APPENDIX A
CALCULATIONS

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
MAXIMUM DRAINAGE CAPACITY ANALYSIS
TOAL LEAKAGE RATE INPUT TABLE

OBJECTIVE

Estimate the total leakage rate into the Seondary Leachate Collection System

METHOD

Use calculation methods described in Giroud, J.P., and Bonaparte, R (1989) Leakage Through Liners Constructed with Geomembranes. Full reference provided in text of RAP. Sum the individual leakage rates to compute a total leakage rate.

CALCULATION

Cells	Lined Area	Permeation through Primary Geomembrane		Primary Geomembrane Leakage			Primary Sump Geomembrane Leakage		Permeation through Secondary Geomembrane		Secondary Geomembrane Consolidation Water Leakage			Total Leakage Into Secondary LCRS (gpd)
		Leakage Rate (gpd/acre)	Leakage (gpd)	Holes	Leakage from Holes[1] (gpd)	Leakge from Tears[2] (gpd)	Leakage from Holes[3] (gpd)	Leakage from Tears[4] (gpd)	Leakage Rate (gpd/acre)	Leakage (gpd)	Holes per Cell	Leakage from Holes (gpd)	Leakge from Tears (gpd)	
1	6.5	0.037	0.241	26.0	1.482	12.1	0.76	7.35	0.0075	0.049	26	0.676	0.5	23.2
2	4.1	0.037	0.152	16.4	0.935	12.1	0.76	7.35	0.0075	0.031	16.4	0.4264	0.5	22.3
3	4	0.037	0.148	16.0	0.912	12.1	0.76	7.35	0.0075	0.030	16	0.416	0.5	22.2
4	8.5	0.037	0.315	34.0	1.938	12.1	0.76	7.35	0.0075	0.064	34	0.884	0.5	23.9
5	5.3	0.037	0.196	21.2	1.208	12.1	0.76	7.35	0.0075	0.040	21.2	0.5512	0.5	22.7
6	5.2	0.037	0.192	20.8	1.186	12.1	0.76	7.35	0.0075	0.039	20.8	0.5408	0.5	22.7
7	9.3	0.037	0.344	37.2	2.120	12.1	0.76	7.35	0.0075	0.070	37.2	0.9672	0.5	24.2
8	9	0.037	0.333	36.0	2.052	12.1	0.76	7.35	0.0075	0.068	36	0.936	0.5	24.1

Notes
1. Assumed 4 holes/acre with leakage rate of 0.0057 gpd/hole
2. Assumed 1 tear/cell with leakage rate of 12.1 gpd/tear
3. Assumed 2 holes per sump with leakage rate of 0.38 gpd/hole
4. Assumed 1 tear per sump with leakage rate of 7.35 gpd/tear
5. Assumed 4 holes per acre with leakage rate of 0.026 gpd/hole
6. Assumed 1 tear per cell with leakage rate of 0.5 gpd/tear

Calculated By: David Spang Date: 1/22/2020
Checked By: Tim Mitchell Date: 2/3/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
LDS MAXIMUM DRAINAGE CAPACITY ANALYSIS
INPUT TABLE

OBJECTIVE

Estimate the maximum drainage capacity of the leachate detection system geocomposite.

METHOD

Use Darcy's equation to estimate the maximum drainage capacity based

ASSUMPTIONS

Geocomposite transmissivity = 3x10^-5 m^2/sec, as required by 40 CFR 264.301

The geocomposite remains free draining so that the slope of the cell floor is equal to the flow gradient.

The geometry of the cell floor is given in the design drawings.

CALCULATIONS

	Cell	1	2	3	4	5	6	7	8
Minimum Required Transmissivity	m^2/sec	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05	3.00E-05
	m^2/day	2.59	2.59	2.59	2.59	2.59	2.59	2.59	2.59
	ft^2/day	27.90	27.90	27.90	27.90	27.90	27.90	27.90	27.90
Cell Floor Width (Approximate*)	ft	210	214	214	120	140	140	140	140
Cell Floor Gradient		0.010	0.010	0.015	0.015	0.015	0.015	0.015	0.015
LDS Capacity	ft3/day	58.59	59.71	89.56	50.22	58.59	58.59	58.59	58.59
	gpd	438	447	670	376	438	438	438	438

***Due to the herringbone configurations of cells 5 through 8, the perimeter length of the sump was used instead of the cell width.**

Calculated By: Zach Metzler Date: 1/20/2020

Checked By: David Spang Date: 1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 1 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 1

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	175	232	246	90	-	-	-	743
Gradient		0.333	0.010	0.015	0.007	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	1.40E-03	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	0.240	-	-	-	
	m	0.0061	0.0061	0.0061	0.0061	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	0.230	-	-	-	
Flow Velocity	m/sec	0.0765	0.0023	0.0034	0.0016	-	-	-	
	ft/sec	0.2508	0.0075	0.0113	0.0053	-	-	-	
Sectional Travel Time	sec	698	30,806	21,777	17,073	-	-	-	
	hours	0.19	8.56	6.05	4.74	-	-	-	
Total Travel Time	hours					-	-	-	19.5
	days					**-**	**-**	**-**	**0.81**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 1 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump. Flow paths in Cells 2, 3, 5, and 6 are faster than the design conditions for Cell 1, so those cell detection times are not calculated here.

Calculated By:	Zach Metzler	Date:	1/21/2020
Checked By:	David Spang	Date:	1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 4 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 4

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	222	213	252	114	-	-	-	801
Gradient		0.333	0.025	0.025	0.025	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	1.40E-03	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	0.240	-	-	-	
	m	0.0061	0.0061	0.0061	0.0061	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	0.230	-	-	-	
Flow Velocity	m/sec	0.0765	0.0057	0.0057	0.0057	-	-	-	
	ft/sec	0.2508	0.0188	0.0188	0.0188	-	-	-	
Sectional Travel Time	sec	885	11,313	13,385	6,055	-	-	-	
	hours	0.25	3.14	3.72	1.68	-	-	-	
Total Travel Time	hours					-	-	-	8.8
	days					**-**	**-**	**-**	**0.37**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 4 sum will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By: Zach Metzler Date: 1/21/2020

Checked By: David Spang Date: 1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 7 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 7

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	200	571	118	-	-	-	-	889
Gradient		0.333	0.020	0.017	-	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	-	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	-	-	-	-	
	m	0.0061	0.0061	0.0061	-	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	-	-	-	-	
Flow Velocity	m/sec	0.0765	0.0046	0.0039	-	-	-	-	
	ft/sec	0.2508	0.0151	0.0128	-	-	-	-	
Sectional Travel Time	sec	798	37,911	9,217	-	-	-	-	
	hours	0.22	10.53	2.56	-	-	-	-	
Total Travel Time	hours				-	-	-	-	13.3
	days				**-**	**-**	**-**	**-**	**0.55**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 7 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By:	Zach Metzler	Date:	1/21/2020
Checked By:	David Spang	Date:	1/22/2020

CHEMICAL WASTE MANAGEMENT LANDFILL
L14 EXPANSION
DETECTION TIME ESTIMATE ANALYSIS
CELL 8 INPUT TABLE

OBJECTIVE

Estimate the detection time of a leak into the secondary LCRS that occurs at the hydraulically most distant point within a cell from the cell's sump.

METHOD

Use Darcy's equation to estimate the travel times along each subsection of the theoretical flow path and sum the sectional travel times to estimate the total travel time.

ASSUMPTIONS

Geocomposite transmissivity = 1.4x10^-3 m^2/sec. This value is only used to calculate the equivalent hydraulic conductivity with the apparent thickness under normal loading. Only the creep and void intrusion partial factors of safety are applied because localized chemical and biological clogging will not significantly affect the flow path.

Due to the high porosity of the geocomposite the porosity is assumed to be 1. This assumption results in longer detection time estimates since it will underestimate the flow velocity.

The average normal stress on the geocomposite is approximately 14,000 psf. This assumes that the landfill is at final grade.

CALCULATIONS FOR CELL 8

Subsection of Flow Path		A	B	C	D	E	F	G	**Total**
Flowline Length	ft	175	570	93	-	-	-	-	838
Gradient		0.333	0.020	0.022	-	-	-	-	
Geocomposite Transmissivity	m2/sec	1.40E-03	1.40E-03	1.40E-03	-	-	-	-	
Geocomposite Thickness	inch	0.240	0.240	0.240	-	-	-	-	
	m	0.0061	0.0061	0.0061	-	-	-	-	
Equivalent Hydraulic Conductivity	m/sec	0.230	0.230	0.230	-	-	-	-	
Flow Velocity	m/sec	0.0765	0.0046	0.0051	-	-	-	-	
	ft/sec	0.2508	0.0151	0.0166	-	-	-	-	
Sectional Travel Time	sec	698	37,844	5,613	-	-	-	-	
	hours	0.19	10.51	1.56	-	-	-	-	
Total Travel Time	hours				-	-	-	-	12.3
	days				**-**	**-**	**-**	**-**	**0.51**

RESULTS

The calculations demonstrate that leakage into the secondary LCRS at the hydraulically most distant point from the Cell 8 sump will be detected in one day or less. Other locations within the cell will be detected in shorter times, as they are hydraulically closer to the sump.

Calculated By: Zach Metzler   Date: 1/21/2020

Checked By: David Spang   Date: 1/22/2020