

APPENDIX D

WATER BALANCE TABLES

TABLE B.1 - Climate Data

Fergus Shand Dam Station, Ontario

Latitude: 43°44' N

Longitude: 80°19' W

Elevation: 417.6 m

Temperature: Temperature:	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Average (°C)	-7.4	-6.3	-1.9	5.7	12.2	17.5	20.0	19.0	14.9	8.3	2.1	-3.9	6.7
Rainfall (mm)	27.8	25.3	36.7	67.9	86.8	83.8	89.2	96.6	93.1	75.6	80.5	34.7	798
Snowfall (mm)	40.1	30.6	22.9	6.2	0.1	0.0	0.0	0.0	0.0	1.6	12.5	33.9	147.9
Precipitation (mm)	67.9	55.9	59.6	74.1	86.9	83.8	89.2	96.6	93.1	77.2	93.0	68.6	945.9

TABLE B.2

Pre- and Post-Development Water Balance Components Based on Thornthwaite's Soil Moisture Balance Approach													
Potential Evapotranspiration Calculation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Davily Average Temperature (°C)	-7	-6	-2	6	12	18	20	19	15	8	2	-4	7
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.22	3.86	6.66	8.16	7.55	5.22	2.15	0.27	0.00	35.1
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	26.65	59.36	86.76	99.85	94.61	73.26	39.58	9.32	0.00	489
Adjusting Factor K for U (Latitude 43° 44' N)	0.77	0.87	0.99	1.11	1.23	1.29	1.27	1.17	1.05	0.92	0.80	0.74	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	73	112	127	111	77	36	7	0	573
PRE-DEVELOPMENT WATER BALANCE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	946
Potential Evapotranspiration (PET)	0	0	0	30	73	112	127	111	77	36	7	0	573
P - PET	68	56	60	44	14	-28	-37	-14	16	41	86	69	373
Change in Soil Moisture Storage	0	0	0	0	0	-28	-37	-14	16	41	23	0	0
Soil Moisture Storage (Assume January Soil Moisture Storage = 100% SMS)	250	250	250	250	250	222	184	170	186	227	250	250	
Actual Evapotranspiration (AET)	0	0	0	30	73	112	127	111	77	36	7	0	573
Soil Moisture Deficit (in mm)	0	0	0	0	0	28	66	80	64	23	0	0	
Surplus - available for infiltration or runoff	68	56	60	44	14	0	0	0	0	0	63	69	373
Potential Infiltration (based on MOE methodology*; independent of temperature)	34.0	28.0	29.8	22.2	6.9	0.0	0.0	0.0	0.0	0.0	31.4	34.3	187
Potential Surface Water Runoff (independent of temperature)	34.0	28.0	29.8	22.2	6.9	0.0	0.0	0.0	0.0	0.0	31.4	34.3	187
POST- DEVELOPMENT WATER BALANCE ON IMPERVIOUS AREAS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	946
Potential Evaporation (PE) from impervious areas (assume 20%)	13.6	11.2	11.9	14.8	17.4	16.8	17.8	19.3	18.6	15.4	18.6	13.7	189
P-PE (surplus available from impervious areas)	54	45	48	59	70	67	71	77	74	62	74	55	757
Water surplus change compared to pre-condition (for areas that change from vegetated open areas to impervious areas)	-14	-11	-12	15	56	67	71	77	74	62	12	-14	384

Soil Moisture Storage 250
PE from impervious areas % 20

*MOE SWM infiltration factor calculation	
topography - Rolling land (approximately 2.8 to 3.8m/km)	0.2
soils - relatively tight silty clay till materials	0.2
cover - predominantly cultivated land	0.1
Infiltration Factor	0.5

TABLE B.3 - Annual Pre-Construction Water Balance

	Pre-Construction		
	Unpaved Areas	Impervious Areas (building)	Totals
Area	403000	1000	404000
Pervious Area	403000	0	403000
Impervious Area	0	1000	1000
Infiltration Factors			
Topography Infiltration Factor	0.2	0.15	
Soil Infiltration Factor	0.2	0.1	
Land Cover Infiltration Factor	0.1	0	
MOE Infiltration Factor	0.5	0.25	
Actual Infiltration Factor	0.5	0	
Runoff Coefficient Pervious Surfaces	0.5	1	
Runoff from Impervious Surfaces	0	0.8	
Inputs (per Unit Area)			
Precipitation (mm/yr)	946	946	946
Run-On (mm/yr)	0	0	0
Other Inputs (mm/yr)	0	0	0
Total Inputs (mm/yr)	946	946	946
Outputs (per Unit Area)			
Precipitation Surplus (mm/yr)	373	757	374
Net Surplus (mm/yr)	373	757	374
Evapotranspiration (mm/yr)	573	189	572
Infiltration (mm/yr)	187	0	186
Rooftop Infiltration (mm/yr)	0	0	0
Total Infiltration (mm/yr)	187	0	186
Runoff Pervious Areas	187	0	186
Runoff Impervious Areas	0	757	2
Total Runoff (mm/yr)	187	757	188
Total Outputs (mm/yr)	946	946	946
Difference (Inputs - Outputs)	0	0	
Inputs (Volumes)			
Precipitation (m3/yr)	381198	946	382144
Run-On (m3/yr)	0	0	0
Other Inputs (m3/yr)	0	0	0
Total Inputs (m3/yr)	381198	945.9	382144
Outputs (Volumes)			
Precipitation Surplus (m3/yr)	150360	757	151117
Net Surplus (m3/yr)	150360	757	151117
Evapotranspiration (m3/yr)	230838	189	231027
Infiltration (m3/yr)	75180	0	75180
Rooftop Infiltration (m3/yr)	0	0	0
Total Infiltration (m3/yr)	75180	0	75180
Runoff Pervious Area (m3/yr)	75180	0	75180
Runoff Impervious Areas (m3/yr)	0	757	757
Total Runoff (m3/yr)	75180	757	75937
Total Outputs (m3/yr)	381198	946	382144
Difference (Inputs - Outputs)	0	0	0

* Evaporation from impervious areas was assumed to be 20% of precipitation

TABLE B.4 - WATER BALANCE COMPONENTS FOR CASE WHERE RUNOFF IS DIRECTED TO PERVIOUS AREAS

POTENTIAL EVAPOTRANSPIRATION CALCULATION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average Temperature (° C)	-7.4	-6.3	-1.9	5.7	12.2	17.5	20.0	19.0	14.9	8.3	2.1	-3.9	6.7
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.22	3.86	6.66	8.16	7.55	5.22	2.15	0.27	0.00	35.1
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	26.65	59.36	86.76	99.85	94.61	73.26	39.58	9.32	0.00	489
Adjusting Factor K for U (Latitude 43° 44' N)	0.77	0.87	0.99	1.11	1.23	1.29	1.27	1.17	1.05	0.92	0.80	0.74	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	73	112	127	111	77	36	7	0	573
POST-DEVELOPMENT WATER BALANCE													
Pervious areas will receive rainfall plus some runoff from impervious areas, so the following balance calculations use this total water supply to assess potential infiltration.													
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	946
Potential Evaporation (PE) from impervious areas (assume 20% of P)	14	11	12	15	17	17	18	19	19	15	19	14	189
P-PE (surplus available for runoff from impervious areas)	54	45	48	59	70	67	71	77	74	62	74	55	757
WAT (Total water supply to pervious areas = rain plus impervious area runoff)	122	101	107	133	156	151	161	174	168	139	167	123	1703
Potential Evapotranspiration from pervious areas (PET)	0	0	0	30	73	112	127	111	77	36	7	0	573
WAT - PET	122	101	107	104	83	39	34	63	91	103	160	123	1130
Change in Soil Moisture (mm)	0	0	0	0	0	0	0	0	0	0	0	0	0
Soil Moisture Storage (mm)*	125	125	125	125	125	125	125	125	125	125	125	125	
Actual Evapotranspiration (AET)	0	0	0	30	73	112	127	111	77	36	7	0	573
Total surplus - available for infiltration or runoff on pervious areas	122	101	107	104	83	39	34	63	91	103	160	123	1130
Estimate of I and R (based on MOE infiltration factor)*													
Potential Infiltration* (based on soil conditions; independent of temperature)	55.0	45.3	48.3	46.6	37.5	17.5	15.3	28.3	40.9	46.2	72.0	55.6	508
Potential Surface Water Runoff (independent of temperature)	67.2	55.3	59.0	57.0	45.9	21.4	18.7	34.6	50.0	56.4	87.9	67.9	621
Estimate of I and R (based on MOE Factors and CA Guideline assumption of a 10% reduction in infiltration reduction related to soil compaction)													
Potential Infiltration (based on soil conditions; independent of temperature)	49.5	40.8	43.4	42.0	33.8	15.7	13.8	25.5	36.8	41.6	64.8	50.0	458
Potential Surface Water Runoff (independent of temperature)	72.7	59.9	63.8	61.7	49.6	23.1	20.2	37.5	54.1	61.0	95.1	73.5	672

Max SMS 125
PE from impervious areas % 20

*MOE SWM infiltration factor calculation	
topography - flat to rolling	0.2
soils - tight sandy to clayey silt till	0.2
cover - predominantly impervious paved surface	0.05
Infiltration Factor	0.45

TABLE B.5 - Annual Post-Construction Water Balance without LID

	Unpaved Areas	Impervious Areas (Paved/Buildings)	Water (Pond)	Totals
Area	138260	237640	28100	404000
Pervious Area	138260	0	0	138260
Impervious Area	0	237640	28100	265740
Infiltration Factors				
Topography Infiltration Factor	0.2	0	0	
Soil Infiltration Factor	0.2	0	0	
Land Cover Infiltration Factor	0.05	0	0	
MOE Infiltration Factor	0.45	0	0	
Actual Infiltration Factor	0.55	0	0	
Runoff Coefficient Pervious Surfaces	0.45	1	1	
Runoff from Impervious Surfaces	0	0.8	0.8	
Inputs (per Unit Area)				
Precipitation (mm/yr)	946	946	946	946
Run-On (mm/yr)	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0
Total Inputs (mm/yr)	946	946	946	946
Outputs (per Unit Area)				
Precipitation Surplus (mm/yr)	373	757	757	625
Net Surplus (mm/yr)	373	757	757	625
Evapotranspiration (mm/yr)	573	189	189	320
Infiltration (mm/yr)	205	0	0	70
Rooftop Infiltration (mm/yr)	0	0	0	0
Total Infiltration (mm/yr)	205	0	0	70
Runoff Pervious Areas	168	0	0	57
Runoff Impervious Areas	0	757	757	498
Total Runoff (mm/yr)	168	757	757	555
Total Outputs (mm/yr)	946	946	946	946
Difference (Inputs - Outputs)	0	0	0	
Inputs (Volumes)				
Precipitation (m3/yr)	130780	224784	26580	382144
Run-On (m3/yr)	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0
Total Inputs (m3/yr)	130780	224784	26580	382144
Outputs (Volumes)				
Precipitation Surplus (m3/yr)	51585	179827	21264	252676
Net Surplus (m3/yr)	51585	179827	21264	252676
Evapotranspiration (m3/yr)	79195	44957	5316	129468
Infiltration (m3/yr)	28372	0	0	28372
Rooftop Infiltration (m3/yr)	0	0	0	0
Total Infiltration (m3/yr)	28372	0	0	28372
Runoff Pervious Area (m3/yr)	23213	0	0	23213
Runoff Impervious Areas (m3/yr)	0	179827	21264	201091
Total Runoff (m3/yr)	23213	179827	21264	224304
Total Outputs (m3/yr)	130780	224784	26580	382144
Difference (Inputs - Outputs)	0	0	0	0

* Evaporation from impervious areas was assumed to be 20% of precipitation

TABLE B.6 - Annual Post-Construction Water Balance with LID

	Unpaved Areas (Landscape)	Impervious Areas (Roads/Buildings)	LID (Infiltration Trenches)	Water	Totals
Area	74270	101700	199930	28100	404000
Pervious Area	74270	0	0	0	74270
Impervious Area	0	101700	199930	28100	329730
Infiltration Factors					
Topography Infiltration Factor	0.2	0	0	0	
Soil Infiltration Factor	0.2	0	0	0	
Land Cover Infiltration Factor	0.05	0	0	0	
MOE Infiltration Factor	0.45	0	0	0	
Actual Infiltration Factor	0.55	0	0	0	
Runoff Coefficient Pervious Surfaces	0.45	1	1	1	
Runoff from Impervious Surfaces	0	0.8	0.8	0.8	
Inputs (per Unit Area)					
Precipitation (mm/yr)	946	946	946	946	946
Run-On (mm/yr)	0	0	0	0	0
Other Inputs (mm/yr)	0	0	0	0	0
Total Inputs (mm/yr)	946	946	946	946	946
Outputs (per Unit Area)					
Precipitation Surplus (mm/yr)	373	757	757	757	686
Net Surplus (mm/yr)	373	757	757	757	686
Evapotranspiration (mm/yr)	573	189	189	189	260
Infiltration (mm/yr)	205	0	0	0	38
LID (mm/yr)	0	0	306	0	152
Total Infiltration (mm/yr)	205	0	306	0	189
Runoff Pervious Areas	168	0	0	0	31
Runoff Impervious Areas	0	757	450	757	466
Total Runoff (mm/yr)	168	757	450	757	497
Total Outputs (mm/yr)	946	946	946	946	946
Difference (Inputs - Outputs)	0	0	0		
Inputs (Volumes)					
Precipitation (m3/yr)	70252	96198	189114	26580	382144
Run-On (m3/yr)	0	0	0	0	0
Other Inputs (m3/yr)	0	0	0	0	0
Total Inputs (m3/yr)	70252	96198	189114	26580	382144
Outputs (Volumes)					
Precipitation Surplus (m3/yr)	27710	76958	151291	21264	277224
Net Surplus (m3/yr)	27710	76958	151291	21264	277224
Evapotranspiration (m3/yr)	42542	19240	37823	5316	104920
Infiltration (m3/yr)	15241	0	0	0	15241
Rooftop Infiltration/Other LID (m3/yr)	0	0	61273	0	61273
Total Infiltration (m3/yr)	15241	0	61273	0	76514
Runoff Pervious Area (m3/yr)	12470	0	0	0	12470
Runoff Impervious Areas (m3/yr)	0	76958	90018	21264	188240
Total Runoff (m3/yr)	12470	76958	90018	21264	200709
Total Outputs (m3/yr)	70252	96198	189113	26579	382143
Difference (Inputs - Outputs)	0	0	0	0	1

* Evaporation from impervious areas was assumed to be 20% of precipitation