Table A-1. Current ARI System Mass Removal Calculations, Focused Feasibility Study, Colesville Landfill, Colesvile, New York.

Equations:

Total Mass Removed by ARI System = (Active Mass Flux through Treatment Zone) x (Operational Period) + (Total Adsorbed Mass Within Treatment Zone)

Active Mass Flux through Treatment Zone = (Average Advective GW Velocity) x (Average Injection Well Screen Thickness) x (Width of Treatment Zone) x (Average TVOC) x (Migratory Porosity)

Total Adsorbed Mass Within Treatment Zone = [(Injection Well Radius of Influence) + (Travel Distance Downgradient Based on Mass Transport Velocity)] x (Width of Treatment Zone) x (Average Well Screen Thickness) x (Average TVOC) x (Total Porosity)

Data and Calculations:

Average Advective GW Velocity (1)	0.4	ft/d
Average Injection Well Screen Thickness	20	ft.
Width of Treatment Zone (2)	500	ft.
Average TVOC (3)	265	ug/L
Migratory Porosity (1)	0.05	
Active Mass Flux through Treatment Zone	**1,523,380**	**ug/d**
Date of First Injection	9/1/2002	
Date of Last Injection	7/14/2011	
Operational Period	**3,238**	**d**
Injection Well Radius of Influence (4)	0.33	ft.
Mass Transport Velocity (5)	0.035	ft/d
Time Period Between Injections	262	d
TOC Travel Distance Downgradient (6)	9	ft.
Total Porosity (1)	0.4	
Total Adsorbed Mass within Treatment Zone	**299,699,621**	**ug**
Total Mass Removed by ARI System	**12.00**	**lbs**

See notes on last page.

Table A-1. Current ARI System Mass Removal Calculations, Focused Feasibility Study, Colesville Landfill, Colesvile, New York.

Notes

1. Refer to Section 2 of this FFS for additional information.
2. Width of treatment zone is equal to the width of the entire injection transect.
3. Average TVOC Concentration is equal to the average of the baseline monitoring wells GMMW-7 and W-5 chlorinated ethene concentrations.
4. Injection well radius of influence is equal to two times the injection well diameter.
5. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
6. TOC travel distance downgradient calculated by multiplying the mass transfer velocity by the number of days between injections.

d Days.
ft. Feet.
f/d Feet per day.
GW Groundwater.
lbs. Pounds.
ug/L Micrograms per liter.

Table A-2. Downgradient Landfill Boundary Attenuation Data and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Location ID:		GMMW-07	GMMW-07	GMMW-07	GMMW-07	GMMW-07	GMMW-07	GMMW-07	
Date Collected:		9/14/2005	9/21/2006	9/19/2007	9/18/2008	9/23/2009	9/22/2010	9/28/2011	Attenuation
Cumulative Days:		0	372	735	1,100	1,470	1,834	2,205	Rate [3]
Sample Name:	Units	GMMW-07	GMMW-07	GMMW-07	GMMW-7	GMMW-7	GMMW-7	GMMW-7	(d^{-1})
Concentration [1]									
1,1,1-Trichloroethane	ug/L	16	0.0	6.5	5.6	3.1	0.0	0.0	NA
1,1,2-Trichloroethane	ug/L	2.2	0.0	1.0	0.0	0.0	0.0	0.0	NA
1,1-Dichloroethane	ug/L	240	74	110	140	55	47	110	NA
1,1-Dichloroethene	ug/L	2.6	0.0	1.4	1.4	0.0	0.0	0.9	NA
1,2-Dichloroethane	ug/L	2.4	0.0	0.0	1.3	0.0	0.0	0.0	NA
Chloroethane	ug/L	79	18	34	42	16	15	47	NA
cis-1,2-Dichloroethene	ug/L	200	110	130	130	40	62	89	NA
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA
Trichloroethene	ug/L	59	22	37	50	27	3.7	38	NA
Vinyl Chloride	ug/L	88	27	35	55	28	25	42	NA
Natural Log of Concentration [2]									
1,1,1-Trichloroethane	NA	2.77	--	1.87	1.72	1.13	--	--	-1.07E-03
1,1,2-Trichloroethane	NA	0.79	--	0.00	--	--	--	--	-1.07E-03
1,1-Dichloroethane	NA	5.48	4.30	4.70	4.94	4.01	3.85	4.70	-3.84E-04
1,1-Dichloroethene	NA	0.96	--	0.34	0.34	--	--	-0.07	-4.40E-04
1,2-Dichloroethane	NA	0.88	--	--	0.26	--	--	--	-5.57E-04
Chloroethane	NA	4.37	2.89	3.53	3.74	2.77	2.71	3.85	-2.61E-04
cis-1,2-Dichloroethene	NA	5.30	4.70	4.87	4.87	3.69	4.13	4.49	-4.63E-04
trans-1,2-Dichloroethene	NA	--	--	--	--	--	--	--	NA
Tetrachloroethene	NA	--	--	--	--	--	--	--	NA
Trichloroethene	NA	4.08	3.09	3.61	3.91	3.30	1.31	3.64	-5.06E-04
Vinyl Chloride	NA	4.48	3.30	3.56	4.01	3.33	3.22	3.74	-2.53E-04

See notes on last page.

Table A-2. Downgradient Landfill Boundary Attenuation Data and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Data in this table corresponds to historic Monitoring Well GMMW-7 analytical data collected between 2002 and 2011. Chlorobenzene has been emitted from this evaluation due to inconsistent concentration trends throughout the life of the project.
2. Values calculated by taking the natural log of historic Monitoring Well GMMW-7 analytical data collected between 2002 and 2011.
3. Attenuation rate calculated by taking the slope of the first order time concentration data presented in this table:

$$\text{Attenuation Rate} = \text{SLOPE}\left(\frac{\ln(\text{Concentration})}{\text{Cumulative Days}}\right)$$

NA Not applicable.

-- Value could not be calculated because the associated concentration value is zero (i.e., cannot calculate the natural log of zero).

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Mass Travel Time Calculations:

Mass Transport Velocity [1] 0.035 ft/d

Well ID	Distance from Monitoring Well GMMW-7	Travel Time to Well [2]	
	(ft)	*(days)*	*(years)*
W-5	168	4,800	13
GMMW-2	228	6,514	18
PW-4	372	10,629	29
W-18	724	20,686	57

Analytical Data and Site-Wide Attenuation Rate Calculations:

Baseline - July 2002:

Location ID:		W-5	GMMW-2	PW-4	W-18
Date Collected:		7/24/2002	7/25/2002	7/25/2002	7/23/2002
Sample Name:	Units	W-5	GMMW-2	PW-4	W-18
Concentration [3]					
1,1,1-Trichloroethane	ug/L	8.5	88	69	12
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	160	93	62	15
1,1-Dichloroethene	ug/L	1.2	4.2	2.8	0.0
1,2-Dichloroethane	ug/L	1.3	0.0	0.0	0.0
Chloroethane	ug/L	70	27	17	0.0
cis-1,2-Dichloroethene	ug/L	53	200	72	9.8
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	1.0	0.0	0.0	0.0
Trichloroethene	ug/L	6.0	120	38	19
Vinyl Chloride	ug/L	91	29	5.4	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						**Attenuation Rate** [5] **(d^{-1})**
1,1,1-Trichloroethane	NA	2.14	4.48	4.23	2.48	-1.47E-04 [6]
1,1,2-Trichloroethane	NA	--	--	--	--	--
1,1-Dichloroethane	NA	5.08	4.53	4.13	2.71	-1.41E-04
1,1-Dichloroethene	NA	0.18	1.44	1.03	--	-9.86E-05 [6]
1,2-Dichloroethane	NA	0.26	--	--	--	--
Chloroethane	NA	4.25	3.30	2.83	--	-2.19E-04
cis-1,2-Dichloroethene	NA	3.97	5.30	4.28	2.28	-2.10E-04 [6]
trans-1,2-Dichloroethene	NA	--	--	--	--	--
Tetrachloroethene	NA	0.00	--	--	--	--
Trichloroethene	NA	1.79	4.79	3.64	2.94	-1.19E-04 [6]
Vinyl Chloride	NA	4.51	3.37	1.69	--	-4.71E-04

Injection Baseline - December 2002

Location ID:		**W-5**	**GMMW-2**	**PW-4**	**W-18**
Date Collected:		**12/10/2002**	**12/10/2002**	**12/10/2002**	**4/3/2003**
Sample Name:	**Units**	**W-5**	**GMMW-2**	**PW-4**	**W-18**
Concentration [3]					
1,1,1-Trichloroethane	ug/L	6.6	65	62	0.0
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	180	87	73	0.0
1,1-Dichloroethene	ug/L	0.0	6.3	7.2	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	82	23	20	0.0
cis-1,2-Dichloroethene	ug/L	8.2	180	130	0.0
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	2.2	0.0	0.0
Trichloroethene	ug/L	3.8	120	82	11
Vinyl Chloride	ug/L	36	19	6.5	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						**Attenuation Rate** [5] **(d^{-1})**
1,1,1-Trichloroethane	NA	1.89	4.17	4.13	--	-1.15E-05 [6]
1,1,2-Trichloroethane	NA	--	--	--	--	--
1,1-Dichloroethane	NA	5.19	4.47	4.29	--	-1.34E-04
1,1-Dichloroethene	NA	--	1.84	1.97	--	--
1,2-Dichloroethane	NA	--	--	--	--	--
Chloroethane	NA	4.41	3.14	3.00	--	-2.04E-04
cis-1,2-Dichloroethene	NA	2.10	5.19	4.87	--	-7.91E-05 [6]
trans-1,2-Dichloroethene	NA	--	--	--	--	--
Tetrachloroethene	NA	--	0.79	--	--	--
Trichloroethene	NA	1.34	4.79	4.41	2.40	-1.74E-04 [6]
Vinyl Chloride	NA	3.58	2.94	1.87	--	-2.88E-04

Injection Intermediate - July 2006

Location ID:		**W-5**	**GMMW-2**	**PW-4**	**W-18**
Date Collected:		**7/27/2006**	**7/27/2006**	**7/27/2006**	**9/21/2006**
Sample Name:	**Units**	**W-5**	**GMMW-2**	**PW-4**	**W-18**
Concentration [3]					
1,1,1-Trichloroethane	ug/L	0.0	19	12	13
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	81	83	13	10
1,1-Dichloroethene	ug/L	0.0	1.3	0.0	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	79	24	2.5	1.4
cis-1,2-Dichloroethene	ug/L	1.7	100	15	8.8
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0
Trichloroethene	ug/L	1.7	60	15	15
Vinyl Chloride	ug/L	3.1	14	0.0	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Natural Log of Concentration [4]						**Attenuation Rate** [5] **(d^{-1})**	
1,1,1-Trichloroethane	NA	--	2.94	2.48	2.56	-2.03E-05	(6)
1,1,2-Trichloroethane	NA	--	--	--	--	--	
1,1-Dichloroethane	NA	4.39	4.42	2.56	2.30	-1.26E-04	(6)
1,1-Dichloroethene	NA	--	0.26	--	--	--	
1,2-Dichloroethane	NA	--	--	--	--	--	
Chloroethane	NA	4.37	3.18	0.92	0.34	-2.33E-04	
cis-1,2-Dichloroethene	NA	0.53	4.61	2.71	2.17	-1.49E-04	(6)
trans-1,2-Dichloroethene	NA	--	--	--	--	--	
Tetrachloroethene	NA	--	--	--	--	--	
Trichloroethene	NA	0.53	4.09	2.71	2.71	-3.37E-04	Excludes W-5 and W-18 data.
Vinyl Chloride	NA	1.13	2.64	--	--	--	

Injection Current - September 2012

Location ID:		**W-5**	**GMMW-2**	**PW-4**	**W-18**
Date Collected:		**9/28/2011**	**9/28/2011**	**9/28/2011**	**9/27/2011**
Sample Name:	**Units**	**W-5**	**GMMW-2**	**PW-4**	**W-18**
Concentration [3]					
1,1,1-Trichloroethane	ug/L	0.0	2.5	4.0	3.5
1,1,2-Trichloroethane	ug/L	0.0	0.0	0.0	0.0
1,1-Dichloroethane	ug/L	52	63	5.5	4.4
1,1-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
1,2-Dichloroethane	ug/L	0.0	0.0	0.0	0.0
Chloroethane	ug/L	71	15	0.0	0.0
cis-1,2-Dichloroethene	ug/L	5.8	33	3.7	5.0
trans-1,2-Dichloroethene	ug/L	0.0	0.0	0.0	0.0
Tetrachloroethene	ug/L	0.0	0.0	0.0	0.0
Trichloroethene	ug/L	5.0	17	8.2	9.1
Vinyl Chloride	ug/L	1.4	8.4	0.0	0.0

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

	Natural Log of Concentration [4]					Attenuation Rate [5] (d^{-1})	
1,1,1-Trichloroethane	NA	--	0.92	1.39	1.25	-1.33E-05	Excludes W-5 and GMMW-2 data.
1,1,2-Trichloroethane	NA	--	--	--	--	--	
1,1-Dichloroethane	NA	3.95	4.14	1.70	1.48	-1.57E-04	(6)
1,1-Dichloroethene	NA	--	--	--	--	--	
1,2-Dichloroethane	NA	--	--	--	--	--	
Chloroethane	NA	4.26	2.71	--	--	-9.07E-04	
cis-1,2-Dichloroethene	NA	1.76	3.50	1.31	1.61	-1.03E-04	(6)
trans-1,2-Dichloroethene	NA	--	--	--	--	--	
Tetrachloroethene	NA	--	--	--	--	--	
Trichloroethene	NA	1.61	2.83	2.10	2.21	-3.39E-05	(6)
Vinyl Chloride	NA	0.34	2.13	--	--	--	

Compound	Average Attenuation Rate [8] (d^{-1})	
1,1,1-Trichloroethane	-4.80E-05	(6)
1,1,2-Trichloroethane	--	
1,1-Dichloroethane	-1.40E-04	
1,1-Dichloroethene	-9.86E-05	
1,2-Dichloroethane	--	
Chloroethane	-3.91E-04	
cis-1,2-Dichloroethene	-1.35E-04	(6)
trans-1,2-Dichloroethene	--	
Tetrachloroethene	--	
Trichloroethene	-1.66E-04	(6)
Vinyl Chloride	-3.79E-04	

See notes on last page.

Table A-3. Site-Wide Attenuation Rate Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
2. Travel time calculated by dividing the distance between the monitoring well and Monitoring Well GMMW-7 by the mass transport velocity.
3. Data in this table corresponds to historic Monitoring Well W-5, GMMW-2, PW-4, and W-18 analytical data collected between 2002 and 2011. Chlorobenzene has been emitted from this evaluation due to inconsistent concentration trends throughout the life of the project.
4. Values calculated by taking the natural log of historic monitoring well analytical data collected during the time period shown.
5. Attenuation rate calculated by taking the slope of the first order time concentration data presented in this table:

$$\text{Attenuation Rate} = \text{SLOPE}\left(\frac{\ln(\text{Concentration})}{\text{Travel Time to Monitoring Well GMMW-7}}\right)$$

6. Monitoring Well W-5 data excluded from calculation due to apparent increase in concentration downgradient caused by biodegradation of the respective contaminant in the vicinity of Monitoring Well W-5.
7. Monitoring Well W-5 and GMMW-2 data excluded from calculation due to apparent increase in concentration downgradient caused by biodegradation of the respective contaminant in the vicinity of the monitoring wells.
8. Average attenuation rate calculated by taking the average of the baseline, injection baseline, injection intermediate, and injection current attenuation rates.

d^{-1} Per day.

d Days.

ft. Feet.

ft/d Feet per day.

ug/L Micrograms per liter.

-- Value could not be calculated due to insufficient data.

ARCADIS

Table A-4. Summary of Attenuation Rates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

	Natural Attenuation Rates (ARI System Offline)				
	Downgradient Landfill Boundary Half Life		**Site-Wide Half Life**		**Typical Half Life Values** [4]
	First Order Rate Constant [1] (d^{-1})	Compound Specific Half Life [2] (d) / (years)	First Order Rate Constant [3] (d^{-1})	Compound Specific Half Life [2] (d) / (years)	Anaerobic (years)
1,1,1-Trichloroethane	-1.07E-03	648 / 1.8	-4.80E-05	14,450 / 40	1.5 - 3.0
1,1,2-Trichloroethane	-1.07E-03	646 / 1.8	--	-- / --	2.0 - 4.0
1,1-Dichloroethane	-3.84E-04	1,804 / 4.9	-1.40E-04	4,965 / 14	0.35 - 1.7
1,1-Dichloroethene	-4.40E-04	1,575 / 4.3	-9.86E-05	7,033 / 19	0.22 - 0.5
1,2-Dichloroethane	-5.57E-04	1,244 / 3.4	--	-- / --	1.1 - 2.0
Chloroethane	-2.61E-04	2,655 / 7.3	-3.91E-04	1,774 / 4.9	0.08 - 0.3
cis-1,2-Dichloroethene	-4.63E-04	1,497 / 4.1	-1.35E-04	5,124 / 14	0.31 - 2.0
Tetrachloroethene	--	-- / --	--	-- / --	0.27 - 4.5
trans-1,2-Dichloroethene	--	-- / --	--	-- / --	0.31 - 2.0
Trichloroethene	-5.06E-04	1,370 / 3.8	-1.66E-04	4,176 / 11	0.27 - 4.5
Vinyl Chloride	-2.53E-04	2,736 / 7.5	-3.79E-04	1,828 / 5.0	0.31 - 2.0

Notes:

1. Values calculated using historical Monitoring Well GMMW-7 analytical data (see Table A-2). A first order rate constant was not calculated for chlorobenzene due to inconsistent concentration trends throughout the life of the project.
2. Compound specific half life calculated using a first order rate equation:

$$C = C_o e^{-kt}$$

$$at\ t = t_{1/2}, C/C_o = 0.5 \therefore$$

$$t_{1/2} = \frac{\ln\left(C/C_o\right)}{-k}$$

3. Values calculated using an average of analytical data collected over the life of the project from monitoring wells W-5, GMMW-2, PW-4, and W-18 (see Table A-3).
4. Values referenced in Handbook of Environmental Degradation Rates (Howard 1991).

d^{-1} Per day.
d Days.
-- Value could not be calculated due to insufficient data.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternative 1 (No Action) and Alternative 2 (Monitored Natural Attenuation and Engineering and Institutional Controls) Calculations

Downgradient Landfill Boundary Attenuation Timeframes:

	MCL	Monitoring Well GMMW-7 Average Concentration (1)	Downgradient Landfill Boundary Compound-Specific Half Life (2)	Time to Reach MCLs (3)	
	(ug/L)	(ug/L)	(years)	(years)	
1,1,1-Trichloroethane	5	3.0	1.8	0	
1,1,2-Trichloroethane	5	0.20	1.8	0	
1,1-Dichloroethane	5	92	4.9	21	
1,1-Dichloroethene	5	0.75	4.3	0	
1,2-Dichloroethane	5	0.26	3.4	0	
Chloroethane	5	31	7.3	19	
cis-1,2-Dichloroethene	5	90	4.1	17	
Tetrachloroethene	5	0.0	--	--	
trans-1,2-Dichloroethene	5	0.0	--	--	
Trichloroethene	5	31	3.8	10	
Vinyl Chloride	2	37	7.5	31	Limiting Rate

Time for Clean Water Front to Reach Plume Boundary:

Mass Transport Velocity (4)	0.035	ft/d
Distance Between Monitoring Well GMMW-7 and End of Plume (5)	920	ft
Time (6)	26,286	days
	72	years

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Site Wide Attenuation Timeframes (IRZ Offline):

	MCL	Average Concentration (1)	Site-Wide Compound-Specific Half Life (2)	Time to Reach MCLs (3)	
	(ug/L)	(ug/L)	(years)	(years)	
1,1,1-Trichloroethane	5	6.4	40	13	
1,1,2-Trichloroethane	5	0.20	--	0	
1,1-Dichloroethane	5	92	14	57	
1,1-Dichloroethene	5	0.75	19	0	
1,2-Dichloroethane	5	0.26	--	0	
Chloroethane	5	31	5	13	
cis-1,2-Dichloroethene	5	90	14	59	Limiting Rate
Tetrachloroethene	5	0.0	--	0	
trans-1,2-Dichloroethene	5	0.0	--	0	
Trichloroethene	5	31	11	30	
Vinyl Chloride	2	37	5	21	

Alternatives 1 and 2 Total Remedial Timeframe:

Time for Site-Wide MNA to Reach MCLs	59	years	Site-wide MNA controls remedial timeframe. Alternative 1 requires no action during this time period, and Alternative 2 requires MNA for the entire time period.
Time for Monitoring Well GMMW-7 to Reach MCLs Plus Time for Clean Water Front to Reach Plume Boundary	103	years	

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Alternative 3 (Operation of the Existing ARI System until Remedial Action Objectives are Achieved) Calculations

Summary of Calculation Methodology:

An iterative process was used to determine the remedial timeframe for Alternatives 3 and 4. The estimated location of the clean water front was calculated assuming a number of years of operation. Historical analytical data from monitoring wells was then used to estimate the current average concentration of each compound at the estimated location of the clean water front. The average compound concentration was then used in a first order rate equation (see Alternative 1 calculations) to determine the number of years for each compound to degrade (through attenuation processes) to MCLs. This process was repeated until the time period for compound concentrations to reach MCLs was equal to the timeframe required for the clean water front to reach the location of the average compound concentrations.

The results of the iterative process indicate that after 37-years of operation, the clean water front will be approximately 592-feet from the injection transect. An average of analytical results from samples collected from Monitoring Wells PW-4 and W-18 and Recovery Well GMPW-4 over the past 5-years of system operatic was used to represent current compound concentrations 592-feet from the injection transect.

Estimated Location of Clean Water Front after Thirty Seven (37) Years of ARI System Operation:

Mass Transport Velocity (4)	0.035	ft/d
Date of First Injection	9/1/2002	
Years of Operation	37	years
Estimated Location of Clean Water Front (10)	592	ft from injection transect

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Site Wide Attenuation Timeframes (IRZ Operating):

	Site-Wide Compound-Specific Half Life [2]	MCL	Average Concentration	Time to Achieve MCLs [3]	
	(years)	(ug/L)	(ug/L)	(years)	
1,1,1-Trichloroethane	40	5	9.6	37	Limiting Rate
1,1,2-Trichloroethane	--	5	0.0	--	
1,1-Dichloroethane	14	5	34	37	Limiting Rate
1,1-Dichloroethene	19	5	0.40	0.0	
1,2-Dichloroethane	--	5	0.0	--	
Chloroethane	4.9	5	14	7.1	
cis-1,2-Dichloroethene	14	5	26	33	
Tetrachloroethene	--	5	0.0	--	
trans-1,2-Dichloroethene	--	5	0.0	--	
Trichloroethene	11	5	33	31	
Vinyl Chloride	5.0	2	4.7	6.2	

Location of Clean Water Front

Mass Transport Velocity [4]	0.035	ft/d
Date of First Injection	9/1/2002	
Location of Clean Water Front [10]	120	ft from injection transect

Time for Clean Water Front to Reach End of Plume:

Mass Transport Velocity [4]	0.035	ft/d
Distance Between Clean Water Front and End of Plume [5]	748	ft
Time [6]	21,381	days
	59	years

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

See notes on last page.

Alternative 3 Total Remedial Timeframe:

Time for Contaminants to Reach MCLs	37	years	Controlled by the site-wide MNA rate for when the IRZ is operating.
Time for Monitoring Well GMMW-7 to Reach MCLs Plus Time for Clean Water Front to Reach Plume Boundary	59	years	

Alternative 4 (No Further Action/Continue Existing Remedy) Calculations

Same remedial timeframe as Alternative 3. Refer to Alternative 3 calculations.

Total Remedial Timeframe:

Time:	37	years	Controlled by the site-wide MNA rate for when the IRZ is operating; Pumping provides no additional remedial benefit.

Summary of Remedial Timeframes

Alternative	Remedial Timeframe
Alternative 1	59 years
Alternative 2	59 years
Alternative 3	37 years
Alternative 4	37 years

See notes on last page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes:

1. Average concentration calculated by taking an average of historic Monitoring Well GMMW-7 analytical data collected over the past five years of system operation.
2. Refer to Tables A-2 through A-4 for compound-specific half life calculations.
3. Time to reach MCLs calculated using the compound-specific half life:

Calculate "n" Using the Following Equation :

$$C = C_o\left(\frac{1}{2^n}\right)$$

C = Final Compound Concentration (MCL)

C_o = Initial Compound Concentration (Avg. Conc.)

n = Number of Half Lives Elapsed

Time to Reach MCLs $= t_{1/2} \times n$

n = Number of Half Lives Elapsed

$t_{1/2}$ = Compound Specific Half Life

4. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
5. The distance to the end of the plume was determined using data from the Volatile Organic Compound Plume Delineation Report (ARCADIS 2011).
6. Time for clean water front to reach the end of the plume was calculated by dividing the distance to the end of the plume by the mass transport velocity.
7. Travel time to East Windsor Road was calculated by dividing the distance between Monitoring Well GMMW-7 and East Windsor Road by the mass transport velocity.

Notes continued on next page.

Table A-5. Summary of Remedial Timeframe Estimates and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Notes Continued:

8. Target Monitoring Well GMMW-7 concentration is the concentration of each contaminant at Monitoring Well GMMW-7 that will naturally degrade to below MCLs by the time mass reaches East Windsor Road. The target GMMW-7 concentration is the point where operation of the existing ARI system would be discontinued. Values were calculated using a first order rate equation:

Calculate C_o Using First Order Rate Equation:

$$C = C_o e^{-kt}$$

C = Final Contaminant Concentration (MCL)

C_o = Initial Contaminant Concentration

k = Attenuation Rate

t = Travel Time to East Windsor Road

9. Time to reach target Monitoring Well GMMW-7 concentrations calculated using the compound-specific half life:

Calculate "n" Using the Following Equation:

$$C = C_o\left(\frac{1}{2^n}\right)$$

C = Final Compound Concentration (Target GMMW - 7 Concentration)

C_o = Initial Compound Concentration (Avg. Conc.)

n = Number of Half Lives Elapsed

$$\text{Time to Reach MCLs} = t_{1/2} \times n$$

n = Number of Half Lives Elapsed

$t_{1/2}$ = Compound Specific Half Life

10. Current location of clean water front calculated by multiplying the mass transport velocity by the time period between the present and the date of the first injection minus one year. One year is subtracted from the time period to account for the time for the injection zone to establish itself.

11. Average concentration calculated by taking an average of analytical data from samples collected from Recovery Wells GMPW-3 and GMPW-4 and Monitoring Wells GMMW-2 and PW-4 collected over the past five years of system operation. These concentrations represent current concentrations at the location of the clean water front.

ft Feet.
ft/d Feet per day.
IRZ In-situ reactive zone.
MCL Maximum contaminant level.
MNA Monitored natural attenuation.
ug/L Micrograms per liter.

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Table A-6. Summary of SP-5 Remedial Timeframe Estimate and Calculations, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Current Location of Clean Water Front:		
Mass Transport Velocity [1]	0.035	ft/d
Date of First Injection	9/1/2002	
Current Location of Clean Water Front [2]	120	ft from injection transect
Time for Clean Water Front to Reach SP-5:		
Mass Transport Velocity [1]	0.035	ft/d
Distance Between Injection Transect and SP-5	384	ft
Distance Between Clean Water Front and SP-5	264	ft
Time [3]	7,552	days
	21	years

Notes:

1. Mass transport velocity calculated based upon bromide tracer results from the Hydraulic Injection Test and Alternate Electron Donor Pilot Test (ARCADIS 2006).
2. Current location of clean water front calculated by multiplying the mass transport velocity by the time period between the present and the date of the first injection minus one year. One year is subtracted from the time period to account for the time for the injection zone to establish itself.
3. Time for clean water front to reach SP-5 calculated by dividing the distance between the clean water front and SP-5 by the mass transport velocity. Value represents an estimate for cost estimating purposes only.

ft Feet.
ft/d Feet per day.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Plume Mass Estimate:

Average Plume Thickness [1]	20	ft
Total Porosity [2]	0.4	

July 2002 (Baseline Conditions)

TVOC (ug/L)	Area [3] (ft^2)	Mass [4] (lbs.)
5	1,167,779	2.9
50	242,615	6.1
100	146,612	7.3
250	77,531	9.7
500	35,342	8.8
1,000	9,224	
	TOTAL	**34.8**

September 2011 (Current Conditions)

TVOC (ug/L)	Area [3] (ft^2)	Mass [4] (lbs.)
5	632,471	1.6
50	97,242	2.4
100	57,614	2.9
250	26,627	3.3
500	2,214	0.6
	TOTAL	**10.8**

See notes on last page.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Groundwater Extraction System Mass Removal Estimate:

Alternative 1: NA

Alternative 2: NA

Alternative 3: NA

Alternative 4:

Estimated Mass Removal Rate [5]:	0.03	lbs/year
Estimated Operational Period [6]:	37	years
Estimated Mass to be Removed [7]:	**0.93**	**lbs**

ARI System Mass Removal Estimate:

Alternative 1: NA

Alternative 2: NA

Alternative 3:

Average Advective Groundwater Velocity [2]	0.4	ft/d
Average Injection Well Screen Thickness	20	ft.
Width of Treatment Zone [8]	500	ft.
Average TVOC [9]	19	ug/L
Migratory Porosity [2]	0.05	
Active Mass Flux through Treatment Zone	**109,922**	**ug/d**
Operational Period	**13,505**	**d**
Total Mass Removed by ARI System	**4.0**	**lbs**

Alternative 4:

Same as Alternative 3	**4.0**	**lbs**

See notes on last page.

Table A-7. Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

SP-5 Spring Water Remediation System Mass Removal Estimate:

Alternative 1 through Alternative 4:

Estimated Mass Removal Rate [5]:	0.17	lbs/year
Estimated Operational Period [6]:	21	years
Estimated Mass to be Removed [7,10]:	**3.5**	**lbs**

Notes:

1. Average plume thickness is equal to the average injection well screen thickness.
2. Refer to Section 2 of this FFS for additional information.
3. Area estimates extracted from Figures 2-1 and 2-2. The unknown source mass controlled by the landfill cap was not included in calculations. Accordingly, these calculations represent treatment of the dissolved phase plume located downgradient of the landfill cap
4. Plume mass estimated using the following equation:

$$Mass = Area \times Average\ Plume\ Thickness \times Total\ Porosity \times TVOC \times 28.32 \frac{L}{ft^3} \times 2.2 \times 10^{-9} \frac{lb}{ug}$$

5. Estimated mass removal rate calculated by dividing the Operational Year 9 mass removal rate (as stated in the operation, maintenance and monitoring reports) by two. The Operational Year 9 mass removal rate was divided by two to account for the declining influent concentration trend.
6. Refer to Table A-5 (Appendix A) for remedial timeframe estimates.
7. Estimated mass to be removed calculated by multiplying the estimated mass removal rate by the operational time period.
8. Width of treatment zone is equal to the width of the entire injection transect.
9. Average TVOC Concentration estimated by using the downgradient landfill boundary half lives (Table A-4, Appendix A) to determine what the TVOC concentration will be at the mid point of the remedial timeframe (i.e, after 18.5 years).
10. Refer to Table A-8 (Appendix A) for a summary of Remedial Alternative mass removal estimates.

ARI	Automated reagent injection.
FFS	Focused feasibility study.
ft.	Feet.
ft^2	Square feet.
L/ft^3	Liters per cubic foot.
lb/ug	Pounds per microgram
lbs.	Pounds.
MNA	Monitored natural attenuation.
NA	Not applicable.
TVOC	Total volatile organic compounds.
ug/L	Micrograms per liter.

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Table A-8. Summary of Remedial Alternative Mass Removal Estimates, Focused Feasibility Study, Colesville Landfill, Colesville, New York.

Summary of Mass Removal Estimates:

Remedial Alternative (1)	Remedial Timeframe (1)	Total Mass (2)	Total Mass Removed through Active Remediation (3)	Total Mass Removed through MNA (4)	Overall Active Remediation Mass Removal Rate (5)	Overall MNA Mass Removal Rate (6)	Overall Active Remediation Cost Rate (7)	Overall Remediation Cost Rate (8)	Active Remediation Incremental Cost Rate (9)
	(years)	(lbs)	(lbs)	(lbs)	(lbs/year)	(lbs/year)	($/lb)	($/lb)	($/lb)
1	59	10.8	0.0	10.8	0	1.82E-01	--		--
2	59	10.8	3.5	7.3	5.87E-02	1.24E-01	$536,508	$172,732	--
3	37	10.8	7.5	3.3	2.02E-01	8.91E-02	$637,562	$442,228	$101,054
4	37	10.8	8.4	2.4	2.27E-01	6.41E-02	$663,409	$517,175	$126,901

Notes:

1. Refer to Section 5.2 of this FFS for a description of Remedial Alternatives 1 through 4.
2. Refer to Plume Mass Estimate calculations on Table A-7 (Appendix A).
3. Active remediation refers to operation of the Groundwater Extraction System, ARI System, and SP-5 Remediation Systems. Refer to Mass Estimate calculations on Table A-7 (Appendix A).
4. Total mass removed through MNA calculated by subtracting the total mass removed through active remediation from the total mass.
5. Overall active remediation mass removal rate calculated by dividing the total mass removed through active remediation by the remedial timeframe.
6. Overall MNA mass removal rate calculated by dividing the total mass removed through MNA by the remedial timeframe.
7. Overall active remediation cost rate calculated by dividing the total remedial alternative cost (Appendix B) by the total mass removed through active remediation.
8. Overall remediation cost rate calculated by dividing the total remedial alternative cost (Appendix B) by the total mass.
9. Active remediation incremental cost rate calculated by subtracting the overall active remediation cost rate for Alternatives 3 and 4 from the overall active remediation cost rate for Alternative 2. This calculation provides a comparison of the active remediation alternatives to Alternative 2 (MNA).

ARI Automated reagent injection system.
FFS Focused feasibility study.
lbs. Pounds.
MNA Monitored natural attenuation.
-- Not applicable.
$/lb Dollars per pound.