Maryland.* Technical Memorandum. 19 November.

EA. 2016. *Stormwater Engineering Evaluation.* Technical Memorandum. 4 April.

Schroeder, P. R., Aziz, N. M., Lloyd, C. M. and Zappi, P. A. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: User's Guide for Version 3," EPA/600/R-94/168a, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

Schroeder, P. R., Dozier, T.S., Zappi, P. A., McEnroe, B. M., Sjostrom, J. W., and Peyton, R. L. (1994). "The Hydrologic Evaluation of Landfill Performance (HELP) Model: Engineering Documentation for Version 3," EPA/600/R-94/168b, September 1994, U.S. Environmental Protection Agency Office of Research and Development, Washington, DC.

OBJECTIVE:

Estimate the average annual leachate generation volume which infiltrates (percolates) through the bottom of the landfill. Compare the average annual leachate generation volume with and without an engineered geosynthetic cap over the existing landfill cover soil.

PROCEDURE:

Using the Hydrologic Evaluation of Landfill Performance (HELP) Model (Version 3.07, November 1997), determine the average annual leachate volume (generated by precipitation percolating through the landfill) which infiltrates through the bottom layer of the landfill.

The HELP Model rainfall was synthetically generated over a 30-year period using HELP Model data for the Washington, DC area. The estimated annual rainfall is approximately 38 in. (see attached HELP Model output). The volume of leachate generated from the rainfall was averaged over the same 30-year period.

The average annual leachate volume was calculated over the entire landfill, including portions of the landfill that will remain uncapped. The landfill layer properties were estimated using averages of the soil properties based on the information obtained during drilling for the four temporary piezometers TPZ-1, TPZ-3, TPZ-4, and TPZ-6 (EA 2015). Hydraulic conductivity for the existing cover soil was estimated using the results of double ring infiltration testing (Soil and Land Use Technology, Inc. 2015).

The calculation for leachate volume produced from the uncapped side slopes were performed separately and added to the leachate volume produced by the remaining portions of the landfill with and without a geosynthetic cap. The capping scenario assumed a geocomposite drainage layer and a geosynthetic cap will be installed over the existing cover soil to promote drainage off of the landfill.

It was assumed that that 99.5% of the landfill allows runoff without a cap and 100% of the landfill area allows runoff with a cap. The runoff percent without a cap was calculated using the results of a Stormwater Engineering Evaluation (EA 2016).

REFERENCES (continued):

Soil and Land Use Technology, Inc. (SaLUT-TLB). 2015. Re: Gude Landfill Double Ring Infiltration Testing; Montgomery County, MD.; SaLUT Summary Report. Letter from Edward H. Dalton, Soil and Land Use Technology, Inc. to Laura Jo Oakes, EA Engineering, Science, and Technology, Inc., PBC. 20 November.

CONCLUSION:

The total leachate volume produced over the Landfill with and without a geosynthetic cap is shown in the table below (identified as percolation/leakage in the HELP Model). With the installation of a toupee cap, leachate volume decreased by approximately 65% over the entire landfill.

	Annual Percolation (cft) - no cap	Annual Percolation (cft) - with cap	Percent Decrease in Infiltration
Top and West Side Slopes	5,581,584	43,687	99
Uncapped Side Slopes	2,982,499	2,982,499	0
Total	**8,565,787**	**2,085,978**	**65**

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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: T:\GUDEPREP.D4
TEMPERATURE DATA FILE: T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE: T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA: T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE: T:\GUDESSLP.D10
OUTPUT DATA FILE: T:\GUDESSLO.OUT

TIME: 17:16 DATE: 4/ 8/2016

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TITLE: GUDE SIDE SLOPES

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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 6

THICKNESS	=	4.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2138	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 5.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	57.00	INCHES
POROSITY	=	0.5010	VOL/VOL
FIELD CAPACITY	=	0.0020	VOL/VOL
WILTING POINT	=	0.0010	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5010	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.146000006000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	30.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3003	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	495.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3010	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	93.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2554	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-

GUDESSLO
SPECIFIED CURVE NUMBER OF 70.0, A SURFACE SLOPE
OF 24.% AND A SLOPE LENGTH OF 167. FEET.

SCS RUNOFF CURVE NUMBER	=	73.40	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	49.080	ACRES
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.855	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	1.812	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.340	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	211.184	INCHES
TOTAL INITIAL WATER	=	211.184	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

STATION LATITUDE	=	38.90	DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50	
START OF GROWING SEASON (JULIAN DATE)	=	104	
END OF GROWING SEASON (JULIAN DATE)	=	296	
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	62.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	68.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.76	2.62	3.46	2.93	3.48	3.35
3.88	4.40	3.22	2.90	2.82	3.18

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.40	33.60	42.40	53.30	62.40	70.70
75.50	74.30	67.40	55.30	44.80	35.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

GUDESSLO
AND STATION LATITUDE = 38.90 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.55	2.78	3.17	3.03	3.40	3.79
	4.10	3.32	2.85	3.25	2.62	2.90
STD. DEVIATIONS	1.38	1.13	1.46	1.38	2.11	1.86
	2.25	1.65	1.98	2.21	1.10	1.63
RUNOFF						
TOTALS	0.345	1.287	0.453	0.000	0.012	0.022
	0.008	0.010	0.026	0.022	0.002	0.079
STD. DEVIATIONS	0.604	1.402	0.789	0.002	0.037	0.049
	0.023	0.045	0.091	0.050	0.012	0.330
EVAPOTRANSPIRATION						
TOTALS	0.876	0.833	1.745	1.780	1.986	2.375
	2.533	2.051	1.536	1.195	1.095	0.938
STD. DEVIATIONS	0.304	0.410	0.435	0.689	0.901	0.931
	0.979	0.917	0.808	0.494	0.418	0.213
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.9875	0.6654	1.7116	1.1888	1.4860	1.4725
	1.4923	1.3257	1.2554	1.9576	1.4363	1.5940
STD. DEVIATIONS	1.1129	0.7931	1.0903	0.7819	1.4536	1.2536
	1.5175	1.0179	1.3344	1.8606	0.9343	1.4222
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	1.6592	1.3607	1.7790	1.3540	1.1891	1.2390
	1.3224	1.5223	1.2737	1.4857	1.3190	1.2365
STD. DEVIATIONS	0.8982	0.6758	0.8034	0.6511	0.6308	0.6924
	0.6514	0.6621	0.7585	0.7165	0.7502	0.6910

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0192	0.0186	0.0394	0.0231	0.0297	0.0311

		GUDESSLO				
	0.0305	0.0245	0.0260	0.0367	0.0290	0.0271
STD. DEVIATIONS	0.0225	0.0223	0.0242	0.0175	0.0317	0.0297
	0.0354	0.0214	0.0284	0.0391	0.0218	0.0265

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.77 (5.959)	6729058.0	100.00
RUNOFF	2.268 (1.4899)	404004.06	6.004
EVAPOTRANSPIRATION	18.944 (2.9354)	3375101.25	50.157
PERCOLATION/LEAKAGE THROUGH LAYER 2	16.57330 (3.78598)	2952706.000	43.87993
AVERAGE HEAD ON TOP OF LAYER 2	0.028 (0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	16.74053 (4.04880)	2982499.000	44.32268
CHANGE IN WATER STORAGE	-0.183 (3.4512)	-32544.67	-0.484

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	595055.750
RUNOFF	2.193	390710.0620
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.551147	454513.40600
AVERAGE HEAD ON TOP OF LAYER 2	1.789	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.195620	34851.67970
SNOW WATER	3.40	605259.6870

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4528
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	0.3917	0.0979
2	28.5570	0.5010
3	8.7480	0.2916
4	145.5473	0.2940
5	22.4598	0.2415
SNOW WATER	0.000	

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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: T:\GUDEPREP.D4
TEMPERATURE DATA FILE: T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE: T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA: T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE: T:\WOCAPIN.D10
OUTPUT DATA FILE: T:\WOCAPOUT.OUT

TIME: 17:31 DATE: 4/ 8/2016

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TITLE: GUDE AVERAGE TOP WITHOUT CAP

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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 6

THICKNESS	=	4.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2139	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 5.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 3 - BARRIER SOIL LINER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	57.00	INCHES
POROSITY	=	0.5010	VOL/VOL
FIELD CAPACITY	=	0.0020	VOL/VOL
WILTING POINT	=	0.0010	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.5010	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.146000006000E-03	CM/SEC

LAYER 3

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	30.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2994	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	495.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3012	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	93.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2550	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-

WOCAPOUT
SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE
OF 2.% AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER	=	69.30	
FRACTION OF AREA ALLOWING RUNOFF	=	99.5	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	91.350	ACRES
EVAPORATIVE ZONE DEPTH	=	4.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	0.855	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	1.812	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.340	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	211.216	INCHES
TOTAL INITIAL WATER	=	211.216	INCHES
TOTAL SUBSURFACE INFLOW	=	0.00	INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

STATION LATITUDE	= 38.90	DEGREES
MAXIMUM LEAF AREA INDEX	= 4.50	
START OF GROWING SEASON (JULIAN DATE)	= 104	
END OF GROWING SEASON (JULIAN DATE)	= 296	
EVAPORATIVE ZONE DEPTH	= 4.0	INCHES
AVERAGE ANNUAL WIND SPEED	= 9.30	MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	= 60.00	%
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	= 62.00	%
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	= 68.00	%
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	= 65.00	%

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.76	2.62	3.46	2.93	3.48	3.35
3.88	4.40	3.22	2.90	2.82	3.18

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.40	33.60	42.40	53.30	62.40	70.70
75.50	74.30	67.40	55.30	44.80	35.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	2.55	2.78	3.17	3.03	3.40	3.79
	4.10	3.32	2.85	3.25	2.62	2.90
STD. DEVIATIONS	1.38	1.13	1.46	1.38	2.11	1.86
	2.25	1.65	1.98	2.21	1.10	1.63
RUNOFF						
TOTALS	0.344	1.283	0.450	0.000	0.003	0.007
	0.001	0.004	0.009	0.008	0.000	0.073
STD. DEVIATIONS	0.602	1.397	0.784	0.000	0.012	0.021
	0.006	0.024	0.035	0.022	0.002	0.327
EVAPOTRANSPIRATION						
TOTALS	0.878	0.834	1.747	1.780	1.985	2.371
	2.535	2.050	1.537	1.192	1.092	0.937
STD. DEVIATIONS	0.304	0.410	0.436	0.690	0.901	0.935
	0.980	0.921	0.809	0.494	0.419	0.212
PERCOLATION/LEAKAGE THROUGH LAYER 2						
TOTALS	0.9754	0.6700	1.7137	1.1903	1.4960	1.4910
	1.4959	1.3345	1.2703	1.9778	1.4381	1.6123
STD. DEVIATIONS	1.0999	0.7955	1.0892	0.7834	1.4744	1.2746
	1.5203	1.0263	1.3757	1.8803	0.9363	1.4490
PERCOLATION/LEAKAGE THROUGH LAYER 5						
TOTALS	1.6628	1.3726	1.7890	1.3617	1.1957	1.2398
	1.3220	1.5249	1.2914	1.4929	1.3310	1.2485
STD. DEVIATIONS	0.9012	0.6817	0.8052	0.6515	0.6293	0.6927
	0.6539	0.6683	0.7743	0.7189	0.7532	0.6979

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 2						
AVERAGES	0.0186	0.0188	0.0392	0.0233	0.0297	0.0318

WOCAPOUT

	0.0309	0.0252	0.0262	0.0387	0.0285	0.0280
STD. DEVIATIONS	0.0223	0.0227	0.0240	0.0171	0.0319	0.0305
	0.0351	0.0219	0.0297	0.0412	0.0220	0.0281

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.77 (5.959)	12524438.0	100.00
RUNOFF	2.184 (1.4619)	724125.81	5.782
EVAPOTRANSPIRATION	18.936 (2.9482)	6279219.00	50.136
PERCOLATION/LEAKAGE THROUGH LAYER 2	16.66524 (3.80584)	5526200.500	44.12334
AVERAGE HEAD ON TOP OF LAYER 2	0.028 (0.006)		
PERCOLATION/LEAKAGE THROUGH LAYER 5	16.83225 (4.06800)	5581584.000	44.56554
CHANGE IN WATER STORAGE	-0.182 (3.4667)	-60488.99	-0.483

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	1107545.620
RUNOFF	2.183	723971.3120
PERCOLATION/LEAKAGE THROUGH LAYER 2	2.520311	835736.37500
AVERAGE HEAD ON TOP OF LAYER 2	1.783	
PERCOLATION/LEAKAGE THROUGH LAYER 5	0.196413	65130.56250
SNOW WATER	3.40	1126537.6200

MAXIMUM VEG. SOIL WATER (VOL/VOL)	0.4500
MINIMUM VEG. SOIL WATER (VOL/VOL)	0.0850

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FINAL WATER STORAGE AT END OF YEAR 30

LAYER	(INCHES)	(VOL/VOL)
1	0.3936	0.0984
2	28.5570	0.5010
3	8.7484	0.2916
4	145.5685	0.2941
5	22.4758	0.2417
SNOW WATER	0.000	

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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: T:\GUDEPREP.D4
TEMPERATURE DATA FILE: T:\GUDETEMP.D7
SOLAR RADIATION DATA FILE: T:\GUDESOLR.D13
EVAPOTRANSPIRATION DATA: T:\GUDEEVAT.D11
SOIL AND DESIGN DATA FILE: T:\WCAPIN.D10
OUTPUT DATA FILE: T:\WCAPOUT.OUT

TIME: 17:39 DATE: 4/ 8/2016

****

TITLE: GUDE AVERAGE TOP WITH CAP

****

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 6

THICKNESS	=	24.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2466	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

NOTE: SATURATED HYDRAULIC CONDUCTIVITY IS MULTIPLIED BY 5.00
FOR ROOT CHANNELS IN TOP HALF OF EVAPORATIVE ZONE.

LAYER 2

TYPE 2 - LATERAL DRAINAGE LAYER
MATERIAL TEXTURE NUMBER 20

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	=	0.2105	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	10.0000000000	CM/SEC
SLOPE	=	4.00	PERCENT
DRAINAGE LENGTH	=	1000.0	FEET

LAYER 3

TYPE 4 - FLEXIBLE MEMBRANE LINER
MATERIAL TEXTURE NUMBER 36

THICKNESS	=	0.04	INCHES
POROSITY	=	0.0000	VOL/VOL
FIELD CAPACITY	=	0.0000	VOL/VOL
WILTING POINT	=	0.0000	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0000	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.399999993000E-12	CM/SEC
FML PINHOLE DENSITY	=	1.00	HOLES/ACRE
FML INSTALLATION DEFECTS	=	10.00	HOLES/ACRE
FML PLACEMENT QUALITY	=	3 - GOOD	

LAYER 4

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	4.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2102	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

LAYER 5

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 0

THICKNESS	=	57.00	INCHES
POROSITY	=	0.5010	VOL/VOL
FIELD CAPACITY	=	0.2840	VOL/VOL
WILTING POINT	=	0.1350	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2846	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.146000006000E-03	CM/SEC

LAYER 6

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 8

THICKNESS	=	30.00	INCHES
POROSITY	=	0.4630	VOL/VOL
FIELD CAPACITY	=	0.2320	VOL/VOL
WILTING POINT	=	0.1160	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.369999994000E-03	CM/SEC

LAYER 7

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 18

THICKNESS	=	495.00	INCHES
POROSITY	=	0.6710	VOL/VOL
FIELD CAPACITY	=	0.2920	VOL/VOL
WILTING POINT	=	0.0770	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2920	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.100000005000E-02	CM/SEC

LAYER 8

TYPE 1 - VERTICAL PERCOLATION LAYER
MATERIAL TEXTURE NUMBER 6

THICKNESS	=	93.00	INCHES
POROSITY	=	0.4530	VOL/VOL
FIELD CAPACITY	=	0.1900	VOL/VOL
WILTING POINT	=	0.0850	VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.1900	VOL/VOL
EFFECTIVE SAT. HYD. COND.	=	0.720000011000E-03	CM/SEC

GENERAL DESIGN AND EVAPORATIVE ZONE DATA

NOTE: SCS RUNOFF CURVE NUMBER WAS COMPUTED FROM A USER-SPECIFIED CURVE NUMBER OF 71.0, A SURFACE SLOPE OF 4.% AND A SLOPE LENGTH OF 1000. FEET.

SCS RUNOFF CURVE NUMBER	=	69.80	
FRACTION OF AREA ALLOWING RUNOFF	=	100.0	PERCENT
AREA PROJECTED ON HORIZONTAL PLANE	=	91.350	ACRES
EVAPORATIVE ZONE DEPTH	=	10.0	INCHES
INITIAL WATER IN EVAPORATIVE ZONE	=	2.343	INCHES
UPPER LIMIT OF EVAPORATIVE STORAGE	=	4.530	INCHES
LOWER LIMIT OF EVAPORATIVE STORAGE	=	0.850	INCHES
INITIAL SNOW WATER	=	0.000	INCHES
INITIAL WATER IN LAYER MATERIALS	=	192.186	INCHES
TOTAL INITIAL WATER	=	192.186	INCHES

WCAPOUT

TOTAL SUBSURFACE INFLOW = 0.00 INCHES/YEAR

EVAPOTRANSPIRATION AND WEATHER DATA

NOTE: EVAPOTRANSPIRATION DATA WAS OBTAINED FROM
WASHINGTON DISTRICT OF COLUMB

STATION LATITUDE	=	38.90 DEGREES
MAXIMUM LEAF AREA INDEX	=	4.50
START OF GROWING SEASON (JULIAN DATE)	=	104
END OF GROWING SEASON (JULIAN DATE)	=	296
EVAPORATIVE ZONE DEPTH	=	10.0 INCHES
AVERAGE ANNUAL WIND SPEED	=	9.30 MPH
AVERAGE 1ST QUARTER RELATIVE HUMIDITY	=	60.00 %
AVERAGE 2ND QUARTER RELATIVE HUMIDITY	=	62.00 %
AVERAGE 3RD QUARTER RELATIVE HUMIDITY	=	68.00 %
AVERAGE 4TH QUARTER RELATIVE HUMIDITY	=	65.00 %

NOTE: PRECIPITATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY PRECIPITATION (INCHES)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
2.76	2.62	3.46	2.93	3.48	3.35
3.88	4.40	3.22	2.90	2.82	3.18

NOTE: TEMPERATURE DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA

NORMAL MEAN MONTHLY TEMPERATURE (DEGREES FAHRENHEIT)

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
31.40	33.60	42.40	53.30	62.40	70.70
75.50	74.30	67.40	55.30	44.80	35.10

NOTE: SOLAR RADIATION DATA WAS SYNTHETICALLY GENERATED USING
COEFFICIENTS FOR WASHINGTON DISTRICT OF COLUMBIA
AND STATION LATITUDE = 38.90 DEGREES

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 30

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

WCAPOUT

PRECIPITATION						
TOTALS	2.55	2.78	3.17	3.03	3.40	3.79
	4.10	3.32	2.85	3.25	2.62	2.90
STD. DEVIATIONS	1.38	1.13	1.46	1.38	2.11	1.86
	2.25	1.65	1.98	2.21	1.10	1.63
RUNOFF						
TOTALS	0.231	0.972	0.321	0.000	0.004	0.004
	0.002	0.002	0.009	0.009	0.002	0.054
STD. DEVIATIONS	0.420	1.178	0.581	0.000	0.020	0.014
	0.008	0.009	0.036	0.031	0.008	0.255
EVAPOTRANSPIRATION						
TOTALS	0.944	0.922	2.334	2.535	2.902	3.224
	3.272	2.864	2.026	1.400	1.297	1.017
STD. DEVIATIONS	0.368	0.491	0.466	0.883	1.107	1.329
	1.371	1.185	1.072	0.444	0.353	0.182
LATERAL DRAINAGE COLLECTED FROM LAYER 2						
TOTALS	1.1878	0.8607	1.7002	0.6985	0.8250	0.6237
	0.5717	0.5986	0.5606	1.2947	1.1587	1.2389
STD. DEVIATIONS	0.8557	0.8771	0.8414	0.7193	1.0662	0.6719
	0.7315	0.6480	0.7825	1.4524	1.0477	1.1715
PERCOLATION/LEAKAGE THROUGH LAYER 3						
TOTALS	0.0087	0.0091	0.0212	0.0051	0.0089	0.0047
	0.0043	0.0038	0.0127	0.0219	0.0118	0.0160
STD. DEVIATIONS	0.0108	0.0168	0.0230	0.0100	0.0246	0.0083
	0.0108	0.0051	0.0426	0.0426	0.0226	0.0327
PERCOLATION/LEAKAGE THROUGH LAYER 8						
TOTALS	0.0131	0.0106	0.0138	0.0173	0.0207	0.0135
	0.0051	0.0045	0.0033	0.0060	0.0088	0.0151
STD. DEVIATIONS	0.0139	0.0122	0.0148	0.0162	0.0267	0.0192
	0.0108	0.0096	0.0087	0.0119	0.0104	0.0146

AVERAGES OF MONTHLY AVERAGED DAILY HEADS (INCHES)

DAILY AVERAGE HEAD ON TOP OF LAYER 3						
AVERAGES	0.0656	0.0860	0.2015	0.0345	0.0766	0.0339
	0.0295	0.0226	0.1344	0.2227	0.1068	0.1495
STD. DEVIATIONS	0.1149	0.1979	0.2571	0.1084	0.2721	0.0871
	0.1159	0.0467	0.5061	0.4779	0.2578	0.3676

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

	INCHES	CU. FEET	PERCENT
PRECIPITATION	37.77 (5.959)	12524438.0	100.00
RUNOFF	1.611 (1.2442)	534291.81	4.266
EVAPOTRANSPIRATION	24.737 (3.4278)	8202647.00	65.493
LATERAL DRAINAGE COLLECTED FROM LAYER 2	11.31905 (3.66468)	3753401.500	29.96862
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.12807 (0.09013)	42467.023	0.33907
AVERAGE HEAD ON TOP OF LAYER 3	0.097 (0.085)		
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.13175 (0.08414)	43687.285	0.34882
CHANGE IN WATER STORAGE	-0.029 (1.1838)	-9586.85	-0.077

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 30

	(INCHES)	(CU. FT.)
PRECIPITATION	3.34	1107545.620
RUNOFF	1.980	656660.1870
DRAINAGE COLLECTED FROM LAYER 2	0.44825	148639.28100
PERCOLATION/LEAKAGE THROUGH LAYER 3	0.044864	14876.79390
AVERAGE HEAD ON TOP OF LAYER 3	15.952	
MAXIMUM HEAD ON TOP OF LAYER 3	27.743	
LOCATION OF MAXIMUM HEAD IN LAYER 2 (DISTANCE FROM DRAIN)	129.1 FEET	
PERCOLATION/LEAKAGE THROUGH LAYER 8	0.005176	1716.27661
SNOW WATER	3.40	1126537.6200

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4066

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.0850

*** 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 30

LAYER	(INCHES)	(VOL/VOL)
1	5.1823	0.2159
2	0.0216	0.1096
3	0.0000	0.0000
4	0.7600	0.1900
5	16.1873	0.2840
6	6.9597	0.2320
7	144.5277	0.2920
8	17.6797	0.1901
SNOW WATER	0.000	

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