APPENDIX B

Calculations

Surface Type	CN	C	Imperv	IA (mm)
Building/Apshalt/ Concrete/Pond	98	0.95	1	1.5
Gravel/Recycled Asphalt	89	0.8	0.6	3
Landscaped/Landfill top area	81	0.25	0	3
Landfill side slopes	83	0.35	0	1.5

Drainage Area	Area	Asphalt/Building Area/pond	Gravel Area	Landscaped Area Flat	Landfill Side slopes	CN	C	% Imperv	IA (mm)	TP (hr)	Description	Discharges To
101	14.5					81			6	0.34	pre-development	
102	16.6					81			6	0.43	pre-development	
103	13					81			6	0.38	pre-development	
104	52					81			6	0.6	pre-development	
105	46					81			6	0.62	pre-development	
201	14.4					81			1.5	0.26	current condition	Dingmans/Pond 1
202/3	29.6					81			1.5	0.31	current condition	Dodd/Pond 2
204	57.7					81			1.5	0.41	current condition	Dodd/Pond4
205	41					81			1.5	0.43	current condition	Dodd/Pond 5
301	34.48	2		25.48	7	82.4	0.31	0.06	2.6	0.3	proposed condition	Dingmans/Pond1
302	18.47	2		8.47	8	83.7	0.37	0.11	2.2	0.13	proposed condition	Dodd/Pond 2/3
303	6.25	0.7		3.55	2	83.5	0.36	0.11	2.4	0.11	proposed condition	Dodd/Pond 2/3
304	25.17	2		13.17	10	83.1	0.35	0.08	2.3	0.16	proposed condition	Dodd/Pond 4
305	56.6	3.523		33.077	20	82.8	0.33	0.06	2.4	0.52	proposed condition	Dodd/Pond 5

Time to Peak Calculations

	Overland Flow						Overland Flow						Channel Flow				
Drainage Area ID	Length	Elevation U/S	Elevation D/S	Slope	Velocity (Uplands)	Travel Time	Length	Elevation U/S	Elevation D/S	Slope	Velocity (Uplands)	Travel Time	Length	Velocity	Travel Time (min)	Time of Concentration	Time to Peak
	(m)	(m)	(m)	%	(m/s)	(min)	(m)	(m)	(m)	%	(m/s)	(min)	(m)	(m/s)	(min)	(min)	(hr)
101	425			1.5	0.25	28							100	0.6	3	31	0.34
102	545			1.5	0.25	36							100	0.6	3	39	0.43
103	465			1.5	0.25	31							100	0.6	3	34	0.38
104	760			1.5	0.25	51							100	0.6	3	54	0.6
105	800			1.5	0.25	53							100	0.6	3	56	0.62
201	425			2.8	0.36	20							100	0.6	3	23	0.26
202	545			3.0	0.37	25							100	0.6	3	28	0.31
203	465			4.0	0.42	18							100	0.6	3	21	0.23
204	750			3.0	0.37	34							100	0.6	3	37	0.41
205	800			3.0	0.37	36							100	0.6	3	39	0.43
301	480			5.0	0.5	16	60			25	0.6	2	550	0.8	11	27	0.3
302	0			5.0	0.5	0	115			25	0.6	3	560	0.8	12	12	0.13
303	220			5.0	0.5	7	120			25	0.6	3	130	0.8	3	10	0.11
304	220			5.0	0.5	7	120			25	0.6	3	320	0.8	7	14	0.16
305	480			5	0.5	16	60			25	0.6	2	1470	0.8	31	47	0.52

Area 301

Area	34.48	ha						
Imperviousness	55	%	Permanent Pool		Extended Detention		Baseflow	Total
Enhanced 80% TSS Requirements	190	m3/ha	5172	m3	1379.2	m3		6551 m3
Provided			7,402.0	m3	2253	m3	4000 m3	

Main Pond

Depth	Elevation	Length	Width	Incrementat Volume (m3)	Total Volume (m3)	Total Active Volume (m3)	Volume above baseflow	Orifice Dia. (m)	Head (above centre of orifice)	Orifice Discharge (m3/s)	Pipe 1 Overflow discharge (m3/s)	Pipe 2 Overflow Discharg e (m3/s)	Total Discharge (m3/s)	Notes
0.0	273.00	120.0	31.0	0.0	0.0									
0.1	273.10	121.0	32.0	647.0	647.0									
0.2	273.20	122.0	33.0	667.0	1,314.0									
0.3	273.30	123.0	34.0	688.0	2,002.0									
0.4	273.40	124.0	35.0	708.0	2,710.0									
0.5	273.50	125.0	36.0	729.0	3,439.0									
0.6	273.60	126.0	37.0	750.0	4,189.0									
0.7	273.70	127.0	38.0	771.0	4,960.0									
0.8	273.80	128.0	39.0	792.0	5,752.0									
0.9	273.90	129.0	40.0	814.0	6,566.0									
1.0	274.00	130.0	41.0	836.0	7,402.0	0.0		0					0	Perm Pool
1.1	274.10	131.0	42.0	857.0	8,259.0	857.0		0.075	0.0625	0.003			0.003	
1.2	274.20	132.0	43.0	879.0	9,138.0	1,736.0		0.075	0.1625	0.005			0.005	
1.3	274.30	133.0	44.0	905.0	10,043.0	2,641.0		0.075	0.2625	0.006			0.006	
1.4	274.40	134.0	45.0	927.0	10,970.0	3,568.0		0.075	0.3625	0.007			0.007	
1.5	274.50	135.0	46.0	949.0	11,919.0	4,517.0	0.0	0.075	0.4625	0.008			0.008	baseflow 4000 m3
1.6	274.60	136.0	47.0	971.0	12,890.0	5,488.0	971.0	0.075	0.5625	0.009			0.009	
1.7	274.70	137.0	48.0	993.0	13,883.0	6,481.0	1,964.0	0.075	0.6625	0.010			0.010	
1.8	274.80	138.0	49.0	1,013.0	14,896.0	7,494.0	2,977.0	0.075	0.7625	0.010	0.000		0.010	
1.9	274.90	139.0	50.0	1,039.0	15,935.0	8,533.0	4,016.0	0.075	0.8625	0.011	0.017		0.028	
2.0	275.00	140.0	51.0	1,061.0	16,996.0	9,594.0	5,077.0	0.075	0.9625	0.012	0.089		0.101	
2.1	275.10	141.0	52.0	1,084.0	18,080.0	10,678.0	6,161.0	0.075	1.0625	0.012	0.187		0.200	
2.2	275.20	142.0	53.0	1,108.0	19,188.0	11,786.0	7,269.0	0.075	1.1625	0.013	0.304		0.317	
2.3	275.30	143.0	54.0	1,131.0	20,319.0	12,917.0	8,400.0	0.075	1.2625	0.013	0.431		0.444	
2.4	275.40	144.0	55.0	1,154.0	21,473.0	14,071.0	9,554.0	0.075	1.3625	0.014	0.468		0.482	
2.5	275.50	145.0	56.0	1,178.0	22,651.0	15,249.0	10,732.0	0.075	1.4625	0.014	0.483	0.000	0.498	
2.6	275.60	146.0	57.0	1,202.0	23,853.0	16,451.0	11,934.0	0.075	1.5625	0.015	0.540	0.017	0.572	
2.7	275.70	147.0	58.0	1,225.0	25,078.0	17,676.0	13,159.0	0.075	1.6625	0.015	0.592	0.089	0.696	
2.8	275.80	148.0	59.0	1,249.0	26,327.0	18,925.0	14,408.0	0.075	1.7625	0.016	0.639	0.187	0.842	
2.9	275.90	149.0	60.0	1,274.0	27,601.0	20,199.0	15,682.0	0.075	1.8625	0.016	0.683	0.304	1.004	
3.0	276.00	150.0	61.0	1,298.0	28,899.0	21,497.0	16,980.0	0.075	1.9625	0.017	0.725	0.431	1.172	

	Volume (ha*m))	Volume (m3)	Elevation	Depth	Uncontrolled (L/s)	Proposed Discharge (L/s)	Pre Dev Discharg e (L/s)	Current Discharge
25mm	0.2253	2253	274.73	0.73	562	10	78	
1:5 year	0.5808	5808	275.07	1.07	1824	167	315	10
1:10 year	0.6999	6999	275.18	1.18	2420	288	434	
1:100 year	1.1740	11740	275.58	1.58	4407	560	941	430
1:250 year	1.556	15560	275.89	1.89	6112	988	1206	

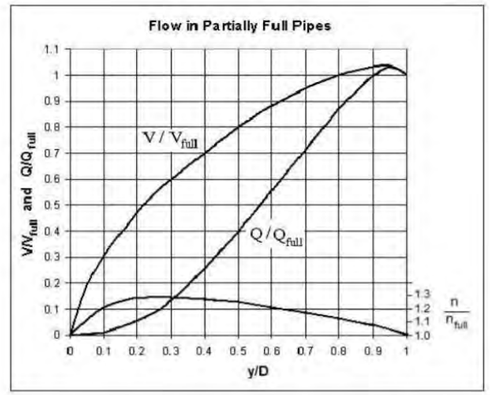

Figure 3. Flow in Partially Full Pipes

Manning's Eq.
Q = R^0.67 * S^0.5 * A / n **MTO Eqn 8.66**

Diameter D =	0.6	
A =	0.283	m2
P =	1.885	m
R = A/P	0.15	m
S =	0.005	m/m
n =	0.012	
Q full =	0.468	m3/s

Flow Qfull =

y/D	Q/Qfull	y (m)	Q m3/s
0	0	0	0
0.1	0.01	0.06	0.005
0.2	0.05	0.12	0.0234
0.3	0.15	0.18	0.0702
0.4	0.27	0.24	0.12636
0.5	0.4	0.3	0.1872
0.6	0.55	0.36	0.2574
0.7	0.7	0.42	0.3276
0.8	0.88	0.48	0.41184
0.9	1	0.54	0.468
1	1	0.6	0.468

Orifice Flow MTO Eqn 8.79
Q = Cd*A*(2*g*H)^0.5

Orifice Dia	0.600	m

Depth	Head above centre of orifice	Partially Full Flow (m3/s)	Orifice Flow (m3/s)
0.000	0	0	0.000
0.100	0	0.017	0.000
0.200	0	0.089	0.000
0.300	0	0.187	0.000
0.400	0.1	0.304	0.242
0.500	0.2	0.431	0.342
0.600	0.3	0.468	0.418
0.700	0.4		0.483
0.800	0.5		0.540
0.900	0.6		0.592
1.000	0.7		0.639
1.100	0.8		0.683
1.200	0.9		0.725

Area 302, 303

Proposed Area	24.71	ha	Current Area		29.6 (from SWM Facility No. 2/3 drawing, Earthtech, Asbuilt Mar. 15, 2007)				
Imperviousness	55	%	Permanent Pool		Extended Detention		Baseflow		Total	
Enhanced 80% TSS Requirements	190	m3/ha	3707	m3	988.4	m3	6000	m3	5624	m3
Existing			3256	m3						
Proposed			4,602.0	m3	1604	m3				

Depth	Elevation	Incremental Volume (m3)	Total Volume (m3)	Total Active Volume (m3)	Volume Above Baseflow	Orifice Dia. (m)	Head (above centre of orifice)	Orifice Discharge (m3/s)	Pipe Outlet 1	Total Discharge (m3/s)	
0	270.40	0	0.0								
0.1	270.50	140	140.0								
0.2	270.60	290	430.0								
0.3	270.70	304	734.0								
0.4	270.80	319	1,053.0								
0.5	270.90	333	1,386.0								
0.6	271.00	347	1,733.0								
0.7	271.10	362	2,095.0								
0.8	271.20	377	2,472.0								
0.9	271.30	392	2,864.0								
1	271.40	406	3,270.0								
1.1	271.50	422	3,692.0								
1.2	271.60	437	4,129.0								
1.3	271.70	473	4,602.0	0.0		0.075	0	0.000		0.000	Perm pool
1.4	271.80	489	5,091.0	489.0		0.075	0.0625	0.003		0.003	
1.5	271.90	506	5,597.0	995.0		0.075	0.7625	0.010		0.010	
1.6	272.00	523	6,120.0	1,518.0		0.075	0.8625	0.011		0.011	
1.7	272.10	540	6,660.0	2,058.0		0.075	0.9625	0.012		0.012	
1.8	272.20	557	7,217.0	2,615.0		0.075	1.0625	0.012		0.012	
1.9	272.30	574	7,791.0	3,189.0		0.075	1.1625	0.013		0.013	
2	272.40	591	8,382.0	3,780.0		0.075	1.2625	0.013		0.013	
2.1	272.50	608	8,990.0	4,388.0		0.075	1.3625	0.014		0.014	
2.2	272.60	625	9,615.0	5,013.0		0.075	1.4625	0.014		0.014	
2.3	272.70	642	10,257.0	5,655.0		0.075	1.5625	0.015		0.015	
2.4	272.80	660	10,917.0	6,315.0	0.0	0.075	1.6625	0.015		0.015	Baseflow
2.5	272.90	677	11,594.0	6,992.0	677.0	0.075	1.7625	0.016		0.016	
2.6	273.00	694	12,288.0	7,686.0	1,371.0	0.075	1.8625	0.016		0.016	
2.7	273.10	712	13,000.0	8,398.0	2,083.0	0.075	1.9625	0.017	0.000	0.017	
2.8	273.20	729	13,729.0	9,127.0	2,812.0	0.075	2.0625	0.017	0.023	0.040	
271.7	273.30	747	14,476.0	9,874.0	3,559.0	0.075	270.9625	0.196	0.083	0.280	
271.8	273.40	752	15,228.0	10,626.0	4,311.0	0.075	271.0625	0.197	0.185	0.381	
271.9	273.50	765	15,993.0	11,391.0	5,076.0	0.075	271.1625	0.197	0.334	0.531	
272	273.60	782	16,775.0	12,173.0	5,858.0	0.075	271.2625	0.197	0.537	0.734	
272.1	273.70	800	17,575.0	12,973.0	6,658.0	0.075	271.3625	0.197	0.800	0.997	
272.2	273.80	818	18,393.0	13,791.0	7,476.0	0.075	271.4625	0.197	1.129	1.325	
272.3	273.90	836	19,229.0	14,627.0	8,312.0	0.075	271.5625	0.197	1.528	1.725	
272.4	274.00	854	20,083.0	15,481.0	9,166.0	0.075	271.6625	0.197	2.004	2.201	
272.5	274.10	872	20,955.0	16,353.0	10,038.0	0.075	271.7625	0.197	2.561	2.758	
272.6	274.20	890	21,845.0	17,243.0	10,928.0	0.075	271.8625	0.197	3.204	3.401	
272.7	274.30	908	22,753.0	18,151.0	11,836.0	0.075	271.9625	0.197	3.939	4.136	
272.8	274.40	926	23,679.0	19,077.0	12,762.0	0.075	272.0625	0.197	4.770	4.967	
272.9	274.50	944	24,623.0	20,021.0	13,706.0	0.075	272.1625	0.197	9.142	9.339	

	Volume (m3)	Elevation	Depth	Uncontrolled (L/s)	Discharge (L/s)	Pre-Dev Discharge	Current Discharge
25mm	1604	273.03	1.33	676	16	143	
1:5 year	3551.0	273.30	1.60	2171	277	571	150
1:10 year	4384.0	273.41	1.71	2851	394	783	
1:100 year	6951.0	273.74	2.04	5132	1113	1513	730
1:250 year	8944	273.97	2.27	7082	2059	2172	

Overflow Ditch Characteristics						**Flow Rate**
Manning's Roughness	**Slope**	**Bottom Width**	**Side Slope**	**Depth of flow above ditch**		**From Manning's**
Coefficient		**(max steepness 3:1)**				Q=(AR$^{2/3}$ √ S)/n
n	**m/m**	**m**	**X:1**	**m**	**A$^{5/3}$/P$^{2/3}$**	**m3/s**
0.033	**0.001**	1.00	3	0.10	0.024	0.023058483
0.033	0.001	1.00	3	0.20	0.087	0.083183129
0.033	0.001	1.00	3	0.30	0.193	0.184760241
0.033	0.001	1.00	3	0.40	0.349	0.33403243
0.033	0.001	1.00	3	0.50	0.561	0.537174494
0.033	0.001	1.00	3	0.60	0.835	0.800126337
0.033	0.001	1.00	3	0.70	1.178	1.128588621
0.033	0.001	1.00	3	0.80	1.595	1.528045012
0.033	0.001	1.00	3	0.90	2.091	2.003786796
0.033	0.001	1.00	3	1.00	2.672	2.560934888
0.033	0.001	1.00	3	1.10	3.344	3.204458571
0.033	0.001	1.00	3	1.20	4.111	3.939191252
0.033	0.001	1.00	3	1.30	4.978	4.76984376
0.033	0.001	1.00	3	1.40	5.949	5.701015613
0.033	0.001	1.00	3	1.50	7.031	6.737204658
0.033	0.001	1.00	3	1.60	8.226	7.882815366
0.033	0.001	1.00	3	1.70	9.540	9.142166044
0.033	0.001	1.00	3	1.80	10.978	10.51949514
0.033	0.001	1.00	3	1.90	12.542	12.01896677
0.033	0.001	1.00	3	2.00	14.239	13.64467566
0.033	0.001	1.00	3	2.10	16.071	15.40065152

Area 304

Proposed Area	25.17	ha	Current Area	57.7	ha			
Imperviousness	55	%	Permanent Pool			Extended Detention		Baseflow
Enhanced 80% TSS Requirements	190	m3/ha	3776	m3		1006.8	m3	0 m3
Existing			5193	m3		2308	m3	
Proposed			4,387.0	m3		1479	m3	

Main Pond

Depth	Elevation	Incremental Volume (m3)	Total Volume (forebary and main)	Total Active Volume	Orifice Dia. (m)	Head (above centre of orifice)	Orifice Discharge (m3/s)	Overflow Pipe	Total Discharge (m3/s)	
0.0	268.30	0	0.0							
0.1	268.40	321	321.0							
0.2	268.50	335	656.0							
0.3	268.60	350	1,006.0							
0.4	268.70	365	1,371.0							
0.5	268.80	381	1,752.0							
0.6	268.90	397	2,149.0							
0.7	269.00	413	2,562.0							
0.8	269.10	430	2,992.0							
0.9	269.20	447	3,439.0							
1.0	269.30	465	3,904.0	0.0						
0.0	269.40	483	4,387.0	0.0	0.2	0	0.000		0.000	perm pool
0.1	269.50	502	4,889.0	502.0	0.2	0	0.000		0.000	
0.2	269.60	587	5,476.0	1,089.0	0.2	0.1	0.027		0.027	
0.3	269.70	604	6,080.0	1,693.0	0.2	0.2	0.038		0.038	
0.4	269.80	621	6,701.0	2,314.0	0.2	0.3	0.046		0.046	
0.5	269.90	638	7,339.0	2,952.0	0.2	0.4	0.054		0.054	
0.6	270.00	655	7,994.0	3,607.0	0.2	0.5	0.060		0.060	
0.7	270.10	672	8,666.0	4,279.0	0.2	0.6	0.066		0.066	
0.8	270.20	690	9,356.0	4,969.0	0.2	0.7	0.071		0.071	
0.9	270.30	707	10,063.0	5,676.0	0.2	0.8	0.076		0.076	
1.0	270.40	725	10,788.0	6,401.0	0.2	0.9	0.081	0.000	0.081	
1.1	270.50	742	11,530.0	7,143.0	0.2	1	0.085	0.017	0.102	
1.2	270.60	758	12,288.0	7,901.0	0.2	1.1	0.089	0.089	0.178	
1.3	270.70	774	13,062.0	8,675.0	0.2	1.2	0.093	0.187	0.280	
1.4	270.80	790	13,852.0	9,465.0	0.2	1.3	0.097	0.304	0.401	
1.5	270.90	807	14,659.0	10,272.0	0.2	1.4	0.100	0.431	0.531	
1.6	271.00	824	15,483.0	11,096.0	0.2	1.5	0.104	0.468	0.572	
1.7	271.10	837	16,320.0	11,933.0	0.2	1.6	0.107	0.483	0.591	
1.8	271.20	839	17,159.0	12,772.0	0.2	1.7	0.111	0.540	0.651	
1.9	271.30	854	18,013.0	13,626.0	0.2	1.8	0.114	0.592	0.706	
2.0	271.40	871	18,884.0	14,497.0	0.2	1.9	0.117	0.639	0.756	

Model Outputs:

	Volume (m3)	Elevation	Depth above Perm Pool (m)	Uncontrolled (L/s)	Discharge (L/s)	Pre-Dev Discharge	Current Discharge
25mm	1479	269.67	0.37	596	34	200	
1:5 year	4569	270.14	0.84	1948	68	770	80
1:10 year	5959	270.34	1.04	2567	78	1050	
1:100 year	9225	270.77	1.47	4677	363	2013	1800
1:250 year	11954	271.1	1.80	6484	593	2868	

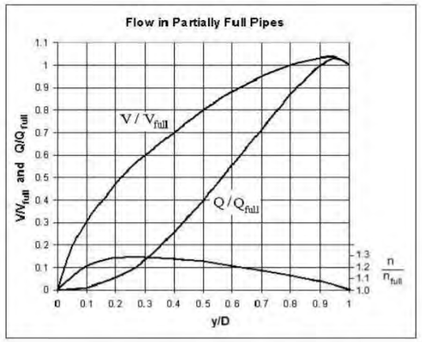

Figure 3. Flow in Partially Full Pipes

Manning's Eq.
Q = R^0.67 * S^0.5 * A / n **MTO Eqn 8.66**

Diameter D =	0.6	
A =	0.283	m2
P =	1.885	m
R = A/P	0.15	m
S =	0.005	m/m
n =	0.012	
Q full =	0.468	m3/s

Flow Qfull =

y/D	Q/Qfull	y (m)	Q m3/s
0	0	0	0.000
0.1	0.01	0.06	0.005
0.2	0.05	0.12	0.023
0.3	0.15	0.18	0.070
0.4	0.27	0.24	0.126
0.5	0.4	0.3	0.187
0.6	0.55	0.36	0.257
0.7	0.7	0.42	0.328
0.8	0.88	0.48	0.412
0.9	1	0.54	0.468
1	1	0.6	0.468

Orifice Flow MTO Eqn 8.79
Q = Cd*A*(2*g*H)^0.5

Orifice Dia	0.600	m
Invert	269.400	m

Depth of weir overflow

Depth	Head above centre of orifice	Partially Full Flow (m3/s)	Orifice Flow (m3/s)
0.00	0	0	0.000
0.10	0	0.017	0.000
0.20	0	0.089	0.000
0.30	0	0.187	0.000
0.40	0.1	0.304	0.242
0.50	0.2	0.431	0.342
0.60	0.3	0.468	0.418
0.70	0.4		0.483
0.80	0.5		0.540
0.90	0.6		0.592
1.00	0.7		0.639
1.10	0.8		0.683
1.20	0.9		0.725
1.30	1		0.764
1.40	1.1		0.801
1.50	1.2		0.837
1.60	1.3		0.871
1.70	1.4		0.904
1.80	1.5		0.936
1.90	1.6		0.966
2.00	1.7		0.996
2.10	1.8		1.025

Area 305

			Permanent Pool		Extended Detention		Total	
Area	56.6	ha						
Imperviousness	55	%						
Enhanced 80% TSS Requirements	190	m3/ha	8490	m3	2264	m3	10754	m3
Provided			12,098.0	m3	2393	m3		

Depth	Elevation	Incremental Volume (m3)	Total Volume (m3)	Volume above perm pool (m3)	Orifice Dia. (m)	Head (above centre of orifice)	Orifice Discharge (m3/s)	Weir Overflow discharge (m3/s)	Total Discharge (m3/s)
0.0	267.00	0	0.0						
0.1	267.10	711.0	711.0						
0.2	267.20	724.0	1,435.0						
0.3	267.30	737.0	2,172.0						
0.4	267.40	751.0	2,923.0						
0.5	267.50	765.0	3,688.0						
0.6	267.60	778.0	4,466.0						
0.7	267.70	792.0	5,258.0						
0.8	267.80	806.0	6,064.0						
0.9	267.90	820.0	6,884.0						
1.0	268.00	834.0	7,718.0						
1.1	268.10	848.0	8,566.0						
1.2	268.20	862.0	9,428.0						0.000
1.3	268.30	876.0	10,304.0						0.000
1.4	268.40	890.0	11,194.0						0.000
1.5	268.50	904.0	12,098.0	0.0	0.15	0	0.000		0.000
1.6	268.60	919.0	13,017.0	919.0	0.15	0.025	0.008		0.008
1.7	268.70	933.0	13,950.0	1,852.0	0.15	0.125	0.017		0.017
1.8	268.80	948.0	14,898.0	2,800.0	0.15	0.225	0.023		0.023
1.9	268.90	963.0	15,861.0	3,763.0	0.15	0.325	0.027		0.027
2.0	269.00	977.0	16,838.0	4,740.0	0.15	0.425	0.031		0.031
2.1	269.10	992.0	17,830.0	5,732.0	0.15	0.525	0.035		0.035
2.2	269.20	1,007.0	18,837.0	6,739.0	0.15	0.625	0.038		0.038
2.3	269.30	1,022.0	19,859.0	7,761.0	0.15	0.725	0.041		0.041
2.4	269.40	1,037.0	20,896.0	8,798.0	0.15	0.825	0.043	0.000	0.043
2.5	269.50	1,052.0	21,948.0	9,850.0	0.15	0.925	0.046	0.070	0.116
2.6	269.60	1,067.0	23,015.0	10,917.0	0.15	1.025	0.048	0.199	0.248
2.7	269.70	1,083.0	24,098.0	12,000.0	0.15	1.125	0.051	0.366	0.417
2.8	269.80	1,098.0	25,196.0	13,098.0	0.15	1.225	0.053	0.563	0.616
2.9	269.90	1,113.0	26,309.0	14,211.0	0.15	1.325	0.055	0.787	0.842
3.0	270.00	1,129.0	27,438.0	15,340.0	0.15	1.425	0.057	1.035	1.092
3.1	270.10	1,144.0	28,582.0	16,484.0	0.15	1.525	0.059	1.304	1.363
3.2	270.20	1,160.0	29,742.0	17,644.0	0.15	1.625	0.061	1.594	1.655
3.3	270.30	1,176.0	30,918.0	18,820.0	0.15	1.725	0.063	1.902	1.964
3.4	270.40	1,192.0	32,110.0	20,012.0	0.15	1.825	0.065	2.227	2.292
3.5	270.50	1,207.0	33,317.0	21,219.0	0.15	1.925	0.066	2.569	2.636
3.6	270.60	1,223.0	34,540.0	22,442.0	0.15	2.025	0.068	2.928	2.996
3.7	270.70	1,239.0	35,779.0	23,681.0	0.15	2.125	0.070	3.301	3.371
3.8	270.80	1,255.0	37,034.0	24,936.0	0.15	2.225	0.071	3.689	3.761
3.9	270.90	1,272.0	38,306.0	26,208.0	0.15	2.325	0.073	4.092	4.164
4.0	271.00	1,288.0	39,594.0	27,496.0	0.15	2.425	0.074	4.508	4.582

Overflow Weir (MTO Weir Equation)

L = 1.2 m

Q = 1.856 L * H ^ 1.5

Q = 1.856 * 25 * 0.25 ^ 1.5

Q = 5.8 m3/s

Depth	Weir Flow (m3/s)
0.1	0.07043
0.2	0.19921
0.3	0.36597
0.4	0.56344
0.5	0.78743
0.6	1.03511
0.7	1.30439
0.8	1.59365
0.9	1.90162
1	2.2272
1.1	2.5695
1.2	2.92773
1.3	3.30122
1.4	3.68936
1.5	4.09163
1.6	4.50754
1.7	4.93665

	Volume (m3)	Elevation	Depth	Uncontrolled Discharge (L/s)	Discharge (L/s)	Pre Dev Flow (L/s)	Current Conditions Peak Flow (L/s)
25mm	2393	268.76	0.26	382	20	170	25
1:5 year	8813.0	269.4	0.90	1549	44	654	147
1:10 year	10866	269.6	1.10	2132	242	892	
1:100 year	15803.0	270.04	1.54	4126	1204	1705	1584
1:250 year	19763	270.38	1.88	5915	2220	2427	

APPENDIX C

Model Outputs

```
================================================================================
=========================

       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O    Company

        OOO     T      T    H   H    Y    M   M   OOO                Serial


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                  *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files (x86)\Visual Otthymo 2.4\VO2\voin.dat

  Output  filename:
C:\Users\mknowles\AppData\Local\Temp\d97b5569-d61a-46ac-bfa5-8a950329a4be\Scenario
.out
  Summary filename:
C:\Users\mknowles\AppData\Local\Temp\d97b5569-d61a-46ac-bfa5-8a950329a4be\Scenario
.sum


DATE: 08/05/2020                          TIME: 11:32:40

USER:



COMMENTS: _____________________________________________________________


--------------------------------------------------------------------------------
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  ***************************
  ** SIMULATION NUMBER:   1 **
  ***************************

--------------------
```

| CHICAGO STORM | IDF curve parameters: A= 538.850
| Ptotal= 25.04 mm | B= 6.331
C= 0.809
used in: INTENSITY = A / (t + B)^C

Duration of storm = 4.00 hrs
Storm time step = 10.00 min
Time to peak ratio = 0.33

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	1.53	1.17	13.51	2.17	3.79	3.17	1.83
0.33	1.76	1.33	56.25	2.33	3.19	3.33	1.70
0.50	2.09	1.50	17.85	2.50	2.77	3.50	1.58
0.67	2.60	1.67	9.19	2.67	2.45	3.67	1.48
0.83	3.49	1.83	6.19	2.83	2.20	3.83	1.39
1.00	5.43	2.00	4.69	3.00	2.00	4.00	1.32

CALIB	
NASHYD (0101)	Area (ha)= 14.50 Curve Number (CN)= 81.0
ID= 1 DT= 5.0 min	Ia (mm)= 6.00 # of Linear Res.(N)= 1.50
	U.H. Tp(hrs)= 0.31

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.53	1.083	13.51	2.083	3.79	3.08	1.83
0.167	1.53	1.167	13.51	2.167	3.79	3.17	1.83
0.250	1.76	1.250	56.25	2.250	3.19	3.25	1.70
0.333	1.76	1.333	56.25	2.333	3.19	3.33	1.70
0.417	2.09	1.417	17.85	2.417	2.77	3.42	1.58
0.500	2.09	1.500	17.85	2.500	2.77	3.50	1.58
0.583	2.60	1.583	9.19	2.583	2.45	3.58	1.48
0.667	2.60	1.667	9.19	2.667	2.45	3.67	1.48
0.750	3.49	1.750	6.19	2.750	2.20	3.75	1.39
0.833	3.49	1.833	6.19	2.833	2.20	3.83	1.39
0.917	5.43	1.917	4.69	2.917	2.00	3.92	1.32
1.000	5.43	2.000	4.69	3.000	2.00	4.00	1.32

Unit Hyd Qpeak (cms)= 0.799

PEAK FLOW (cms)= 0.078 (i)
TIME TO PEAK (hrs)= 2.000
RUNOFF VOLUME (mm)= 4.559

```
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.182

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

---------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0104) |   Area    (ha)=  52.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.53

     Unit Hyd Qpeak  (cms)=   1.675

     PEAK FLOW       (cms)=   0.200 (i)
     TIME TO PEAK    (hrs)=   2.500
     RUNOFF VOLUME    (mm)=   4.588
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.183

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

---------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0105) |   Area    (ha)=  46.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   1.402

     PEAK FLOW       (cms)=   0.170 (i)
     TIME TO PEAK    (hrs)=   2.500
     RUNOFF VOLUME    (mm)=   4.590
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.183

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

---------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=  16.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.39

     Unit Hyd Qpeak  (cms)=   0.727

     PEAK FLOW       (cms)=   0.078 (i)
     TIME TO PEAK    (hrs)=   2.167
```

```
     RUNOFF VOLUME    (mm)=   4.574
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.183

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=  13.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.34

     Unit Hyd Qpeak  (cms)=   0.653

     PEAK FLOW       (cms)=   0.066 (i)
     TIME TO PEAK    (hrs)=   2.083
     RUNOFF VOLUME    (mm)=   4.565
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.182

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0011) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):    16.60   0.078     2.17     4.57
        + ID2= 2 (0103):    13.00   0.066     2.08     4.57
          ================================================
          ID = 3 (0011):    29.60   0.143     2.17     4.57

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   3 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1183.740
| Ptotal= 46.68 mm |                          B=   7.641
--------------------                          C=   0.838
                       used in:   INTENSITY =  A / (t + B)^C

                       Duration of storm  =  4.00 hrs
                       Storm time step    = 10.00 min
                       Time to peak ratio =  0.33
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	2.55	1.17	26.33	2.17	6.80	3.17	3.10
0.33	2.97	1.33	106.82	2.33	5.65	3.33	2.85
0.50	3.58	1.50	35.10	2.50	4.84	3.50	2.64
0.67	4.53	1.67	17.60	2.67	4.23	3.67	2.46
0.83	6.22	1.83	11.55	2.83	3.77	3.83	2.31
1.00	10.04	2.00	8.56	3.00	3.40	4.00	2.17

CALIB			
NASHYD (0101)	Area (ha)=	14.50	Curve Number (CN)= 81.0
ID= 1 DT= 5.0 min	Ia (mm)=	6.00	# of Linear Res.(N)= 1.50
	U.H. Tp(hrs)=	0.31	

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.55	1.083	26.33	2.083	6.80	3.08	3.10
0.167	2.55	1.167	26.33	2.167	6.80	3.17	3.10
0.250	2.97	1.250	106.82	2.250	5.65	3.25	2.85
0.333	2.97	1.333	106.82	2.333	5.65	3.33	2.85
0.417	3.58	1.417	35.10	2.417	4.84	3.42	2.64
0.500	3.58	1.500	35.10	2.500	4.84	3.50	2.64
0.583	4.53	1.583	17.60	2.583	4.23	3.58	2.46
0.667	4.53	1.667	17.60	2.667	4.23	3.67	2.46
0.750	6.22	1.750	11.55	2.750	3.77	3.75	2.31
0.833	6.22	1.833	11.55	2.833	3.77	3.83	2.31
0.917	10.04	1.917	8.56	2.917	3.40	3.92	2.17
1.000	10.04	2.000	8.56	3.000	3.40	4.00	2.17

Unit Hyd Qpeak (cms)= 0.799

PEAK FLOW (cms)= 0.315 (i)
TIME TO PEAK (hrs)= 1.833
RUNOFF VOLUME (mm)= 16.320
TOTAL RAINFALL (mm)= 46.683
RUNOFF COEFFICIENT = 0.350

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB

```
| NASHYD    (0104) |   Area    (ha)=  52.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
-------------------   U.H. Tp(hrs)=   0.53

     Unit Hyd Qpeak  (cms)=   1.675

     PEAK FLOW       (cms)=   0.770 (i)
     TIME TO PEAK    (hrs)=   2.250
     RUNOFF VOLUME    (mm)=  16.423
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.352

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0105) |   Area    (ha)=  46.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
-------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   1.402

     PEAK FLOW       (cms)=   0.654 (i)
     TIME TO PEAK    (hrs)=   2.333
     RUNOFF VOLUME    (mm)=  16.430
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.352

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=  16.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
-------------------   U.H. Tp(hrs)=   0.39

     Unit Hyd Qpeak  (cms)=   0.727

     PEAK FLOW       (cms)=   0.307 (i)
     TIME TO PEAK    (hrs)=   2.000
     RUNOFF VOLUME    (mm)=  16.374
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.351

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
```

```
| CALIB             |
| NASHYD    (0103) |   Area    (ha)=  13.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.34

     Unit Hyd Qpeak  (cms)=   0.653

     PEAK FLOW       (cms)=   0.265 (i)
     TIME TO PEAK    (hrs)=   1.917
     RUNOFF VOLUME    (mm)=  16.344
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.350

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0011) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):    16.60   0.307     2.00    16.37
        + ID2= 2 (0103):    13.00   0.265     1.92    16.34
          ================================================
          ID = 3 (0011):    29.60   0.571     2.00    16.36

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
  ****************************
  ** SIMULATION NUMBER:   4 **
  ****************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1574.382
| Ptotal= 54.74 mm |                          B=   9.025
--------------------                          C=   0.860
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  =  4.00 hrs
                         Storm time step    = 10.00 min
                         Time to peak ratio =  0.33

                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.17    2.75 |  1.17   32.16 |  2.17    7.84 |  3.17    3.39
                0.33    3.24 |  1.33  124.99 |  2.33    6.43 |  3.33    3.10
                0.50    3.95 |  1.50   43.04 |  2.50    5.45 |  3.50    2.86
                0.67    5.08 |  1.67   21.33 |  2.67    4.73 |  3.67    2.65
                0.83    7.12 |  1.83   13.73 |  2.83    4.17 |  3.83    2.47
```

1.00	11.86	2.00	10.01	3.00	3.74	4.00	2.32

CALIB			
NASHYD (0101)	Area (ha)=	14.50	Curve Number (CN)= 81.0
ID= 1 DT= 5.0 min	Ia (mm)=	6.00	# of Linear Res.(N)= 1.50
	U.H. Tp(hrs)=	0.31	

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.75	1.083	32.16	2.083	7.84	3.08	3.39
0.167	2.75	1.167	32.16	2.167	7.84	3.17	3.39
0.250	3.24	1.250	124.99	2.250	6.43	3.25	3.10
0.333	3.24	1.333	124.99	2.333	6.43	3.33	3.10
0.417	3.95	1.417	43.04	2.417	5.45	3.42	2.86
0.500	3.95	1.500	43.04	2.500	5.45	3.50	2.86
0.583	5.08	1.583	21.33	2.583	4.73	3.58	2.65
0.667	5.08	1.667	21.33	2.667	4.73	3.67	2.65
0.750	7.12	1.750	13.73	2.750	4.17	3.75	2.47
0.833	7.12	1.833	13.73	2.833	4.17	3.83	2.47
0.917	11.86	1.917	10.01	2.917	3.74	3.92	2.32
1.000	11.86	2.000	10.01	3.000	3.74	4.00	2.32

Unit Hyd Qpeak (cms)= 0.799

PEAK FLOW (cms)= 0.434 (i)
TIME TO PEAK (hrs)= 1.833
RUNOFF VOLUME (mm)= 21.679
TOTAL RAINFALL (mm)= 54.736
RUNOFF COEFFICIENT = 0.396

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB			
NASHYD (0104)	Area (ha)=	52.00	Curve Number (CN)= 81.0
ID= 1 DT= 5.0 min	Ia (mm)=	6.00	# of Linear Res.(N)= 1.50
	U.H. Tp(hrs)=	0.53	

Unit Hyd Qpeak (cms)= 1.675

PEAK FLOW (cms)= 1.050 (i)
TIME TO PEAK (hrs)= 2.250

```
     RUNOFF VOLUME    (mm)=  21.816
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.399

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0105) |   Area    (ha)=  46.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   1.402

     PEAK FLOW       (cms)=   0.892 (i)
     TIME TO PEAK    (hrs)=   2.250
     RUNOFF VOLUME    (mm)=  21.825
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.399

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=  16.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.39

     Unit Hyd Qpeak  (cms)=   0.727

     PEAK FLOW       (cms)=   0.421 (i)
     TIME TO PEAK    (hrs)=   2.000
     RUNOFF VOLUME    (mm)=  21.751
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.397

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=  13.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.34

     Unit Hyd Qpeak  (cms)=   0.653

     PEAK FLOW       (cms)=   0.364 (i)
```

```
     TIME TO PEAK    (hrs)=   1.917
     RUNOFF VOLUME    (mm)=  21.711
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.397

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```

```
--------------------
| ADD HYD   (0011) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):    16.60   0.421     2.00    21.75
        + ID2= 2 (0103):    13.00   0.364     1.92    21.71
          ================================================
          ID = 3 (0011):    29.60   0.783     1.92    21.73

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
```

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  ***************************
  ** SIMULATION NUMBER:   7 **
  ***************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=2619.363
| Ptotal= 79.36 mm |                          B=  10.500
--------------------                          C=   0.884
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  4.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =  0.33

                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.17    3.61 |  1.17   48.51 |  2.17   11.13 |  3.17    4.52
                0.33    4.31 |  1.33  181.39 |  2.33    9.00 |  3.33    4.11
                0.50    5.33 |  1.50   65.14 |  2.50    7.54 |  3.50    3.76
                0.67    6.99 |  1.67   31.96 |  2.67    6.47 |  3.67    3.47
                0.83   10.05 |  1.83   20.19 |  2.83    5.66 |  3.83    3.22
                1.00   17.30 |  2.00   14.45 |  3.00    5.03 |  4.00    3.01
```

```
--------------------
| CALIB            |
| NASHYD    (0101) |   Area    (ha)=  14.50   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
```

```
--------------------   U.H. Tp(hrs)=   0.31

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----							
TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	3.61	1.083	48.51	2.083	11.13	3.08	4.52
0.167	3.61	1.167	48.51	2.167	11.13	3.17	4.52
0.250	4.31	1.250	181.39	2.250	9.00	3.25	4.11
0.333	4.31	1.333	181.39	2.333	9.00	3.33	4.11
0.417	5.33	1.417	65.14	2.417	7.54	3.42	3.76
0.500	5.33	1.500	65.14	2.500	7.54	3.50	3.76
0.583	6.99	1.583	31.96	2.583	6.47	3.58	3.47
0.667	6.99	1.667	31.96	2.667	6.47	3.67	3.47
0.750	10.05	1.750	20.19	2.750	5.66	3.75	3.22
0.833	10.05	1.833	20.19	2.833	5.66	3.83	3.22
0.917	17.30	1.917	14.45	2.917	5.03	3.92	3.01
1.000	17.30	2.000	14.45	3.000	5.03	4.00	3.01

```
     Unit Hyd Qpeak  (cms)=   0.799

     PEAK FLOW       (cms)=   0.841 (i)
     TIME TO PEAK    (hrs)=   1.833
     RUNOFF VOLUME    (mm)=  40.019
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.504

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

---------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0104) |   Area    (ha)=  52.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.53

     Unit Hyd Qpeak  (cms)=   1.675

     PEAK FLOW       (cms)=   2.013 (i)
     TIME TO PEAK    (hrs)=   2.167
     RUNOFF VOLUME    (mm)=  40.272
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.507

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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```
| CALIB            |
| NASHYD    (0105) |   Area    (ha)=  46.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   1.402

     PEAK FLOW       (cms)=   1.705 (i)
     TIME TO PEAK    (hrs)=   2.167
     RUNOFF VOLUME    (mm)=  40.288
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.508

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0102) |   Area    (ha)=  16.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.39

     Unit Hyd Qpeak  (cms)=   0.727

     PEAK FLOW       (cms)=   0.811 (i)
     TIME TO PEAK    (hrs)=   1.917
     RUNOFF VOLUME    (mm)=  40.152
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.506

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=  13.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.34

     Unit Hyd Qpeak  (cms)=   0.653

     PEAK FLOW       (cms)=   0.704 (i)
     TIME TO PEAK    (hrs)=   1.833
     RUNOFF VOLUME    (mm)=  40.078
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.505

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0011) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):    16.60   0.811     1.92    40.15
        + ID2= 2 (0103):    13.00   0.704     1.83    40.08
          ================================================
          ID = 3 (0011):    29.60   1.513     1.92    40.12

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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  ****************************
  ** SIMULATION NUMBER:  15 **
  ****************************


--------------------
| CHICAGO STORM    |    IDF curve parameters: A=3048.220
| Ptotal=114.01 mm |                          B=  10.030
--------------------                          C=   0.888
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  = 24.00 hrs
                         Storm time step    = 10.00 min
                         Time to peak ratio =  0.33

                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.17    0.57 |  6.17    2.42 | 12.17    2.07 | 18.17    0.86
                0.33    0.59 |  6.33    2.68 | 12.33    1.99 | 18.33    0.85
                0.50    0.60 |  6.50    3.00 | 12.50    1.91 | 18.50    0.83
                0.67    0.61 |  6.67    3.42 | 12.67    1.85 | 18.67    0.82
                0.83    0.62 |  6.83    3.97 | 12.83    1.78 | 18.83    0.81
                1.00    0.64 |  7.00    4.74 | 13.00    1.72 | 19.00    0.80
                1.17    0.65 |  7.17    5.88 | 13.17    1.67 | 19.17    0.79
                1.33    0.67 |  7.33    7.72 | 13.33    1.61 | 19.33    0.78
                1.50    0.68 |  7.50   11.14 | 13.50    1.56 | 19.50    0.76
                1.67    0.70 |  7.67   19.26 | 13.67    1.52 | 19.67    0.75
                1.83    0.72 |  7.83   54.92 | 13.83    1.48 | 19.83    0.74
                2.00    0.74 |  8.00  212.89 | 14.00    1.43 | 20.00    0.73
                2.17    0.76 |  8.17   74.08 | 14.17    1.40 | 20.17    0.72
                2.33    0.78 |  8.33   35.85 | 14.33    1.36 | 20.33    0.72
                2.50    0.80 |  8.50   22.52 | 14.50    1.33 | 20.50    0.71
                2.67    0.83 |  8.67   16.06 | 14.67    1.29 | 20.67    0.70
                2.83    0.85 |  8.83   12.34 | 14.83    1.26 | 20.83    0.69
                3.00    0.88 |  9.00    9.97 | 15.00    1.23 | 21.00    0.68
                3.17    0.91 |  9.17    8.33 | 15.17    1.20 | 21.17    0.67
                3.33    0.94 |  9.33    7.14 | 15.33    1.18 | 21.33    0.66
                3.50    0.97 |  9.50    6.24 | 15.50    1.15 | 21.50    0.66
```

3.67	1.01	9.67	5.54	15.67	1.13	21.67	0.65
3.83	1.05	9.83	4.98	15.83	1.10	21.83	0.64
4.00	1.09	10.00	4.52	16.00	1.08	22.00	0.64
4.17	1.14	10.17	4.14	16.17	1.06	22.17	0.63
4.33	1.19	10.33	3.82	16.33	1.04	22.33	0.62
4.50	1.25	10.50	3.54	16.50	1.02	22.50	0.61
4.67	1.31	10.67	3.31	16.67	1.00	22.67	0.61
4.83	1.38	10.83	3.10	16.83	0.98	22.83	0.60
5.00	1.45	11.00	2.92	17.00	0.97	23.00	0.60
5.17	1.54	11.17	2.75	17.17	0.95	23.17	0.59
5.33	1.64	11.33	2.61	17.33	0.93	23.33	0.58
5.50	1.75	11.50	2.48	17.50	0.92	23.50	0.58
5.67	1.88	11.67	2.36	17.67	0.90	23.67	0.57
5.83	2.03	11.83	2.26	17.83	0.89	23.83	0.57
6.00	2.20	12.00	2.16	18.00	0.87	24.00	0.56

CALIB			
NASHYD (0101)	Area (ha)= 14.50	Curve Number (CN)= 81.0	
ID= 1 DT= 5.0 min	Ia (mm)= 6.00	# of Linear Res.(N)= 1.50	
	U.H. Tp(hrs)= 0.31		

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.57	6.083	2.42	12.083	2.07	18.08	0.86
0.167	0.57	6.167	2.42	12.167	2.07	18.17	0.86
0.250	0.59	6.250	2.68	12.250	1.99	18.25	0.85
0.333	0.59	6.333	2.68	12.333	1.99	18.33	0.85
0.417	0.60	6.417	3.00	12.417	1.91	18.42	0.83
0.500	0.60	6.500	3.00	12.500	1.91	18.50	0.83
0.583	0.61	6.583	3.42	12.583	1.85	18.58	0.82
0.667	0.61	6.667	3.42	12.667	1.85	18.67	0.82
0.750	0.62	6.750	3.97	12.750	1.78	18.75	0.81
0.833	0.62	6.833	3.97	12.833	1.78	18.83	0.81
0.917	0.64	6.917	4.74	12.917	1.72	18.92	0.80
1.000	0.64	7.000	4.74	13.000	1.72	19.00	0.80
1.083	0.65	7.083	5.88	13.083	1.67	19.08	0.79
1.167	0.65	7.167	5.88	13.167	1.67	19.17	0.79
1.250	0.67	7.250	7.72	13.250	1.61	19.25	0.78
1.333	0.67	7.333	7.72	13.333	1.61	19.33	0.78
1.417	0.68	7.417	11.14	13.417	1.56	19.42	0.76
1.500	0.68	7.500	11.14	13.500	1.56	19.50	0.76
1.583	0.70	7.583	19.26	13.583	1.52	19.58	0.75
1.667	0.70	7.667	19.26	13.667	1.52	19.67	0.75

1.750	0.72	7.750	54.92	13.750	1.48	19.75	0.74
1.833	0.72	7.833	54.93	13.833	1.48	19.83	0.74
1.917	0.74	7.917	212.89	13.917	1.43	19.92	0.73
2.000	0.74	8.000	212.88	14.000	1.43	20.00	0.73
2.083	0.76	8.083	74.08	14.083	1.40	20.08	0.72
2.167	0.76	8.167	74.07	14.167	1.40	20.17	0.72
2.250	0.78	8.250	35.85	14.250	1.36	20.25	0.72
2.333	0.78	8.333	35.85	14.333	1.36	20.33	0.72
2.417	0.80	8.417	22.52	14.417	1.33	20.42	0.71
2.500	0.80	8.500	22.52	14.500	1.33	20.50	0.71
2.583	0.83	8.583	16.06	14.583	1.29	20.58	0.70
2.667	0.83	8.667	16.06	14.667	1.29	20.67	0.70
2.750	0.85	8.750	12.34	14.750	1.26	20.75	0.69
2.833	0.85	8.833	12.34	14.833	1.26	20.83	0.69
2.917	0.88	8.917	9.97	14.917	1.23	20.92	0.68
3.000	0.88	9.000	9.97	15.000	1.23	21.00	0.68
3.083	0.91	9.083	8.33	15.083	1.20	21.08	0.67
3.167	0.91	9.167	8.33	15.167	1.20	21.17	0.67
3.250	0.94	9.250	7.14	15.250	1.18	21.25	0.66
3.333	0.94	9.333	7.14	15.333	1.18	21.33	0.66
3.417	0.97	9.417	6.24	15.417	1.15	21.42	0.66
3.500	0.97	9.500	6.24	15.500	1.15	21.50	0.66
3.583	1.01	9.583	5.54	15.583	1.13	21.58	0.65
3.667	1.01	9.667	5.54	15.667	1.13	21.67	0.65
3.750	1.05	9.750	4.98	15.750	1.10	21.75	0.64
3.833	1.05	9.833	4.98	15.833	1.10	21.83	0.64
3.917	1.09	9.917	4.52	15.917	1.08	21.92	0.64
4.000	1.09	10.000	4.52	16.000	1.08	22.00	0.64
4.083	1.14	10.083	4.14	16.083	1.06	22.08	0.63
4.167	1.14	10.167	4.14	16.167	1.06	22.17	0.63
4.250	1.19	10.250	3.82	16.250	1.04	22.25	0.62
4.333	1.19	10.333	3.82	16.333	1.04	22.33	0.62
4.417	1.25	10.417	3.54	16.417	1.02	22.42	0.61
4.500	1.25	10.500	3.54	16.500	1.02	22.50	0.61
4.583	1.31	10.583	3.31	16.583	1.00	22.58	0.61
4.667	1.31	10.667	3.31	16.667	1.00	22.67	0.61
4.750	1.38	10.750	3.10	16.750	0.98	22.75	0.60
4.833	1.38	10.833	3.10	16.833	0.98	22.83	0.60
4.917	1.45	10.917	2.92	16.917	0.97	22.92	0.60
5.000	1.45	11.000	2.92	17.000	0.97	23.00	0.60
5.083	1.54	11.083	2.75	17.083	0.95	23.08	0.59
5.167	1.54	11.167	2.75	17.167	0.95	23.17	0.59
5.250	1.64	11.250	2.61	17.250	0.93	23.25	0.58
5.333	1.64	11.333	2.61	17.333	0.93	23.33	0.58
5.417	1.75	11.417	2.48	17.417	0.92	23.42	0.58
5.500	1.75	11.500	2.48	17.500	0.92	23.50	0.58
5.583	1.88	11.583	2.36	17.583	0.90	23.58	0.57
5.667	1.88	11.667	2.36	17.667	0.90	23.67	0.57
5.750	2.03	11.750	2.26	17.750	0.89	23.75	0.57
5.833	2.03	11.833	2.26	17.833	0.89	23.83	0.57

```
               5.917    2.20 |11.917    2.16 |17.917    0.87 | 23.92    0.56
               6.000    2.20 |12.000    2.16 |18.000    0.87 | 24.00    0.56

     Unit Hyd Qpeak  (cms)=   0.799

     PEAK FLOW       (cms)=   1.206 (i)
     TIME TO PEAK    (hrs)=   8.417
     RUNOFF VOLUME    (mm)=  68.822
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.604

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD    (0104) |   Area    (ha)=  52.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.53

     Unit Hyd Qpeak  (cms)=   1.675

     PEAK FLOW       (cms)=   2.868 (i)
     TIME TO PEAK    (hrs)=   8.750
     RUNOFF VOLUME    (mm)=  69.257
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.607

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD    (0105) |   Area    (ha)=  46.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   1.402

     PEAK FLOW       (cms)=   2.427 (i)
     TIME TO PEAK    (hrs)=   8.833
     RUNOFF VOLUME    (mm)=  69.285
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.608

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| CALIB            |
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```
| NASHYD    (0102) |   Area    (ha)=  16.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
-------------------   U.H. Tp(hrs)=   0.39

     Unit Hyd Qpeak  (cms)=   0.727

     PEAK FLOW       (cms)=   1.162 (i)
     TIME TO PEAK    (hrs)=   8.500
     RUNOFF VOLUME    (mm)=  69.051
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.606

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0103) |   Area    (ha)=  13.00   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 1.50
-------------------   U.H. Tp(hrs)=   0.34

     Unit Hyd Qpeak  (cms)=   0.653

     PEAK FLOW       (cms)=   1.010 (i)
     TIME TO PEAK    (hrs)=   8.500
     RUNOFF VOLUME    (mm)=  68.924
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.605

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0011) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0102):    16.60   1.162     8.50    69.05
        + ID2= 2 (0103):    13.00   1.010     8.50    68.92
          ================================================
          ID = 3 (0011):    29.60   2.172     8.50    68.99

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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 FINISH
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       V    V   I    SSSSS  U   U    A    L
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O    Company

        OOO     T      T    H   H    Y    M   M   OOO                Serial


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                  *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files (x86)\Visual Otthymo 2.4\VO2\voin.dat

  Output  filename:
C:\Users\mknowles\AppData\Local\Temp\41b9ed09-dd8a-42df-b886-9a74b5ec9a22\Scenario
.out
  Summary filename:
C:\Users\mknowles\AppData\Local\Temp\41b9ed09-dd8a-42df-b886-9a74b5ec9a22\Scenario
.sum


DATE: 08/24/2020                          TIME: 09:04:45

USER:



COMMENTS: _____________________________________________________________


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  ***************************
  ** SIMULATION NUMBER:   1 **
  ***************************

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CHICAGO STORM	Ptotal= 25.04 mm

IDF curve parameters: A= 538.850
B= 6.331
C= 0.809
used in: INTENSITY = A / (t + B)^C

Duration of storm = 4.00 hrs
Storm time step = 10.00 min
Time to peak ratio = 0.33

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	1.53	1.17	13.51	2.17	3.79	3.17	1.83
0.33	1.76	1.33	56.25	2.33	3.19	3.33	1.70
0.50	2.09	1.50	17.85	2.50	2.77	3.50	1.58
0.67	2.60	1.67	9.19	2.67	2.45	3.67	1.48
0.83	3.49	1.83	6.19	2.83	2.20	3.83	1.39
1.00	5.43	2.00	4.69	3.00	2.00	4.00	1.32

CALIB NASHYD (0301)	ID= 1 DT= 5.0 min

Area (ha)= 34.48 Curve Number (CN)= 83.0
Ia (mm)= 2.40 # of Linear Res.(N)= 3.00
U.H. Tp(hrs)= 0.30

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.53	1.083	13.51	2.083	3.79	3.08	1.83
0.167	1.53	1.167	13.51	2.167	3.79	3.17	1.83
0.250	1.76	1.250	56.25	2.250	3.19	3.25	1.70
0.333	1.76	1.333	56.25	2.333	3.19	3.33	1.70
0.417	2.09	1.417	17.85	2.417	2.77	3.42	1.58
0.500	2.09	1.500	17.85	2.500	2.77	3.50	1.58
0.583	2.60	1.583	9.19	2.583	2.45	3.58	1.48
0.667	2.60	1.667	9.19	2.667	2.45	3.67	1.48
0.750	3.49	1.750	6.19	2.750	2.20	3.75	1.39
0.833	3.49	1.833	6.19	2.833	2.20	3.83	1.39
0.917	5.43	1.917	4.69	2.917	2.00	3.92	1.32
1.000	5.43	2.000	4.69	3.000	2.00	4.00	1.32

Unit Hyd Qpeak (cms)= 4.390

PEAK FLOW (cms)= 0.562 (i)
TIME TO PEAK (hrs)= 1.667
RUNOFF VOLUME (mm)= 6.863

```
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.274

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0001) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   0.4440      0.8400
                          0.0090     0.0971    |   0.4819      0.9554
                          0.0097     0.1964    |   0.4976      1.0732
                          0.0104     0.2977    |   0.5724      1.1934
                          0.0284     0.4016    |   0.6961      1.3159
                          0.1006     0.5077    |   0.8422      1.4408
                          0.1995     0.6161    |   1.0038      1.5682
                          0.3171     0.7269    |   1.1720      1.6980

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0301)     34.480      0.562      1.67       6.86
     OUTFLOW: ID= 1 (0001)     34.480      0.010      4.67       6.78

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.76
                    TIME SHIFT OF PEAK FLOW         (min)=180.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.2253

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0302) |   Area    (ha)=  18.47   Curve Number   (CN)= 83.8
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.13

     Unit Hyd Qpeak  (cms)=   5.427

     PEAK FLOW       (cms)=   0.501 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=   7.180
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.287

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD    (0303) |   Area    (ha)=   6.24   Curve Number   (CN)= 83.9
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```
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.30   # of Linear Res.(N)= 3.00
-------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   2.167

     PEAK FLOW       (cms)=   0.177 (i)
     TIME TO PEAK    (hrs)=   1.333
     RUNOFF VOLUME    (mm)=   7.101
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.284

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0012) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0302):    18.47   0.501     1.42     7.18
        + ID2= 2 (0303):     6.24   0.177     1.33     7.10
          ================================================
          ID = 3 (0012):    24.71   0.676     1.42     7.16

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| RESERVOIR (0023) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   2.2000      0.6658
                          0.0150     0.0677   |   2.7600      0.7476
                          0.0390     0.1371   |   3.4000      0.8312
                          0.0990     0.2083   |   4.1400      0.9166
                          0.2010     0.2812   |   4.9700      1.0038
                          0.7300     0.3559   |   5.9000      1.0928
                          0.9970     0.4311   |   6.9300      1.1836
                          1.3200     0.5076   |   8.0800      1.2762
                          1.7000     0.5858   |   9.3400      1.3706

                                    AREA     QPEAK     TPEAK       R.V.
                                    (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0012)     24.710      0.676      1.42       7.16
     OUTFLOW: ID= 1 (0023)     24.710      0.043      4.00       7.11

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  6.39
                    TIME SHIFT OF PEAK FLOW         (min)=155.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.1421
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--------------------
| CALIB            |
| NASHYD    (0304) |   Area    (ha)=  25.17   Curve Number   (CN)= 83.4
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.16

     Unit Hyd Qpeak  (cms)=   6.009

     PEAK FLOW       (cms)=   0.596 (i)
     TIME TO PEAK    (hrs)=   1.500
     RUNOFF VOLUME    (mm)=   7.076
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.283

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0004) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   0.1020      0.7140
                          0.0270     0.1090    |   0.1780      0.7900
                          0.0380     0.1690    |   0.2800      0.8680
                          0.0460     0.2310    |   0.4010      0.9470
                          0.0540     0.2950    |   0.5310      1.0270
                          0.0600     0.3610    |   0.5720      1.1100
                          0.0660     0.4280    |   0.5910      1.1930
                          0.0710     0.4970    |   0.6510      1.2770
                          0.0760     0.5680    |   0.7060      1.3630
                          0.0810     0.6400    |   0.7560      1.4500

                                 AREA     QPEAK     TPEAK       R.V.
                                 (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0304)     25.170      0.596      1.50       7.08
     OUTFLOW: ID= 1 (0004)     25.170      0.034      4.08       7.04

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  5.72
                    TIME SHIFT OF PEAK FLOW         (min)=155.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.1479

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0305) |   Area    (ha)=  56.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.56
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```
     Unit Hyd Qpeak  (cms)=   3.860

     PEAK FLOW       (cms)=   0.382 (i)
     TIME TO PEAK    (hrs)=   2.083
     RUNOFF VOLUME    (mm)=   4.611
     TOTAL RAINFALL   (mm)=  25.041
     RUNOFF COEFFICIENT   =   0.184

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0005) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.1160      0.9850
                          0.0080     0.0919   |   0.2480      1.0917
                          0.0170     0.1852   |   0.4170      1.2000
                          0.0230     0.2800   |   0.6160      1.3098
                          0.0270     0.3763   |   1.0920      1.5340
                          0.0310     0.4740   |   1.6550      1.7644
                          0.0350     0.5732   |   2.2920      2.0012
                          0.0380     0.6739   |   2.9960      2.2442
                          0.0410     0.7761   |   3.7610      2.4936
                          0.0430     0.8798   |   4.5820      2.7496

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0305)     56.600      0.382      2.08       4.61
     OUTFLOW: ID= 1 (0005)     56.600      0.020      5.17       4.56

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  5.35
                    TIME SHIFT OF PEAK FLOW         (min)=185.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.2393

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  ****************************
  ** SIMULATION NUMBER:   3 **
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--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1183.740
| Ptotal= 46.68 mm |                          B=   7.641
--------------------                          C=   0.838
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  =  4.00 hrs
                         Storm time step    = 10.00 min
```

Time to peak ratio = 0.33

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	2.55	1.17	26.33	2.17	6.80	3.17	3.10
0.33	2.97	1.33	106.82	2.33	5.65	3.33	2.85
0.50	3.58	1.50	35.10	2.50	4.84	3.50	2.64
0.67	4.53	1.67	17.60	2.67	4.23	3.67	2.46
0.83	6.22	1.83	11.55	2.83	3.77	3.83	2.31
1.00	10.04	2.00	8.56	3.00	3.40	4.00	2.17

CALIB			
NASHYD (0301)	Area (ha)=	34.48	Curve Number (CN)= 83.0
ID= 1 DT= 5.0 min	Ia (mm)=	2.40	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	0.30	

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.55	1.083	26.33	2.083	6.80	3.08	3.10
0.167	2.55	1.167	26.33	2.167	6.80	3.17	3.10
0.250	2.97	1.250	106.82	2.250	5.65	3.25	2.85
0.333	2.97	1.333	106.82	2.333	5.65	3.33	2.85
0.417	3.58	1.417	35.10	2.417	4.84	3.42	2.64
0.500	3.58	1.500	35.10	2.500	4.84	3.50	2.64
0.583	4.53	1.583	17.60	2.583	4.23	3.58	2.46
0.667	4.53	1.667	17.60	2.667	4.23	3.67	2.46
0.750	6.22	1.750	11.55	2.750	3.77	3.75	2.31
0.833	6.22	1.833	11.55	2.833	3.77	3.83	2.31
0.917	10.04	1.917	8.56	2.917	3.40	3.92	2.17
1.000	10.04	2.000	8.56	3.000	3.40	4.00	2.17

Unit Hyd Qpeak (cms)= 4.390

PEAK FLOW (cms)= 1.824 (i)
TIME TO PEAK (hrs)= 1.667
RUNOFF VOLUME (mm)= 20.354
TOTAL RAINFALL (mm)= 46.683
RUNOFF COEFFICIENT = 0.436

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| RESERVOIR (0001) |
| IN= 2---> OUT= 1 |
DT= 5.0 min	OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
	0.0000	0.0000	0.4440	0.8400
	0.0090	0.0971	0.4819	0.9554
	0.0097	0.1964	0.4976	1.0732
	0.0104	0.2977	0.5724	1.1934
	0.0284	0.4016	0.6961	1.3159
	0.1006	0.5077	0.8422	1.4408
	0.1995	0.6161	1.0038	1.5682
	0.3171	0.7269	1.1720	1.6980

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0301)	34.480	1.824	1.67	20.35
OUTFLOW: ID= 1 (0001)	34.480	0.167	4.00	20.17

PEAK FLOW REDUCTION [Qout/Qin](%)= 9.17
TIME SHIFT OF PEAK FLOW (min)=140.00
MAXIMUM STORAGE USED (ha.m.)= 0.5808

CALIB NASHYD (0302) ID= 1 DT= 5.0 min				
	Area	(ha)=	18.47	Curve Number (CN)= 83.8
	Ia	(mm)=	2.20	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=		0.13	

Unit Hyd Qpeak (cms)= 5.427

PEAK FLOW (cms)= 1.612 (i)
TIME TO PEAK (hrs)= 1.417
RUNOFF VOLUME (mm)= 20.934
TOTAL RAINFALL (mm)= 46.683
RUNOFF COEFFICIENT = 0.448

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

CALIB NASHYD (0303) ID= 1 DT= 5.0 min				
	Area	(ha)=	6.24	Curve Number (CN)= 83.9
	Ia	(mm)=	2.30	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=		0.11	

Unit Hyd Qpeak (cms)= 2.167

PEAK FLOW (cms)= 0.588 (i)
TIME TO PEAK (hrs)= 1.333

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     RUNOFF VOLUME    (mm)=  20.764
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.445

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0012) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0302):    18.47   1.612     1.42    20.93
        + ID2= 2 (0303):     6.24   0.588     1.33    20.76
          ================================================
          ID = 3 (0012):    24.71   2.171     1.42    20.89

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0023) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   2.2000      0.6658
                          0.0150     0.0677    |   2.7600      0.7476
                          0.0390     0.1371    |   3.4000      0.8312
                          0.0990     0.2083    |   4.1400      0.9166
                          0.2010     0.2812    |   4.9700      1.0038
                          0.7300     0.3559    |   5.9000      1.0928
                          0.9970     0.4311    |   6.9300      1.1836
                          1.3200     0.5076    |   8.0800      1.2762
                          1.7000     0.5858    |   9.3400      1.3706

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0012)     24.710      2.171      1.42      20.89
     OUTFLOW: ID= 1 (0023)     24.710      0.431      2.00      20.84

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)= 19.84
                    TIME SHIFT OF PEAK FLOW         (min)= 35.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.3140

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0304) |   Area    (ha)=  25.17   Curve Number   (CN)= 83.4
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.16
```

```
     Unit Hyd Qpeak  (cms)=   6.009

     PEAK FLOW       (cms)=   1.948 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=  20.726
     TOTAL RAINFALL   (mm)=  46.683
     RUNOFF COEFFICIENT   =   0.444

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| RESERVOIR (0004) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.1020      0.7140
                          0.0270     0.1090   |   0.1780      0.7900
                          0.0380     0.1690   |   0.2800      0.8680
                          0.0460     0.2310   |   0.4010      0.9470
                          0.0540     0.2950   |   0.5310      1.0270
                          0.0600     0.3610   |   0.5720      1.1100
                          0.0660     0.4280   |   0.5910      1.1930
                          0.0710     0.4970   |   0.6510      1.2770
                          0.0760     0.5680   |   0.7060      1.3630
                          0.0810     0.6400   |   0.7560      1.4500

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0304)     25.170      1.948      1.42      20.73
     OUTFLOW: ID= 1 (0004)     25.170      0.068      4.17      20.69

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  3.50
                    TIME SHIFT OF PEAK FLOW         (min)=165.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.4569

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0305) |   Area    (ha)=  56.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   3.860

     PEAK FLOW       (cms)=   1.549 (i)
     TIME TO PEAK    (hrs)=   2.000
     RUNOFF VOLUME    (mm)=  16.507
     TOTAL RAINFALL   (mm)=  46.683
```

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     RUNOFF COEFFICIENT   =   0.354

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0005) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   0.1160      0.9850
                          0.0080     0.0919    |   0.2480      1.0917
                          0.0170     0.1852    |   0.4170      1.2000
                          0.0230     0.2800    |   0.6160      1.3098
                          0.0270     0.3763    |   1.0920      1.5340
                          0.0310     0.4740    |   1.6550      1.7644
                          0.0350     0.5732    |   2.2920      2.0012
                          0.0380     0.6739    |   2.9960      2.2442
                          0.0410     0.7761    |   3.7610      2.4936
                          0.0430     0.8798    |   4.5820      2.7496

                                  AREA     QPEAK     TPEAK       R.V.
                                  (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0305)     56.600      1.549      2.00      16.51
     OUTFLOW: ID= 1 (0005)     56.600      0.044      5.25      16.36

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.84
                    TIME SHIFT OF PEAK FLOW         (min)=195.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.8813

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  ***************************
  ** SIMULATION NUMBER:   4 **
  ***************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1574.382
| Ptotal= 54.74 mm |                          B=   9.025
--------------------                          C=   0.860
                         used in:   INTENSITY =  A / (t + B)^C

                         Duration of storm  =  4.00 hrs
                         Storm time step    = 10.00 min
                         Time to peak ratio =  0.33

                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.17    2.75 |  1.17   32.16 |  2.17    7.84 |  3.17    3.39
                 0.33    3.24 |  1.33  124.99 |  2.33    6.43 |  3.33    3.10
                 0.50    3.95 |  1.50   43.04 |  2.50    5.45 |  3.50    2.86
```

0.67	5.08	1.67	21.33	2.67	4.73	3.67	2.65
0.83	7.12	1.83	13.73	2.83	4.17	3.83	2.47
1.00	11.86	2.00	10.01	3.00	3.74	4.00	2.32

CALIB	
NASHYD (0301)	Area (ha)= 34.48 Curve Number (CN)= 83.0
ID= 1 DT= 5.0 min	Ia (mm)= 2.40 # of Linear Res.(N)= 3.00
	U.H. Tp(hrs)= 0.30

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.75	1.083	32.16	2.083	7.84	3.08	3.39
0.167	2.75	1.167	32.16	2.167	7.84	3.17	3.39
0.250	3.24	1.250	124.99	2.250	6.43	3.25	3.10
0.333	3.24	1.333	124.99	2.333	6.43	3.33	3.10
0.417	3.95	1.417	43.04	2.417	5.45	3.42	2.86
0.500	3.95	1.500	43.04	2.500	5.45	3.50	2.86
0.583	5.08	1.583	21.33	2.583	4.73	3.58	2.65
0.667	5.08	1.667	21.33	2.667	4.73	3.67	2.65
0.750	7.12	1.750	13.73	2.750	4.17	3.75	2.47
0.833	7.12	1.833	13.73	2.833	4.17	3.83	2.47
0.917	11.86	1.917	10.01	2.917	3.74	3.92	2.32
1.000	11.86	2.000	10.01	3.000	3.74	4.00	2.32

Unit Hyd Qpeak (cms)= 4.390

PEAK FLOW (cms)= 2.420 (i)
TIME TO PEAK (hrs)= 1.667
RUNOFF VOLUME (mm)= 26.236
TOTAL RAINFALL (mm)= 54.736
RUNOFF COEFFICIENT = 0.479

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

RESERVOIR (0001)				
IN= 2---> OUT= 1				
DT= 5.0 min	OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
	0.0000	0.0000	0.4440	0.8400
	0.0090	0.0971	0.4819	0.9554
	0.0097	0.1964	0.4976	1.0732

```
                        0.0104     0.2977   |   0.5724      1.1934
                        0.0284     0.4016   |   0.6961      1.3159
                        0.1006     0.5077   |   0.8422      1.4408
                        0.1995     0.6161   |   1.0038      1.5682
                        0.3171     0.7269   |   1.1720      1.6980

                                    AREA     QPEAK     TPEAK       R.V.
                                    (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0301)        34.480      2.420      1.67       26.24
     OUTFLOW: ID= 1 (0001)        34.480      0.288      3.25       26.04

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 11.92
                  TIME SHIFT OF PEAK FLOW         (min)= 95.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.6999

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--------------------
| CALIB            |
| NASHYD    (0302) |   Area    (ha)=  18.47   Curve Number   (CN)= 83.8
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.13

     Unit Hyd Qpeak  (cms)=   5.427

     PEAK FLOW       (cms)=   2.117 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=  26.886
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.491

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0303) |   Area    (ha)=   6.24   Curve Number   (CN)= 83.9
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.30   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   2.167

     PEAK FLOW       (cms)=   0.772 (i)
     TIME TO PEAK    (hrs)=   1.333
     RUNOFF VOLUME    (mm)=  26.675
     TOTAL RAINFALL   (mm)=  54.736
     RUNOFF COEFFICIENT   =   0.487

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0012) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0302):    18.47   2.117     1.42    26.89
        + ID2= 2 (0303):     6.24   0.772     1.33    26.68
          ================================================
          ID = 3 (0012):    24.71   2.851     1.42    26.83

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0023) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   2.2000      0.6658
                          0.0150     0.0677   |   2.7600      0.7476
                          0.0390     0.1371   |   3.4000      0.8312
                          0.0990     0.2083   |   4.1400      0.9166
                          0.2010     0.2812   |   4.9700      1.0038
                          0.7300     0.3559   |   5.9000      1.0928
                          0.9970     0.4311   |   6.9300      1.1836
                          1.3200     0.5076   |   8.0800      1.2762
                          1.7000     0.5858   |   9.3400      1.3706

                                  AREA     QPEAK     TPEAK       R.V.
                                  (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0012)     24.710      2.851      1.42      26.83
     OUTFLOW: ID= 1 (0023)     24.710      0.772      1.83      26.79

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)= 27.09
                    TIME SHIFT OF PEAK FLOW         (min)= 25.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.3690

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0304) |   Area    (ha)=  25.17   Curve Number   (CN)= 83.4
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.16

     Unit Hyd Qpeak  (cms)=   6.009

     PEAK FLOW       (cms)=   2.567 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=  26.651
     TOTAL RAINFALL   (mm)=  54.736
```

RUNOFF COEFFICIENT = 0.487

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

RESERVOIR (0004)				
IN= 2---> OUT= 1				
DT= 5.0 min	OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
	0.0000	0.0000	0.1020	0.7140
	0.0270	0.1090	0.1780	0.7900
	0.0380	0.1690	0.2800	0.8680
	0.0460	0.2310	0.4010	0.9470
	0.0540	0.2950	0.5310	1.0270
	0.0600	0.3610	0.5720	1.1100
	0.0660	0.4280	0.5910	1.1930
	0.0710	0.4970	0.6510	1.2770
	0.0760	0.5680	0.7060	1.3630
	0.0810	0.6400	0.7560	1.4500

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0304)	25.170	2.567	1.42	26.65
OUTFLOW: ID= 1 (0004)	25.170	0.078	4.17	26.61

PEAK FLOW REDUCTION [Qout/Qin](%)= 3.04
TIME SHIFT OF PEAK FLOW (min)=165.00
MAXIMUM STORAGE USED (ha.m.)= 0.5959

CALIB			
NASHYD (0305)	Area (ha)= 56.60	Curve Number (CN)= 81.0	
ID= 1 DT= 5.0 min	Ia (mm)= 6.00	# of Linear Res.(N)= 3.00	
	U.H. Tp(hrs)= 0.56		

Unit Hyd Qpeak (cms)= 3.860

PEAK FLOW (cms)= 2.132 (i)
TIME TO PEAK (hrs)= 2.000
RUNOFF VOLUME (mm)= 21.927
TOTAL RAINFALL (mm)= 54.736
RUNOFF COEFFICIENT = 0.401

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

RESERVOIR (0005)

IN= 2---> OUT= 1
DT= 5.0 min

OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
0.0000	0.0000	0.1160	0.9850
0.0080	0.0919	0.2480	1.0917
0.0170	0.1852	0.4170	1.2000
0.0230	0.2800	0.6160	1.3098
0.0270	0.3763	1.0920	1.5340
0.0310	0.4740	1.6550	1.7644
0.0350	0.5732	2.2920	2.0012
0.0380	0.6739	2.9960	2.2442
0.0410	0.7761	3.7610	2.4936
0.0430	0.8798	4.5820	2.7496

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0305)	56.600	2.132	2.00	21.93
OUTFLOW: ID= 1 (0005)	56.600	0.242	4.42	21.75

PEAK FLOW REDUCTION [Qout/Qin](%)= 11.33
TIME SHIFT OF PEAK FLOW (min)=145.00
MAXIMUM STORAGE USED (ha.m.)= 1.0866

****
** SIMULATION NUMBER: 7 **
****

CHICAGO STORM
Ptotal= 79.36 mm

IDF curve parameters: A=2619.363
B= 10.500
C= 0.884
used in: INTENSITY = A / (t + B)^C

Duration of storm = 4.00 hrs
Storm time step = 10.00 min
Time to peak ratio = 0.33

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	3.61	1.17	48.51	2.17	11.13	3.17	4.52
0.33	4.31	1.33	181.39	2.33	9.00	3.33	4.11
0.50	5.33	1.50	65.14	2.50	7.54	3.50	3.76
0.67	6.99	1.67	31.96	2.67	6.47	3.67	3.47
0.83	10.05	1.83	20.19	2.83	5.66	3.83	3.22
1.00	17.30	2.00	14.45	3.00	5.03	4.00	3.01

```
| CALIB             |
| NASHYD    (0301) |   Area    (ha)=  34.48   Curve Number   (CN)= 83.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.40   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.30

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	3.61	1.083	48.51	2.083	11.13	3.08	4.52
0.167	3.61	1.167	48.51	2.167	11.13	3.17	4.52
0.250	4.31	1.250	181.39	2.250	9.00	3.25	4.11
0.333	4.31	1.333	181.39	2.333	9.00	3.33	4.11
0.417	5.33	1.417	65.14	2.417	7.54	3.42	3.76
0.500	5.33	1.500	65.14	2.500	7.54	3.50	3.76
0.583	6.99	1.583	31.96	2.583	6.47	3.58	3.47
0.667	6.99	1.667	31.96	2.667	6.47	3.67	3.47
0.750	10.05	1.750	20.19	2.750	5.66	3.75	3.22
0.833	10.05	1.833	20.19	2.833	5.66	3.83	3.22
0.917	17.30	1.917	14.45	2.917	5.03	3.92	3.01
1.000	17.30	2.000	14.45	3.000	5.03	4.00	3.01

```
     Unit Hyd Qpeak  (cms)=   4.390

     PEAK FLOW       (cms)=   4.407 (i)
     TIME TO PEAK    (hrs)=   1.583
     RUNOFF VOLUME    (mm)=  45.899
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.578

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0001) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.4440      0.8400
                          0.0090     0.0971   |   0.4819      0.9554
                          0.0097     0.1964   |   0.4976      1.0732
                          0.0104     0.2977   |   0.5724      1.1934
                          0.0284     0.4016   |   0.6961      1.3159
                          0.1006     0.5077   |   0.8422      1.4408
                          0.1995     0.6161   |   1.0038      1.5682
                          0.3171     0.7269   |   1.1720      1.6980

                                AREA     QPEAK     TPEAK       R.V.
```

```
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0301)     34.480      4.407      1.58      45.90
     OUTFLOW: ID= 1 (0001)     34.480      0.560      3.00      45.69

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 12.71
                   TIME SHIFT OF PEAK FLOW         (min)= 85.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  1.1740

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0302) |   Area    (ha)=  18.47   Curve Number   (CN)= 83.8
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.13

     Unit Hyd Qpeak  (cms)=   5.427

     PEAK FLOW       (cms)=   3.816 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=  46.683
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.588

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0303) |   Area    (ha)=   6.24   Curve Number   (CN)= 83.9
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.30   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   2.167

     PEAK FLOW       (cms)=   1.407 (i)
     TIME TO PEAK    (hrs)=   1.333
     RUNOFF VOLUME    (mm)=  46.332
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.584

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD   (0012) |
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0302):    18.47   3.816     1.42    46.68
        + ID2= 2 (0303):     6.24   1.407     1.33    46.33
```

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          ================================================
          ID = 3 (0012):    24.71   5.132     1.42    46.59

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0023) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   2.2000      0.6658
                          0.0150     0.0677    |   2.7600      0.7476
                          0.0390     0.1371    |   3.4000      0.8312
                          0.0990     0.2083    |   4.1400      0.9166
                          0.2010     0.2812    |   4.9700      1.0038
                          0.7300     0.3559    |   5.9000      1.0928
                          0.9970     0.4311    |   6.9300      1.1836
                          1.3200     0.5076    |   8.0800      1.2762
                          1.7000     0.5858    |   9.3400      1.3706

                                  AREA     QPEAK     TPEAK       R.V.
                                  (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0012)     24.710      5.132      1.42      46.59
     OUTFLOW: ID= 1 (0023)     24.710      1.701      1.75      46.55

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)= 33.14
                    TIME SHIFT OF PEAK FLOW         (min)= 20.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  0.5881

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD    (0304) |   Area    (ha)=  25.17   Curve Number   (CN)= 83.4
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.20   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.16

     Unit Hyd Qpeak  (cms)=   6.009

     PEAK FLOW       (cms)=   4.677 (i)
     TIME TO PEAK    (hrs)=   1.417
     RUNOFF VOLUME    (mm)=  46.403
     TOTAL RAINFALL   (mm)=  79.357
     RUNOFF COEFFICIENT   =   0.585

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| RESERVOIR (0004) |
```

| IN= 2---> OUT= 1 |
DT= 5.0 min	OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
	0.0000	0.0000	0.1020	0.7140
	0.0270	0.1090	0.1780	0.7900
	0.0380	0.1690	0.2800	0.8680
	0.0460	0.2310	0.4010	0.9470
	0.0540	0.2950	0.5310	1.0270
	0.0600	0.3610	0.5720	1.1100
	0.0660	0.4280	0.5910	1.1930
	0.0710	0.4970	0.6510	1.2770
	0.0760	0.5680	0.7060	1.3630
	0.0810	0.6400	0.7560	1.4500

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0304)	25.170	4.677	1.42	46.40
OUTFLOW: ID= 1 (0004)	25.170	0.363	2.83	46.36

PEAK FLOW REDUCTION [Qout/Qin](%)= 7.77
TIME SHIFT OF PEAK FLOW (min)= 85.00
MAXIMUM STORAGE USED (ha.m.)= 0.9225

| CALIB |
| NASHYD (0305) |
| ID= 1 DT= 5.0 min |

Area (ha)= 56.60 Curve Number (CN)= 81.0
Ia (mm)= 6.00 # of Linear Res.(N)= 3.00
U.H. Tp(hrs)= 0.56

Unit Hyd Qpeak (cms)= 3.860

PEAK FLOW (cms)= 4.126 (i)
TIME TO PEAK (hrs)= 2.000
RUNOFF VOLUME (mm)= 40.478
TOTAL RAINFALL (mm)= 79.357
RUNOFF COEFFICIENT = 0.510

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| RESERVOIR (0005) |
| IN= 2---> OUT= 1 |
DT= 5.0 min	OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
	0.0000	0.0000	0.1160	0.9850
	0.0080	0.0919	0.2480	1.0917
	0.0170	0.1852	0.4170	1.2000
	0.0230	0.2800	0.6160	1.3098

0.0270	0.3763	1.0920	1.5340
0.0310	0.4740	1.6550	1.7644
0.0350	0.5732	2.2920	2.0012
0.0380	0.6739	2.9960	2.2442
0.0410	0.7761	3.7610	2.4936
0.0430	0.8798	4.5820	2.7496

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0305)	56.600	4.126	2.00	40.48
OUTFLOW: ID= 1 (0005)	56.600	1.204	3.25	40.29

PEAK FLOW REDUCTION [Qout/Qin](%)= 29.18
TIME SHIFT OF PEAK FLOW (min)= 75.00
MAXIMUM STORAGE USED (ha.m.)= 1.5803

****
** SIMULATION NUMBER: 15 **
****

CHICAGO STORM
Ptotal=114.01 mm

IDF curve parameters: A=3048.220
B= 10.030
C= 0.888
used in: INTENSITY = A / (t + B)^C

Duration of storm = 24.00 hrs
Storm time step = 10.00 min
Time to peak ratio = 0.33

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	0.57	6.17	2.42	12.17	2.07	18.17	0.86
0.33	0.59	6.33	2.68	12.33	1.99	18.33	0.85
0.50	0.60	6.50	3.00	12.50	1.91	18.50	0.83
0.67	0.61	6.67	3.42	12.67	1.85	18.67	0.82
0.83	0.62	6.83	3.97	12.83	1.78	18.83	0.81
1.00	0.64	7.00	4.74	13.00	1.72	19.00	0.80
1.17	0.65	7.17	5.88	13.17	1.67	19.17	0.79
1.33	0.67	7.33	7.72	13.33	1.61	19.33	0.78
1.50	0.68	7.50	11.14	13.50	1.56	19.50	0.76
1.67	0.70	7.67	19.26	13.67	1.52	19.67	0.75
1.83	0.72	7.83	54.92	13.83	1.48	19.83	0.74
2.00	0.74	8.00	212.89	14.00	1.43	20.00	0.73
2.17	0.76	8.17	74.08	14.17	1.40	20.17	0.72
2.33	0.78	8.33	35.85	14.33	1.36	20.33	0.72
2.50	0.80	8.50	22.52	14.50	1.33	20.50	0.71
2.67	0.83	8.67	16.06	14.67	1.29	20.67	0.70
2.83	0.85	8.83	12.34	14.83	1.26	20.83	0.69

3.00	0.88	9.00	9.97	15.00	1.23	21.00	0.68
3.17	0.91	9.17	8.33	15.17	1.20	21.17	0.67
3.33	0.94	9.33	7.14	15.33	1.18	21.33	0.66
3.50	0.97	9.50	6.24	15.50	1.15	21.50	0.66
3.67	1.01	9.67	5.54	15.67	1.13	21.67	0.65
3.83	1.05	9.83	4.98	15.83	1.10	21.83	0.64
4.00	1.09	10.00	4.52	16.00	1.08	22.00	0.64
4.17	1.14	10.17	4.14	16.17	1.06	22.17	0.63
4.33	1.19	10.33	3.82	16.33	1.04	22.33	0.62
4.50	1.25	10.50	3.54	16.50	1.02	22.50	0.61
4.67	1.31	10.67	3.31	16.67	1.00	22.67	0.61
4.83	1.38	10.83	3.10	16.83	0.98	22.83	0.60
5.00	1.45	11.00	2.92	17.00	0.97	23.00	0.60
5.17	1.54	11.17	2.75	17.17	0.95	23.17	0.59
5.33	1.64	11.33	2.61	17.33	0.93	23.33	0.58
5.50	1.75	11.50	2.48	17.50	0.92	23.50	0.58
5.67	1.88	11.67	2.36	17.67	0.90	23.67	0.57
5.83	2.03	11.83	2.26	17.83	0.89	23.83	0.57
6.00	2.20	12.00	2.16	18.00	0.87	24.00	0.56

CALIB			
NASHYD (0301)	Area (ha)=	34.48	Curve Number (CN)= 83.0
ID= 1 DT= 5.0 min	Ia (mm)=	2.40	# of Linear Res.(N)= 3.00
	U.H. Tp(hrs)=	0.30	

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	0.57	6.083	2.42	12.083	2.07	18.08	0.86
0.167	0.57	6.167	2.42	12.167	2.07	18.17	0.86
0.250	0.59	6.250	2.68	12.250	1.99	18.25	0.85
0.333	0.59	6.333	2.68	12.333	1.99	18.33	0.85
0.417	0.60	6.417	3.00	12.417	1.91	18.42	0.83
0.500	0.60	6.500	3.00	12.500	1.91	18.50	0.83
0.583	0.61	6.583	3.42	12.583	1.85	18.58	0.82
0.667	0.61	6.667	3.42	12.667	1.85	18.67	0.82
0.750	0.62	6.750	3.97	12.750	1.78	18.75	0.81
0.833	0.62	6.833	3.97	12.833	1.78	18.83	0.81
0.917	0.64	6.917	4.74	12.917	1.72	18.92	0.80
1.000	0.64	7.000	4.74	13.000	1.72	19.00	0.80
1.083	0.65	7.083	5.88	13.083	1.67	19.08	0.79
1.167	0.65	7.167	5.88	13.167	1.67	19.17	0.79
1.250	0.67	7.250	7.72	13.250	1.61	19.25	0.78
1.333	0.67	7.333	7.72	13.333	1.61	19.33	0.78

1.417	0.68	7.417	11.14	13.417	1.56	19.42	0.76
1.500	0.68	7.500	11.14	13.500	1.56	19.50	0.76
1.583	0.70	7.583	19.26	13.583	1.52	19.58	0.75
1.667	0.70	7.667	19.26	13.667	1.52	19.67	0.75
1.750	0.72	7.750	54.92	13.750	1.48	19.75	0.74
1.833	0.72	7.833	54.93	13.833	1.48	19.83	0.74
1.917	0.74	7.917	212.89	13.917	1.43	19.92	0.73
2.000	0.74	8.000	212.88	14.000	1.43	20.00	0.73
2.083	0.76	8.083	74.08	14.083	1.40	20.08	0.72
2.167	0.76	8.167	74.07	14.167	1.40	20.17	0.72
2.250	0.78	8.250	35.85	14.250	1.36	20.25	0.72
2.333	0.78	8.333	35.85	14.333	1.36	20.33	0.72
2.417	0.80	8.417	22.52	14.417	1.33	20.42	0.71
2.500	0.80	8.500	22.52	14.500	1.33	20.50	0.71
2.583	0.83	8.583	16.06	14.583	1.29	20.58	0.70
2.667	0.83	8.667	16.06	14.667	1.29	20.67	0.70
2.750	0.85	8.750	12.34	14.750	1.26	20.75	0.69
2.833	0.85	8.833	12.34	14.833	1.26	20.83	0.69
2.917	0.88	8.917	9.97	14.917	1.23	20.92	0.68
3.000	0.88	9.000	9.97	15.000	1.23	21.00	0.68
3.083	0.91	9.083	8.33	15.083	1.20	21.08	0.67
3.167	0.91	9.167	8.33	15.167	1.20	21.17	0.67
3.250	0.94	9.250	7.14	15.250	1.18	21.25	0.66
3.333	0.94	9.333	7.14	15.333	1.18	21.33	0.66
3.417	0.97	9.417	6.24	15.417	1.15	21.42	0.66
3.500	0.97	9.500	6.24	15.500	1.15	21.50	0.66
3.583	1.01	9.583	5.54	15.583	1.13	21.58	0.65
3.667	1.01	9.667	5.54	15.667	1.13	21.67	0.65
3.750	1.05	9.750	4.98	15.750	1.10	21.75	0.64
3.833	1.05	9.833	4.98	15.833	1.10	21.83	0.64
3.917	1.09	9.917	4.52	15.917	1.08	21.92	0.64
4.000	1.09	10.000	4.52	16.000	1.08	22.00	0.64
4.083	1.14	10.083	4.14	16.083	1.06	22.08	0.63
4.167	1.14	10.167	4.14	16.167	1.06	22.17	0.63
4.250	1.19	10.250	3.82	16.250	1.04	22.25	0.62
4.333	1.19	10.333	3.82	16.333	1.04	22.33	0.62
4.417	1.25	10.417	3.54	16.417	1.02	22.42	0.61
4.500	1.25	10.500	3.54	16.500	1.02	22.50	0.61
4.583	1.31	10.583	3.31	16.583	1.00	22.58	0.61
4.667	1.31	10.667	3.31	16.667	1.00	22.67	0.61
4.750	1.38	10.750	3.10	16.750	0.98	22.75	0.60
4.833	1.38	10.833	3.10	16.833	0.98	22.83	0.60
4.917	1.45	10.917	2.92	16.917	0.97	22.92	0.60
5.000	1.45	11.000	2.92	17.000	0.97	23.00	0.60
5.083	1.54	11.083	2.75	17.083	0.95	23.08	0.59
5.167	1.54	11.167	2.75	17.167	0.95	23.17	0.59
5.250	1.64	11.250	2.61	17.250	0.93	23.25	0.58
5.333	1.64	11.333	2.61	17.333	0.93	23.33	0.58
5.417	1.75	11.417	2.48	17.417	0.92	23.42	0.58
5.500	1.75	11.500	2.48	17.500	0.92	23.50	0.58

5.583	1.88	11.583	2.36	17.583	0.90	23.58	0.57
5.667	1.88	11.667	2.36	17.667	0.90	23.67	0.57
5.750	2.03	11.750	2.26	17.750	0.89	23.75	0.57
5.833	2.03	11.833	2.26	17.833	0.89	23.83	0.57
5.917	2.20	11.917	2.16	17.917	0.87	23.92	0.56
6.000	2.20	12.000	2.16	18.000	0.87	24.00	0.56

Unit Hyd Qpeak (cms)= 4.390

PEAK FLOW (cms)= 6.112 (i)
TIME TO PEAK (hrs)= 8.250
RUNOFF VOLUME (mm)= 76.099
TOTAL RAINFALL (mm)= 114.013
RUNOFF COEFFICIENT = 0.667

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

RESERVOIR (0001)
IN= 2---> OUT= 1
DT= 5.0 min

OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
0.0000	0.0000	0.4440	0.8400
0.0090	0.0971	0.4819	0.9554
0.0097	0.1964	0.4976	1.0732
0.0104	0.2977	0.5724	1.1934
0.0284	0.4016	0.6961	1.3159
0.1006	0.5077	0.8422	1.4408
0.1995	0.6161	1.0038	1.5682
0.3171	0.7269	1.1720	1.6980

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0301)	34.480	6.112	8.25	76.10
OUTFLOW: ID= 1 (0001)	34.480	0.988	9.33	75.77

PEAK FLOW REDUCTION [Qout/Qin](%)= 16.16
TIME SHIFT OF PEAK FLOW (min)= 65.00
MAXIMUM STORAGE USED (ha.m.)= 1.5560

CALIB			
NASHYD (0302)	Area (ha)= 18.47	Curve Number (CN)= 83.8	
ID= 1 DT= 5.0 min	Ia (mm)= 2.20	# of Linear Res.(N)= 3.00	
	U.H. Tp(hrs)= 0.13		

Unit Hyd Qpeak (cms)= 5.427

```
     PEAK FLOW       (cms)=   5.189 (i)
     TIME TO PEAK    (hrs)=   8.083
     RUNOFF VOLUME    (mm)=  76.924
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.675

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD    (0303) |   Area    (ha)=   6.24   Curve Number   (CN)= 83.9
|ID= 1 DT= 5.0 min |   Ia      (mm)=   2.30   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.11

     Unit Hyd Qpeak  (cms)=   2.167

     PEAK FLOW       (cms)=   1.970 (i)
     TIME TO PEAK    (hrs)=   8.000
     RUNOFF VOLUME    (mm)=  76.347
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.670

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD   (0012) |
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
          ID1= 1 (0302):    18.47   5.189     8.08    76.92
        + ID2= 2 (0303):     6.24   1.970     8.00    76.35
          ================================================
          ID = 3 (0012):    24.71   7.082     8.00    76.78

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR (0023) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   2.2000      0.6658
                          0.0150     0.0677   |   2.7600      0.7476
                          0.0390     0.1371   |   3.4000      0.8312
                          0.0990     0.2083   |   4.1400      0.9166
                          0.2010     0.2812   |   4.9700      1.0038
                          0.7300     0.3559   |   5.9000      1.0928
```

0.9970	0.4311	|	6.9300	1.1836
1.3200	0.5076	|	8.0800	1.2762
1.7000	0.5858	|	9.3400	1.3706

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0012)	24.710	7.082	8.00	76.78
OUTFLOW: ID= 1 (0023)	24.710	2.866	8.33	76.73

PEAK FLOW REDUCTION [Qout/Qin](%)= 40.47
TIME SHIFT OF PEAK FLOW (min)= 20.00
MAXIMUM STORAGE USED (ha.m.)= 0.7648

CALIB					
NASHYD (0304)	Area	(ha)=	25.17	Curve Number (CN)=	83.4
ID= 1 DT= 5.0 min	Ia	(mm)=	2.20	# of Linear Res.(N)=	3.00
	U.H. Tp(hrs)=		0.16		

Unit Hyd Qpeak (cms)= 6.009

PEAK FLOW (cms)= 6.484 (i)
TIME TO PEAK (hrs)= 8.083
RUNOFF VOLUME (mm)= 76.651
TOTAL RAINFALL (mm)= 114.013
RUNOFF COEFFICIENT = 0.672

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

RESERVOIR (0004)
IN= 2---> OUT= 1
DT= 5.0 min

OUTFLOW (cms)	STORAGE (ha.m.)	|	OUTFLOW (cms)	STORAGE (ha.m.)
0.0000	0.0000	|	0.1020	0.7140
0.0270	0.1090	|	0.1780	0.7900
0.0380	0.1690	|	0.2800	0.8680
0.0460	0.2310	|	0.4010	0.9470
0.0540	0.2950	|	0.5310	1.0270
0.0600	0.3610	|	0.5720	1.1100
0.0660	0.4280	|	0.5910	1.1930
0.0710	0.4970	|	0.6510	1.2770
0.0760	0.5680	|	0.7060	1.3630
0.0810	0.6400	|	0.7560	1.4500

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (0304)	25.170	6.484	8.08	76.65

```
     OUTFLOW: ID= 1 (0004)     25.170      0.593      9.17      76.61

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.14
                    TIME SHIFT OF PEAK FLOW         (min)= 65.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  1.1954

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--------------------
| CALIB            |
| NASHYD    (0305) |   Area    (ha)=  56.60   Curve Number   (CN)= 81.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   6.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.56

     Unit Hyd Qpeak  (cms)=   3.860

     PEAK FLOW       (cms)=   5.915 (i)
     TIME TO PEAK    (hrs)=   8.583
     RUNOFF VOLUME    (mm)=  69.611
     TOTAL RAINFALL   (mm)= 114.013
     RUNOFF COEFFICIENT   =   0.611

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR (0005) |
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE    |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)    |   (cms)     (ha.m.)
                          0.0000     0.0000    |   0.1160      0.9850
                          0.0080     0.0919    |   0.2480      1.0917
                          0.0170     0.1852    |   0.4170      1.2000
                          0.0230     0.2800    |   0.6160      1.3098
                          0.0270     0.3763    |   1.0920      1.5340
                          0.0310     0.4740    |   1.6550      1.7644
                          0.0350     0.5732    |   2.2920      2.0012
                          0.0380     0.6739    |   2.9960      2.2442
                          0.0410     0.7761    |   3.7610      2.4936
                          0.0430     0.8798    |   4.5820      2.7496

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
     INFLOW : ID= 2 (0305)     56.600      5.915      8.58      69.61
     OUTFLOW: ID= 1 (0005)     56.600      2.220      9.58      69.31

                    PEAK   FLOW   REDUCTION [Qout/Qin](%)= 37.54
                    TIME SHIFT OF PEAK FLOW         (min)= 60.00
                    MAXIMUM  STORAGE   USED       (ha.m.)=  1.9763

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FINISH
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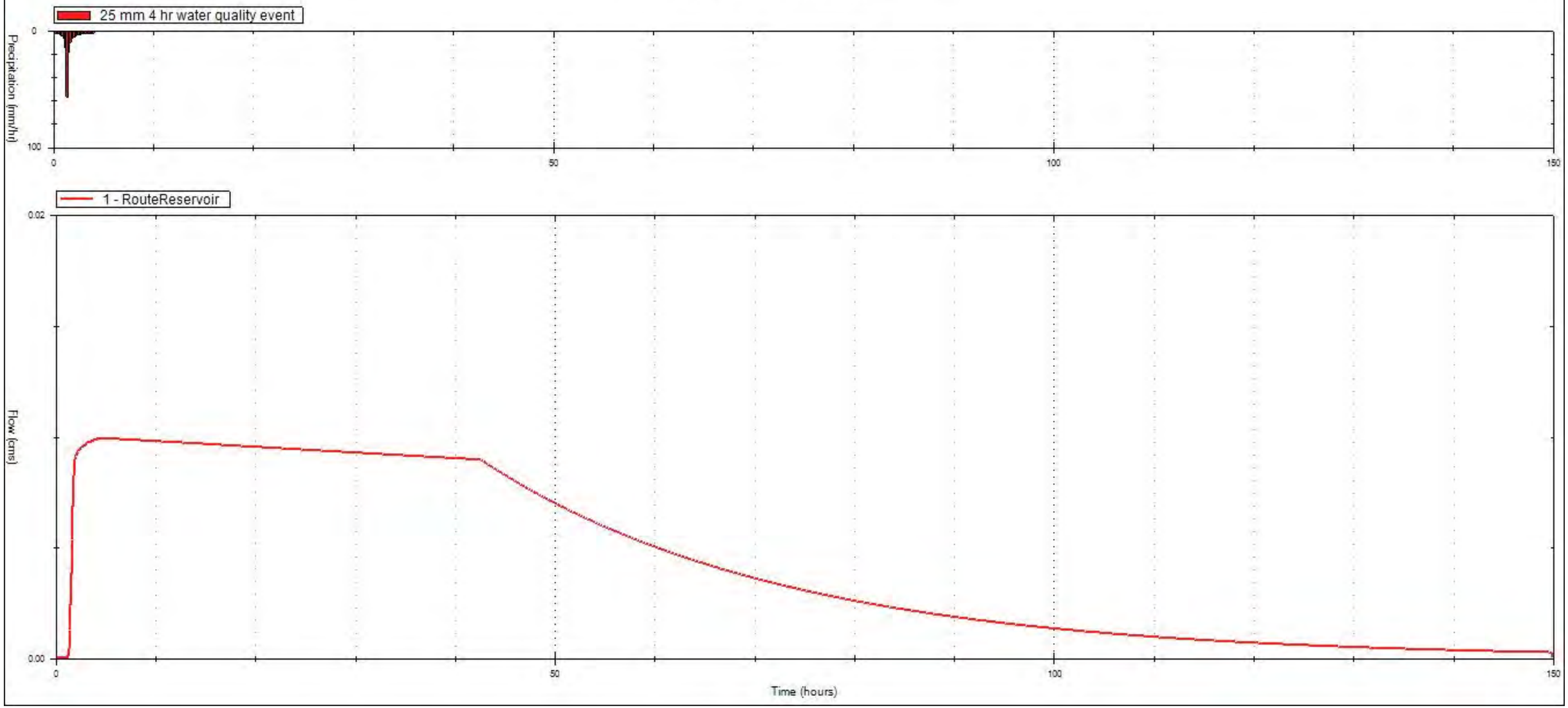
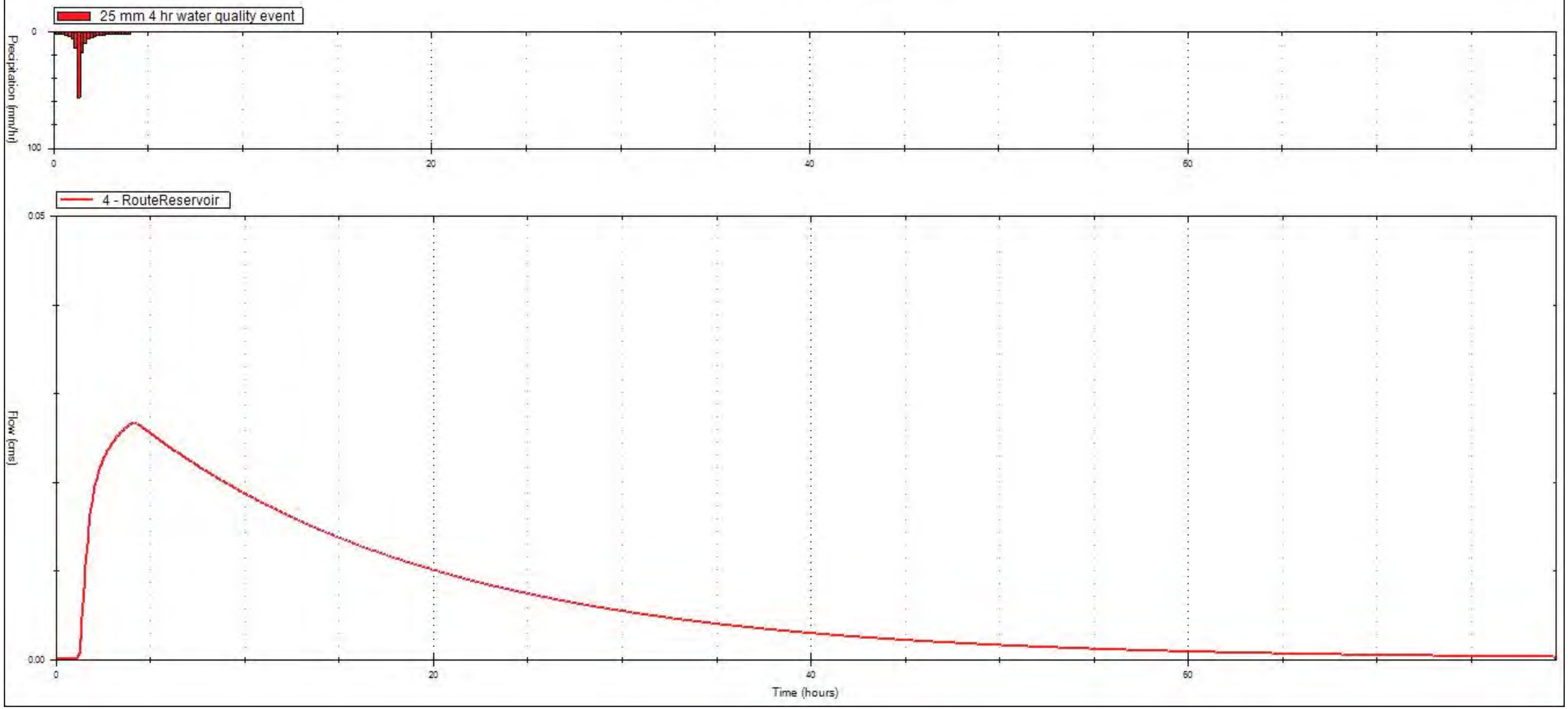
APPENDIX D

Pond Hydrographs

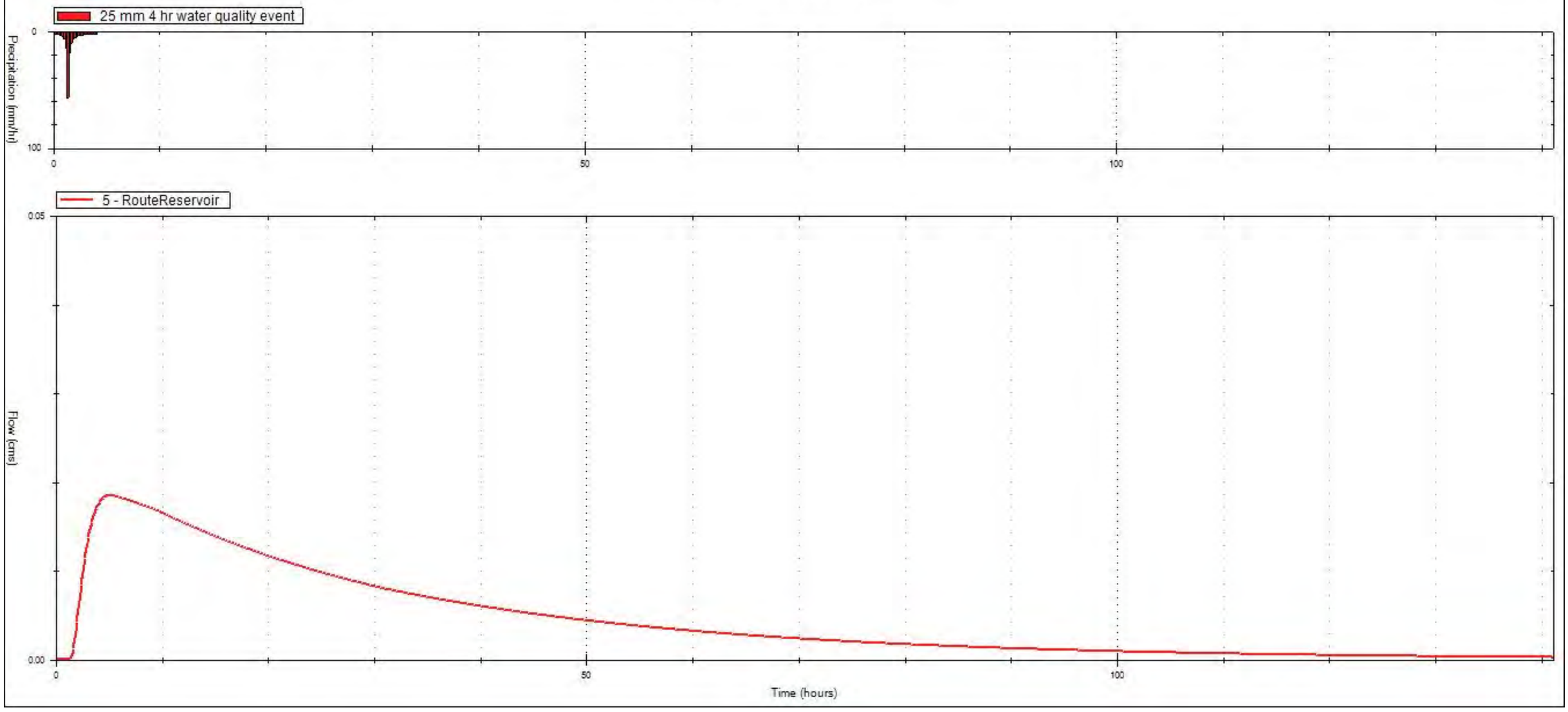
Visual OTTHYMO Hydrograph Plots
Proposed Conditions



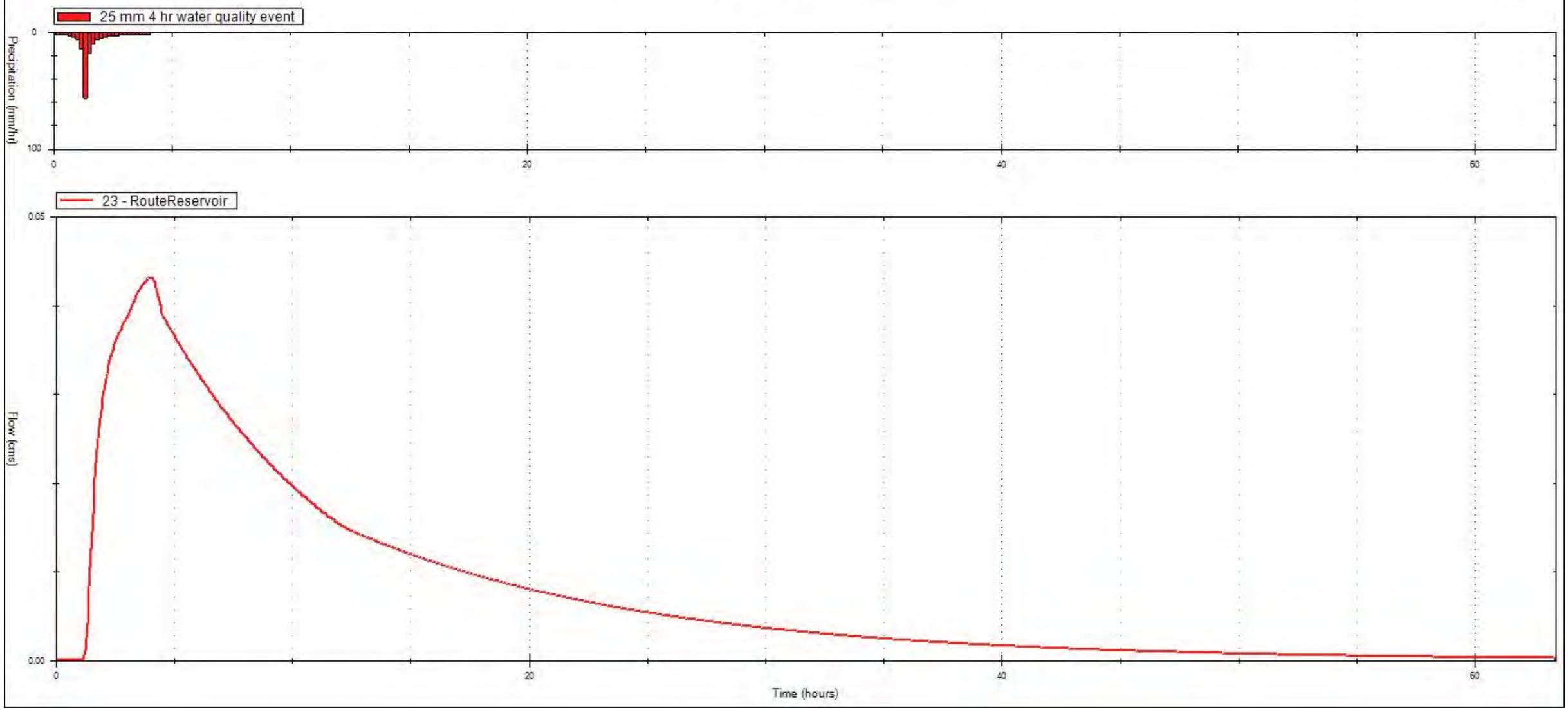
Visual OTTHYMO Hydrograph Plots
Proposed Conditions



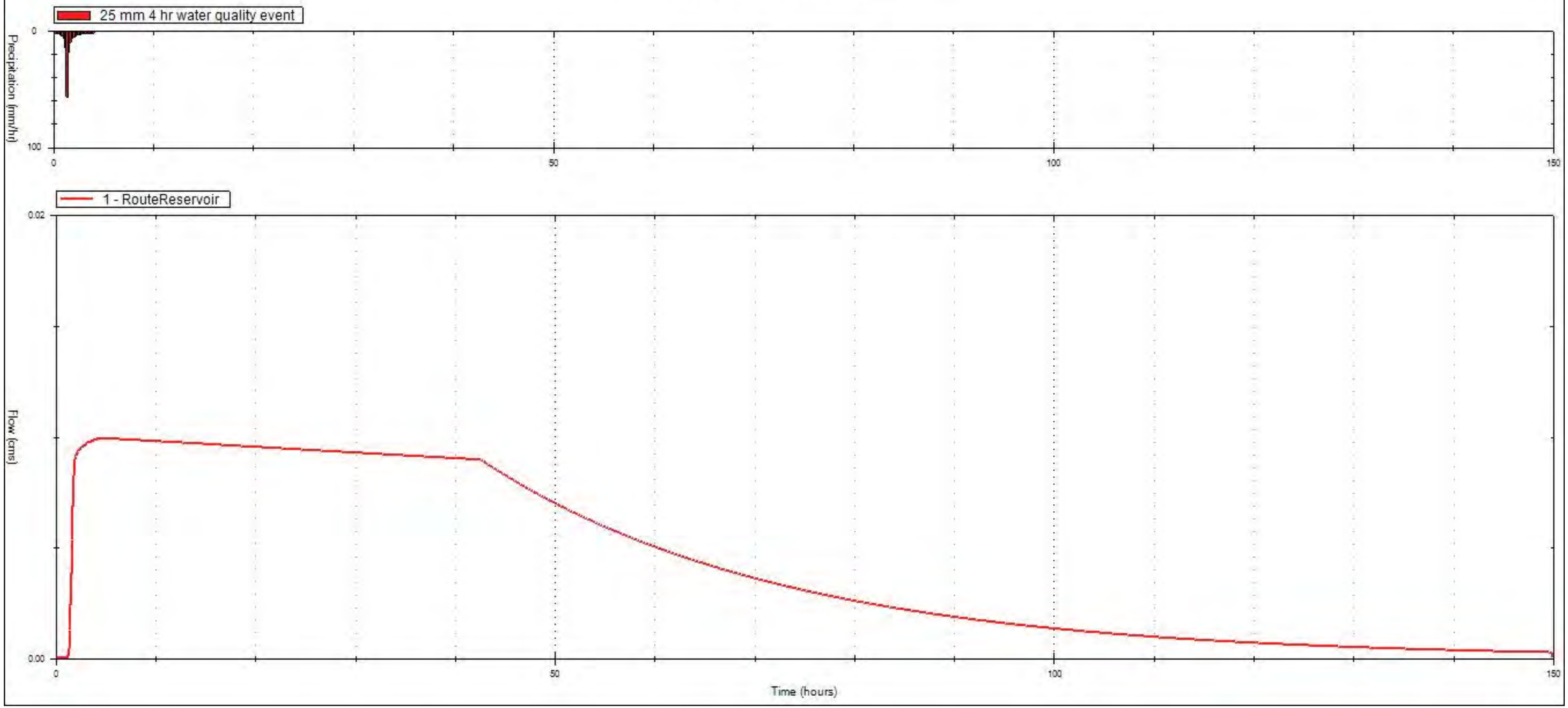
Visual OTTHYMO Hydrograph Plots
Proposed Conditions



Visual OTTHYMO Hydrograph Plots
Proposed Conditions



Visual OTTHYMO Hydrograph Plots
Proposed Conditions



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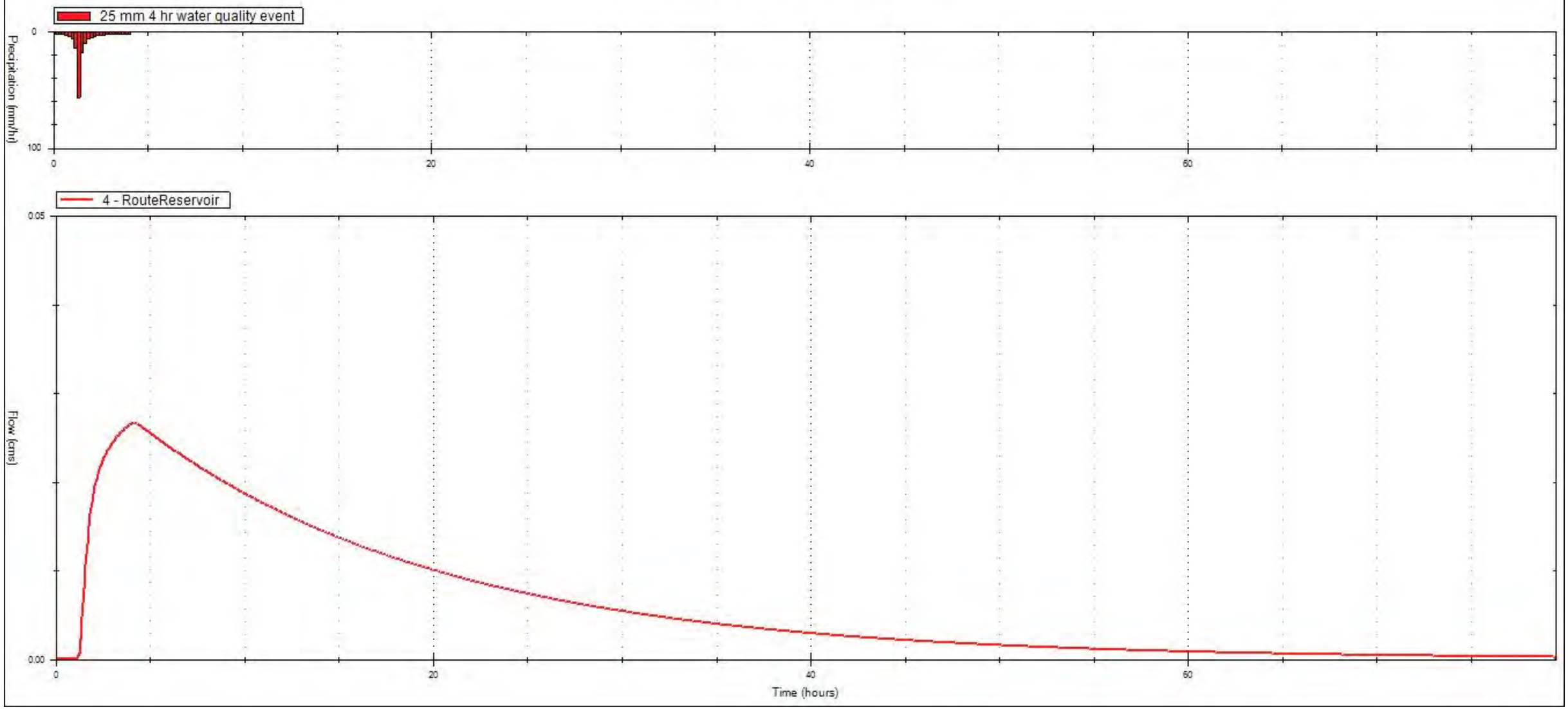

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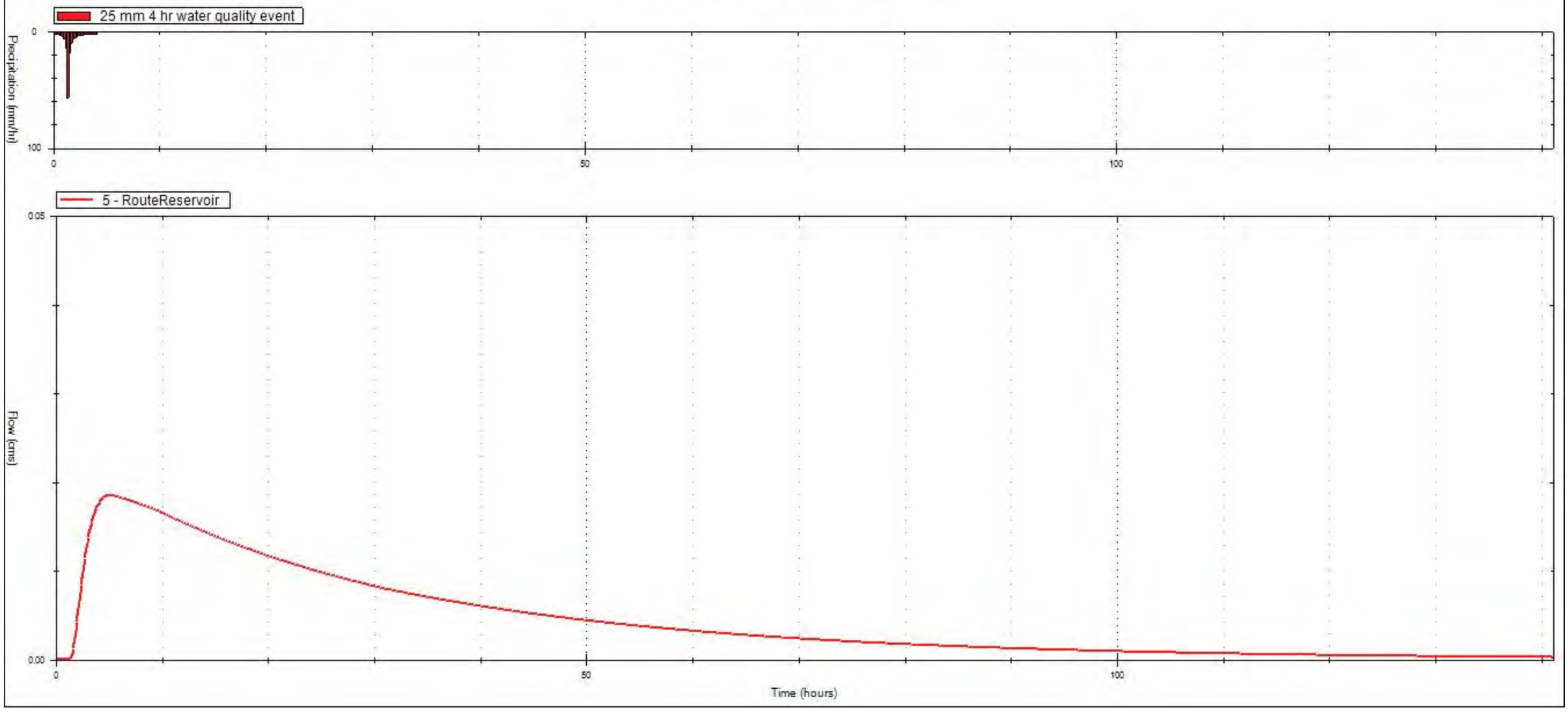

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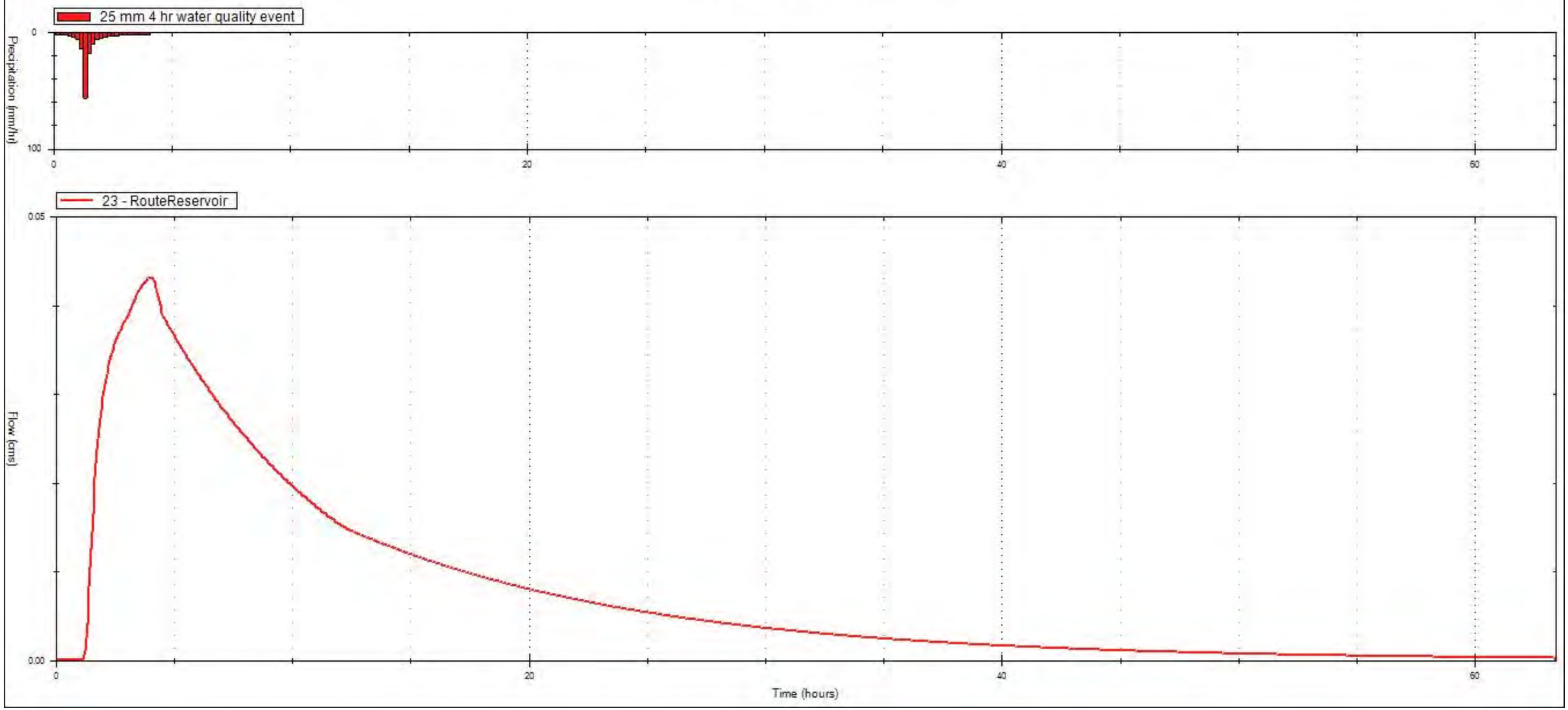

D.05 Biology (Aquatic and Terrestrial Ecosystems) Existing Conditions and Impact Assessment Report; completed by AECOM

March 2021

City of London

W12A Landfill Expansion Environmental Assessment - Biology

Existing Conditions and Impact Assessment Report

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Revision History

Rev #	Date	Revised By:	Revision Description

November 19, 2020

City of London
300 Dufferin Avenue
London, ON
N6B 1Z2

Project #
60556244

Dear Mr. Wesley Abbott:

Subject: W12A Landfill Expansion
Environmental Assessment - Biology
Existing Conditions and Impact Assessment Report

We are pleased to provide the W12A Landfill Expansion Environmental Assessment - Biology Existing Conditions and Impact Assessment Report as supporting documentation to the W12A Landfill Expansion Environmental Assessment.

This Biology Assessment Report has been prepared as a requirement of the Individual Environmental Assessment in accordance with the requirements of The London Plan and London's Environmental Management Guidelines (2007). This report is consistent with the Provincial Policy Statement (2020), the Natural Heritage Reference Manual (2010), and other relevant Provincial and Federal legislation, policies and regulations.

Sincerely,
AECOM Canada Ltd.

Gary A. Epp, M.Sc., Ph.D.
Practice Lead, Water & Natural Resources &
Senior Ecologist, Environment

JW:jw
Encl.
cc:

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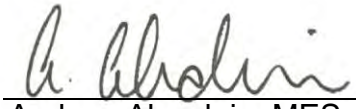

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List of Abbreviations

Abbreviation	Definition
ANSI	Areas of Natural and Scientific Interest
CC	Coefficient of Conservatism
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
COSSARO	Committee on the Status of Species at Risk in Ontario
CWS	Canadian Wildlife Services
DBH	Diameter at Breast Height
DFO	Fisheries and Oceans Canada
EA	Environmental Assessment
EASR	Environmental Assessment Study Report
EC-CWS	Environment Canada-Canadian Wildlife Service
EIS	Environmental Impact Study
ELC	Ecological Land Classification
END	Endangered
ESA	Endangered Species Act
FAC	Facultative
FACU	Facultative Upland
FACW	Facultative Wetland
FQI	Floristic Quality Index
HADD	Harmful Alteration, Disruption, or Destruction
HBI	Hilsenhoff Biotic Index
KCCA	Kettle Creek Conservation Authority
LCS	Leachate Collection System
LFG	Landfill Gas
LIO	Land Information Ontario
LSW	Locally Significant Wetland
MBCA	Migratory Bird Convention Act
MECP	Ministry of Environment, Conservation and Parks
MNHSS	Middlesex Natural Heritage Systems Study
MNRF	Ontario Ministry of Natural Resources
MRF	Materials Recovery Facility
NHIC	Natural Heritage Information Centre
NHRM	Natural Heritage Reference Manual
OBBA	Ontario Breeding Bird Atlas
OBL	Obligate Wetland
OMAFRA	Ontario Ministry of Agriculture, Food, and Rural Affairs
O. Reg	Ontario Regulation
PPS	Provincial Policy Statement
PSW	Provincially Significant Wetland
PTE	Permission to Enter
PWQO	Provincial Water Quality Objectives
SAR	Species at Risk
SARA	Species at Risk Act
SWHTG	Significant Wildlife Habitat Technical Guide
SC	Special Concern

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SOCC	Species of Conservation Concern
SWH	Significant Wildlife Habitat
SWM	Stormwater Management
TDS	Total Dissolved Solids
THR	Threatened
ToR	Terms of Reference
TSS	Total Suspended Solids
UPL	Upland
UTRCA	Upper Thames Region Conservation Authority
VES	Visual Encounter Survey
WQI	Water Quality Index
WWTP	Wastewater Treatment Plant

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1. Introduction

The City of London is proposing an expansion of the existing W12A Landfill site (the Project) located 3502 Manning Drive, part of Lots 18, 19, and 20 of Concession 6 in the former Township of Westminster, in the south end of the City of London, Ontario.

The environment is considered in broad terms to include the natural, social, cultural, and economic aspects of the environment. This document presents the *Biology* component existing conditions and impact assessment for the Environmental Assessment (EA) of the proposed W12A Landfill expansion. This work has been conducted in accordance with the requirements set out in the approved amended Terms of Reference (ToR), dated February 2019 and the work plan dated October 2019 prepared following commencement of the EA and circulated to the Ministry of Environment, Conservation, and Parks (MECP)/Ministry of Natural Resources and Forestry (MNRF)/Conservation Authority.

This report is a supporting document to the Environmental Assessment Study Report (EASR).

1.1 Background

AECOM was retained by the City of London (hereafter referred to as the City) to complete a Biology Study in support of an Individual EA for the proposed expansion of the W12A Landfill within the City of London, Ontario.

All residential residual waste (i.e., waste remaining after reduction, reuse, recycling, composting and resource recovery program) and some business residual waste from the City, is disposed of at the W12A Landfill site. At the current disposal rate, the W12A Landfill's existing approved capacity is expected to be depleted at the end of 2023. As such, the City is developing a Residual Waste Disposal Strategy to provide for the disposal of residual wastes generated from the City for the 25 year period 2024 through 2048.

A previous study (*W12A Landfill Area Plan*) looked at a number of alternatives for managing residual waste and concluded the preferred alternative was the expansion of the W12A Landfill.

The Existing Conditions and Impact Assessment Report for the W12A Landfill site has been prepared to document the existing conditions within and within the vicinity of the W12A landfill, as well as provide an impact assessment for the preferred expansion alternative from a biological perspective. The biology assessment will work to support the decision of the preferred alternative from an environmental perspective for the expansion of the W12A landfill site. This report has been prepared as a requirement of the Individual Environmental Assessment in accordance with the requirements of The London Plan and London's Environmental Management Guidelines (2007). This report is consistent with the Provincial Policy Statement (PPS; 2020), the Natural Heritage Reference Manual (NHRM; 2010), and other relevant Provincial and Federal legislation, policies and regulations.

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1.2 Study Area and Surrounding Land Use

The subject lands consist of 234 ha of land which are bounded by Scotland Drive to the north, Manning Drive to the south, White Oak Road to the west, existing agricultural land to the east and includes the existing W12A Landfill located at 3502 Manning Drive, London, Ontario. For the purpose of this report, the Study Area includes a 500 meter area of investigation surrounding the subject property in order to capture natural heritage features and adjacent lands which may be affected by the proposed expansion.

The Study Area is located within the MNRF Aylmer District and in both the Upper Thames Region Conservation Authority (UTRCA) and Kettle Creek Conservation Authority (KCCA) watersheds.

Land Use within the Study Area is comprised predominantly of the existing landfill as well as agricultural lands to the east, west and south, with an aggregate facility and natural heritage features present north of the subject lands.

A review of Map 1 of the London Plan (2017) identifies land use within the Study Area as Waste Management Resource Recovery Area, Farmland, Green Space and Environmental Review. Map 5 of the London Plan (2017) further identifies the following Natural Heritage Features within the Study Area:

- Unevaluated Vegetated Patches
- Unevaluated Wetlands
- Wetlands (i.e., Locally Significant Wetlands)
- Potential Environmentally Significant Area
- Significant Woodlands

Figure 1 illustrates the Study Area in addition to land uses including natural heritage features identified in the London Plan (2017) and MNRF's Land Information Ontario (LIO) mapping.

Maps 1 and 5 of The London Plan are provided in **Appendix A.**

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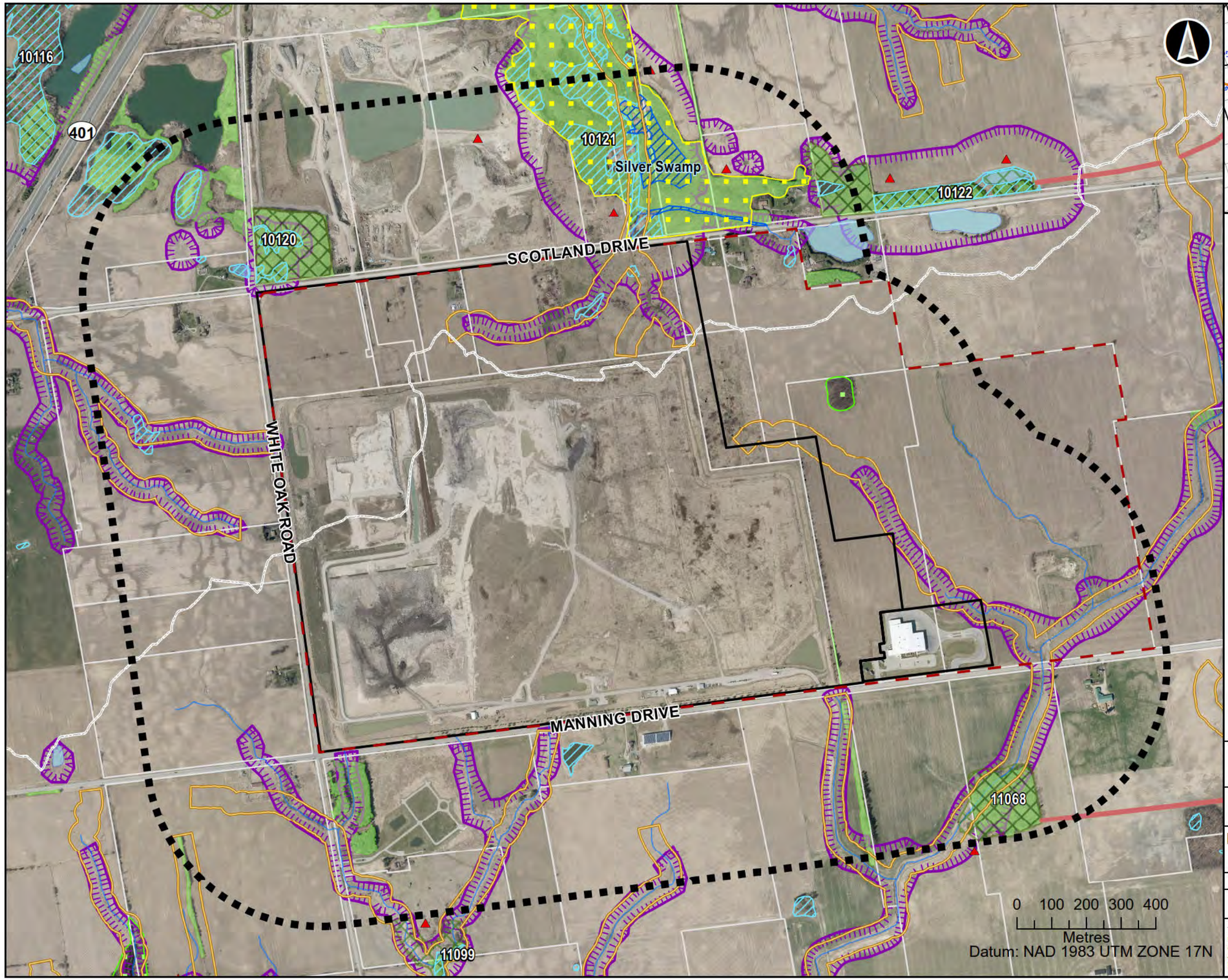

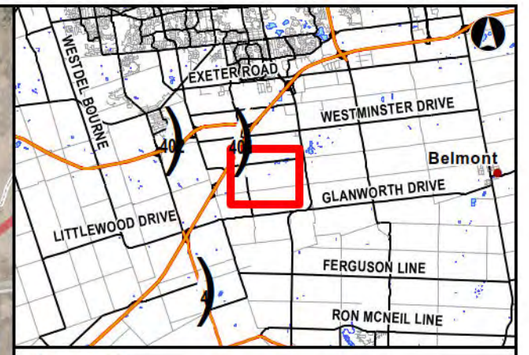

Legend

- Watercourse
- Waterbody
- Wooded Area (MNRF, 2018)
- Conservation Authority Regulation Limit
- Parcel Fabric
- Site Study
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary

Natural Heritage Features (2017)

- 11088 Vegetation Patch ID
- Potential Naturalization
- Conservation Authority
- Upland Corridor
- Unevaluated Valleyland
- Locally Significant Wetlands
- Unevaluated Wetland
- Significant Woodland
- Unevaluated Vegetation Patch
- Potential ESA

W12A Landfill Expansion
Biology Assessment

Study Area and Surrounding Land Use

November 2020	1:10,500 * when printed 11"x17"	Source: LIO, City of London
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AECOM		**Figure 1**

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1.3 Background Information Review

A review of background information was completed to identify natural heritage features, as well as flora and fauna known within or in proximity to the Study Area. The following online databases and faunal atlases were reviewed for the W12A Landfill Study Area:

- MNRF's Make-a-Map: Natural Heritage Areas application (NHIC);
- MNRF Land Information Ontario geospatial database information;
- Fisheries and Oceans Canada (DFO) Aquatic Species at Risk mapping;
- Ontario Ministry of Agriculture, Food and Rural Affairs' (OMAFRA) AgMaps online mapping tool;
- Ontario Breeding Bird Atlas (2006); and,
- Ontario Reptile and Amphibian Atlas (Ontario Nature 2015).

Additional studies and reports reviewed for relevant information include the following:

W12A Landfill Area Plan Study – Ecological Background Study and Natural Heritage Study (Earth Tech, 2005);
Natural Environment Assessment Report (BioLogic Incorporated, 2013);
Middlesex Natural Heritage Systems Study (MNHSS; Middlesex County, 2014);
The London Plan (2017);
City of London Inventory and Evaluation of Woodlands (North-South Environmental Inc., 2009);
Dingman Creek Watershed Report Card (2017); and,
Kettle Creek Watershed Report Card (2013).

1.4 Relevant Legislation, Policies and Guidelines

Table 1 below provides a summary of the relevant legislation, policies and guidelines that may apply to the proposed expansion of the W12A Landfill site.

Table 1: Applicable Legislation, Regulations and Guidelines

Level of Governance	Legislation	Policies/Regulations	Guidelines	Applicability to W12A Landfill Project
Federal	*Fisheries Act (1985)*	Fish Protection Policy Statement	N/A	On June 21, 2019, Bill C-68 (An Act to amend the Fisheries Act and other Acts in consequence) was passed into law. This included several changes to the habitat provisions and associated sections. On August 28, 2019, the habitat provisions came into force. Any proposed work with the potential to

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Level of Governance	Legislation	Policies/Regulations	Guidelines	Applicability to W12A Landfill Project
				cause Harmful Alteration, Disruption or Destruction (HADD) of fish habitat or the death of fish needs to be assessed under the Fisheries Act and determination of the need for DFO review as per the Self-Assessment process currently in place.
	Migratory Bird Convention Act (MBCA)(1994)	Regulations Respecting the Protection of Migratory Birds (1994)	N/A	The MBCA affords protection to Birds listed under Article 1 of the *Migratory Birds Convention Act.* "No person shall disturb, destroy or take a nest, egg [...] of a migratory bird." (MBCA 1994). Bird nests that are destroyed during construction and/or related activities is referred to as incidental take and is illegal except under the authority of a permit obtained by Canadian Wildlife Services (CWS).
	Species at Risk Act (SARA) (2002)	N/A	N/A	The *SARA* lists Species at Risk in Canada and affords protection to species listed as Threatened or Endangered, as well as their habitat, on federal land, which includes the internal waters of Canada.
Provincial	Planning Act (1990)	Provincial Policy Statement (2020)	Natural Heritage Reference Manual (2010) Ecoregion Criterion	The PPS, NHRM and Ecoregion Criterion Schedule outline the protection of Natural Heritage Features within Ontario including Significant Wetlands,

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Level of Governance	Legislation	Policies/Regulations	Guidelines	Applicability to W12A Landfill Project
			Schedule 7E (2015)	Woodlands and Wildlife Habitat.
	Conservation Authorities Act (1990)	Ontario Regulation 157/06 (Upper Thames River Conservation Authority) Ontario Regulation 97/04 Ontario Regulation 181/06 (Kettle Creek)	Environmental Planning Policy Manual for the Upper Thames River Conservation Authority (June 28, 2006).	The Study Area falls within lands that are regulated by the Kettle Creek Conservation Authority and the Upper Thames River Conservation Authority.
	Fish and Wildlife Conservation Act (1997)	N/A	N/A	The *Fish and Wildlife Act* affords protection to some species of birds, amphibians, reptiles and mammals in Ontario. Some bird species which are not afforded protection under the federal MBCA are afforded protection through this act (i.e., raptors).
	Endangered Species Act (ESA)(2007)	Ontario Regulation 242/08 Ontario Regulation 230/08	N/A	The *ESA* and its associated regulations list Species at Risk within Ontario and afford protection to species listed as Threatened or Endangered, as well as their habitats.
Municipal	City of London Official Plan (2006) The London Plan (2016) – currently under appeal	Environmental Policies (Section 15)	Environmental Management Guidelines (2007)	These documents outline the City's objectives and policies to guide the physical development of all lands found within the boundaries of the municipality.
	City of London Tree Protection By-law (2016)	N/A	Tree Planting and Protection Guidelines (2015)	The City of London's Tree Protection by-law outlines the requirements for a tree removal permit within the City of London.

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Level of Governance	Legislation	Policies/Regulations	Guidelines	Applicability to W12A Landfill Project
				Note: The City of London is exempt from this by-law.

1.5 Study Scope

A work plan and description of existing conditions were prepared for this study on October 17, 2017 for inclusion in the ToR. The work plan was expanded upon in May 2019 for review by the MNRF. The work plan outlined the surveys to be completed during field investigations in order to characterize existing aquatic and terrestrial ecosystems within the Study Area.

The ToR was submitted to the MECP in October 2018, with an amended version submitted in February 2019 for MECP review and approval.

Appendix B provides a copy of the Terms of Reference for the Biology Assessment component of the Environmental Assessment.

1.6 Agency Consultation

On October 16th and 17th, 2017, information requests were sent to Kathleen Buck at the Aylmer District of the MNRF and Christine Creighton at the UTRCA, respectively. On October 30th, 2018, an information request was also sent to Joe Gordon at the KCCA requesting the following information:

- Presence of Natural Areas (Environmentally Significant Areas, Provincially Significant Wetlands, Areas of Natural and Scientific Interest, Provincial Parks, Conservation Reserves and Wildlife Management Areas);
- Natural Area Reports;
- Species at Risk Occurrences and potential to occur;
- Identification of Restricted species;
- Rare Species Occurrences (locally and provincially rare);
- In-water Timing Restrictions;
- Important Commercial or Recreation Fisheries;
- Water Quantity/Quality Data;
- Groundwater Discharge Areas;
- Watercourse Names, Thermal and Flow Regimes;
- Fish Habitat Sensitivity;
- Habitat Information and Location;
- Fisheries Management Objectives/plans;
- Fish Community Records;
- Benthic Invertebrate data;
- Known fish spawning;
- Aboriginal Fisheries; and,
- Significant Wildlife Habitat or Wildlife use of the area.

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On December 15th, 2017 an email response was received from Kathleen Buck. A response was also received from Cari Ramsey of the UTRCA on October 30th, 2018 and on November 19th, 2018 a response was received from Jennifer Dow of the KCCA. Agency Correspondence can be found in **Appendix C**.

Additional information regarding natural heritage features for the Study Area is provided in the Middlesex Natural Heritage System Study prepared by the UTRCA. Relevant mapping of natural heritage features is provided in **Appendix D.**

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2. Existing Conditions

The following sections provide a description of the existing physical and natural heritage features within the Study Area.

2.1 Physical Features and Functions

2.1.1 Terrain and Drainage

The northern portion of the W12A Landfill Study Area is located within the Dingman Creek subwatershed and the southern portion within the Dodd Creek subwatershed. The northern portion of the Study Area slopes gently towards the northwest where the Silver Swamp Locally Significant Wetland (LSW) is located adjacent to the subject lands (see **Figure 2**). The southern portion of the Study Area slopes gently to the south. The highest elevation occurs within the subject lands on the landfill itself and slopes to the north and south to low points where tributaries of Dingman Creek and Dodd Creek drain to the northwest and south, respectively. The northwest flow passes through the Silver Swamp LSW and continues to Dingman Creek. Cultivated agricultural lands occupy the majority of the Study Area, with the active W12A landfill, natural features, cemetery, material recovery facility, aggregate pits and rural residences occupying the remainder.

2.1.2 Soils

According to Middlesex County soils data (Hagerty and Kingston 1992), the following soil associations are noted for the site and surrounding area:

- The Muriel Association – Drainage is moderately well to imperfect. Textures range between silt loam, loam and silty clay loam. Parent material is clayey glacial till.
- The Burford Association – Drainage is rapid to imperfect. Textures range from loam to fine sandy loam. Parent material is glaciofluvial outwash.

Most slopes are mapped as simple and less than 5% with some complex slopes greater than 5%. These conditions were also observed during site investigations. In general, soils for this region are predominantly grey-brown podzols (Chapman and Putnam 1984).

The W12A landfill has a 15-20 m underlay of low permeability clay till below which is a 2-8 m sandy layer and then a 20 m thick clayey till. The presence of these low permeable soils mean that the landfill footprint does not affect the groundwater flows or contributions to adjacent natural heritage features.

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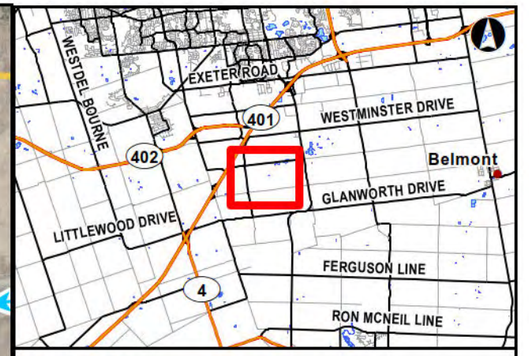

Legend

- Drainage Direction
- Watercourse
- Waterbody
- Ponds and Stormwater Management Facilties
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary
- Locally Significant Wetlands
- Subwatershed Boundary

W12A Landfill Expansion
Biology Assessment

Terrain and Drainage within the Study

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Figure 2

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2.2 Natural Heritage Features

2.2.1 Field Investigations Summary

Field investigations for the Study Area were intended to provide a comprehensive inventory of ecological features, and local flora and fauna. Field investigations completed by AECOM included: aquatic habitat assessments, vegetation community (Ecological Land Classification) delineation, snake cover board surveys, floral species inventories, anuran call surveys, breeding bird surveys, bat habitat assessments, lepidoptera/odonata surveys, a vernal pools assessment as well as a Significant Wildlife Habitat (SWH) assessment.

Benthic Invertebrate Surveys were completed by StraightUp Environmental in April 2018.

Prior to commencing field investigations, properties requiring Permission to Enter (PTE) were identified using aerial photography and property parcel mapping. AECOM prepared notification letters to individual landowners, which described the nature of the studies (i.e., ecological field investigations), the anticipated timing of each investigation and request to enter their property. A total of thirty-one (31) PTE letters were issued by the City of London for properties within the study area.

Twenty-five (25) signed PTE letters granting property access were received from landowners. Where site access was not granted, field investigations were completed roadside or within an adjacent property with granted access. **Figure 3** displays the PTE status for the Study Area.

The location of the anuran call, aquatic habitat assessment, benthic invertebrate surveys, snake coverboard and breeding bird field investigation surveys completed within the Study Area can also be found on **Figure 4**.

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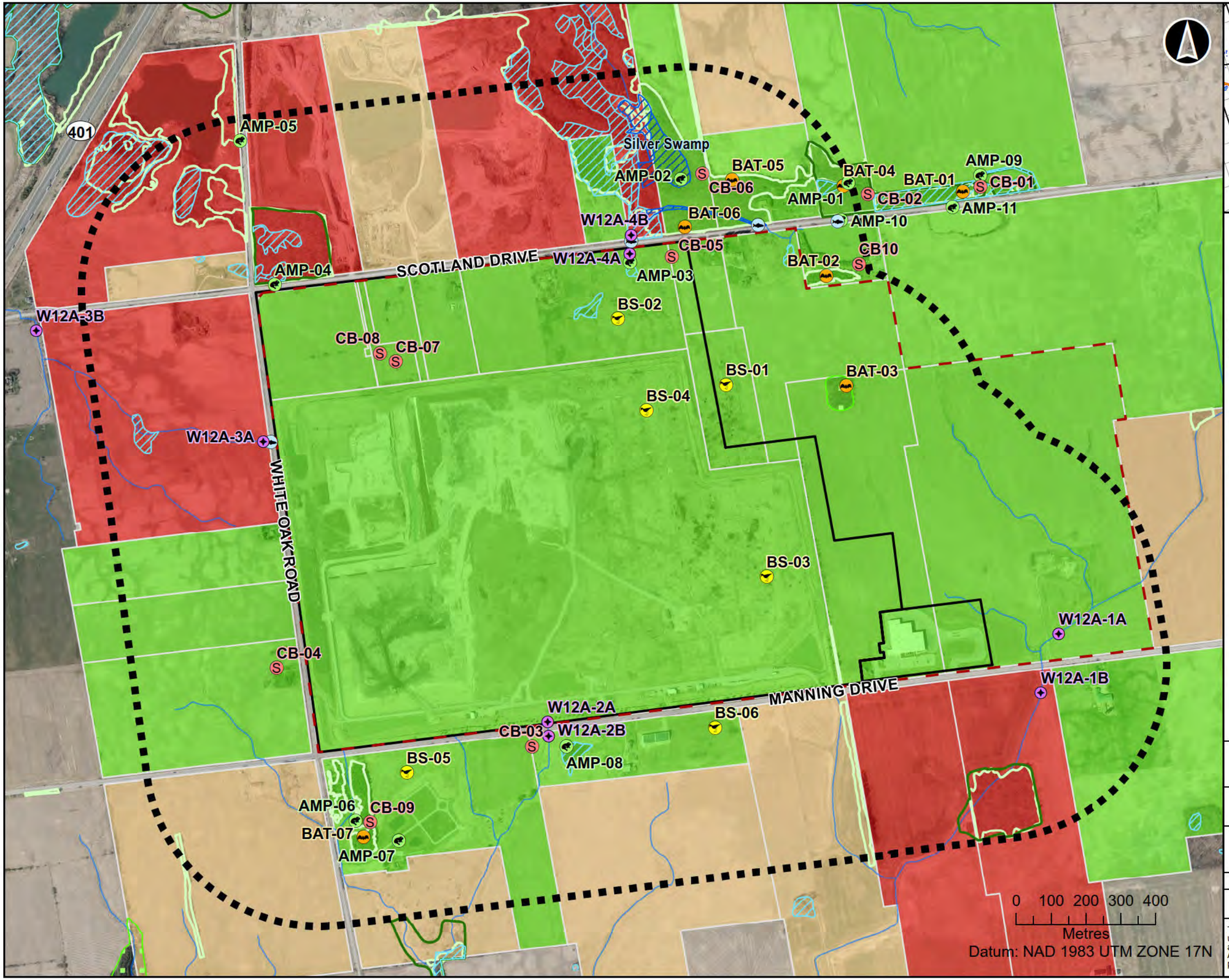

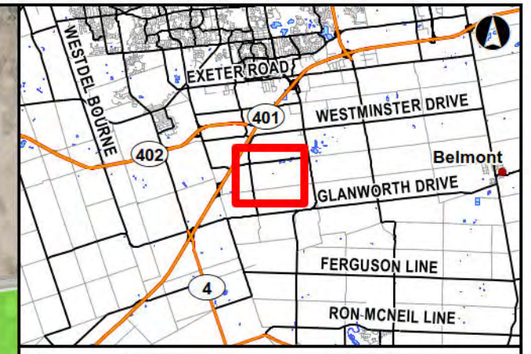

Legend

- Watercourse
- Wooded Area (MNRF, 2018)
- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary

Natural Heritage Features (2017)

- Locally Significant Wetlands
- Unevaluated Wetland
- Significant Woodland
- Unevaluated Vegetation Patch

Field Survey Location

- Snake Coverboard Location
- Anuran Call Survey Location
- Aquatic Survey Location
- Benthic Survey Location
- Breeding Bird Survey Location

Permission To Enter (PTE)

- Aquired
- PTE Not Gained
- No Access Needed

W12A Landfill Expansion
Biology Assessment

Field Investigation Locations

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Figure 3

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The remaining surveys were not confined to a specific location and are therefore not displayed on this figure. **Table 2** summarizes all field investigations completed for the Study Area.

Table 2: Field Investigations Summary

Field Investigation/Survey	Date	Investigators
Anuran Call Surveys	April 23rd 2018 May 9th 2018 May 31st 2018 July 3rd 2018	Emily McNaughton and Alex McKinstry Emily McNaughton and Jack Brand Nataliya Simonova and Andrew Minielly Emily McNaughton and Jack Brand
Aquatic Habitat Assessments	June 14th 2018	Olivia Butty and Andrew Aberdein
Benthic Invertebrate Surveys	June 5, 2018	StraightUp Environmental
Vernal Pool Surveys	April 24th 2018	Nataliya Simonova and Emily McNaughton
Bat Habitat Assessment	April 23rd 2018 April 24th 2018 May 7th 2018 May 31st 2018	Emily McNaughton and Nataliya Simonova Emily McNaughton and Nataliya Simonova Emily McNaughton and Nataliya Simonova Andrew Minielly and Nataliya Simonova
Snake Cover Board & Area Searches	April 24th, 2018 May 31st 2018 July 20th 2018 July 27th 2018 August 9th 2018	Emily McNaughton and Nataliya Simonova Andrew Minielly and Nataliya Simonova Matthew Ross and Emily McNaughton Matthew Ross and Kasey McKenzie Kasey McKenzie and Nataliya Simonova
Breeding Bird Surveys	June 7th 2018 June 18th 2018 June 28th 2018	Matthew Ross and Nataliya Simonova Matthew Ross and Edyta Ratajczyk Matthew Ross and Emily McNaughton
Lepidoptera and Odonata Surveys	July 20th 2018 July 27th 2018 August 9th 2018	Matthew Ross and Emily McNaughton Matthew Ross and Kasey McKenzie Kasey McKenzie and Nataliya Simonova
Ecological Land Classification	April 23rd 2018 May 7th 2018 May 31st 2018 June 7th 2018 July 20th 2018 July 27th 2018 August 9th 2018 October 23rd 2018	Nataliya Simonova and Emily McNaughton Nataliya Simonova and Emily McNaughton Nataliya Simonova and Andrew Minielly Nataliya Simonova and Matthew Ross Matthew Ross and Emily McNaughton Matthew Ross and Kasey McKenzie Kasey McKenzie and Nataliya Simonova Nataliya Simonova and Matthew Ross
Floral Inventory	April 23rd 2018 May 7th 2018 May 31st 2018 June 7th 2018 July 20th 2018 July 27th 2018 August 9th 2018 October 23rd 2018	Nataliya Simonova and Emily McNaughton Nataliya Simonova and Emily McNaughton Nataliya Simonova and Andrew Minielly Nataliya Simonova and Matthew Ross Matthew Ross and Emily McNaughton Matthew Ross and Kasey McKenzie Kasey McKenzie and Nataliya Simonova Nataliya Simonova and Matthew Ross
Significant Wildlife Habitat Survey	April 23rd 2018 May 7th 2018 May 31st 2018	Nataliya Simonova and Emily McNaughton Nataliya Simonova and Emily McNaughton Nataliya Simonova and Andrew Minielly

Field Investigation/Survey	Date	Investigators
	June 7th 2018 July 20th 2018 July 27th 2018 August 9th 2018 October 23rd 2018	Nataliya Simonova and Matthew Ross Matthew Ross and Emily McNaughton Matthew Ross and Kasey McKenzie Kasey McKenzie and Nataliya Simonova Nataliya Simonova and Matthew Ross

Methods for the investigations noted above are described in **Section 2.2.2** and **Section 2.2.3**.

2.2.2 Aquatic Ecosystems

The following section documents the existing aquatic conditions within the Study Area. Aquatic ecosystems are those associated with bodies of water such as, but not limited to, pools, ponds, lakes, rivers, streams and wetlands. Aquatic ecosystems provide habitat for a variety of wildlife species, some of which are rare or sensitive. Aquatic systems and the species which are known in the area were identified through background review of secondary sources and the completion of site investigations.

Background

A review of the background information as outlined in **Section 1.2** identified the following six (6) Municipal Drains within the Study Area (OMAFRA, 2019): Shore Drain, Sterling Drain, W12A Municipal Drain (all within the Dodd Creek subwatershed), Gouge Drain, Bannister-Johnson Drain, and C.B. Smith Drain (all within the Dingman Creek subwatershed). These watercourses have been altered (e.g., channelized) to facilitate drainage for surrounding land use.

The northern portion of the Study Area is located in the Dingman Creek subwatershed and within the jurisdiction of the Upper Thames River Conservation Authority (UTRCA). The Dingman Creek subwatershed is situated in the agricultural heartland of southwestern Ontario in close proximity to Lakes Huron, St. Clair and Erie. The subwatershed drains 176 square kilometres of land, and ultimately flows into the Thames River.

According to the Dingman Creek Watershed Report Card (2017), the watershed is comprised of 56% agricultural, 24% urban, 18% natural cover, 1% aggregates and 1% water. There are 46 fish species and 13 freshwater mussels recorded within the watershed, with specific gamefish including Smallmouth Bass (*Micropterus dolomieu*), Largemouth Bass (*Micropterus salmoides*), Black Crappie (*Pomoxis nigromaculatus*) Northern Pike (*Esox lucius*), and Brown Trout (*Salmo trutta*). The Report Card identifies one fish SAR, Silver Shiner (*Notropis photogenis*), under the *Endangered Species Act* (ESA) and one species at risk (SAR) mussel species, Rainbow (*Villosa iris*), under the *Species at Risk Act* (SARA) recorded within the watershed. A review of Fisheries and Oceans Canada (DFO) SAR Habitat Mapping indicates that no aquatic SAR have been identified within the Study Area. The Ontario Ministry of Natural Resources and Forestry (MNRF) and the UTRCA did not have any fish, benthic or mussel data pertaining to the Study Area beyond those data reported in the Watershed Report Card. The Natural Environment Assessment Report completed by BioLogic Incorporated (2013) for Aaroc Aggregates Limited indicates that the Bannister-Johnson Drain provides warm water habitat for small-bodied fish species.

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The southern portion of the Study Area is located within the Dodd Creek subwatershed, which is part of Kettle Creek watershed under the jurisdiction of the Kettle Creek Conservation Authority (KCCA). According to the Kettle Creek Watershed Report Card (2013), the Dodd Creek subwatershed is the largest tributary of the main branch of Kettle Creek. It is located within an area of extensive agricultural land use with few natural areas and little wetland cover, disturbed riparian zones and altered stream reaches. These characteristics result in warm water temperatures, rapid water level fluctuation, and poor surface water quality. Thirty species of fish are found in the Dodd Creek subwatershed.

Fish community data collected on August 17, 2018 from Shore Creek Drain at Manning Drive provided by the KCCA (**Appendix C**) indicated the following small-bodied fish species were present: Johnny Darter (*Etheostoma nigrum*), Creek Chub (*Semotilus atromaculatus*), Brook Stickleback (*Culaea inconstans*), and Bluntnose Minnow (*Pimephales notatus*). Sampling at another site within Shore Creek Drain at Glanworth Drive south of the Study Area on August 30th, 2018 found the above species as well as White Sucker (*Catostomus commersonii*) and Blacknose Dace (*Rhinichthys atratulus*). Other sampling sites, including benthic and water quality sites, were located well outside of the Study Area. A review of DFO SAR Habitat Mapping indicates that no aquatic SAR have been identified within the Study Area.

Field Investigation Methods

Aquatic Habitat Assessment

Potential aquatic natural heritage features were identified within the Study Area from aerial photography and agency mapping. Detailed aquatic habitat assessments were undertaken on July 14, 2018 to confirm aquatic natural heritage features and document aquatic existing conditions. The location of aquatic surveys is shown on **Figure 3** and a photographic log of aquatic features is provided on **Figure 4**. Criteria recorded during the aquatic habitat assessment were:

- Documentation of surrounding natural features and land uses (e.g., wetland, agriculture, etc.);
- Channel dimensions, substrate composition, bank stability, and channel morphology including:
    - Runs - typically deep, fast moving water with little to no turbulence of water;
    - Riffles - shallow, fast moving water typically running over rocks; riffles providing areas of high oxygenation;
    - Flats - low flowing water with a smooth un-agitated surface;
    - Pools - are described as deep pockets of slow moving water that provide ideal habitat for fish;
- Substrate composition (i.e., clay, silt, sand, gravel, cobble, rock, boulder, muck and detritus);
- Indicators of water quality; water clarity, water colour, presence and type of macrophytes and algal growth, evidence of runoff;
- Basic field parameters such as pollution sources (i.e. tile drain discharges, other piped discharges and road runoff); and,
- Suitable fish habitat parameters.

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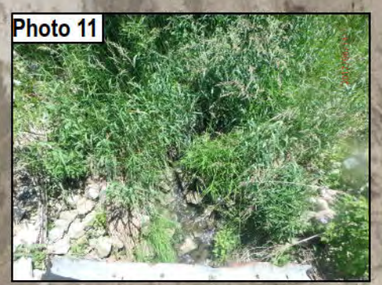

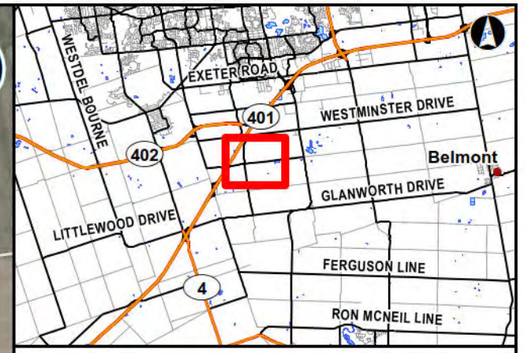

WHITE OAK ROAD

SCOTLAND DRIVE

1 2 3 4 5 6 7 8 9 10 11

0 100 200 300 400
Metres

Datum: NAD 1983 UTM ZONE 17N

Legend

- Photo Location and Direction
- Watercourse
- Waterbody
- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary

W12A Landfill Expansion
Biology Assessment

Aquatic Existing Conditions

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AECOM		**Figure 4**

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Results and Discussion

Aquatic Habitat Assessment

Bannister-Johnson Drain

The Bannister-Johnson Drain crossing at 3713 Scotland Drive was assessed upstream (south) of the roadway crossing. The watercourse consisted of an intermittent channel with sloping valley topography surrounding the watercourse. The surrounding land use upstream was meadow and an agricultural drainage pond adjacent to the watercourse with agricultural land use beyond. Evidence of overland flow (bent grasses) providing inputs from additional drainage features was present. Channel dimensions were assessed to have a mean wetted width of 0.30 m and mean wetted depth of 0.05 m. The pond dimensions were approximately 21 m wide by 21 m long. Channel banks were well vegetated and stable. Substrate was composed predominantly of muck, with lesser amounts of detritus. Dense (90%) in-stream cover was provided by aquatic vegetation, both emergent and submergent. The channel morphology consisted of pools of standing water. Low flow barriers to fish passage were present in the form of intermittently dry sections of watercourse. The watercourse may provide marginal fish habitat and potential warm water refuge habitat within the agricultural drainage pond during high flow conditions, but connectivity downstream to fish bearing watercourses could not be assessed due to PTE restrictions. However, based on watercourse characteristics and aerial photo interpretation, the Bannister-Johnson Drain and the adjacent pond have the potential to support fish and fish habitat that are regulated under the *Fisheries Act*. No important or exceptional fish habitat was observed.

Unnamed Pond (3405 Scotland Drive)

The waterbody was a permanent offline pond with rolling hill topography surrounding the waterbody. The surrounding land use was residential southeast of the pond and a plantation tree-row along the southern bank and forest beyond. The pond dimensions were approximately 90 m wide and 170 m long. Water depth at the northern bank was approximately 0.4 m, but high turbidity prevented an estimation of water depth deeper in the pond. Inputs into the pond from roadside and residential drainage were present, as was a dry overflow drain crossing under Scotland Drive at the northeast portion of the pond. Waterbody banks were stable and sparsely vegetated with low (0-30%) cover provided predominantly (90%) by willow trees and small patches (10%) by herbaceous common reed (*Phragmites australis)*. High turbidity prevented assessment of substrate composition. The pond has the capacity to support fish species, but none were observed. Furthermore, the pond is offline. Since the pond is offline, it does not have the potential to support fish and fish habitat that is regulated under the *Fisheries Act*.

Unnamed Drain (3502 Scotland Drive)

The watercourse upstream (south) of Scotland Drive was channelized for 10 m leading from a buried plastic culvert and dry at the time of assessment, while downstream (north) the channel was intermittent and increasingly defined with more standing water further downstream away from the Study Area. The topography was rolling hills with surrounding land use of forest with residential and agricultural land beyond. The watercourse received roadside drainage inputs from ditches along Scotland Drive. The bankfull depth where the watercourse became more defined downstream was approximately 0.3 m. The banks at this location were stable and had high (90-100%) canopy cover provided by trees and grasses. Substrate was composed entirely of muck within the channel. Low flow barriers to fish passage were present in the form of intermittently dry sections of watercourse. The watercourse may provide marginal fish habitat during high flow conditions, but connectivity downstream to fish bearing watercourses could not be assessed due to limited PTE. However, based on watercourse characteristics, the unnamed drain has the

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potential to support fish and fish habitat that is regulated under the *Fisheries Act*. No important or exceptional fish habitat was observed.

C.B. Smith Drain

The C.B. Smith Drain crossing under White Oaks Road from the W12A Landfill site downstream onto 4067 Scotland Drive was assessed from the road right-of-way. The watercourse was intermittent and dry at the time of assessment where it crosses White Oak Road, but flow was present further downstream where the watercourse crosses Scotland Drive outside the 500 m area of investigation. Existing conditions within the watercourse on the property at 4067 Scotland Drive could not be assessed due to limited PTE. The topography was sloping toward the watercourse and surrounding land use was agricultural downstream at 4067 Scotland Drive and landfill upstream at the W12A Landfill site. Channel dimensions at the Scotland Drive crossing were a wetted width of 0.5 m and wetted depth of 0.1 m. In-stream cover was provided by algae and aquatic vegetation. Substrate was composed of 60% muck, 30% silt, and 10% cobble. The channel morphology was 90% standing pool and 10% run. The watercourse may provide marginal fish habitat at the Scotland Drive crossing, but no fish were observed and this watercourse crossing was outside the 120 m Study Area buffer; however, incidental observations of fish within the C.B. Smith Drain at the White Oak Road crossing were recorded during benthic sampling when a precipitation event provided flow in the channel (see the StraightUp Environmental Consulting W12A Landfill Benthic Water Quality Report in **Appendix E)**. Since C.B. Smith Drain is connected to other fish bearing watercourses downstream and supports fish and fish habitat, it is regulated under the *Fisheries Act.* However, no important or exceptional fish habitat was observed.

Benthic Invertebrates

Water chemistry parameters measured during benthic invertebrate sampling documented high conductivity, total dissolved solids (TDS), and salinity in at least one sampling reach within each site (**Table 3**). The Provincial Water Quality Objectives (PWQO) do not provide specific guidance for these parameters. Additionally, the water quality measurements were taken during a precipitation event, which may have contributed to an increase in these parameters due to increased flow from surrounding roadways and agricultural runoff.

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Table 3: Water Chemistry Parameter Results

Reach	Temperature (°C)	Conductivity (µS/cm)	Total Dissolved Solids (mg/l)	Salinity (Practical Salinity Units)	Dissolved Oxygen (mg/l)	pH	Turbidity	Algae
W12A-1A	15.85	649	0.422	0.32	5.82	7.44	Turbid	Sparse
W12A-1B	14.67	**2013**	**1.311**	**1.04**	7.21	7.48	Turbid	Sparse
W12A-2A	19.14	**5791**	**3.81**	**3.23**	5.94	6.80	Turbid	Sparse
W12A-2B	16.47	**1701**	**1.106**	**0.87**	5.89	7.27	Turbid	Sparse
W12A-3A	15.33	**2156**	**1.403**	**1.11**	3.78	6.97	Turbid	Sparse
W12A-3B	15.59	469	0.304	0.23	8.73	7.51	Turbid	Sparse
W12A-4A	14.56	651	0.423	0.32	6.39	7.06	Turbid	Sparse
W12A-4B	13.57	**2048**	**1.329**	**1.05**	7.12	7.30	Turbid	Sparse

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All sites sampled had a BioMAP Water Quality Index (WQI) rating less than 14, which indicated the water quality was impaired under the protocol (**Table 4**). Similarly, the Hilsenhoff Biotic Index (HBI) rating was above 7.26 for all sites indicating very poor water quality and severe organic pollution was likely. The predominantly agricultural surrounding land use may have contributed to these indices scores and acted as a source of organic pollution. Complete benthic invertebrate sampling results are provided in the StraightUp Environmental Consulting W12A Landfill Benthic Water Quality Report in **Appendix E.**

Table 4: Benthic Water Quality Indices Results

Standard	Reach							
	W12A-1A	**W12A-1B**	**W12A-2A**	**W12A-2B**	**W12A-3A**	**W12A-3B**	**W12A-4A**	**W12A-4B**
Average BioMap WQI	1.36	2.46	1.29	1.11	1.722	3.449	2.69	3.09
Hilsenhoff Biotic Index	9.34	8.81	9.65	9.95	8.5	7.281	8.85	8.66

2.2.3 Terrestrial Ecosystems

The following sections document the existing terrestrial conditions within the Study Area. Terrestrial ecosystems are those associated with land including, but not limited to, forests, meadows, thickets and wetlands. Ecosystems and species identified within the Study Area during the background review and site investigations are described in detail below.

Vegetation Communities

Background

A review of the background information as outlined in **Section 1.3** identified the following natural heritage features within the Study Area:

- Potential Environmentally Significant Area on the north side of Scotland Drive (Vegetation Patch #10121);
- Unevaluated vegetation patches north of Scotland Drive (vegetation patches #10120 and #10122);
- Unevaluated vegetation patches south of Manning Drive (vegetation patch #11068);
- Unevaluated wetlands north of Scotland Drive;
- Locally Significant Wetland north of Scotland Drive (Silver Swamp); and,
- Significant Woodlands (vegetation patches #10120, #10122, and #11068) and an Unevaluated Vegetation Patch at the north end of the property at 3438 Manning Drive.

Field Investigation & Analysis Methods

The following section outlines the methods used to assess the vegetation communities within the Study Area.

Vegetation Community Classification & Delineation – Each vegetation community within the Study Area was assessed and classified into Ecological Land Classification (ELC) units as per the MNRF guidelines (Lee et al, 1998). This system provides a standard for comparing similar communities across Ontario and classifies vegetation communities through the completion of a multilayer (canopy, sub-canopy, ground cover) vegetation inventory. A summary of disturbance factors, community conditions, plant species list and representative photographs were also recorded for each vegetation patch. The plant list was established through the completion of a three season floral species inventory completed in the spring, summer and fall of 2018. Where wetland communities were encountered, the wetland boundary delineation was refined using the 50/50 rule (i.e., 50% of plants were comprised of wetland plant species and 50% were comprised of upland plant species) as per the MNRF Wetland Evaluation Guidelines for Southern Ontario (OMNRF 3rd Edition, 2013).

Where property access was not granted, communities were identified and delineated through a combination of roadside and aerial imagery interpretation or through the review of previously completed reports. Species lists for these communities are truncated due to limited visibility and in some instances were limited to genus.

Variables captured in the field were used to determine numerous indices which provide insight into the vegetation community quality and sensitivity. The variables included species richness (i.e., the number of species within a community), Coefficient of Conservatism (CC), Floristic Quality Index (FQI), Weediness Index and Wetness Index.

Vegetation community sensitivity was based on the Floristic Quality Assessments System for Southern Ontario (Oldham *et al.,* 1995) which included the calculation of the *Mean Coefficient of Conservatism,* the *Floristic Quality Index* and the *Weediness Index* for all wetland communities and quadrats located within the Study Area. These three parameters are intended to be used together in order to assign an ecological community sensitivity ranking based on plant species composition. The ranking is not intended to provide a measure of the overall value of a community, but rather reflects the sensitivity of the community to disturbance based on the grouping of plants present within the community. The following provides a summary of the parameters used to assess community sensitivity:

Coefficient of Conservatism

These values range from 0 (low) to 10 (high) and are based on species tolerance to disturbance and fidelity to a specific habitat. Vegetation species and community sensitivity were assessed through the application of CC values, assigned to each native species in southern Ontario (Oldham *et al*., 1995). The occurrence of species with a CC of 9 or 10 can be indicators of undisturbed habitats such as mature forests, fens or bogs. General habitat values associated with CC values are:

- **0 – 3** Species found in a wide variety of communities including disturbed sites.
- **4 – 6** Species associated with a specific community; tolerate to moderate disturbance.
- **7 – 8** Species associated with a community in an advanced successional stage, tolerant of minor disturbances.
- **9 – 10** Species with a high degree of fidelity to a narrow range of ecological parameters.

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Floristic Quality Index

The floristic quality of an area is reflected in the mean value of CC. The FQI is an indication of native vegetation quality for a vegetation community area. The following summarizes the FQI rankings:

1-19 Indicates low vegetative quality
20-35 Indicates high vegetative quality and high-quality aquatic resources
> 35 Indicate "Natural Area" quality.

FQI = mean CC x √N

Where √N is the square root of the number of native species observed.

Weediness Index

The sensitivity of natural areas can be assessed through application of the Weediness Index. The Weediness Index quantifies the potential invasiveness of non-native plants. In combination with the percentage of non-native plants, this value can be used as an indicator of disturbance. Values ranging from -1 (low) to -3 (high) have been assigned to most non-native species based on the potential impact each species can have in natural areas:

(-1) Little or no impact on natural areas (most non-native plants fall into this category)
(-2) Occasional impacts on natural areas; generally infrequent or localized
(-3) Major potential impacts on natural areas; very invasive

Wetness Index

All plants in southern Ontario have been assigned a wetland category, based on the designations developed for use by the United States Fish and Wildlife Service. Plants are designated into the following categories:

OBL (Obligate Wetland) occurs almost always in wetlands under natural conditions (estimated >99% probability)
FACW (Facultative Wetland) usually occurs in wetlands, but occasionally found in non-wetlands (estimated 67-99% probability)
FAC (Facultative) equally likely to occur in wetlands or non-wetlands (estimated 34-66% probability)
FACU (Facultative Upland) occasionally occurs in wetlands, but usually occurs in non-wetlands (estimated 1-33% probability)
UPL (Upland) occurs almost never in wetlands under natural conditions (estimated <1% probability)

Further refinement of the Facultative categories is denoted by a "+" or "-" to express exaggerated tendencies for those species. The "+" denotes a greater estimated probability occurring in wetlands than species in the general indicator category, but a lesser probability than species occurring in the next higher category. The "-" denotes a lesser estimated probability of occurring in wetlands than species in the general indicator category, but a greater probability than species occurring in the next lower general category. Each wetland

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category has been assigned a numerical value to facilitate the quantification of the wetness index.

Natural Heritage Features Mapping - A mapping exercise was completed to identify and delineate natural heritage features within the Study Area. This exercise included a compilation of digital vegetation layers obtained through the background information review as well as ELC community identification and delineation through the completion of field investigations and aerial photo interpretation as described above. Mapping of natural heritage features within the Study Area was completed following the guidelines outlined in the Middlesex Natural Heritage System Study (MNHSS; 2014). To maintain a consistent approach with that undertaken during field investigations, ELC community terminologies were used in place of the MNHSS defined Vegetation Communities. Following the MNHSS (2014), Vegetation Groups were established by grouping vegetation communities of similar structure within 20 m of each other. This assessment resulted in the identification of five (5) Vegetation Groups within the Study Area consisting of woodlands, wetlands, thickets, meadows, connected vegetation features and water features. Vegetation patches were then delineated by combining one or more abutting (< 20 m apart) vegetation groups. Using criteria outlined in Table 9 of the MNHSS (2014), an assessment was completed to identify significant natural features. **Table 5** below summarizes the criteria used to assess the natural heritage features identified within the W12A Landfill Study Area.

Table 5: Summary of Criteria for Significant Natural Heritage Features as outlined in Table 9 of the Middlesex Natural Heritage Systems Study (2014).

Criterion #	Feature Type	Description	Meets Criteria for Provincial Significance
Applied to Vegetation Groups			
1	Significant Valleylands	Any Vegetation Group within or touching a Significant Valleyland	Yes
2	Areas of Natural and Scientific Interest (ANSI)	Any vegetation Group located within or touching a provincial or regional Life Science ANSI	Yes
3	Open Watercourse	Any Vegetation Group located within 30 m of an Open Watercourse	Yes
4	Wetlands	All evaluated wetlands and all unevaluated Wetland Vegetation Groups > 0.5 ha	No; unless identified by MNRF
5	Woodland Size	Any Woodland Vegetation Group ≥ 4ha	Yes
6	Woodland Proximity	Any Woodland Vegetation Group within 100 m of a ≥ 4 ha Woodland Vegetation Group	Yes
7	Thicket Size	Any Thicket Vegetation Group ≥ 2 ha	No
8	Meadow Size	Any Meadow Vegetation Group 10 ≥ ha	No
9	Meadow Proximity	Any Meadow Vegetation Group within 100 m of a ≥ 4ha Woodland or ≥ 2 ha Thicket Vegetation Group	No
Applied to Vegetation Patches			
10	Patches with Vegetation Group that meet a Group Criteria	Any Vegetation Patch that contains a Vegetation Group that meets a group of Criteria (i.e., Meets Criteria 1-9 above)	No

Criterion #	Feature Type	Description	Meets Criteria for Provincial Significance
11	Diversity	Any Vegetation Patch that contains a diversity of Vegetation Communities, Groups or Ecosystems	No
12	Proximity	Any Vegetation Patch within 100 m of a significant Vegetation Patch (i.e., meets Criteria 10 or 11 above)	No
13	Significant Wildlife Habitat	Any Vegetation Group that contains Significant Wildlife Habitat	Yes
14	Groundwater Dependent Wetland	Any Vegetation Group that contains Groundwater Dependent Wetland	Yes
15	Bluff or Depositional Area	All Watercourse Bluff or Depositional Areas	No

Results and Discussion

Vegetation communities identified within the Study Area included meadows, forests, woodlands, thickets and wetlands. The majority of the Study Area includes agricultural lands and cultural meadow communities associated with the active W12A Landfill. Two more contiguous natural heritage features are present north of Scotland Drive and contain a mosaic of vegetation communities. Five (5) Vegetation Patches were identified within the Study Area. **Table 6** below provides a summary of the Vegetation Community Series identified within each Vegetation Patch, as well as a brief description of the natural heritage features identified within the Study Area. Vegetation communities and patches are delineated on **Figure 5**.

A list of plant species observed during field investigations can be found in **Appendix F**.

Table 6: Vegetation Communities Summary for W12A Landfill Study Area

Vegetation Patch ID	Total Area	ELC Community Series Present	ELC Delineation Method	Patch Description	Natural Heritage Features Present
P01	16.00 ha	FOD OAO CUW CUW-1 CUM SWT2 FOD5-5	Aerial photo interpretation and roadside assessment	Patch P01 is located northwest of the subject lands and includes a mosaic of natural and cultural communities identified through field investigations.	Natural heritage features identified through review of MNHSS criteria (2014) and the London Plan (2017) include the following: • Significant Woodlands • Unevaluated Wetland The Significant Woodlands have the potential to provide

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Vegetation Patch ID	Total Area	ELC Community Series Present	ELC Delineation Method	Patch Description	Natural Heritage Features Present
					suitable conditions for SWH and/or SAR habitat such as Bat Maternity Roosting Habitat and/or SAR bat habitat.
P02	166.1 ha	A CUH CUM1-1 CUP3 CUP3-2 CUT CUT1 FOD2-4 FOD5 FOD5-5 MAM2 MAM2-2 MAS OAO SAS SWD SWD2 SWT SWT2 SWT2-2 SWT2-5	Field investigations completed for W12A Landfill Expansion Environmental Assessment: Biology Assessment	Patch P02 is located south-southwest of the subject lands, within the subject lands, and north-northeast of the subject lands. The communities south and within the subject lands are primarily cultural communities, while the communities to the north of the subject lands are a mosaic of natural and cultural communities.	Natural heritage features identified through review of MNHSS criteria (2014) and the London Plan (2017) include the following: • Significant Woodlands • Locally Significant Wetlands (Silver Swamp) • Unevaluated Wetland • Valleyland • Potential Environmentally Significant Areas Additionally, SAR habitat has been confirmed within the vegetation patch for the following species: • Bobolink • Eastern Meadowlark Vegetation groups within this patch have been confirmed as SWH for the following: • Eastern Wood-pewee • Monarch • Terrestrial Crayfish

Vegetation Patch ID	Total Area	ELC Community Series Present	ELC Delineation Method	Patch Description	Natural Heritage Features Present
					• Amphibian Breeding (Woodland) Vegetation groups within this patch have also been identified as Candidate SWH for the following: • Bat Maternity Colonies (Little Brown Myotis/Northern Myotis) • Turtle Overwintering Treed communities within this patch also have the potential to provide suitable bat SAR habitat.
P03	0.694 ha	FOD2-3	Field investigations completed for W12A Landfill Expansion Environmental Assessment: Biology Assessment	Patch P03 is located in the eastern portion of the subject lands and consists entirely of a single natural deciduous forest community.	Vegetation groups within this patch have been identified as Candidate SWH for the following: • Bat Maternity Colonies (Little Brown Myotis/Northern Myotis) This community may also provide suitable bat SAR habitat.
P04	3.263 ha	CUM1-1	Field investigations completed for W12 Landfill Expansion Environmental Assessment: Biology Assessment	Patch P04 is located immediately southeast of the subject lands and consists entirely of a single cultural meadow community.	Natural heritage features identified through review of MNHSS criteria (2014) and the London Plan (2017) include the following: • Valleyland

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Vegetation Patch ID	Total Area	ELC Community Series Present	ELC Delineation Method	Patch Description	Natural Heritage Features Present
P05	0.365 ha	FOD	Field investigations completed for W12A Landfill Expansion Environmental Assessment: Biology Assessment	Patch P05 is located southeast of subject lands and south of P04. This patch consists entirely of a single natural deciduous forest community.	Natural heritage features identified through review of MNHSS criteria (2014) and the London Plan (2017) include the following: • Significant Woodlands • Valleyland The Significant Woodlands have the potential to provide suitable conditions for SWH and/or SAR habitat such as Bat Maternity Roosting Habitat and/or SAR bat habitat.

Legend:

A – Anthropogenic
CUH – Cultural Hedgerow
CUM – Cultural Meadow
CUM1-1 – Mineral Cultural Meadow Ecosite
CUP3 – Coniferous Plantation
CUP3-2 – White Pine Coniferous Plantation
CUT – Cultural Thicket
CUT1 – Mineral Cultural Thicket Ecosite
CUW – Cultural Woodland
CUW1 – Mineral Cultural Woodland Ecosite
OAO – Open Aquatic
FOD – Deciduous Forest
FOD2-3 – Dry-Fresh Hickory Deciduous Forest
FOD2-4 – Dry-Fresh Oak – Hardwood Deciduous Forest
FOD5 – Dry-Fresh Sugar Maple Deciduous Forest
FOD5-5 – Dry-Fresh Sugar Maple – Hickory Deciduous Forest
MAM2 – Mineral Meadow Marsh Ecosite
MAM2-2 – Reed Canary Grass Mineral Meadow Marsh
MAS2 – Mineral Shallow Marsh
OAO – Open Water Aquatic
SAS1 – Submerged Shallow Aquatic Ecosite
SWD – Deciduous Swamp
SWD2 – Ash Mineral Marsh Deciduous Swamp Ecosite
SWT – Thicket Swamp
SWT2 – Mineral Thicket Swamp
SWT2-2 – Willow Mineral Thicket Swamp Type
SWT2-5 – Red Osier Dogwood Mineral Thicket Swamp

A full description of ELC communities identified within the Study Area can be found in **Appendix G**.

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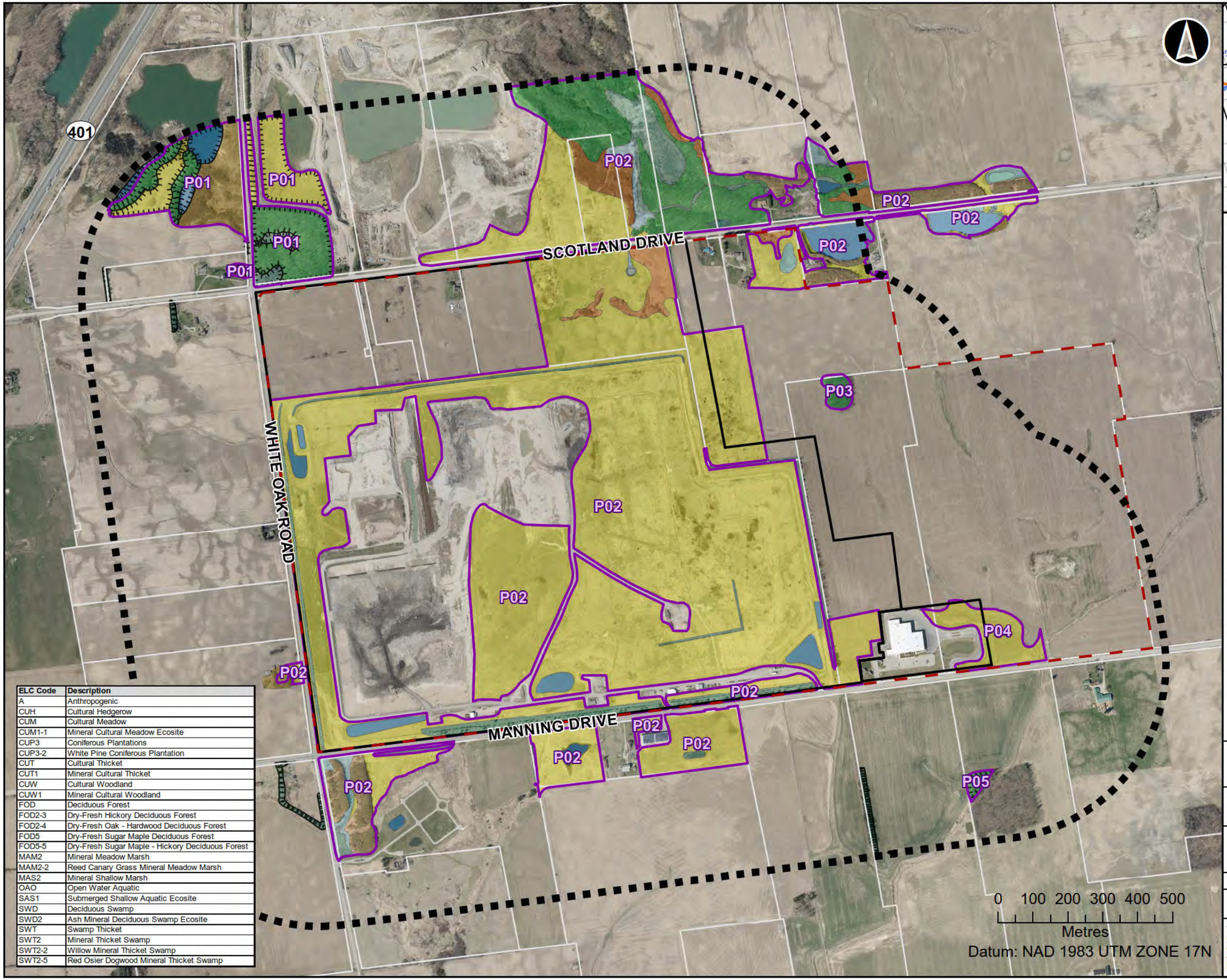

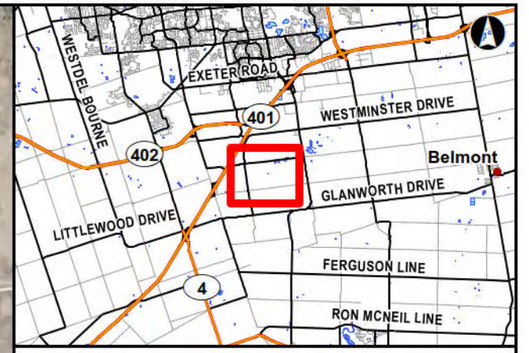

Legend

- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary
- Vegetation Patch

Vegetation Community

- CUH
- CUM
- CUP
- CUT
- CUW
- FOD
- MAM
- MAS
- OAO
- SAS
- SWD
- SWT

Aerial Photo Interpretation / Roadside Assessment

ELC Code	Description
A	Anthropogenic
CUH	Cultural Hedgerow
CUM	Cultural Meadow
CUM1-1	Mineral Cultural Meadow Ecosite
CUP3	Coniferous Plantations
CUP3-2	White Pine Coniferous Plantation
CUT	Cultural Thicket
CUT1	Mineral Cultural Thicket
CUW	Cultural Woodland
CUW1	Mineral Cultural Woodland
FOD	Deciduous Forest
FOD2-3	Dry-Fresh Hickory Deciduous Forest
FOD2-4	Dry-Fresh Oak - Hardwood Deciduous Forest
FOD5	Dry-Fresh Sugar Maple Deciduous Forest
FOD5-5	Dry-Fresh Sugar Maple - Hickory Deciduous Forest
MAM2	Mineral Meadow Marsh
MAM2-2	Reed Canary Grass Mineral Meadow Marsh
MAS2	Mineral Shallow Marsh
OAO	Open Water Aquatic
SAS1	Submerged Shallow Aquatic Ecosite
SWD	Deciduous Swamp
SWD2	Ash Mineral Deciduous Swamp Ecosite
SWT	Swamp Thicket
SWT2	Mineral Thicket Swamp
SWT2-2	Willow Mineral Thicket Swamp
SWT2-5	Red Osier Dogwood Mineral Thicket Swamp

0 100 200 300 400 500

Metres

Datum: NAD 1983 UTM ZONE 17N

W12A Landfill Expansion
Biology Assessment

ELC Vegetation Communities and Vegetation Patches

August 2020	1:300,000 * when printed 11"x17"	Source: LIO, City of London

P#: 60556244

AECOM

Figure 5

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Bat Habitat Assessment

Background

During the background review and agency consultation as outlined in **Section 1.3** and **Section 1.6**, correspondence with the MNRF identified the potential for four (4) species of SAR bats to occur within the Study Area: Eastern Small-footed (*Myotis leibii*), Little Brown Myotis (*Myotis lucifugus*), Tri-coloured Bat (*Perimyotis subflavus*) and Northern Myotis (*Myotis septentrionalis*) (see **Appendix C**). These species are listed as Endangered provincially and are therefore afforded protection under the ESA. As the Study Area contains treed forest and swamp communities, a bat habitat assessment was completed to determine the presence of maternity roosting habitat for SAR and for SWH (Bat Maternity Roosting Habitat).

Field Investigation Methods

Trees within the Study Area were assessed for candidate bat habitat according to the MNRF guidelines outlined in the Survey Protocol for Species at Risk Bats within Treed Habitats (OMNRF, 2017). Surveys included area searches within suitable ecosites <10 ha in size (properties at 3298 Scotland Drive, 3405 Scotland Drive, 6100 White Oak Road) and plot surveys in those ecosites >10 ha (properties at 3502 Scotland Drive and 3483 and 3583 Westminster Drive). The surveys were conducted during the leaf-off period to assess trees with a diameter at breast height (DBH) >10 cm for cavities, cracks, loose bark, or knot holes in addition to leaf clusters that provide maternity roosting habitat for SAR bats. Dates of the bat habitat assessments are provided in **Section 2.2.1**. The location of the surveys is presented on **Figure 3**.

Results and Discussion

Eighty-nine (89) trees were observed that showed suitable characteristics for Little Brown Myotis/ Northern Myotis bats. Twenty-seven (27) trees were identified within the FOD2-3 at 3438 Manning Drive, twelve (12) within the FOD5-5 at 3502 Scotland Drive, twenty-eight (28) within the FOD5-5 at 3483 Westminster Drive, eight (8) within the FOD5-5 at 3583 Westminster Drive, three (3) within the CUP3 at 3298 Scotland Drive, and eleven (11) within the CUP3 at 6100 White Oak Road. No suitable leaf clusters were observed. **Appendix H** provides the results of the bat habitat assessment.

According to the Survey Protocol for Species at Risk Bats within Treed Habitats (OMNRF, 2017), there is no minimum threshold for snags/ha to be considered suitable maternity roost habitat, although ELC ecosites with 10 or more snags/ha may be considered high quality habitat. Based upon the results of the bat habitat assessment, candidate habitat for SAR bats and corresponding SWH may be present within the Study Area. Further acoustic monitoring would be required to confirm the presence of SAR bats and/or SWH for Bat Maternity Roosting Habitat in the identified candidate habitat within the Study Area. If SAR bats are recorded during acoustic monitoring and impacts to these features were anticipated, this data can be used to calculate snag densities to determine the quality of bat habitat present, which would then be used in consultation with MECP to determine requirements under the ESA.

Since the identified bat cavity trees are outside of the Subject Lands, there will be no loss of bat cavity trees from landfill expansion within the subject lands.

Additional details on SAR bats and SWH for bats can be found in **Section 2.3.4** and **Section 2.3.5**, respectively.

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Breeding Birds

Background

A review of background information outlined in **Section 1.3** identified ninety-one (91) species of birds with various levels of breeding evidence within the 10 by 10 km square (17MH84) that encompasses the Study Area (BSC *et al.*, 2016). Of these species, four (4) were listed as provincially Threatened and four (4) were listed as Special Concern under the Species at Risk in Ontario List (O.Reg. 230/08) (see **Table 7**). **Appendix I** presents a list of Breeding Birds within the Study Area. Breeding bird surveys were completed to determine the presence of SAR and Species of Conservation Concern (SOCC) birds within the Study Area.

Table 7: Ontario Breeding Bird Atlas (OBBA) Significant Species Records Within or in the Vicinity of the Study Area

Common Name	Scientific Name	S-Rank	*Endangered Species Act* Status	Breeding Evidence
Red-headed Woodpecker	*Melanerpes erythrocephalus*	S4B	SC	Confirmed
Bank Swallow	*Riparia riparia*	S4B	THR	Confirmed
Barn Swallow	*Hirundo rustica*	S4B	THR	Confirmed
Bobolink	*Dolichonyx oryzivorus*	S4B	THR	Confirmed
Eastern Meadowlark	*Sturnella magna*	S4B	THR	Confirmed
Eastern Wood-pewee	*Contopus virens*	S4B	SC	Probable
Golden-winged Warbler	*Vermivora chrysoptera*	S4B	SC	Possible
Wood Thrush	*Hylocichla mustelina*	S4B	SC	Confirmed

Legend:

END – Endangered
THR – Threatened
SC – Special Concern
S4B – Apparently Secure Breeding Population

Field Investigation Methods

Due to the size and diversity of habitats within southern Ontario, several bird monitoring protocols have been developed that focus on targeting groups of birds including the Forest Bird Monitoring Program developed by the Environment Canada - Canadian Wildlife Service (EC-CWS 2009) and the Marsh Monitoring Program (Bird Studies Canada et al. 2009). Similarly, the Ontario Breeding Bird Atlas (OBBA) *Guide for Participants* (2001) provides additional methods for conducting breeding bird surveys throughout Ontario. These protocols outline the methods to be conducted in order to obtain representative and unbiased data. The methods listed below outline proper site selection, timing including time of day and time of year to conduct the surveys and suitable weather conditions (EC-CWS 2009, OBBA, 2001).

Under the Canadian Wildlife Service Forest Bird Monitoring Program, survey stations should typically occur within an individual community that is characterized by uniform community structure. Within these communities, stations should be located at least 250 m apart and 100 m from the edge (EC-CWS, 2009). Survey stations were situated in natural areas that occur within the Study Area boundary. These natural areas were comprised predominantly of cultural meadow communities. Each station was located at least 200 m apart to maintain a degree of separation and reduce the chances of double counting individual birds. Six (6) stations were established within natural features located in the subject lands. Locations of breeding bird survey stations are shown on **Figure 3**.

Due to the presence of Bobolink and Eastern Meadowlark, as determined during the first visit conducted on June 7th, 2018, three point-count surveys were completed at each station during the breeding bird period between May 24 and July 10 in order to confirm breeding evidence for these species (OBBA 2001, OMNRF 2012). The separate surveys are recommended as they typically provide data that more accurately reflects the number of species and birds utilizing the habitat at each station (EC-CWS 2009). Surveys were completed between 5:00 am and 10:00 am under appropriate weather conditions (i.e., no precipitation, calm to light wind) (EC-CWS 2009). Each point-count consisted of a ten (10) minute survey during which time, species, breeding evidence and individual bird movement within a 100 m radius was recorded. Species heard outside of the 100 m radius or that were observed outside of their breeding habitat within the 100 m radius (i.e., flyovers) were recorded separately.

Results and Discussion

Forty-three (43) bird species, included in **Table 8**, were identified within the subject lands during field investigations. Of these species, four (4) were recorded as 'confirmed', eleven (11) as 'probable' and eighteen (18) as 'possible' breeders within the subject lands. Ten (10) species were observed but were not exhibiting breeding evidence. Additionally, five (5) provincially listed species under the ESA were observed within the subject lands, including four (4) Threatened species - Bank Swallow (*Riparia riparia*), Barn Swallow (*Hirundo rustica*), Bobolink (*Dolichonyx oryzivorus*), and Eastern Meadowlark (*Sturnella magna*), and one (1) Special Concern species - Eastern Wood-pewee (*Contopus virens*).

Table 8: Summary of Breeding Bird Evidence recorded within the W12A Landfill Study Area

Common Name	Scientific Name	AECOM Observations (see Figure 3 locations)						
		BS-01	BS-02	BS-03	BS-04	BS-05	BS-06	Incidental
Green Heron	*Butorides virescens*							X
Canada Goose	*Branta canadensis*							X
Mallard	*Anas platyrhynchos*							H
Turkey Vulture	*Cathartes aura*							X
Sharp-shinned Hawk	*Accipiter striatus*							X
Red-tailed Hawk	*Buteo jamaicensis*							X

Common Name	Scientific Name	AECOM Observations (see Figure 3 locations)						
		BS-01	BS-02	BS-03	BS-04	BS-05	BS-06	Incidental
Wild Turkey	*Meleagris gallopavo*							S
Killdeer	*Charadrius vociferus*			A			S	FY
Spotted Sandpiper	*Actitis macularia*							FY
Mourning Dove	*Zenaida macroura*						S	S
Eastern Wood-Pewee	*Contopus virens*							S
Alder Flycatcher	*Empidonax alnorum*		T					S
Willow Flycatcher	*Empidonax traillii*	T	T					S
Eastern Kingbird	*Tyrannus tyrannus*		S			P	X	S
Horned Lark	*Eremophila alpestris*							S
Tree Swallow	*Tachycineta bicolor*	X		X			X	
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*				X		X	
Bank Swallow	*Riparia riparia*	X	X					
Barn Swallow	*Hirundo rustica*	X		X		X	X	X
American Crow	*Corvus brachyrhynchos*			S			S	
Black-capped Chickadee	*Poecile atricapillus*			S				S
House Wren	*Troglodytes aedon*					S		S
American Robin	*Turdus migratorius*		S	S			A	S
Gray Catbird	*Dumetella carolinensis*					S		
Cedar Waxwing	*Bombycilla cedrorum*							S
Red-eyed Vireo	*Vireo olivaceus*							S
Yellow Warbler	*Dendroica petechia*		T				S	S
Common Yellowthroat	*Geothlyphis trichas*	T		T		T		S
Northern Cardinal	*Cardinalis cardinalis*	T	T	A		T		S

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Common Name	Scientific Name	AECOM Observations (see Figure 3 locations)						
		BS-01	BS-02	BS-03	BS-04	BS-05	BS-06	Incidental
Indigo Bunting	*Passerina cyanea*					S		
Chipping Sparrow	*Spizella passerina*						S	S
Clay-coloured Sparrow	*Spizella pallida*	S						
Field Sparrow	*Spizella pusilla*	T	T				T	S
Savannah Sparrow	*Passerculus sandwichensis*	T	A	T	T	A		S
Song Sparrow	*Melospiza melodia*	T	T	T	S	T	A	A
Bobolink	*Dolichonyx oryzivorus*		CF	A	P	P		CF
Red-winged Blackbird	*Agelaius phoeniceus*		T	CF	S	A	A	S
Eastern Meadowlark	*Sturnella magna*	T	P	T	T		S	S
Common Grackle	*Quiscalus quiscula*							X
Brown-headed Cowbird	*Molothrus ater*	S					H	
Orchard Oriole	*Icterus spurius*							S
Baltimore Oriole	*Icterus galbula*						S	
American Goldfinch	*Cardeulis tristis*		S			S	S	S

Legend: ***Breeding Bird Evidence (OBBA 2001)***

Observed *X - Species observed in its breeding season (no evidence of breeding).*

Possible *H - Species observed in its breeding season in suitable habitat*

S - Singing male present, or breeding calls heard, in its breeding season in suitable nesting habitat

Probable *P - Pair observed in their breeding season in suitable nesting habitat.*

T - Permanent territory presumed through registration of territorial song on at least 2 days, a week or more apart at the same place

A - Agitated behaviour or anxiety calls of an adult

Confirmed *FY - Recently fledged young or downy young, including young incapable of sustained flight*

CF - Adult carrying food for young.

Bank Swallows (*Riparia riparia*) were observed foraging over cultural meadow at BS-01 and BS-02 during breeding bird surveys completed in 2018. This species builds their nests within burrows dug into natural (e.g., banks of rivers or lakes) and human-made vertical surfaces (i.e., active

sand and gravel pits where banks remain stable) made of silt and sand deposits (OMNRF 2018). Bank swallows are considered colonially nesters which can range in size from several to a few thousand pairs (OMNRF 2018). This species is designated as Threatened provincially and will be discussed in more detail in **Section 2.2.4** and **Section 2.2.8** below. Although no nesting habitat for Bank Swallow was observed during field investigations, it is anticipated that the species is utilizing potential habitat provided by the aggregate facility located north of Scotland Drive. Access to this property was not granted at the time of investigations and, therefore, habitat for the species could not be confirmed.

Similar to Bank Swallow, Barn Swallows (*Hirundo rustica*) were observed foraging over agricultural fields and cultural meadow at BS-01, BS-03, BS-05 and BS-06 during breeding bird surveys completed in 2018. Barn Swallow habitat consists almost exclusively of human-made structures including barns, bridges and culverts which provide ledges on which they can build their cup-shaped nests out of mud (MECP 2019). Barn Swallows are aerial-insectivores which are frequently observed foraging over open areas including pastures, meadows, wetlands, agricultural fields and parks. No nesting was observed during site investigations; however, it is anticipated that the species is nesting in structures present within the Study Area. Barn Swallow is listed as Threatened in Ontario –protection for this species, along with its habitat is afforded protection under the ESA. This species will be discussed in more detail in **Section 2.2.4** and **Section 2.2.8** below.

Bobolink (*Dolichonyx oryzivorus*) was observed within cultural meadow communities in the Study Area during breeding bird surveys (BS-02, BS-03, BS-04, BS-05). This species breeds in a variety of natural and anthropogenic grasslands such as meadows, pastures and hayfields where small trees, shrubs and fence posts are used as elevated song perches (OMNRF 2018). This species was confirmed breeding within the Study Area. Bobolink is designated as Threatened provincially and is afforded protection under the ESA. This species will be discussed further in **Section 2.2.4** and **Section 2.2.8** below.

Eastern Meadowlark (*Sturnella magna*) was also observed within cultural meadow communities (BS-01, BS-02, BS-03, BS-04 and BS-06) throughout the Study Area during breeding bird surveys. Similar to Bobolink, Eastern Meadowlark primarily breeds in tall grasslands including pastures and hayfields, but they can also be observed in alfalfa fields, weedy borders or croplands, roadsides, orchards, airports, overgrown fields and other open areas (OMNRF 2018). This species is designated as Threatened under the Species at Risk in Ontario List (O. Reg 230/08); this species and its habitat is therefore afforded protection under the ESA.

Eastern Wood-pewee (*Contopus virens*) was observed within the Dry-Fresh Sugar Maple – Hickory Deciduous Forest (FOD5-5) located at the northeast portion of the Study Area. This species commonly nests in the mid-canopy of forest clearings and edges of deciduous and mixed forests, commonly with little understory vegetation (OMNRF 2018). A singing male was observed during field investigations completed during the breeding bird season. Eastern Wood-pewee is designated as Special Concern provincially. Although this species is not afforded protection under the ESA, the species is considered a SOCC – habitat for this species is considered SWH as defined by the SWH Ecoregion 7E Criterion Schedule (OMNRF 2015). This species and its habitat are discussed further in **Section 2.2.5** below.

In addition to Bobolink and Eastern Meadowlark, two (2) area-sensitive bird species were also observed during the breeding bird surveys or incidentally:

- Sharp-shinned Hawk (*Accipiter striatus*)

- Savannah Sparrow (*Passerculus sandwichensis*)

These species require larger areas of suitable habitat for successful breeding and, in turn, sustain populations. As such, these species can provide an indicator of habitat quality and availability within the Study Area.

All other bird species observed are fairly common to abundant and widespread in southern Ontario. The majority of native bird species and their active nests are protected under the federal *Migratory Birds Convention Act, 1994* (MBCA). Some bird species which are not under federal jurisdiction, such as raptors, are protected under Ontario's *Fish and Wildlife Conservation Act, 1997*. Nests of these species can only be removed if a permit is obtained from the Ministry of Natural Resources

Amphibians

Background

A review of the background information as outlined in **Section 1.3** identified no significant amphibian species within the Study Area (Ontario Nature, 2017). The potential presence of other species such as gray treefrog (*Hyla versicolor*), spring peeper (*Pseudacris crucifer*), western chorus frog (*Pseudacris triseriata*), and wood frog (*Rana (Lithobates) sylvatica*) indicate the potential for Significant Wildlife Habitat. Therefore, surveys were conducted to determine the presence and populations of anuran species within the Study Area and determine the presence of SWH including Amphibian Breeding Habitat.

Field Investigation Methods

Anuran call surveys were conducted at eleven (11) wetland communities within the Study Area. The location of each anuran call survey can be found on **Figure 3**. These surveys were conducted following the Ontario Marsh Monitoring Program (Bird Studies Canada 2008).

In order to detect both early and late anuran breeders, three (3) site visits were conducted during the breeding season (April to July). In accordance with the protocol, surveys did not begin until at least one-half hour after sunset and were completed before midnight. In addition, surveys were only conducted during suitable weather conditions which included winds less than 19 km/hr (0-4 on the Beaufort wind scale) and minimum night-time air temperatures of at least 5 °C for the first survey, 10 °C for the second survey and 17 °C for the third survey. It should be noted that surveys can be conducted at lower temperatures if there is strong calling activity observed. Species observed and call frequency were recorded by biologists during each three-minute point count. The frequency categories of anuran calls are as follows:

0 - None heard.

1 - Individuals can be counted, calls not overlapping. Abundance is recorded with this call code (e.g., SPPE1-1; Call Code -1, Count 1)

2 - Numbers of some individuals can be estimated or counted, others overlapping. Abundance is recorded with this call code (e.g., SPPE2-5; Call Code – 2, Count - 5)

3 - Full chorus, calls continuous and overlapping, and individuals not distinguishable. Abundance is not recorded with this call as it cannot be reliably estimated (e.g., SPPE3).

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Table 9: Anuran Call Survey Results

Station Name	Date	Start Time	End Time	Temperature (C)	Beaufort Scale	Precipitation	Background Noise	Species observed within 100m station (code/count)	Species observed outside 100m station
Round 1									
AMP-01	23-Apr-18	21:43	21:46	14	3	None	0	**None**	**None**
AMP-02	23-Apr-18	20:33	20:36	20	1	None	0	**SPPE3 WOFR3**	**None**
AMP-03	23-Apr-18	20:50	20:53	20	1	None	0	**SPPE3**	**WOFR1-1 SPPE3**
AMP-04	23-Apr-18	20:59	21:02	20	1	None	0	**SPPE3 WOFR1-1**	**None**
AMP-05	23-Apr-18	21:12	21:15	15	3	None	1	**None**	**None**
AMP-06	9-May-18	21:22	21:25	14	2	None	2	**None**	**None**
AMP-07	9-May-18	21:32	21:36	14	2	None	2	**AMTO1-1 SPPE2-4**	**None**
AMP-08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**
AMP-09	23-Apr-18	21:28	21:31	14	2	None	1	**SPPE3 NLFR1-1**	**None**
AMP-10	23-Apr-18	21:55	21:58	12	2	None	0	**SPPE3**	**SPPE3**

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Station Name	Date	Start Time	End Time	Temperature (C)	Beaufort Scale	Precipitation	Background Noise	Species observed within 100m station (code/count)	Species observed outside 100m station
AMP-11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**
Round 2									
AMP-01	31-May-18	21:29	21:32	23	1	None	2	**GRTR1-3 GRFR1-1**	**SPPE1-2**
AMP-02	31-May-18	21:07	21:10	24	3	None	1	**None**	**None**
AMP-03	31-May-18	22:53	22:56	23	3	None	1	**GRTR2-6**	**None**
AMP-04	31-May-18	22:10	22:13	23	3	None	2	**GRTR2-3**	**None**
AMP-05	31-May-18	22:22	22:25	23	3	None	3	**GRTR2-3**	**None**
AMP-06	31-May-18	22:38	22:41	23	2	None	2	**None**	**None**
AMP-07	31-May-18	22:31	22:35	23	2	None	2	**GRFR1-1**	**None**
AMP-08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**
AMP-09	31-May-18	21:45	21:48	23	2	None	1	**GRFR1-1 GRTR2-7**	**None**
AMP-10	31-May-18	22:02	22:05	24	2	None	2	**GRTR1-1 GRFR1-1**	**None**

Station Name	Date	Start Time	End Time	Temperature (C)	Beaufort Scale	Precipitation	Background Noise	Species observed within 100m station (code/count)	Species observed outside 100m station
AMP-11	31-May-18	21:54	21:58	23	3	None	1	**None**	**None**
Round 3									
AMP-01	3-Jul-18	21:50	21:53	29	1	None	1	**GRFR1-1 GRTR1-1**	**None**
AMP-02	3-Jul-18	22:06	22:09	23	1	None	2	**None**	**None**
AMP-03	3-Jul-18	22:24	22:27	23	1	None	1	**GRFR1-1**	**GRTR2-3**
AMP-04	3-Jul-18	22:35	22:38	22	0	None	2	**GRFR1-1**	**GRTR1-1**
AMP-05	3-Jul-18	22:45	22:48	20	2	None	3	**GRTR3**	**None**
AMP-06	3-Jul-18	22:59	22:02	20	0	None	1	**None**	**GRFR1-1**
AMP-07	3-Jul-18	23:08	23:11	19	2	None	2	**GRFR1-1**	**GRFR1-2 GRTR1-1**
AMP-08	3-Jul-18	23:18	23:21	19	1	None	2	**GRFR1-5**	**GRTR2-3**
AMP-09	3-Jul-18	23:31	23:34	19	2	None	2	**NLFR1-1 GRFR1-3 GRTR1-1**	**None**
AMP-10	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**

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Station Name	Date	Start Time	End Time	Temperature (C)	Beaufort Scale	Precipitation	Background Noise	Species observed within 100m station (code/count)	Species observed outside 100m station
AMP-11	N/A	N/A	N/A	N/A	N/A	N/A	N/A	**N/A**	**N/A**

Legend:

AMTO – American Toad
GRFR – Green Frog
GRTR – Gray Tree Frog
NLFR – Northern Leopard Frog
SPPE – Spring Peeper
WOFR – Wood Frog

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Results and Discussion

The results of anuran call surveys are summarized in Table 9. Species observed within the Study Area during field investigations include spring peeper, wood frog, American toad (Anaxyrus americanus), northern leopard frog (Lithobates pipiens), gray tree frog and green frog (Rana clamitans).

No amphibian Species at Risk (SAR) were recorded during field investigations conducted by AECOM staff in 2018. However, calling activity documented at AMP-02 met criteria for Amphibian Breeding (Woodland) Significant Wildlife Habitat. Therefore, the Mineral Thicket Swamp (SWT2) which is part of the Silver Swamp Locally Significant wetland, is considered Significant Wildlife Habitat. This habitat will be discussed in more detail in **Section 2.2.5** below.

Reptiles

Background

A review of the background information, as outlined in **Section 1.3,** identified two (2) reptile species within the 10 by 10 km square (17MH84) that overlaps the Study Area (Ontario Nature, 2017). These species included two (2) provincially listed Special Concern species. These species are presented in **Table 10**.

Table 10: Ontario Reptile and Amphibian Atlas Significant Reptile Records Within or in the Vicinity of the Study Area

Common Name	Scientific Name	SARA Status	COSEWIC Status	ESA Status	S-rank
Eastern Ribbonsake	*Thamnophis sauritus*	SC Schedule 1	SC	SC	S3
Snapping Turtle	*Chelydra serpentina*	SC Schedule 1	SC	SC	S3

Legend:
SC – Special Concern
S3 – Vulnerable

Field Investigation Methods

During initial site investigations, AECOM staff recorded potential snake habitat/hibernacula within the Study Area. Dimensions of any rock or debris piles observed were recorded as well as a description of surrounding habitat conditions, slope and likelihood of the observed piles extending below frost line. The type of material and approximate size of the hibernacula was also recorded. These observations were used to inform the placement of cover boards for Artificial Cover Surveys within the Study Area.

Snake surveys included both Visual Encounter Surveys (VES) and Artificial Cover (e.g., cover board) surveys following the Survey Protocol for Ontario's Species at Risk Snakes (OMNRF 2016). Five (5) VESs and four (4) cover board surveys were conducted under ideal weather conditions including, calm, clear or partly cloudy days and with a temperature range of 10 to 25^{o}C

(on very warm days, surveys were conducted in the morning). Where large stones or other cover objects were observed, they were slowly and carefully overturned and checked for the presence of snakes. Cover boards were also overturned and gently replaced to check for the presence of snakes. Any snake species observed was visually identified; the estimated length and any other visible distinguishing characteristics were recorded. Locations of snake cover boards are shown on **Figure 3**. A description of cover board locations can also be found in **Table 11** below.

Table 11: Snake Cover Board Locations

Cover Board Name	GPS Location	Description
CB-01	E. 482550 N. 4748521	At edge of coniferous plantation within cultural meadow
CB-02	E. 482228 N. 4748500	In clearing within a cultural thicket
CB-03	E. 481265 N. 4746917	Within cultural meadow adjacent to tree row
CB-04	E. 480533 N. 4747141	Within cultural meadow adjacent to old house foundation
CB-05	E. 481666 N. 4748321	Within cultural meadow adjacent to tree row
CB-06	E. 481753 N. 4748559	In clearing within cultural thicket near edge of deciduous forest
CB-07	E. 480874 N. 4748019	In cultural meadow adjacent to old house foundation
CB-08	E. 480829 N. 4748044	In cultural meadow adjacent to old house foundation
CB-09	E. 480801 N. 4746699	At edge of coniferous plantation within cultural meadow
CB-10	E. 482203 N. 4748301	At edge of coniferous plantation within cultural meadow

Results and Discussion

Three (3) potential hibernacula sites were observed during field investigations. **Table 12** summarizes the potential hibernacula location and brief description of each feature.

Table 12: Potential Snake Hibernacula Locations

Hibernacula	GPS Location	Description
Hibernacula 1	E. 482223 N. 4748312	Concrete debris pile adjacent to coniferous plantation
Hibernacula 2	E. 480872 N. 4748017	Residential building debris in cultural meadow

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Hibernacula 3	E. 480527 N. 4747150	Rock pile and old residence debris/foundation adjacent to small woodland and agricultural field

Table 13 below presents the results of cover board surveys and **Table 14** presents the results of the area searches.

Table 13: Summary of Snake Cover Board Surveys within the Study Area

Visit	Cover Board	Temperature (°C)	Species Observed
Visit 1 – May 31st	**CB-01**	28	None
	CB-02	28	None
	CB-03	28	None
	CB-04	28	None
	CB-05	28	None
	CB-06	28	None
	CB-07	28	None
	CB-08	28	None
	CB-09	28	None
	CB-10	28	None
Visit 2 – July 20th	**CB-01**	24	None
	CB-02	24	None
	CB-03	24	None
	CB-04	24	None
	CB-05	24	None
	CB-06	24	None
	CB-07	24	Boards Buried
	CB-08	24	Boards Buried
	CB-09	24	None
	CB-10	24	None
Visit 3 – July 27th	**CB-01**	17	None
	CB-02	17	None
	CB-03	17	None
	CB-04	17	None
	CB-05	17	None
	CB-06	17	None
	CB-07	17	Boards Buried
	CB-08	17	Boards Buried
	CB-09	17	None
	CB-10	17	None
Visit 4 – August 9th	**CB-01**	19-31	None
	CB-02	19-31	None
	CB-03	19-31	None
	CB-04	19-31	None
	CB-05	19-31	None
	CB-06	19-31	None
	CB-07	19-31	Boards Buried
	CB-08	19-31	Boards Buried
	CB-09	19-31	None
	CB-10	19-31	None

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Table 14: Summary of Visual Encounter Surveys within the Study Area

Visit	Temperature (°C)	Species	GPS Location
Visit 1	19	Eastern Gartersnake	E. 482571 N. 4748516
Visit 2	N/A	None	N/A
Visit 3	N/A	None	N/A
Visit 4	N/A	None	N/A

No significant snake species were observed during area searches or cover board surveys. One species, Eastern Gartersnake (*Thamnophis sirtalis*) was observed during VESs. This species is common and widespread throughout Ontario.

Lepidoptera and Odonata

Background

A review of the background information as outlined in **Section 1.3** identified thirteen (13) butterfly species as potentially present within the square (17MH84) that encompasses the Study Area (**Table 15**). All species identified during the background review as potentially occurring within the Study Area are common and widespread species within Ontario. No SAR butterflies, dragonflies or damselflies were identified during background review.

Table 15. Butterfly Atlas Records Within or in the Vicinity of the Study Area

Common Name	Scientific Name	S-rank
Fiery Skipper	*Hylephila phyleus*	SNA
Tawny-edged Skipper	*Polites themistocles*	S5
Northern Broken-Dash	*Wallengrenia egeremet*	S5
Mulberry Wing	*Poanes massasoit*	S4
Hobomok Skipper	*Poanes hobomok*	S5
Black Dash	*Euphyes conspicua*	S3
Banded Hairstreak	*Satyrium calanus*	S4
Striped Hairstreak	*Satyrium liparops*	S5
Great Spangled Fritillary	*Speyeria cybele*	S5
Meadow Fritillary	*Boloria bellona*	S5
Baltimore Checkerspot	*Euphydryas phaeton*	S4
Viceroy	*Limenitis archippus*	S5
Eyed Brown	*Lethe eurydice*	S5

Legend:

SNA – Not Applicable
S3 – Vulnerable
S4 – Apparently Secure
S5 – Secure

Field Investigation Methods

All observations of butterflies, damselflies and dragonflies were recorded during the completion of other field surveys.

Results and Discussion

Eight (8) odonatan species and six (6) lepidopteran species were observed within the Study Area during field investigations. **Table 16** below presents the results of Lepidoptera and Odonata observations.

Table 16: Summary of Lepidoptera & Odonata Results

Common Name	Scientific Name	S-Rank
White-faced Meadowhawk	*Sympetrum obtrusum*	S5
Eastern Forktail	*Ishnura verticalis*	S5
Black Saddlebags	*Tramea lacerate*	S4
Calico Pennant	*Celithemis elisa*	S5
Widow Skimmer	*Libellula luctuosa*	S5
Common Whitetail	*Plathemis Lydia*	S5
Cabbage White	*Pieris rapae*	SNA
Giant Swallowtail	*Papilio cresphontes*	S4
Common Wood-nymph	*Cercyonis pegala*	S5
Ebony Jewelwing	*Calopteryx maculata*	S5
Viceroy	*Limenitis archippus*	S5
Slender Spreadwing	*Lestes rectangularis*	S5
Monarch	*Danaus plexippus*	S2N, S4B
Eastern Tailed Blue	*Cupido comyntas*	S5

Legend:

SNA – Not Applicable
S2N – Imperiled Nonbreeding Population
S4 – Apparently Secure
S4B – Apparently Secure Breeding Population
S5 – Secure

Monarch (*Danaus plexippus*) was observed within cultural meadow communities throughout the Study Area. This species is listed as Special Concern provincially and is therefore considered a Species of Conservation Concern. Habitat for this species is considered Significant Wildlife Habitat and will be discussed in more detail in **Section 2.2.5**.

All other species observed during field investigations are considered common and widespread within Ontario.

2.2.4 Species at Risk Assessment

Background

The status of species within Ontario is determined by the Committee on the Status of Species at Risk in Ontario (COSSARO) and Schedule 1 of the SARA (as recommended by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC)). The four categories of species classification within SARA and the ESA include (terms in brackets apply solely to the province):

- Extirpated: no longer lives within a certain region (of Ontario), although still lives somewhere in the world;
- Endangered: lives in the wild (in Ontario) but is facing imminent extinction or extirpation;
- Threatened: lives in the wild (in Ontario), is not endangered, but is likely to become endangered if steps are not taken to address factors threatening it; and
- Special concern: lives in the wild (in Ontario), is not endangered or threatened, but may become threatened or endangered due to a combination of biological characteristics and identified threats." (OMNRF 2014d, SARA 2002).

For the purpose of this report, SAR are defined as species that are listed as either Threatened or Endangered provincially or federally (in the case of aquatic organisms). These species, as well as their habitat, are afforded protection under the ESA (2007) and SARA. Species listed as Special Concern are not subject to the prohibitions under the ESA or SARA, but have been included in the SAR screening to avoid future implications should the status of these species change under the ESA (2007) or SARA, and to recognize that in some cases (i.e., aquatic species at risk) they are protected under other legislation. Furthermore, species listed as Special Concern are considered SOCC in the Natural Heritage Reference Manual (NHRM). As such, habitat for these species is considered SWH. These species and their habitats are discussed in detail in **Section 2.2.5**.

A preliminary SAR screening exercise was completed to determine the number of SAR within potentially suitable habitat within the W12A Landfill Study Area.

Methods

A list of SAR which have the potential to occur within the Study Area was compiled based on a review of background information as described in **Section 1.3** as well as input provided by agency correspondence as outlined in **Section 1.6**. Habitat preferences of the listed terrestrial SAR were then compared to onsite habitat characteristics to determine if the Study Area contained potential habitat for SAR. The potential for species to occur was then determined through a probability of occurrence whereby the following rankings were applied:

- **Low Probability**: suitable habitat for the species is not likely present within the study area;
- **Moderate Probability**: potentially suitable SAR habitat may be present within the study area; and,
- **High Probability**: preferred habitat conditions for SAR are likely present within the study area.
- **Confirmed**: species were observed within the Study Area during field investigations.

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The SAR screening was refined, where feasible, using the results of the ELC community delineation and taxa specific surveys completed during field investigations as described in **Section 2.2.1**.

Results and Discussion

A review of background information and input from agency correspondence identified seventy-six (76) SAR have the potential to occur within the Study Area. Of these species, thirty-seven (37) species are listed as Endangered, nineteen (19) species are listed as Threatened, and twenty (20) species are listed as Special Concern.

Based on the results of the SAR Screening, two (2) SAR have a low probability of occurrence within the Study Area, as suitable habitat conditions are not likely present. Twelve (12) were determined to have at least a moderate probability of occurrence within the Study Area as potentially suitable habitat was identified during the review of existing conditions. Of these twelve, four (4) SAR have a high potential for occurrence within the Study Area as preferred habitat conditions were identified during the review of existing conditions. Candidate and confirmed SAR within the Study Area are summarized in **Table 17** below.

Table 17: Potential & Confirmed Species at Risk Within the Study Area

Common Name	Scientific Name	ESA Status	Candidate	Confirmed
Bank Swallow	*Riparia riparia*	THR	X	
Barn Swallow	*Hirundo rustica*	THR	X	
Bobolink	*Dolichonyx oryzivorus*	THR		X
Eastern Meadowlark	*Sturnella magna*	THR		X
Eastern Wood-pewee	*Contopus virens*	SC		X
Little Brown Myotis	*Myotis lucifugus*	END	X	
Eastern Small-footed Myotis	*Myotis leibii*	END	X	
Northern Myotis	*Myotis septentrionalis*	END	X	
Tri-colored Bat	*Perimyotis subflavus*	END	X	
Eastern Ribbonsnake	*Thamnophis sauritus*	SC	X	
Snapping Turtle	*Chelydra serpentina*	SC	X	
Monarch	*Danaus plexippus*	SC		X

Legend:

END – Endangered
THR – Threatened
SC – Special Concern

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Six (6) of these species were observed during field investigations. As summarized in **Section 2.2.3**, Bobolink and Eastern Meadowlark were confirmed breeding within cultural meadow habitats within the Study Area including the current Landfill property. These species are both listed as Threatened provincially and are afforded protection under the ESA. Therefore, any impacts to this species or its habitat will require further considerations under the ESA. Habitat for these species is delineated on **Figure 7**.

Although nesting was not observed for Barn Swallow and Bank Swallow, these species were observed foraging within the Study Area during field investigations. Potential suitable habitat for Barn Swallow and Bank Swallow is present within the Study Area; however, as no nests were found in the landfill footprint, direct habitat under the General Habitat Description for each species is considered absent (MNRF 2015a; MNRF 2015b). These species are listed as Threatened provincially. These species, as well as their habitat are afforded protection under the ESA.

Eastern Wood-Pewee and Monarch were also observed within the Study Area during field investigations. These species are listed as Special Concern provincially and are therefore considered SOCC. These species do not receive habitat protection the ESA; however, their habitat is considered SWH which is should be protected in accordance with the *Provincial Policy Statement, 2020* (PPS). These species are further addressed in **Section 2.2.5**.

The full SAR Screening is provided in **Appendix J**.

2.2.5 Significant Wildlife Habitat Assessment

Background

SWH is defined by the NHRM (2010) as “areas where plants, animals and other organisms live, and find adequate amounts of food, water, shelter and space needed to sustain their populations”. This includes areas where species concentrate at a vulnerable point in their life cycle or areas important for migratory species. The Significant Wildlife Habitat Technical Guide (SWHTG) (2000) which supports the NHRM provides detailed information on the identification, description and prioritization of SWH. The SWHTG (2000) divides wildlife habitat into four categories including Seasonal Concentration Areas, Rare Vegetation Communities or Specialized Habitats for Wildlife, Habitat of Species of Conservation Concern and Animal Movement Corridors. Additionally, due to Ontario’s vast size and biodiversity, the OMNRF created draft Ecoregion Criterion Schedules that support the SWHTG and provide significance criteria that are reflective of geographic differences. The Ecoregion criteria schedules provide guidance for SWH designation for the four categories of SWH outlined in the SWHTG and its appendices. The schedules provide information including descriptions of wildlife habitat, wildlife species, and the criteria required to determine SWH.

The following section outlines the methods completed to determine the presence of candidate and/or confirmed SWH within the Study Area.

Methods

An SWH screening exercise was completed using the Wildlife Habitat Ecoregion Criteria Schedule (OMNRF 2012) to determine the presence of candidate SWH within the Study Area.

The probability of occurrence of candidate SWH for all four categories was determined by comparing existing conditions determined through aerial photo-interpretation and field

investigations, to criterion listed in the schedules. A background review, as described in **Section 1.3**, was conducted to determine the presence of SOCC within the Study Area. The potential for SWH to occur was determined through a probability of occurrence whereby the following rankings were applied:

- **No Probability**: Conditions for Candidate SWH are not present within the Study Area.
- **Low Probability**: suitable conditions to meet criteria for Confirmed SWH is not likely present within the study area;
- **Moderate Probability**: Candidate SWH habitat may be present within the study area;
- **High Probability**: Candidate SWH is likely present within the study area; and,
- **Confirmed**: Defining Criteria for Confirmed SWH were observed/met within the Study Area during field investigations.

Where feasible, the results of field investigations were used to confirm the presence of SWH within the Study Area.

Results and Discussion

Based on the SWH screening completed for the Study Area, conditions for candidate habitat were not met for seventeen (17) habitats. Thirteen (13) habitats had low to moderate probability of occurrence as suitable conditions are not likely present or may be present within the Study Area. Six (6) habitats had a high probability of occurrence within the Study Area including:

- Bat Maternity Colonies;
- Turtle Wintering Areas;
- Colonially-Nesting Bird Breeding Habitat (Trees/Shrubs);
- Amphibian Breeding Habitat (Wetlands);
- Marsh Breeding Bird Habitat; and,
- Special Concern and Rare Wildlife Species.

During field investigations completed in 2018, three (3) SWH were confirmed within the Study Area:

1. ***Amphibian Breeding Habitat (***Woodland) was identified within the Silver Swamp LSW;
2. ***Terrestrial Crayfish SWH*** was identified within the Silver Swamp LSW; and, Terrestrial Crayfish was confirmed within the cultural thicket habitat in the north of the subject lands;
3. ***Special Concern and Rare Wildlife Species Habitat*** for Monarch was identified within cultural meadow throughout the Study Area, while habitat for Eastern Wood-pewee was identified within FOD5-5 Dry-Fresh Sugar Maple – Hickory Deciduous Forest Type in P02 north of the subject lands within the potential ESA shown on **Figure 1**.

The PPS states that development and site alteration is not permitted in SWH unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

Two (2) candidate SWHs were also identified within the Study Area during field investigation in 2018. ***Candidate habitat for Bat Maternity Colonies*** was identified within deciduous forest (FOD5-5) and cultural thicket (CUT) communities north of the subject lands, the cultural plantation communities northeast (CUP3-2) and southwest (CUP3) of the subject lands, and the deciduous forest (FOD2-3) community within the subject lands. Full bat habitat assessments would be

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required to confirm the presence of Bat Maternity Colonies. ***Candidate habitat for Turtle Wintering Areas*** was identified in the open aquatic (OAO) community within the deciduous forest community (FOD2-4) northeast of the subject lands.

The full SWH Screening for the Study Area is provided in **Appendix K**. Locations of confirmed and candidate SWH are identified on **Figure 6.**

2.2.6 Significant Natural Heritage Features & Species

The following section provides a summary of significant features present within the Study Area as identified by federal, provincial and municipal evaluation and ranking systems including the Fisheries Act, the COSEWIC, the MNRF, COSSARO, UTRCA, KCCA and the London Plan (2017) and the MNHSS (2014).

2.2.7 Federally Recognized Features & Species

There are no federally owned lands present within the Study Area. As such, there are no federal implications related to terrestrial SAR. Although several species discussed within this report have been designated Threatened or Endangered on Schedule 1 of the *SARA*, protection of these species is afforded at the provincial level and therefore will be discussed in **Section 2.2.8**.

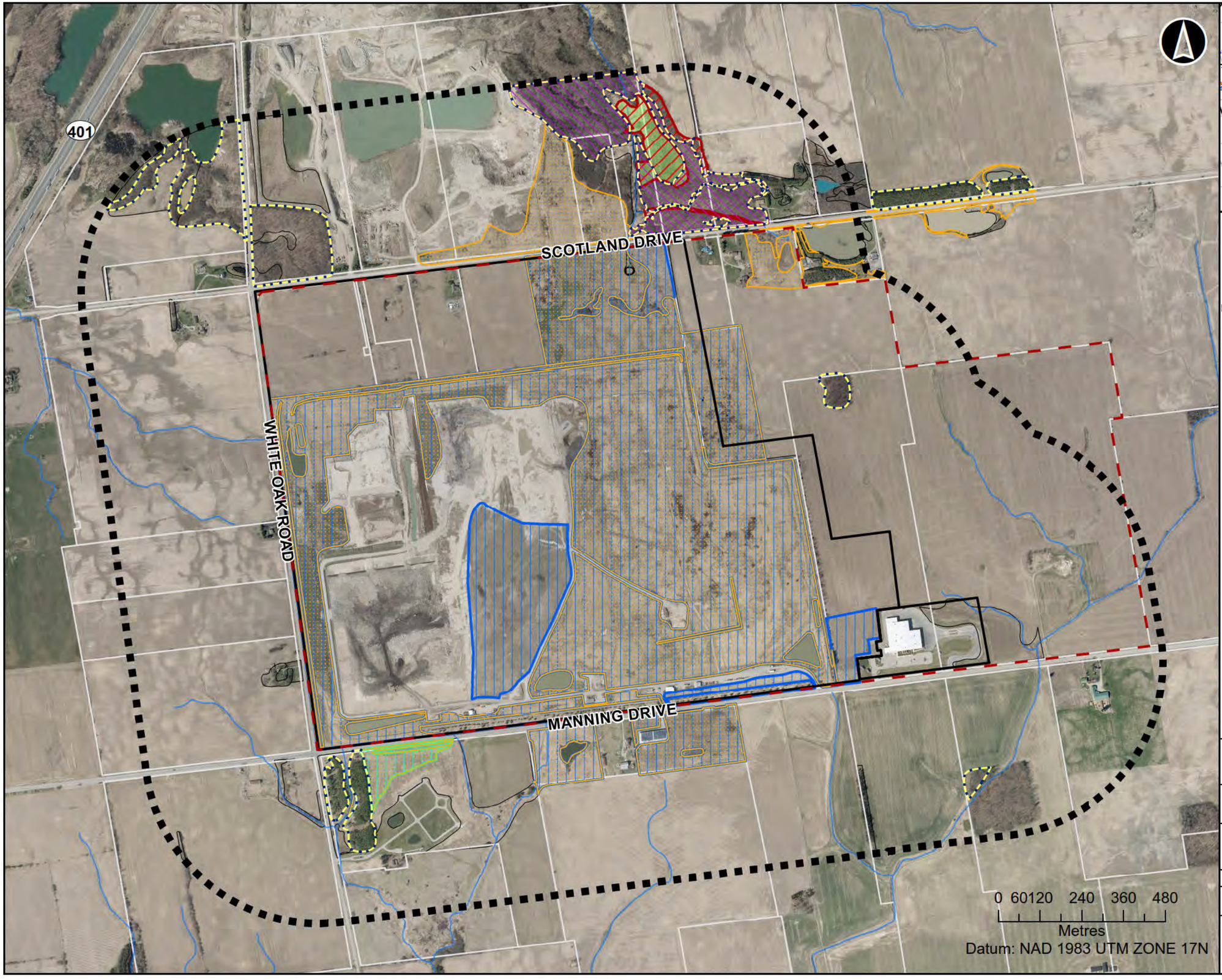
Background data indicate that several water features (e.g., watercourses and waterbodies) support, or are likely to support fish and fish habitat that is regulated under the *Fisheries Act*. Therefore, future work proposed in or near these features must be assessed for the potential to result in Harmful Alteration, Disruption, or Destruction (HADD) as defined by the federal *Fisheries Act*. If proposed work has the potential to cause serious harm, a Request for Review form must be submitted to DFO to determine permitting requirements under the *Fisheries Act*.

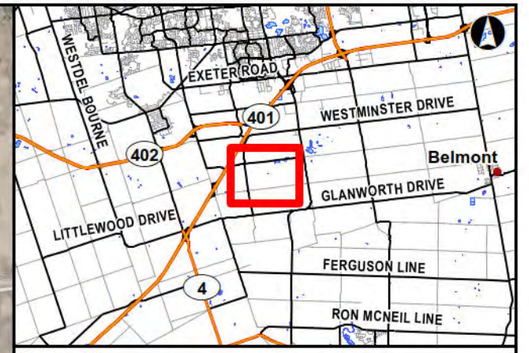
It should be noted that although there are no federally owned lands present within the Study Area, the *MBCA* still applies.

2.2.8 Provincially Recognized Features & Species

As outlined in **Section 2.2.3**, methods employed in the MNHSS (2014) were utilized to identify and delineate natural heritage features within the W12A Landfill Study Area. Using Criteria outlined in Table 9 of the MNHSS (Middlesex County 2014) and criteria outlined in the NHRM (OMNRF 2010), an assessment was completed to identify natural heritage features including Significant Woodlands and SWH. Additionally, field investigations further identified habitat for species listed as Threatened under the ESA. The following summarizes the provincially recognized features and species that are present or have the potential to occur within the Study Area:

> **Significant Woodlands** – Where woodland cover is between 5% and 15% in the county, all woodlands > 4ha in area should be considered significant (OMNRF 2010). Similarly, where land cover is less than 15%, woodlands with any interior habitat (i.e., 100 m from the edge of the feature) should be considered Significant. Therefore, all woodlands which meet Criteria 5 were designated as Significant Woodlands within the W12A Landfill Study Area. These features include Significant Woodlands as delineated on Map 5 of the London Plan are identified on **Figure 7**.





Legend

- Watercourse
- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary
- Ecological Land Classification (ELC)

Candidate Significant Wildlife Habitat (SWH)

- Bat Maternity Colonies
- Turtle Overwintering

Confirmed Significant Wildlife Habitat (SWH)

- Terrestrial Crayfish
- Amphibian Breeding

Confirmed Significant Wildlife Habitat for Special Concern and Rare Species

- Monarch
- Eastern Wood-pewee

Species At Risk (SAR) Habitat

- Bobolink
- Bobolink & Eastern Meadowlark
- Bats

W12A Landfill Expansion
Biology Assessment

Species at Risk and Significant Wildlife Habitat within the Study Area

August 2020	1:10,500 * when printed 11"x17"	Source: LIO, City of London

P#: 60556244

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Figure 6

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Significant Wildlife Habitat – As identified in **Section 2.2.5**, three (3) SWH were confirmed within the W12A Landfill Study Area – Terrestrial Crayfish Habitat, Amphibian Breeding Habitat (Woodlands) and Special Concern and Rare Species Habitat. Two (2) species of Special Concern were observed within the Study Area during field investigations: Eastern Wood-pewee within the FOD5-5 community in Patch P02, as well as Monarch which was observed in the multiple cultural meadow communities throughout Patch P02. Terrestrial Crayfish were observed within Silver Swamp and adjacent cultural thicket within Patch P02. Additionally, Patches P01, P03, P04 and P05 have the potential to support SWH such as Bat Maternity Roosting Habitat, Turtle Overwintering Habitat or Habitat for Special Concern and Rare Species. Confirmed and Candidate Significant Wildlife Habitat can be seen on **Figure 7**.

Species at Risk Habitat – Bobolink and Eastern Meadowlark were confirmed breeding within the cultural meadows in Patch P02. These species are listed as Threatened under the Species at Risk in Ontario list. These species and their habitat are therefore afforded protection under the ESA. Although nesting was not observed for Barn Swallow and Bank Swallow, these species were observed foraging within the Study Area during field investigations. Potential suitable habitat for Barn Swallow and Bank Swallow is present within the Study Area; however, as no nests were found in the landfill footprint, direct habitat under the General Habitat Description for each species is considered absent (MNRF 2015a)(MNRF 2015b). All wooded habitats provide potential suitable habitat for SAR bat species. Confirmed and Candidate SAR habitat can be seen on **Figure 7**.

2.2.9 Municipally Recognized Features & Species

Provincially recognized features outlined in **Section 2.2.8** above, are designated as Green Space Place Type within the London Plan and as shown on Map 1. In addition to these features, the following section summarizes the municipally recognized features identified through a review of Map 5 of the City of London's Plan and field investigations.

Potential Environmentally Significant Area – The larger, contiguous natural feature located north of Scotland Drive and associated with Silver Swamp has been identified as a potential Environmentally Significant Area.
Significant Woodlands - in addition to Significant Woodlands identified through desktop analysis in **Section 2.3.3**, Vegetation Patches #10120, #10122 and #11068 have also been identified as Significant Woodlands as shown on Map 5 of the London Plan.
Locally Significant Wetland - Silver Swamp LSW is present north of Scotland Drive.
Unevaluated Wetlands – unevaluated wetlands identified on Map 5 of the London Plan as well as wetland communities identified during field investigations require an evaluation in accordance with the Ontario Wetland Evaluation System (OMNRF 2013).

These features are designated as Environmental Review Place Type on Map 1 of the London Plan and may require further study to determine their level of significance, should additional studies be required in consultation with the City of London. These features are delineated on **Figure 7**.

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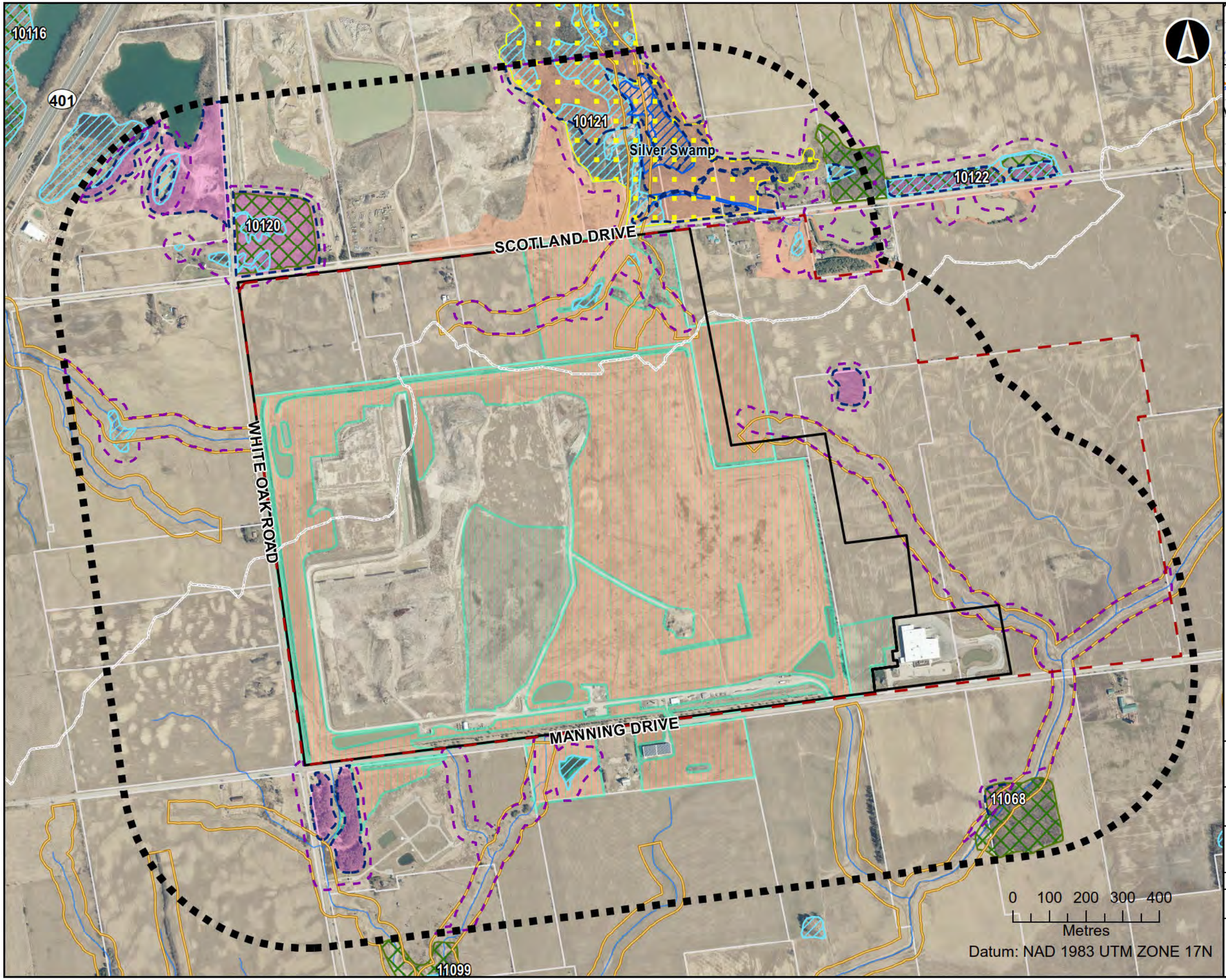

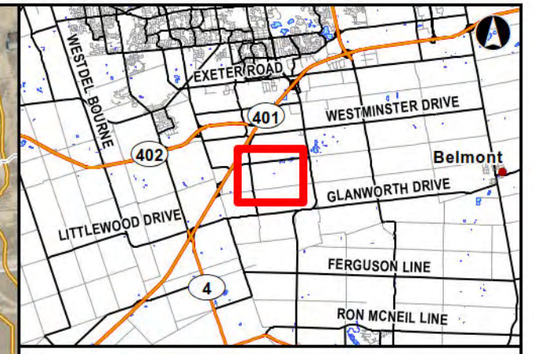

Legend

- Watercourse
- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary

Natural Heritage Features

- 11088 Vegetation Patch ID
- Conservation Authority
- Valleyland
- Potential ESA
- Locally Significant Wetland
- Unevaluated Wetland
- Significant Woodland
- Species At Risk (SAR) Habitat
- Candidate Species at Risk (SAR) Habitat
- Confirmed Significant Wildlife Habitat (SWH)
- Candidate Significant Wildlife Habitat (SWH)
- Preliminary Buffer

W12A Landfill Expansion Environmental Assessment

Natural Heritage Features and Constraints

November 2020	1:10,000 * when printed 11"x17"	Source: LIO, City of London

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Figure 7

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2.2.10 Natural Heritage Features & Constraints

Natural Heritage features identified within the Study Area, as shown on **Figure 7**, were based on the review of applicable background information, field investigations and desktop analysis based on technical criteria outlined in the MNRF's NHRM (OMNR 2010) and are consistent with policies set out in the PPS Natural Heritage policies (OMMAH 2020), as well as through the London Plan Natural Heritage policies. Natural Heritage features included in the Green Space Place Type and identified within the Study Area include:

- Locally Significant Wetlands – Silver Swamp,
- Significant Woodlands,
- Significant Wildlife Habitat,
- Species at Risk Habitat,

These natural heritage components pose various degrees of environmental constraint to development, including landfill expansion. Environmental constraints generally refer to areas where development is precluded or limited, based on the significance or sensitivity of the natural heritage features(s) and/or their functions. In some cases, the constraint to development is absolute (no development or site alteration is permitted); in other cases, development may be permitted if it can be demonstrated that the proposed development will not have a significant negative impact on the feature, and or, its functions. In the latter case, permitting with associated mitigation or compensation may be required.

The following section outlines the degree of constraint for development for each natural heritage feature identified within the W12A Landfill Study Area.

2.2.11 Development Constraints for Natural Heritage Features & Adjacent Lands

Development within and adjacent to natural heritage features identified within the W12A Landfill Study Area should be consistent with the policies outlined in the London Plan (2017) which adhere to the PPS (2020). **Table 18** below summarizes the level of protection required for natural heritage features identified within the Study Area, including preliminary buffer requirements and the development distance from a natural feature that would trigger an Environmental Impact Study (EIS) as outlined in the London Plan and its associate Environmental Management Guidelines. As it is not common practice for a municipality to complete an EIS for a landfill or landfill expansion, the City of London will determine whether an EIS will be required further to the completion of the Environmental Assessment (EA).

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Table 18: Summary of Development Constraints for Natural Heritage Features identified within the W12A Landfill Study Area

Natural Heritage Feature	Adjacent Lands	Development Constraints as per the PPS (2020) and London Plan (2017)	Recommended Preliminary Buffers
Provincially Significant Wetlands, Wetlands and Unevaluated wetlands.	120m	Development and site alteration shall not be permitted within a Provincially Significant Wetland (PSW) or LSW (evaluated as not Provincially Significant). Development and site alteration shall not be permitted within and/or adjacent to an unevaluated wetland identified on Map 5 and/or if an Ecological Land Classification identifies a community as a wetland.	30 metres from the outer boundary of the wetland or individual units in the case of complexes.
Significant Woodlands	120m	Development and site alteration shall not be permitted in Significant Woodlands unless it has been demonstrated that there will be no negative impacts on the natural heritage features or their ecological functions.	15 metres from the woodland dripline.
Significant Wildlife Habitat	120m	Development and site alteration shall not be permitted in and adjacent to SWH unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological function.	5-30 metres depending on the type of SWH identified: ▪ 5 metres for habitats associated with early successional habitats ▪ 15 metres for habitats associated with woodlands ▪ 30 metres for habitats associated with wetlands.
Significant Valleylands	120m	Development and site alteration shall not be permitted in or adjacent to Significant Valleylands unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological function.	To be determined through correspondence with the relevant Conservation Authorities at the site development stage.
Habitat for Threatened or Endangered Species	120m	Development and site alteration shall not be permitted in the habitat of Endangered Species and Threatened species, except in accordance	Buffers will depend on the type of habitat and species identified within the study area. Habitat for Threatened or Endangered Species was not identified within the Study

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Natural Heritage Feature	Adjacent Lands	Development Constraints as per the PPS (2020) and London Plan (2017)	Recommended Preliminary Buffers
(SAR habitat)		with provincial and federal requirements. Development and site alteration shall not be permitted on adjacent lands unless it has been demonstrated that there will be no negative impacts on natural heritage features or their ecological functions.	Area. Therefore, no preliminary buffers are recommended at this time.
Fish Habitat	120m	Development and site alteration shall not be permitted in Fish Habitat except in accordance with relevant provincial and federal requirements. Development and site alteration shall not be permitted on adjacent lands unless it has been demonstrated that there will be no negative impacts on the natural heritage feature or their ecological function.	30 m from watercourses and waterbodies

Natural heritage features identified as part of the Green Space Place Type, through background review and field investigations are delineated on **Figure 7**. Recommended preliminary buffers are based on standard practices for each natural heritage feature.

Natural heritage features which are included in the Environmental Review Place Type designation and that are found within the Study Area include:

Unevaluated wetlands,
Valleylands, and
Potential Environmental Significant Areas.

These features designations are considered to be interim in nature until the significance of these patches can be confirmed through further investigations and the application of evaluation criteria. Some of these unevaluated features could not be evaluated due to lack of property access. Nevertheless, these features are well outside of the proposed expansion area and will not be affected by the proposed expansion. Evaluation of these patches is, therefore, not required.

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3. Project Description

The landfill expansion consists of a vertical expansion over the existing landfill footprint to provide 13.8 million m^3 of airspace for waste and daily cover. To accommodate ancillary features and provide additional on-Site buffer width compared to the existing landfill, the northern boundary of the landfill property will be adjacent to Scotland Drive and a 100 m buffer width will be provided on the east side of the landfill footprint and some additional area in the southeast corner to tie into the adjacent Materials Recovery Facility (MRF) property line. This results in a 106.3 ha landfill footprint within a 192.4 ha landfill property, with a highest ridge elevation of waste of 318.43 masl.

The W12A Landfill Expansion Environmental Assessment report (Golder, 2020a) provides the plans for landfill expansion phasing, drainage areas, stormwater management and ancillary facilities in relation to the descriptions in the following sections.

Figure 8 shows the landfill expansion area in relation to natural heritage features and existing infrastructure.

3.1 Landfill Phasing and Development

The landfill expansion will be developed sequentially in eight Phases, 1E through 8E, progressing from the west side of the landfill towards the east. Landfilling in each Phase will be approximately 2.5 to 3.5 years based on an expected typical annual air space consumption of 500,000 m3 per year, which corresponds to an average annual waste receipt of 370,000 tonnes per year over the 25-year planning period. A separate cell dedicated for disposal of the non-decomposable portion of the waste stream will be provided in the southeastern area of the landfill expansion. Filling in this non-decomposable waste cell will take place in lifts over the 25-year expansion period and will be blended in to meet the temporary side slopes in the adjacent Phases 7E and 8E as they are developed. Because this waste is non-decomposable, it would not receive daily cover; however, if it is observed that specific materials are generating odours or are otherwise of concern if left uncovered, daily cover material would be placed. This fill area would receive final cover consistent with that on the remainder of the landfill, but it is not proposed to install a landfill gas collection system in this area as part of the final cover construction.

To commence filling in each Phase, the existing cover material would be progressively stripped from an area large enough to accommodate the year's disposal, which is estimated to average approximately 4 ha. The area of exposed waste would be limited to that needed to spread, compact and cover the waste received on a daily basis, and will range from about 40 m by 25 m typically (1,000 m2) to 50 m by 30 m (1,500 m2). The waste will be spread and compacted in lifts of about 0.6 m to a height of approximately 3 m. All waste will be covered daily.

For the southern Phases 1E, 3E, 5E and 7E the waste would be placed initially to build a berm along the south side of the Phase and will be covered with final cover soil and seeded to establish vegetation; the berm will screen the view of subsequent filling operations north of the berm from off-Site vantage points to the south. The south side perimeter waste berm would be raised sequentially and filled in behind until the peak elevation is reached. The Phase boundaries have been designed (offset) such that the completed southern Phases (1E, 3E,

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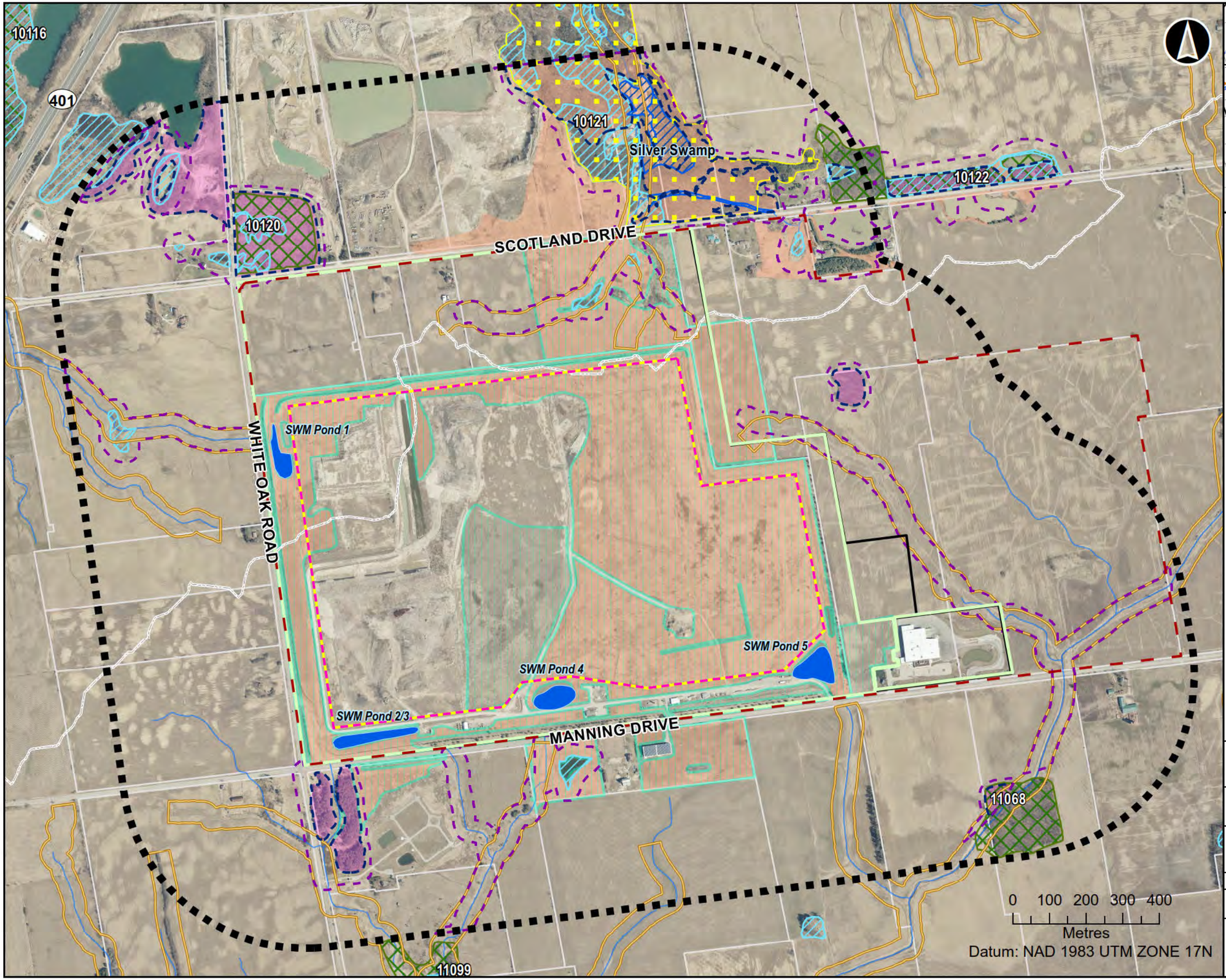

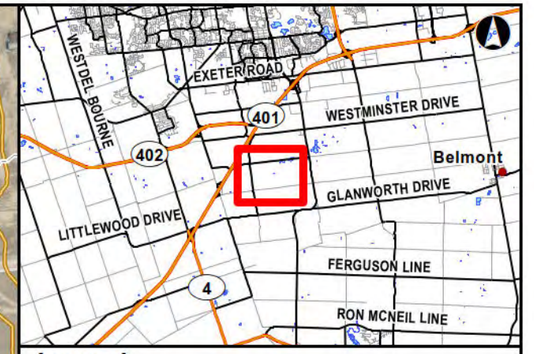

Legend

- Watercourse
- Parcel Fabric
- Site Study Area
- Site-vicinity Study Area
- Waste Management Resource Recovery Area Boundary
- Proposed Property Boundary
- Existing and Proposed Limits of Waste

Natural Heritage Features

- 11088 Vegetation Patch ID
- Conservation Authority Boundary
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- Candidate Species at Risk (SAR) Habitat
- Confirmed Significant Wildlife Habitat (SWH)
- Candidate Significant Wildlife Habitat (SWH)
- Preliminary Buffer
- Ponds and Stormwater Management Facilties

W12A Landfill Expansion
Environmental Assessment

Proposed Landfill Expansion

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Figure 8

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5E, 7E) will effectively screen the view of landfilling operations in the northern Phases (2E, 4E, 6E, 8E) from off-Site vantage points to the south.

Temporary soil berms, and if necessary shallow swales, would be provided to direct surface water runoff from existing covered upslope areas around the active fill areas / Phases to the stormwater management system since this runoff has not been in contact with waste.

On an annual or biannual basis, final cover would then be constructed over areas reaching final grade and permanent vertical landfill gas (LFG) wells will be installed and connected to the LFG gas collection system.

For the portion of the proposed vertical expansion that will involve placement of additional waste above the Phase 2 area, the existing leachate collection system (LCS) will continue to be used to collect and remove leachate from the area.

3.2 Leachate Control and Management

Phase 2 utilizes the clay till as a natural low permeability liner and has a continuous granular drainage blanket and piping system over a shaped subgrade to collect leachate and direct it by gravity to the north end of the Phase 2 area where the collected leachate is removed for subsequent off-site treatment. The waste in the Phase 1 area rests directly on the underlying low permeability clay till and has a perimeter LCS around the north, east and south sides to intercept leachate seepage at the base of the waste. Collected leachate either drains into the Phase 2 collection system or into a separate storage from where it is removed for subsequent off-site treatment.

For the portion of the proposed vertical expansion that will involve placement of additional waste above the Phase 2 area, the existing LCS will continue to be used to collect and remove leachate from the area. For the vertical expansion above the Phase 1 area, it is proposed to replace the existing perimeter LCS with a new perimeter LCS that will more effectively serve the same functions as the existing system. To control the potential for leachate seeps along the perimeter side slopes that could occur as a result of leachate mounding and/or perched leachate in Phase 1, it is proposed to construct granular finger drains around the north, east and south sides of the exterior perimeter of the Phase 1 area and connect them into the replacement Phase 1 perimeter LCS.

The leachate collected from the Phase 1 and Phase 2 LCS will continue to be routed through on-Site piping to the main leachate pumping station located at the southeast corner of the Site. From here, the leachate will be pumped off-Site through a leachate forcemain to the Dingman Road pump station, where combined with municipal sewage it will enter the municipal sanitary sewer system to treatment at the Greenway Wastewater Treatment Plant (WWTP).

3.3 Landfill Gas Generation and Control

It is estimated that the total expanded landfill will theoretically generate a maximum of 4,395 standard cubic feet per minute (scfm) of LFG in 2049 (the year following completion of filling of the expansion), of which typically 50% is methane. LFG is collected from completed areas of the landfill using a vertical well system that is connected to an enclosed flare; the existing flare is sized to combust a maximum of approximately 1,700 scfm of LFG. Considering the actual extent of the LFG well extraction system and its collection efficiency, analysis indicates that the capacity

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of the existing flare may be exceeded around year 2027. The timing for installation of additional flare capacity will depend on the actual operation of the existing flare and its ability to handle the collected gas flow rate. It is proposed to utilize vertical LFG extraction wells to be progressively installed with the construction of final cover following placement of waste to final contours in each Phase. To reduce air emissions (for odour control purposes during landfilling operations and to increase the overall collection of landfill gases), it is proposed that a number of horizontal landfill gas collection pipes will also be installed progressively as waste is placed.

3.4 Stormwater Management

The on-site drainage network is currently divided into four general areas with a system of berms, slopes and perimeter drainage ditches directing runoff generated within the W12A Landfill property envelope to four separate stormwater management ponds. Under the proposed vertical expansion, the peak of the landfill mound will shift to the south and side slopes of the mound will be longer and somewhat steeper in places, resulting in changes of the drainage boundaries to each of the ponds and, in general, reduced times to peak runoff. To address these changes in surface water runoff, some modifications to the existing stormwater management (SWM) ponds will be required.

Under current conditions, Ponds 2/3, 4 and 5 collect an area of 130 hectares of surface water runoff and provide treatment and attenuation prior to discharge off-Site to the south, to the Dodd Creek Watershed. The proposed landfill expansion and mound configuration will result in a reduction of the drainage area being collected and treated by these ponds and discharged to Dodd Creek subwatershed to 95.3 hectares. Under current conditions Pond 1 collects a drainage area of 14.4 hectares of surface water runoff and discharges off-Site to the north, to the Dingman Creek subwatershed. The proposed landfill expansion would result in an increased drainage area of 34.4 hectares to Pond 1. The outlet structure for Pond 1 will be designed such that discharge will match or be below pre-expansion peak flows for the 1:2 year through 1:100-year design storm events.

Stormwater runoff from the proposed expansion will continue to be managed in terms of both quality (80% Total Suspended Solids removal) and quantity (to match post-expansion flows to pre-expansion conditions for the 1:2 year through the 1:100-year return period design storm). The 1:250-year return period design storm was also assessed to predict conditions during such an event to accommodate climate change.

The proposed pond modifications are as follows:

- Pond 1 – to accommodate an increased contributing drainage area and reduction in time to peak, the pond will be expanded to the north, increasing the size of the main pond and forebay. The outlet structure will be modified with an appropriately sized orifice to meet discharge requirements.
- Pond 2/3 – the landfill expansion will result in a decreased drainage area to this pond; however, to meet the Enhanced Level Protection (80% TSS removal) the permanent pool depth will be increased, and some modifications will be made to the existing outlet structure.
- Pond 4 – this pond will receive stormwater runoff from a smaller total drainage area. The existing permanent pool and active storage is sufficiently sized to meet the 80% TSS removal requirements. The existing outlet structure will be modified to control discharge;

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an overflow weir will be added and the existing double inlet catchbasin maintained for larger storm events.

- Pond 5 – this pond will receive stormwater runoff from a larger total drainage area. The pond will be expanded to the east and north to increase both the permanent pool and active storage capacities. The existing outlet structure will be modified with an appropriately sized orifice and a weir.

3.5 Site Operations and Ancillary Components

The expanded landfill will operate, at the maximum, from 7 a.m. to 5 p.m., Monday through Saturday plus one hour before, i.e., 6 a.m. to 7 a.m., for site preparations and one hour after, i.e., 5 p.m. to 6 p.m. to complete placement of daily cover. The Site will be closed on Sundays; on statutory holidays site operations will be as required to accommodate hauling contracts.

It is proposed that the maximum annual receipt of waste for the expanded landfill will be 500,000 tones per year, reduced from the 650,000 tonnes/year allowed for the existing landfill.

The expanded landfill will also need to continue to occasionally operate 24 hours per day, 7 days per week when lime stabilized dewatered biosolids (dewatered sewage sludge) from the Greenway WWTP are being received and disposed at the landfill. This is typically required for three weeks per year; however, some years this period could be extended. In addition, re-builds or major equipment repairs typically occur approximately every five years or longer and can take up to two to three months to complete. The landfill may receive a load of biosolids (approximately 15 tonnes) every 75 to 90 minutes. Disposal of the biosolids involves excavating a hole in the existing waste in the active area (when practical) prior to the load arriving and covering the biosolids with daily cover soil as soon as the load has been dumped.

The main site access for the expansion will be at the same location as for the existing site, off Manning Drive at the southeast corner of the Site. The main ancillary facilities are located along the perimeter road across the south side of the Site. It is proposed that many of the existing ancillary facilities at the site will be progressively upgraded or replaced during the expansion at or close to their existing location, except for a new site office / administration building to be located close to the site entrance. These facilities consist of the contractor's office and garage; administration building; flare and control system; weigh scales and scale house and leachate pump station; and small vehicle waste drop-off. A new enclosed night waste storage facility for receipt and temporary storage of three to five loads of waste may also be constructed; access to the landfill at night will be done using card key access and automatic gates. In addition, in the vacant southeast corner area between the landfill and the MRF there will be a new scale and scale house, a grade-separated small vehicle drop-off for waste, a grade-separated small vehicle drop-off for recyclable materials, an area for drop-off of brush, tires and large items, and a new Household Special Waste depot.

The source of heating for all site buildings will be natural gas.

The existing paved roads on the south and west sides of the landfill are paved and will remain paved for the expansion. It is proposed that the perimeter access road around the north and east sides of the landfill will also be asphalt surfaced, as will the vehicle access roads for the proposed recycling drop-off facilities in the southeast corner between the landfill facilities and the MRF will also be paved. Access for collection vehicles to the expansion Phases will be mainly from the south side perimeter road, and for Phases 1E and 2E from the west

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side perimeter road. From the south side it is anticipated that the two existing granular surfaced haul roads will continue to be utilized.

A secondary site access off Scotland Drive will be used as a secondary site access and service road for operations and maintenance vehicles to the north part of the landfill property and as an emergency access/exit. The secondary access will have a locked gate to prevent unauthorized usage and will be gravel surfaced.

3.6 Closure and Post-closure

The landfill Phases will be progressively closed after the final waste contours have been reached in each Phase and landfill operations have proceeded into the next Phase(s). The final cover on the landfill will consist of a permeable cover design, comprised of 600 mm of soil topped with 150 mm of topsoil or similar and vegetated. The vertical LFG extraction wells will be installed to collect gas from within the expanded waste mass as part of the progressive construction of the final cover system.

Post-closure activities will involve continued operation and maintenance of the leachate collection and removal system, the LFG control system and the stormwater management system. In addition to general inspection of the site, there will be inspection of the landfill cover for evidence of erosion, leachate seeps or instability, and maintenance / repair as required.

3.7 Description of Activities

The time frames over which there will be activities on the Site associated with the proposed vertical expansion can be divided into three: initial construction, operations and post-closure. Following is a general description of the activities that are expected to take place during each of these periods.

Initial Construction: It is anticipated that the initial construction activities associated with the expansion will take place in the 2023 to 2025 period. Because the expansion will be a vertical expansion above the existing footprint, there will be no large-scale excavation required to construct a new cell. Construction of the replacement perimeter leachate collection system immediately adjacent to the existing toe of the landfill around the north, east and south perimeter of Phase 1 will involve conventional trenching and pipe installation; trenches into the waste will also be extended up the existing landfill side slopes to install finger drains. The modifications / enlargements to the existing stormwater management system ponds and their outlet controls will also be completed, involving relatively shallow excavation and soil berm construction in the immediate area of the existing ponds; no construction or alterations are proposed for the existing structures that convey the pond discharge below the adjacent roadways to the downstream watercourses or in the downstream watercourses themselves. Site roads will be constructed/upgraded adjacent to the north and east sides of the existing landfill. Construction of other infrastructure upgrades, i.e., main pump station, some of the buildings and some of the ancillary facilities, will take place along the south side of the Site that is already occupied by Site infrastructure. Construction of the new diversion and drop-off facilities in the southeast corner of the expanded site adjacent to the MRF will involve stripping of existing vegetation and then conventional construction for these types of facilities. Surplus soil resulting from this initial construction will either be temporarily stockpiled on the landfill for re-use in ongoing operations or stockpiled for future use in the on-Site buffer area to the north of the landfill footprint where soil stockpiles already exist.

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Operations: Operation of the expanded landfill is expected to be ongoing between 2024 and 2048. The expansion will commence in Phase 1E in the southwest and in the non-decomposable cell in the southeast, which will involve progressive stripping of the existing cover material from the active area and the placement and compaction of waste and spreading of daily cover soil, compaction and daily covering of the waste. The daily cover will be mostly suitable types of materials incoming to the site on an ongoing basis, supplemented as needed by material from on-Site soil stockpiles. After completion of a cell and moving to the next disposal area (as per the phasing plan), final cover soil will be placed over the waste and revegetated and the landfill gas collection system progressively installed with the final cover. During operations, vehicles will travel on the on-Site perimeter roads and on the haul roads located on the landfill, as well as to and from the soil stockpiles in the north buffer area. There will be ongoing maintenance and monitoring activities. The operations activities during the expansion will basically be a continuation of current site activities both on and adjacent to the existing landfill footprint, with raising of the landfill to reach the design configuration.

Post-Closure: When the approved capacity of the expanded landfill is reached at the end of the 25 year planning period at the end of 2048, the final cover will be placed on the last landfill Phase. After disposal operations cease, it is expected that the diversion activities may continue at the site using the established infrastructure. The activities associated with operation and maintenance of the leachate collection and pumping systems, the conveyance of collected leachate off-Site for treatment, the stormwater management ponds and the operation and maintenance of the landfill gas collection and flaring system will continue. Post-closure groundwater and surface water monitoring programs will continue. The leachate and landfill gas management system operations will extend for many decades post-closure.

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4. Impact Assessment

The following impact assessment considers the potential direct and indirect impacts of the W12A Landfill expansion preferred alternative on the aquatic and terrestrial ecosystems within the Study Area for the construction, operations and closure stages of the project as outlined in **Section 3**.

Potential direct impacts to natural heritage features and functions are those that result in an immediate loss of the feature or function as a consequence of the project works. This may include the removal of a vegetation community or habitat within the area of expansion or ancillary facilities and related works or work areas. Potential indirect impacts are those whereby the project works cause impacts to an adjacent or downstream feature or function through the alteration of the project site.

When considering and assessing the potential environmental impacts of a project on natural heritage features and functions, the first approach is to avoid potential impacts through layout and design of the project. Where impacts cannot be avoided, then mitigation of those impacts should be implemented to reduce the severity of those impacts. If mitigation measures are not possible or sufficient to mitigate potential impacts, then compensation for the loss of features and/or functions is required.

The proposed expansion of the W12A Landfill avoids many potential impacts by situating the future expansion on the existing landfill fill area.

Figure 8 shows the limits of the proposed landfill expansion overlaid with the natural heritage features.

4.1 Construction Stage

4.1.1 Aquatic Ecosystems

Direct Impacts

Since all aquatic habitat for both Dingman Creek and Dodd Creek are outside of the proposed expansion area, no direct impacts to aquatic species or habitat are anticipated.

The proposed modification to stormwater management facilities' (SWMF) weirs and outlets will all occur within the landfill area. As there are no physical alterations to the downstream SWMF infrastructure including the ditches, culverts, or other downstream watercourses, no direct impacts to aquatic species or habitat are anticipated from the proposed modifications to SWMF system.

Indirect Impacts

As described above, construction and alterations associated with the proposed modification to the SWMF weirs and outlets are not proposed for existing structures that convey pond discharge to downstream watercourses. As such, no indirect impacts to aquatic species or habitat are anticipated during the Construction Stage.

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4.1.2 Terrestrial Ecosystems

Direct Impacts

While the preferred alternative avoids areas of natural heritage features and functions by restricting the landfill expansion to the existing landfill footprint, direct impacts are anticipated. These impacts are based on the occurrence of Confirmed Significant Wildlife Habitat for Monarch and Species at Risk Habitat for grassland birds that overlaps with the existing landfill. The habitat for Eastern Meadowlark and Bobolink within the Study Area includes the existing landfill due to the grassland habitat characteristics of the vegetation cover over the existing landfill area and adjacent lands. The direct impacts to these areas during the Construction Stage are not considered to be significant and may be avoided based on the specific location of trenching activities.

Should stripping of existing vegetation for the new diversion and drop-off facilities in the southeastern corner occur during the breeding bird window (April 1st to August 31st), there is potential for impacts to nesting birds and may contravene the *Migratory Birds Convention Act*. Often during the construction phase of projects involving the excavation/stripping and stockpiling of soil there are unintended impacts related to the creation of environments suitable for the nesting of breeding birds or other species (nesting turtles). Should stockpiling of stripped soil or fill be conducted during the breeding bird window, there is a potential for birds such as Banks Swallows or Cliff Swallows to establish nests in newly exposed slopes that are greater than 3:1 in inclination. Once established, the nests cannot be disturbed until the young have fledged from the nests.

Other potential direct impacts may include incidental injury or mortality of common wildlife species that may occupy areas of the existing landfill site; these may include groundhogs, Killdeer, common snake species, etc.

Indirect Impacts

Potential indirect impacts of the construction phase include typical construction-related impacts including:

- Dust deposition on vegetation in adjacent vegetation communities;
- Noise related impacts to wildlife in adjacent habitat;
- Introduction of invasive plant species via construction equipment; and,
- Accidental injury or mortality of wildlife or vegetation (i.e., adjacent trees) from construction equipment and vehicles.

These indirect impacts are not considered significant and are mitigatable with standard measures.

4.2 Operations Stage

4.2.1 Aquatic Ecosystems

Direct Impacts

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During the Operations Stage of the expansion of the W12A Landfill direct impacts to aquatic ecosystems are not anticipated.

Indirect Impacts

While the proposed works associated with the Operations Stage for the preferred alternative are not expected to result in direct impacts to aquatic ecosystems, there will be changes to drainage areas and the resulting water balance. These changes are outlined in the *Stormwater Management Report –W12A Landfill Expansion* (Golder, 2020b) and include the following:

1. The reduction of surface water drainage to Dodd Creek from SWM Ponds 2/3, 4 and 5. The reduction in drainage area from pre-expansion to post-expansion is estimated to be 20.1 hectares, from 127.6 ha to 106.5 ha.

2. The increase in surface water drainage to Dingman Creek from Pond 1. The increase in drainage area from pre-expansion to post-expansion is estimated to be 20 hectares, from 14.5 ha to 34.5 ha.

The alteration to drainage areas for Dingman and Dodd Creek occur in the upper reaches of the subwatershed and represent a 0.12% decrease and 0.20% increase in overall subwatershed area, respectively. Additionally, discharge from the Site to the Dingman Creek subwatershed will be attenuated by Pond 1 to below pre-development flows up to and including the 1:100-yearreturn period design storm under the proposed design (Golder, 2020b). As such, these changes in drainage area are expected to have a negligible effect on runoff and drainage downstream of the Site in both the Dingman and Dodd Creek subwatersheds. Further, modifications to the existing SWM infrastructure, along with mitigation measures (i.e., erosion and sediment control), are expected to result in surface water quality conditions that are comparable to existing conditions and meet the MECP PWQOs (Golder, 2020b).

As described in the *Groundwater Impact Assessment – W12A Landfill Expansion EA* (Golder, 2020c). The existing landfill is located overlying a surficial aquitard of low permeability clayey till (15-20 m thick) and will not affect recharge of the groundwater system or groundwater levels/quantity. Therefore, the proposed vertical expansion is not anticipated to have any direct impacts downgradient groundwater levels or quantity off-site.

The above indirect impacts are not considered significant and are mitigatable with standard measures.

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4.2.2 Terrestrial Ecosystems

Direct Impacts

During the Operations Stage of the Landfill Expansion, potential direct impacts to terrestrial features and functions are anticipated from the progressive removal of grassland cover to facilitate the vertical expansion. These impacts are based on the Confirmed SWH for Monarch and SAR Habitat for grassland birds as described in **Section 4.1.2**. Although the aforementioned habitat will be removed for the proposed landfill expansion, these impacts will be temporary in nature as they will be revegetated when vertical capacity is reached to mimic habitat conditions currently present (e.g., grassland species, common milkweed). In addition to temporary habitat removal, accidental destruction of nests, stockpiling of stripped material creating nesting opportunities for birds, or wildlife mortality may occur as part of the Operations Stage (as outlined for the Construction Stage in **Section 4.1.2**). These occurrences can be avoided through the implementation of standard operational measures, the continuation of measures implemented during the Construction Stage, and potential compensation for SAR Habitat (as described in **Section 5.1**).

Indirect Impacts

During the Operations Stage of the expansion of the W12A Landfill, potential indirect impacts to terrestrial ecosystems are likely to be limited to the following types of impacts:

- Dust and airborne waste deposition in natural habitat;
- Noise related impacts to wildlife in adjacent habitat;
- Introduction of invasive plant species via construction equipment; and,
- Accidental injury or mortality of wildlife or vegetation (i.e., adjacent trees) from construction equipment and/or vehicles.

4.3 Closure and Post-Closure

4.3.1 Aquatic Ecosystems

Direct Impacts

Potential direct impacts to aquatic systems are not anticipated during closure and post-closure activities.

Indirect Impacts

Potential indirect impacts associated with closure and post-closure activities are limited to the management of leachate and stormwater management within the landfill. With the continued operation of the leachate control system and the proposed stormwater management system, indirect impacts as a result of landfill closure are not anticipated.

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4.3.2 Terrestrial Ecosystems

Direct Impacts

Activities associated with landfill closure include the addition of topsoil and plantings of native vegetation; as such, the project closure will result in an overall compensation for natural communities lost during construction and operations.

Indirect Impacts

Potential indirect impacts associated with closure and post-closure activities are limited to the management of leachate and stormwater management within the landfill. With the continued operation of the leachate control system and the proposed stormwater management system, indirect impacts as a result of landfill closure are not anticipated.

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5. Mitigation and Compensation

5.1 Construction Stage

Mitigation of Direct Impacts to Species at Risk and Wildlife

Natural heritage features and habitat are most susceptible during the construction stage of any project as site conditions are most substantially altered during this stage. Therefore, construction activities need to be mitigated and controlled to avoid significant adverse effects.

To avoid or minimize impacts related to the construction stage (as outlined in **Section 4.1**), a detailed Environmental Mitigation and Monitoring Plan (EMMP) will be developed. It is recommended that the EMMP be developed prior to the issuance of engineering drawings to allow for mitigation measures to be incorporated into contract drawings for future planning. The contents of the EMMP will be determined at Detailed Design, but may include typical construction mitigation measures such as erosion and sediment control, work area delineation, construction timing windows, etc.

Based on the proposed expansion, vegetation removal associated with the construction stage will be required. In order to avoid direct impacts to the SAR Birds, including Bobolink and Eastern Meadowlark, all habitat removal should occur outside of the bird nesting season (April 1 to August 31). This also avoids potential incidental take and therefore contravention of the *Migratory Bird Convention Act (MBCA)*. Should vegetation clearing be required during the nesting period, a nest search may be completed by a quality ecologist. Once the ecologist has confirmed no active nests are present, clearing may take place up to 24 hours after completion of the inspection. Nest searches should only be completed within simple habitats or where nests are conspicuous.

Based on the preferred alternative and its proximity to natural heritage features and significant species, the preparation and implementation of a Species at Risk and Wildlife Observation Protocol will be required. This protocol will outline the steps to take in the event of an encounter with wildlife, including Species at Risk (SAR), during the construction stage. Detailed information and specific requirements related to wildlife and SAR encounters will be incorporated in the protocol including proper species identification, taxa- or species-specific handling methods, and reporting of wildlife and SAR as required by provincial legislation.

Along with the Species at Risk and Wildlife Observation Protocol**,** further mitigation related to potential wildlife and SAR encounters during the construction stage will include the following items:

- Species Fact Sheets for SAR that may be encountered on-site during the construction stage will be posted on-site in the site office or trailer where it is visible to workers for review. These fact sheets will outline SAR identification and species-specific protocols in the event they are encountered.
- To ensure compliance with policy and the Species at Risk and Wildlife Observation Protocol, all persons entering the site will receive staff training outlining the proper identification, handling methods, any associated reporting of wildlife and/or SAR

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encounters, and steps to take to ensure compliance with the in the event of wildlife and SAR encounters.

Wildlife exclusionary fencing around the landfill, or portions of the landfill should be considered at Detailed Design to mitigation wildlife encounters on site during construction and operations.

Compensation Mitigation of Potential Impacts to SAR & Wildlife

As habitat for SAR grassland birds cannot be avoided within the proposed expansion alternative, compensation for habitat loss will be required as regulated under the ESA (O.Reg. 242/08). Consultation with the MECP will be required to determine appropriate compensation measures for Bobolink and Eastern Meadowlark. These measures may include enhancing existing grasslands in adjacent habitats or creating additional grassland habitats within the same eco-region. Further details on permitting requirements for SAR birds can be found in **Section 7.2**.

Compensation for Significant Wildlife Habitat for Monarch will be achieved at project closure with the implementation of native plantings which are recommended to include common milkweed (*Asclepias syriaca*), a host plant for the species.

5.2 Operations Stage

During the Operations Stage, standard mitigation measures for erosion and sediment control, dust suppression, timing of operations (e.g., 7am to 7pm), maintenance of the stormwater management system and facilities, and maintenance of the leachate treatment system will be required.

Based on the proposed expansion, vegetation removal associated with the operations stage will be required. To avoid direct impacts to the SAR Birds, including Bobolink and Eastern Meadowlark, all habitat removal should occur outside of the bird nesting season (April 1 to August 31). Further, mitigation measures outlined in **Section 5.1** should be implemented related to vegetation removal and nest searches. Although the vegetation removal during this stage will be progressive, with revegetation upon vertical landfill capacity for a given area, compensation (as described in **Section 5.1**) for the removal of SAR Habitat and SWH may be required as determined through consultation with MECP and other applicable regulatory agencies.

As heavy machinery activity will continue throughout the operations phase, considerations for wildlife exclusionary fencing and implementation of The Species at Risk and Wildlife Observation Protocol developed for the Construction Stage (as outlined in **Section 5.1**) should occur.

5.3 Closure and Post-Closure Stage

The Closure and Post-Closure stage of the project is self mitigating, as the site will be progressively top soiled and vegetated as landfilling is completed in the expansion phases. It is recommended that all plantings include native species that are known to occur within the region and may include compensation plantings as determined through consultation with the MECP for Bobolink and Eastern Meadowlark habitat compensation.

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6. Monitoring

6.1 Construction Stage

As mentioned in **Section 5.1**, an EMMP will be developed and will include a Construction Monitoring Plan that will outline monitoring activities to be completed during construction. These activities will include, but are not limited to, the following:

- Pre-construction inspection to confirm proper installation of ESC and any recommended wildlife exclusionary measures;
- Regular Erosion and Sediment Control (ESC) fencing monitoring and any exclusionary fencing measures; and,
- Training session for on-site personnel which summarizes mitigation measures.

6.2 Operations Stage

Monitoring during operations may include monitoring of any compensation measures necessary to meet MECP permitting or approval requirements for Bobolink and Eastern Meadowlark as well as standard water quality and quantity monitoring necessary to meet relevant provincial permitting and approvals. Monitoring requirements for Operations will be determined at the Detailed Design stage.

6.3 Closure and Post-Closure Stage

Monitoring of compensation plantings and SAR habitat will likely be required to meet requirements under the ESA (O.Reg 242/08). The closure and post-closure monitoring efforts will be determined at the Detailed Design Stage.

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7. Other Approvals

The proposed expansion for the W12A Landfill will require approvals other than the acceptance and approval of the Environmental Assessment (EA). Based on the layout, design and operation of the proposed expansion, approvals may be required under the following legislation:

1. Provincial: *Endangered Species Act*
2. Provincial: *Planning Act*
3. Provincial: *Conservation Authorities Act*
4. Municipal: *The London Plan*

The triggers for these legislation and general permit requirements are outlined in the following sections.

Note that the approvals outlined below all require specific information that can only be determined at the detailed design stage of planning and engineering.

7.1 Provincial

Endangered Species Act

The confirmed presence and breeding of two Species at Risk birds, Bobolink and Eastern Meadowlark, in the cultural meadow habitats (Patch P02) within the proposed expansion area of the W12A Landfill will require review and determination of permitting requirements under the *Endangered Species Act* (*ESA)*. Direct loss and/or damage of Bobolink and Eastern Meadowlark habitat is likely to occur during site preparation (e.g., vegetation stripping and site grading), construction of temporary stockpile areas, transportation of equipment and materials, and excavation. These activities may negatively affect Bobolink and Eastern Meadowlark habitat through direct removal of habitat, increased erosion and sedimentation; soil removal / disturbance and compaction; and accidental soil or water contamination by oils, gasoline, grease and other materials from construction equipment and materials storage or handling. It is possible that mitigation can be put into place to avoid or minimize the effects to the species. The proposed annual removal of habitat for these species is approximately 4ha per year with a totally removal of 63.19 ha. Consultation with the MECP will be required to determine whether the proposed works require a Notice of Activity or Overall Benefit Permit.

Planning Act – Provincial Policy Statement

The presence of Significant Wildlife Habitat (SWH) within and adjacent to the W12A Landfill expansion area triggers the requirement for an Environmental Impact Study (EIS) under the *Planning Act vis a vis* the *Provincial Policy Statement* (PPS). These policies include the exclusion of development within PSWs, habitat of END or THR species, fish habitat, as well as within Significant Wildlife Habitat (SWH), significant woodlands, significant valley lands, ANSIs or adjacent lands "…unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions" (MAH 2020).

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The requirement for an EIS as it relates to SWH may be met by the similar requirement under municipal policies, as noted in the next section (**Section 7.2**). This report is considered to meet the requirements for an EIS under the PPS.

Conservation Authorities Act

While the proposed expansion area for the preferred alternative does not directly overlap with the Regulation Limits for the Upper Thames River Conservation Authority (UTRCA) and the Kettle Creek Conservation Authority (KCCA), it does immediately abut limits for both authorities. It will, therefore, be prudent to engage both the UTRCA and KCCA in discussions to determine the potential requirements for a Section 28 Permit under the *Ontario Regulation 157/06* (UTRCA) and *Ontario Regulation 181/06* (KCCA) under the *Conservation Authorities Act.*

7.2 Municipal

The London Plan

The London Plan (2016) requires an EIS for any proposed works involving development and site alteration within or adjacent to the Natural Heritage System such that they will only be permitted after ecological functions have been evaluated and it is demonstrated that there will be no negative impacts to the Natural Heritage System. While not identified on The London Plan Natural Heritage Features mapping (Map 5), the presence of SAR Habitat and SWH within and adjacent to the proposed landfill expansion area triggers the requirement for an EIS.

As noted above, the preparation of an EIS can meet the requirements under the Provincial Policy Statement (2020) and The London Plan. The requirement for any additional work to meet the requirements for an EIS will be determined in consultation with the City of London (as outlined in **Section 2.2.11** and **7.1**).

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8. Conclusion

The Biology Existing Conditions and Impact Assessment Report for the W12A Landfill Expansion provides documentation of aquatic and terrestrial ecology field investigations, assessment of natural heritage features, an impact assessment for the proposed expansion, recommended mitigation measures, monitoring requirements, and other approval requirements.

Existing Conditions

The following existing natural heritage features and functions were identified for the Site Study Area and Site-vicinity Study Area:

Aquatic Habitat & Fisheries

- The Site Study Area and Site-vicinity Study Area contain three (3) watercourses (Bannister-Johnston Drain, Unnamed Drain, and C.B. Smith Drain) that have the potential to support fish and fish habitat that are regulated under the *Fisheries Act*. However, no important or exceptional fish habitat was observed during field investigations.
- All sites sampled for benthic invertebrates had impaired to very poor water quality based on a BioMAP Water Quality Index (WQI) rating less than 14, and a Hilsenhoff Biotic Index (HBI) rating was above 7.26.

Terrestrial Ecosystems and Species

- Identified Natural Heritage Features in the Site Study Area and Site-vicinity Study Area included Significant Woodlands, Unevaluated Wetlands, Locally Significant Wetland (Silver Swamp), Valleylands, and a Potential ESA based on the review of MNHSS criteria (2014) and the London Plan (2017).
- Candidate habitat for Species at Risk (SAR) bats and Bat Maternity Colonies Significant Wildlife Habitat (SWH) was identified within the Site Study Area and Site-vicinity Study Area.
- Bobolink and Eastern Meadowlark were confirmed breeding within the Site Study Area and Site-vicinity Study Area during field investigations. Further, Bank Swallow and Barn Swallow were observed foraging within the Study Area; however, no nests were observed, and direct habitat was considered absent.
- Special Concern and Rare Wildlife Species Habitat (SWH) for Eastern Wood-Pewee and Monarch was confirmed within the Site Study Area and Site-vicinity Study Area.
- Additionally, Terrestrial Crayfish SWH was confirmed and Candidate habitat for Turtle Wintering Areas was identified within the Site Study Area and Site-vicinity Study Area.

Within the area of the proposed expansion only the following were confirmed:

- Bobolink and Eastern Meadowlark breeding (SAR) habitat was confirmed within the proposed expansion area.
- Special Concern and Rare Species Habitat (SWH) for Monarch was identified within the proposed expansion area.

Impacts of the Preferred Alternative

With the selection of the Preferred Expansion Alternative involving a vertical lift on the existing landfill area, many potential impacts to adjacent natural heritage features are avoided. However,

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with the presence of SAR habitat for Bobolink and Eastern Meadowlark and SWH for Monarch on the existing landfill, certain impacts are unavoidable.

During the Construction Phase, the following potential impacts can be anticipated:

Potential Impacts to Aquatic Habitat & Fish:

- No direct impacts to fish or fish habitat are anticipated as all aquatic habitat is outside of the area of the proposed expansion;

Potential Impacts to Terrestrial Habitat & Species

- Loss of SAR Habitat for Eastern Meadowlark and Bobolink related to the clearing of existing vegetation cover to excavate trenches, construct the MRF, and add finger drains;
- Loss of SWH for Monarch;
- Dust deposition on vegetation in adjacent vegetation communities;
- Noise related impacts to wildlife in adjacent habitat;
- Introduction of invasive plant species via construction equipment;
- Disturbance, accidental injury or mortality of wildlife or vegetation (i.e. adjacent trees) from construction equipment and vehicles

Mitigation & Compensation

The following mitigation and compensation measures will be required for the Construction and Operations Stages;

- Preparation and implementation of an Environmental Mitigation and Monitoring Plan (EMMP);
- Preparation and implementation of a Species at Risk and Wildlife Handling Protocol;
- Restriction of vegetation clearing to periods outside of the breeding bird timing window (April 1st to August 31st); clearing may only take place from September 1st to March 31st;
- To avoid birds such as Banks Swallows from nesting in topsoil or excavated material piles, the slopes of piles should be less than 70 degrees;
- Compensation for the loss of Eastern Meadowlark and Bobolink habitat will be required as part of the conditions of a permit under the *Endangered Species Act.* While the details of compensation are subject to a submission and proposal for compensation at the Detailed Design stage, it can be expected that some measures may include enhancement of existing habitats on adjacent lands, or creation of new habitat within the same EcoRegion;
- Compensation for loss of SWH for Monarch will also be required. Compensation measures may include the enhancement of habitats (planting of common milkweed, butterfly weed, etc) within or adjacent to the site, or the creation of new meadow habitat with native plant species including common milkweed.

Each of the above noted mitigation or compensation measures will need to be developed at the Detailed Design stage of planning and engineering, and hence are provided herein as general requirements.

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Other Approvals

The preferred expansion alternative for the W12A Landfill will require approvals other than the acceptance and approval of the Environmental Assessment (EA). Based on the layout, design and operation alternative approvals may be required under the following legislation:

Provincial: Endangered Species Act
Provincial: Planning Act
Provincial: Conservation Authorities Act
Municipal: The London Plan

The triggers for these legislation and general permit requirements are outlined in Section 7.0. Specific permitting requirements will require specifications that will be determined at the Detailed Design stage of planning and engineering. At that stage, and with further consideration of specific mitigation measures, it is possible that not all of the above approvals are required.

Conclusion

The proposed expansion of the W12A Landfill is expected to result in several impacts to natural heritage features and functions. Overall, the impacts are considered to be low and can be mitigated with the implementation of the mitigation measures identified in this report. With enhanced mitigation and compensation measures there is potential for a net benefit. The details of the mitigation measures and confirmation of net benefit will require additional development at the Detailed Design stage.

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9. References

BioLogic Incorporated. 2013. Natural Environment Assessment Report: Level 1&2 Assessment Report. Prepared for AAROC Aggregates Ltd. January 14, 2013. 75 pp.

Bird Studies Canada, Environment Canada's Canadian Wildlife Service, Ontario Nature, Ontario Field Ornithologists and Ontario Ministry of Natural Resources. 2006. Ontario Breeding Bird Atlas Website. http://www.birdsontario.org/atlas/index.jsp

Chapman, L.J, and D.F. Putnam.1984. The Physiography of Southern Ontario. Ontario Ministry of Natural Resources. 270 pp.

City of London. (2017). The London Plan. Available at: https://www.london.ca/business/Planning-Development/Official-Plan/Pages/The-London-Plan.aspx

Earth Tech. (2005). W12A Landfill Area Plan Study – Ecological Background Study and Natural Heritage Study. Prepared for the City of London.

Environment Canada – Canadian Wildlife Service (EC-CWS). 2009. Forest Bird Monitoring Program Survey Instructions & Codes. May 2009 Edition.

Environment Canada - Canadian Wildlife Services. 2019. Guidelines to reduce risk to migratory birds. Environment Canada. Available at: https://www.canada.ca/en/environment-climate-change/services/avoiding-harm-migratory-birds/reduce-risk-migratory-birds.html

Fisheries and Oceans Canada (DFO). 2018. Aquatic Species at Risk Map tool. Accessed March, 2019. Available: http://www.dfo-mpo.gc.ca/species-especes/sara-lep/map-carte/index-eng.html

Golder. 2020a. Volume I Environmental Assessment of the Proposed W12A Landfill Expansion, City of London.

Golder. 2020b. Stormwater Management Report – W12A Landfill Expansion, City of London, Ontario.

Golder. 2020c. Groundwater Impact Assessment – W12A Landfill Expansion EA, City of London, Ontario.

Government of Canada. 2002. Species at Risk Act (SARA). Accessed March 2019 from: https://laws-lois.justice.gc.ca/PDF/S-15.3.pdf

Hagerty. T.P., and M.S. Kingston. 1992. The soils of Middlesex County. Ontario Centre for Soil Resource Evaluation Report No. 56. Ontario Ministry of Agriculture and Food, Resource Management Branch, Guelph, ON, Canada.

Kettle Creek Conservation Authority (KCCA). 2013. Kettle Creek Watershed Report Card.

DRAFT

Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurry, 1998: Ecological Land Classification for Southern Ontario: First Approximation and its Application. Ontario Ministry of Natural Resources, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02.

Middlesex County. 2014. Middlesex Natural Heritage Systems Study: A study to identify natural heritage systems in Middlesex County. Project management by Upper Thames River Conservation Authority in cooperation with Middlesex County Conservation Authorities.

Marsh Monitoring Program Participant's Handbook Surveying Amphibians. 2008 Edition. 20 Pages. Published by Bird Studies Canada in cooperation with Environment Canada and the U.S Environmental Protection Agency. February 2008.

Ministry of Municipal Affairs and Housing (MAH). 2020. 2020 Provincial Policy Statement. Provincial Planning Policy Branch. Queen's Printer for Ontario.

North-South Environmental Inc. 2009. City of London Inventory and Evaluation of Woodlands. Prepared for the City of London.

Oldham, M.J., W.D. Bakowsky and D.A. Sutherland. 1995. Floristic quality assessment system for Southern Ontario. Ontario Ministry of Natural Resources, Natural Heritage Information Centre. Peterborough, Ontario.

Ontario Breeding Bird Atlas. 2001. Guide for Participants. Atlas Management Board, Federation of Ontario Naturalists, Don Mills.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2000. Significant Wildlife Habitat Technical Guide. October. Queen's Printer for Ontario. 151 pp.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2010: Natural Heritage Reference Manual for Natural Heritage Policies of the Provincial Policy Statement 2005. Queen's Printer for Ontario.

Ministry of Natural Resources and Forestry (OMNRF) Guelph District, 2012: Bobolink Survey Methodology.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2013. Ontario Wetland Evaluation System Southern Manual. 3rd Edition, Version 3.3. Queen's Printer for Ontario.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2014. Species at Risk in Ontario. Accessed March 2019 at: https://www.ontario.ca/environment-and-energy/species-risk-ontario-list

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2014a. Species at Risk – Barn Swallow. © Queen's Printer for Ontario, 2012-14. Available on the internet at: http://www.ontario.ca/environment-and-energy/barn-swallow

DRAFT

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2014b. Species at Risk – Little Brown Myotis. © Queen's Printer for Ontario, 2012-14. Available on the internet at: http://www.ontario.ca/environment-and-energy/little-brown-bat

Ontario Ministry of Natural Resources and Forestry(OMNRF). 2014c. Species at Risk – Northern Myotis. © Queen's Printer for Ontario, 2012-14. Available on the internet at: http://www.ontario.ca/environment-and-energy/northern-long-eared-bat

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2015. Significant Wildlife Habitat Criteria Schedules for Ecoregion 7E. January 2015.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2015a. General Habitat Description for the Bank Swallow (*Riparia riparia*). July 2015. Available on the internet at: https://ossga.com/multimedia/0/bank_swallow_ghd_en.pdf

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2015b. General Habitat Description for the Barn Swallow (*Hirundo rustica*). 2015. Available on the internet at: https://files.ontario.ca/environment-and-energy/species-at-risk/mnr_sar_ghd_brn_swllw_en.pdf

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2016. Survey Protocol for Ontario's Species at Risk Snakes. Ontario Ministry of Natural Resources and Forestry, Species Conservation Policy Branch. Peterborough, Ontario. ii + 17 pp.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2017. Survey Protocol for Species at Risk Bats within Treed Habitats. Ministry of Natural Resources and Forestry – Guelph District. April 2017.

Ontario Ministry of Natural Resources and Forestry (OMNRF). 2018: Make a Map: Natural Heritage Areas Application. Accessed December 2018 from: http://www.gisapplication.lrc.gov.on.ca/mamnh/Index.html?site=MNR_NHLUPS_NaturalHeritage&viewer=NaturalHeritage&locale=en-US

Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA). 2019. AgMaps online mapping tool. Accessed March 2019 at: https://www.gisapplication.lrc.gov.on.ca/AIA/index.html?viewer=AIA.AIA&locale=en-US

Ontario Nature. 2009. Ontario Nature's Ontario Breeding Bird Atlas. Accessed January, 2019.

Ontario Nature. 2015. Ontario Reptile and Amphibian Atlas Program. Accessed January 2019 from: https://ontarionature.org/oraa/maps/

Ontario Nature. 2017. Ontario Reptile and Amphibian Atlas Program. Accessed January 2019 from: https://ontarionature.org/oraa/maps/

Upper Thames River Conservation Authority (UTRCA). 2017. Dingman Creek Watershed Report Card.

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