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April 24, 2015

Via: Email

Mr. Mike Baldesarra
David Schaeffer Engineering Limited
600 Alden Road, Suite 500
Markham ON L3R 0E7

Dear Mr. Baldesarra:

Re: Water Balance Assessment
Saw Whet (Bronte Green) Property, Oakville, Ontario
Project No.: 300031495.0000

R.J. Burnside & Associates Limited (Burnside) completed a hydrogeological assessment of the Merton Tertiary Planning Area (TPA) in the Town of Oakville. The findings of this hydrogeological assessment are presented in the Burnside report entitled “Hydrogeological Study, Merton Tertiary Planning Area, Town of Oakville, Ontario” dated December 2013 (Revised October 2014). The report included detailed water balance calculations for the entire TPA based on three proposed land use options.

The Saw Whet property (also referred to as the Bronte Green property and referred to herein as the Subject Property) is located within the TPA at the southeast corner of Bronte Road and Upper Middle Road. Burnside completed a detailed hydrogeological assessment for the Subject Property, which was included in the Merton TPA study.

As the Subject Property proceeds to Draft Plan submission, a preferred land use concept has now been chosen. David Schaeffer Engineering Limited (DSEL) is completing an assessment of the surface water conditions and stormwater management for the Subject Property. As per DSEL’s request, Burnside has refined the groundwater balance calculations for the Subject Property based on the selected land use concept to provide DSEL with target infiltration volumes for the design of Low Impact Development (LID) measures for stormwater management to promote infiltration. In addition, feature-based groundwater balance calculations have been completed for the Tributary 14W-W1 catchment area. These calculations provide a specific infiltration target for the catchment such that groundwater recharge and subsequent discharge conditions along the watercourse can be maintained.

Water balance calculations for the Subject Property were provided in the Water Balance Assessment letter prepared by Burnside dated January 12, 2015. This updated letter is based on the updated draft plan and addresses the proposed changes to the draft plan layout. The updated water balance calculations are provided in the attached Tables 1 to 7, and are discussed below.

1.0 Water Balance – Existing Conditions

Water balance calculations were completed for the Subject Property using a soil-moisture balance approach, which assumes that soils do not release water as potential infiltration while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration.

A soil moisture storage capacity of 100 mm was selected for golf course and landscaped areas with short-rooted vegetation and 400 mm was selected for the wooded areas which have deeper-rooted vegetation. The attached Tables 1 and 2 detail the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculate the actual evapotranspiration and water surplus components of the water balance based on the monthly precipitation and soil moisture conditions for each of these vegetation types. Climate data from the Hamilton RBG climate station were used.

The MOE SWM Planning and Design Manual (2003) methodology for calculating total infiltration based on topography, soil type and land cover was used and a corresponding runoff component was calculated for the soil moisture storage conditions. The calculated water balance components from Tables 1 and 2 were then used to assess the pre-development infiltration volume as presented on Table 3.

The monthly water balance calculations show that a water surplus is generally available from November to May for the short-rooted vegetation (Table 1) and from December to May for the deeper-rooted vegetation (Table 2). Infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. In winter climates, frozen conditions affect when the actual infiltration will occur, however, the monthly balance calculations show the potential volumes available for this water balance component. The monthly calculations are summed to provide estimates of the annual water balance component values (Tables 1 and 2). The average annual infiltration is estimated to be 126 mm/year in the landscaped areas and 120 mm/year in the wooded areas.

The total area of the Subject Property is approximately 55 ha. Based on the component values calculated in Tables 1 and 2, the total pre-development infiltration volume for the Subject Property is calculated to be about 68,000 m^3/year (Table 3).

It is acknowledged that the infiltration and runoff values presented in Table 1 and Table 2 are estimates. Single values are used for the water balance calculations, but it is important to understand that infiltration rates are dependent upon the hydraulic conductivity of the surficial soils which may vary over several orders of magnitude. As such, the margins of error for the calculated infiltration and runoff component values are potentially quite large. These margins of error are recognized, but for the purposes of this assessment, the numbers used in the water balance calculations are considered reasonable estimates based on the site-specific conditions and useful for comparison of pre- to post-development conditions.

2.0 Potential Development Impacts to Water Balance

Urban development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (i.e., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the soils and the removal of the vegetation removes the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (65% to 70% of precipitation). So the net effect of the construction of impervious surfaces is that most of the precipitation that falls onto impervious surfaces becomes surplus water and direct runoff. The natural infiltration component is reduced.

The increases in surface water runoff that will occur with urban development are typically addressed through the use of appropriate stormwater management techniques to control flows to the watercourses. Details of the stormwater management strategies for the property are provided in the Functional Servicing Report (including the Stormwater Management Report) prepared by David Schaeffer Engineering Limited (December, 2014).

3.0 Post-Development Water Balance with No Stormwater Management Mitigation Measures

3.1 Overall Property Water Balance

The proposed development concept for the Subject Property has been broken down into various land use areas and DSEL has assigned each land use an average percentage of imperviousness. These data have been used to calculate the potential post-development infiltration volume assuming no mitigation measures are in place (Table 3). These calculations are presented as a 'worst-case scenario' of potential development impacts and allow the quantification of an infiltration target for LID and mitigation strategy design to maintain the natural recharge conditions.

Based on the proposed land use analysis, the total post-development infiltration for the site is estimated to be about 29,000 m^3/year (Table 3). These calculated volumes show that without mitigation, there is potential for a decrease in infiltration across the Subject Property of about 39,000 m^3/year (57%). Therefore, this volume becomes the target for post-development stormwater management and infiltration techniques to try to maintain the natural recharge conditions (Table 3).

3.2 Feature-Based Water Balance

It is important to ensure that the infiltration volume in the catchment area to Tributary 14W-W1 can be maintained as close as possible to the pre-development infiltration volume, such that the groundwater contributions to baseflow are maintained. A large portion of the catchment area to Tributary 14W-W1 is proposed for residential development. A feature-based water balance was completed to determine the potential change in infiltration volumes that may occur specifically within the surface-water catchment area to this watercourse. The same methodology and water balance components described above were used to calculate the pre-development infiltration volume.

The portion of the Saw Whet property within the catchment area to Tributary 14W-W1, including the portion of the Natural Heritage System adjacent to the property is approximately 22 ha, and the area of the wooded area was estimated from aerial photography to be approximately 7 ha.

The water balance component values from Tables 1 and 2 were used to calculate the average annual volume of infiltration across this catchment. Based on these component values, the average pre-development infiltration volume is estimated to be approximately 27,000 m^3/year (Table 6).

Post-development water balance calculations were completed based on the proposed land use concept, as shown in Table 6. These calculations assume no mitigation measures are in place, and show a potential decrease in infiltration volume of 11,000 m^3/year (42%).

4.0 Proposed Water Balance Mitigation Strategies

The water balance calculations discussed above in Section 3.0 suggest that, without mitigation, the Subject Property will receive about 43% of the current amount of average annual groundwater infiltration, and the infiltration volume in the specific portion of the Subject Property contributing to Tributary 14W-W1 could be reduced by about 42%. As recommended in the Merton TPA report, LID measures for stormwater management will be used to promote infiltration. The goal is to ensure the post-development groundwater infiltration volume is maintained as close to the pre-development infiltration volume as possible. This is particularly important to maintain the discharge of shallow groundwater that occurs along Fourteen Mile Creek and supports baseflow in this watercourse.

As outlined in the MOE SWMP Design Manual (2003) and Low Impact Development Stormwater Management Planning and Design Guide published by the CVC and TRCA (2010), a suite of techniques may be considered to promote infiltration. These include such measures as permeable pavements, rain gardens, bioswales, subsurface infiltration trenches, galleries and pervious pipe systems. It is noted, however, that subsurface infiltration methods should only be considered in areas where there is sufficient depth to water table to accommodate the system within the unsaturated zone.

DSEL has advised that LID measures designed to promote infiltration will be employed in the proposed development. These measures will include directing roof runoff from low and medium density residential areas to pervious areas such as lawns, side and rear yard swales and other open space areas throughout the development where possible and increasing the topsoil thickness by about 1.5 times the normal thickness (i.e., from 20 cm to about 30 cm). These types of LID measures promote infiltration by providing additional water volumes in the pervious areas. This may be particularly effective in the summer months, when natural infiltration would not generally occur because the additional water overcomes the soil moisture deficit. An assessment of the potential effectiveness of these LID measures for the Subject Property is discussed below.

Quantification of surficial LID techniques is challenging and there are no widely accepted quantification standards. However, as an example to demonstrate the effectiveness of these types of mitigation measures, the water balance components were recalculated for areas where the roof runoff is directed to grass (Table 4). These areas would receive precipitation (893 mm/year) as well as extra water from roof runoff (759 mm/year). Over the available lawn areas, this would be equivalent to providing a total annual water supply of 1,462 mm/year in the low density residential areas and 1,976 mm/year in the medium density residential areas. Under these conditions of increased water supply, evapotranspiration can occur at the maximum potential rate, leaving a water surplus of 836 mm/year and 1,351 mm/year in the low and medium density residential areas, respectively (Table 4). Again using the MOE SWM

Planning and Design Manual (2003) methodology, the potential infiltration that could occur in pervious areas under these conditions of increased water supply is 418 mm/year and 675 mm/year, respectively. The remainder of the surplus water becomes runoff (Table 4). The pre-development infiltration in the proposed development area was calculated to be about 126 mm/year; therefore, these calculations show that the potential infiltration in areas receiving extra water supply can be much higher than natural conditions.

To assess the potential effectiveness of the LID measures for the proposed development, water balance calculations have been completed assuming that half of the runoff from the roofs in the low density and medium density residential areas is directed to pervious areas and that the average topsoil depth is increased to assist with water retention. These calculations are provided in Table 5 for the overall Subject Property and in Table 7 for the Tributary 14W-W1 catchment. The calculations suggest that the use of such LID measures will maintain approximately 90% of the pre-development infiltration volume. The overall groundwater contribution to the watercourses is very small in relation to the surface water contributions, and as such the overall impact of the small remaining deficit in the infiltration volume would not be anticipated to have a significant impact on the tributary flows. It is noted, however, that other LID measures may be considered by DSEL at the detailed design phase.

Yours truly,

R.J. Burnside & Associates Limited

Jackie Shaw, P.Eng.
Geological Engineer

Joanne Thompson, M.Sc., P.Geo.
Senior Group Leader, Development Hydrogeology

JS/JT:cl/mb

Enclosure(s)

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WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

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TABLE 1

Pre- and Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (urban lawns in clayey soils)

Precipitation data from Hamilton RBG Climate Station (1971 - 1997)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-5	-4.4	0.5	6.9	13.3	18.8	22	20.9	16.4	10	4.2	-1.6	**8.5**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.63	4.40	7.43	9.42	8.72	6.04	2.86	0.77	0.00	**41.3**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.43	28.80	61.05	90.73	108.62	102.43	77.60	44.05	16.32	0.00	**531**	
Adjusting Factor for U (Latitude 43^{o} 17' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
PRE-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
P - PET	60	55	74	41	5	-45	-65	-38	4	31	68	77	**267**	
Change in Soil Moisture Storage	0	0	0	0	0	-45	-55	0	4	31	65	0	**0**	
Soil Moisture Storage max 100 mm	100	100	100	100	100	55	0	0	4	35	100	100		
Actual Evapotranspiration (AET)	0	0	1	32	77	116	130	85	81	42	13	0	**577**	
Soil Moisture Deficit max 100 mm	0	0	0	0	0	45	100	100	96	65	0	0		
Water Surplus - available for infiltration or runoff	60	55	74	41	5	0	0	0	0	0	3	77	**315**	
Potential Infiltration (based on MOE methodology*; independent of temperature)	24	22	30	16	2	0	0	0	0	0	1	31	**126**	
Potential Surface Water Runoff (independent of temperature)	36	33	45	25	3	0	0	0	0	0	2	46	**189**	
POST-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	
Potential Evaporation (PE) from impervious areas (assume 15%)	9	8	11	11	12	11	11	13	13	11	12	12	**134**	
P-PE (surplus available for runoff from impervious areas)	51	47	64	62	70	61	64	72	72	62	69	66	**759**	
Water surplus change compared to pre-condition (for areas that change from vegetated open areas to impervious areas)	-9	-8	-10	21	65	61	64	72	72	62	66	-12	**444**	

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 100 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling to hilly land	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - relatively tight silty clay materials	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - golf course fairways and greens	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.4**	

Latitude of site (or climate station) 43 ^{O} N.

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 2

Pre- and Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 400 mm (wooded areas in clayey soils)

Precipitation data from Hamilton RBG Climate Station (1971 - 1997)

Potential Evapotranspiration Calculation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR	
Average Temperature (Degree C)	-5	-4.4	0.5	6.9	13.3	18.8	22	20.9	16.4	10	4.2	-1.6	**8.5**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.63	4.40	7.43	9.42	8.72	6.04	2.86	0.77	0.00	**41.3**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.43	28.80	61.05	90.73	108.62	102.43	77.60	44.05	16.32	0.00	**531**	
Adjusting Factor for U (Latitude 43° 17' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
PRE-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	<--From Environment Canada
Potential Evapotranspiration (PET)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
P - PET	60	55	74	41	5	-45	-65	-38	4	31	68	77	**267**	
Change in Soil Moisture Storage	0	0	0	0	0	-45	-65	-38	4	31	68	45	**0**	
Soil Moisture Storage max 400 mm	400	400	400	400	400	355	290	252	256	287	355	400		
Actual Evapotranspiration (AET)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Soil Moisture Deficit max 400 mm	0	0	0	0	0	45	110	148	144	113	45	0		
Water Surplus - available for infiltration or runoff	60	55	74	41	5	0	0	0	0	0	0	32	**267**	
Potential Infiltration (based on MOE methology*; independent of temperature)	27	25	33	19	2	0	0	0	0	0	0	14	**120**	
Potential Surface Water Runoff (independent of temperature)	33	30	41	23	3	0	0	0	0	0	0	18	**147**	
POST-DEVELOPMENT WATER BALANCE	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	
Potential Evaporation (PE) from impervious areas (assume 15%)	9	8	11	11	12	11	11	13	13	11	12	12	**134**	
P-PE (surplus available for runoff from impervious areas)	51	47	64	62	70	61	64	72	72	62	69	66	**759**	
Water surplus change compared to pre-condition (for areas that change from vegetated open areas to impervious areas)	-9	-8	-10	21	65	61	64	72	72	62	69	33	**492**	

Assume January storage is 100% of Soil Moisture Storage
Soil Moisture Storage 400 mm <-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

*MOE SWM infiltration calculations

topography - rolling to hilly land	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - relatively tight silty clay materials	0.15	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - wooded lands	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration factor	**0.45**	

Latitude of site (or climate station) 43 °N.

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 3

Water Balance - Existing Conditions and Post-development (With No LID Mitigation Measures for Stormwater Management)

Land Use Description	Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Exising Land Use												
Golf Course/Landscaped areas	496,900	0.02	9,938	0.759	7,540	486,962	0.189	92,065	0.126	61,377	99,605	61,377
Wooded Area	54,100	0	0	0.759	0	54,100	0.147	7,946	0.120	6,501	7,946	6,501
TOTAL PRE-DEVELOPMENT	**551,000**		**9,938**		**7,540**	**541,062**		**100,011**		**67,878**	**107,551**	**67,878**
Post-Development Land Use												
Low Density Residential	249,900	0.64	159,936	0.759	121,331	89,964	0.189	17,009	0.126	11,339	138,340	11,339
Medium Density Residential	33,700	0.79	26,623	0.759	20,197	7,077	0.189	1,338	0.126	892	21,535	892
High Density Residential	9,200	0.86	7,912	0.759	6,002	1,288	0.189	244	0.126	162	6,246	162
Mixed Use	7,000	1.00	7,000	0.759	5,310	0	0.189	0	0.126	0	5,310	0
Road/ROW	125,400	0.79	99,066	0.759	75,154	26,334	0.189	4,979	0.126	3,319	80,133	3,319
SWM Facility	35,300	0.50	17,650	0.759	13,390	17,650	0.189	3,337	0.126	2,225	16,727	2,225
Open Space, Buffer, Easement, Enhancement Area	8,800	0.00	0	0.759	0	8,800	0.189	1,664	0.126	1,109	1,664	1,109
Parks	25,100	0.00	0	0.759	0	25,100	0.189	4,745	0.126	3,164	4,745	3,164
NHS	56,600	0.00	0	0.759	0	56,600	0.147	8,313	0.120	6,801	8,313	6,801
TOTAL POST-DEVELOPMENT	**551,000**		**318,187**		**241,385**	**232,813**		**41,628**		**29,011**	**283,012**	**29,011**
% Change from Pre to Post											263	57
Effect of development (with no mitigation)											2.6 times increase in runoff	57% reduction of infiltration

** figures from Table 1 and 2

To balance pre- to post-,
the infiltration target (m^3/a)= **38,867**

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 4

Post-Development Monthly Water Balance Components

Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 100 mm (urban lawns in clayey soils)

Precipitation data from Hamilton RBG Climate Station (1971 - 1997)

Potential Evapotranspiration Calculation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Average Temperature (Degree C)	-5	-4.4	0.5	6.9	13.3	18.8	22	20.9	16.4	10	4.2	-1.6	**8.5**	<--From Environment Canada
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.03	1.63	4.40	7.43	9.42	8.72	6.04	2.86	0.77	0.00	**41.3**	
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	1.43	28.80	61.05	90.73	108.62	102.43	77.60	44.05	16.32	0.00	**531**	
Adjusting Factor for U (Latitude 44° 79' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77		<--From J. M. Lorente (1961). pp. 206
Adjusted Potential Evapotranspiration PET (mm)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Post-Development Water Balance - Pervious Areas in Low Density Residential Areas with Mitigation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	<--From Environment Canada
Potential Evaporation (PE) from impervious areas (assume up to 15% of P)	9	8	11	11	12	11	11	13	13	11	12	12	**134**	
P-PE (surplus water from impervious areas, e.g., roof runoff capture)	51	47	64	62	70	61	64	72	72	62	69	66	**759**	
Roof runoff directed over pervious area (see Note 1)	38	35	48	47	52	46	48	54	54	46	52	49	**569**	
Total water supply directed to pervious areas (rain plus total roof runoff)	97	90	124	120	134	117	123	139	139	119	133	126	**1462**	
Potential Evapotranspiration from pervious areas (PET)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Total water available to pervious areas - PET = total potential surplus on pervious areas	97	90	123	88	57	1	-17	16	58	77	120	126	**836**	
Change in Soil Moisture Storage	0	0	0	0	0	0	-17	16	2	0	0	0	**0**	
Soil Moisture Storage (max 100 mm)	100	100	100	100	100	100	83	98	100	100	100	100		
Actual Evapotranspiration (AET) = PET	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Soil Moisture Deficit (max 100 mm)	0	0	0	0	0	0	17	2	0	0	0	0		
Total water surplus available for infiltration or runoff on pervious areas	97	90	123	88	57	1	-17	16	58	77	120	126	**836**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	49	45	61	44	29	1	-9	8	29	38	60	63	**418**	
Potential Surface Water Runoff (independent of temperature)	49	45	61	44	29	1	-9	8	29	38	60	63	**418**	
Post-Development Water Balance - Pervious Areas in Medium Density Residential Areas with Mitigation	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**YEAR**	
Precipitation (P)	60	55	76	74	82	72	75	85	85	73	82	77	**893**	<--From Environment Canada
Potential Evaporation (PE) from impervious areas (assume up to 15% of P)	9	8	11	11	12	11	11	13	13	11	12	12	**134**	
P-PE (surplus water from impervious areas, e.g., roof runoff capture)	51	47	64	62	70	61	64	72	72	62	69	66	**759**	
Roof runoff directed over pervious area (see Note 1)	72	67	92	89	99	87	91	103	103	88	99	94	**1084**	
Total water supply directed to pervious areas (rain plus total roof runoff)	132	122	168	163	181	159	166	187	188	161	180	171	**1976**	
Potential Evapotranspiration from pervious areas (PET)	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Total water available to pervious areas - PET = total potential surplus on pervious areas	132	122	166	130	104	42	26	64	107	119	167	171	**1351**	
Change in Soil Moisture Storage	0	0	0	0	0	0	0	0	0	0	0	0	**0**	
Soil Moisture Storage (max 100 mm)	100	100	100	100	100	100	100	100	100	100	100	100		
Actual Evapotranspiration (AET) = PET	0	0	1	32	77	116	140	123	81	42	13	0	**626**	
Soil Moisture Deficit (max 100 mm)	0	0	0	0	0	0	0	0	0	0	0	0		
Total water surplus available for infiltration or runoff on pervious areas	132	122	166	130	104	42	26	64	107	119	167	171	**1351**	
Potential Infiltration (based on MOE metholodogy*; independent of temperature)	66	61	83	65	52	21	13	32	54	59	84	85	**675**	
Potential Surface Water Runoff (independent of temperature)	66	61	83	65	52	21	13	32	54	59	84	85	**675**	

Post-Development Water Balance Inputs:
Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage -Urban Lawns - Silt Loam	100 mm	<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003
*MOE SWM infiltration calculations		
topography - rolling land	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
soils - relatively tight silty clay materials + additional topsoil depth	0.2	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
cover - urban lawns	0.1	<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003
Infiltration Factor	**0.50**	
Latitude of site (or climate station)	43 ° N.	

Note 1: Roof Runoff Capture x Ratio
Ratio of Roof Areas to Receiving Pervious Areas

Low Density Residenital - assume 27% of area consists of roofs and 36% consists of pervious receiving roof runoff	0.75
Medium Density Residential - assume 30% of area consists of roofs and 21% consists of pervious receiving roof runoff	1.43

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 5

Water Balance
With Direction of Roof Runoff to Pervious Areas in Low and Medium Density Residential Areas and Increased Topsoil Depth

Land Use Description	Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Exising Land Use												
Golf Course/Landscaped areas	496,900	0.02	9,938	0.759	7,540	486,962	0.189	92,065	0.126	61,377	99,605	61,377
Wooded Area	54,100	0	0	0.759	0	54,100	0.147	7,946	0.120	6,501	7,946	6,501
TOTAL PRE-DEVELOPMENT	**551,000**		**9,938**		**7,540**	**541,062**		**100,011**		**67,878**	**107,551**	**67,878**
Post-Development Land Use												
Low Density Residential	249,900	0.64	159,936	0.759	121,331	89,964	0.418	37,608	0.418	37,608	158,939	37,608
Medium Density Residential	33,700	0.79	26,623	0.759	20,197	7,077	0.675	4,780	0.675	4,780	24,977	4,780
High Density Residential	9,200	0.86	7,912	0.759	6,002	1,288	0.189	244	0.126	162	6,246	162
Mixed Use	7,000	1.00	7,000	0.759	5,310	0	0.189	0	0.126	0	5,310	0
Road/ROW	125,400	0.79	99,066	0.759	75,154	26,334	0.189	4,979	0.126	3,319	80,133	3,319
SWM Facility	35,300	0.50	17,650	0.759	13,390	17,650	0.189	3,337	0.126	2,225	16,727	2,225
Buffer, Easement	8,800	0.00	0	0.759	0	8,800	0.189	1,664	0.126	1,109	1,664	1,109
Parks	25,100	0.00	0	0.759	0	25,100	0.189	4,745	0.126	3,164	4,745	3,164
NHS	56,600	0.00	0	0.759	0	56,600	0.189	10,701	0.126	7,134	10,701	7,134
TOTAL POST-DEVELOPMENT	**551,000**		**318,187**		**241,385**	**232,813**		**68,057**		**59,501**	**309,442**	**59,501**
% Change from Pre to Post											288	12
Effect of development											2.9 times increase in runoff	12% decrease in infiltration

** figures from Table 1, 2 and 4

To balance pre- to post-, the infitlration target (m^3/a)= **8,377**

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 6

Feature-based Water Balance for Tributary 14W-W1
With No LID Mitigation Measures for Stormwater Management

Land Use Description	Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Exising Land Use												
Golf Course/Landscaped areas	150,000	0.00	0	0.759	0	150,000	0.189	28,359	0.126	18,906	28,359	18,906
Wooded Area	68,900	0	0	0.759	0	68,900	0.147	10,119	0.120	8,279	10,119	8,279
TOTAL PRE-DEVELOPMENT	**218,900**		**0**		**0**	**218,900**		**38,478**		**27,185**	**38,478**	**27,185**
Post-Development Land Use												
Low Density Residential	60,500	0.64	38,720	0.759	29,377	21,780	0.189	4,118	0.126	2,745	33,495	2,745
Medium Density Residential	10,200	0.79	8,058	0.759	6,114	2,142	0.189	405	0.126	270	6,519	270
High Density Residential	8,500	0.86	7,310	0.759	5,546	1,190	0.189	225	0.126	150	5,771	150
Mixed Use	3,600	1.00	3,600	0.759	2,731	0	0.189	0	0.126	0	2,731	0
Road/ROW	40,000	0.79	31,600	0.759	23,975	8,400	0.189	1,588	0.126	1,059	25,563	1,059
SWM Facility	0	0.50	0	0.759	0	0	0.189	0	0.126	0	0	0
Open Space, Buffer, Easement	5,400	0.00	0	0.759	0	5,400	0.189	1,021	0.126	681	1,021	681
Parks	4,500	0.00	0	0.759	0	4,500	0.189	851	0.126	567	851	567
NHS	86,200	0.00	0	0.759	0	86,200	0.147	12,660	0.120	10,358	12,660	10,358
TOTAL POST-DEVELOPMENT	**218,900**		**89,288**		**67,744**	**129,612**		**20,867**		**15,830**	**88,611**	**15,830**
% Change from Pre to Post											230	42
Effect of development (with no mitigation)											2.3 times increase in runoff	42% reduction of infiltration

** figures from Table 1 and 2

To balance pre- to post-,
the infiltration target (m^3/a)= **11,356**

WATER BALANCE CALCULATIONS
Saw Whet Property (Bronte Green)
Oakville, Ontario

PROJECT No.300031495

TABLE 7

Feature-based Water Balance for Tributary 14W-W1
With Direction of Roof Runoff to Pervious Areas in Low and Medium Density Residential Areas and Increased Topsoil Depth

Land Use Description	Approx. Land Area (m^2)	Estimated Impervious Fraction for Land Use	Estimated Impervious Area (m^2)	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m^3/a)	Estimated Pervious Area (m^2)	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m^3/a)	Infiltration in Pervious Area** (m/a)	Infiltration Volume in Pervious Area (m^3/a)	Total Runoff Volume (m^3/a)	Total Infiltration Volume (m^3/a)
Exising Land Use												
Golf Course/Landscaped areas	150,000	0.00	0	0.759	0	150,000	0.189	28,359	0.126	18,906	28,359	18,906
Wooded Area	68,900	0	0	0.759	0	68,900	0.147	10,119	0.120	8,279	10,119	8,279
TOTAL PRE-DEVELOPMENT	**218,900**		**0**		**0**	**218,900**		**38,478**		**27,185**	**38,478**	**27,185**
Post-Development Land Use												
Low Density Residential	60,500	0.64	38,720	0.759	29,377	21,780	0.418	9,105	0.418	9,105	38,482	9,105
Medium Density Residential	10,200	0.79	8,058	0.759	6,114	2,142	0.675	1,447	0.675	1,447	7,561	1,447
High Density Residential	8,500	0.86	7,310	0.759	5,546	1,190	0.189	225	0.126	150	5,771	150
Mixed Use	3,600	1.00	3,600	0.759	2,731	0	0.189	0	0.126	0	2,731	0
Road/ROW	40,000	0.79	31,600	0.759	23,975	8,400	0.189	1,588	0.126	1,059	25,563	1,059
SWM Facility	0	0.50	0	0.759	0	0	0.189	0	0.126	0	0	0
Open Space, Buffer, Easement	5,400	0.00	0	0.759	0	5,400	0.189	1,021	0.126	681	1,021	681
Parks	4,500	0.00	0	0.759	0	4,500	0.189	851	0.126	567	851	567
NHS	86,200	0.00	0	0.759	0	86,200	0.189	16,297	0.126	10,865	16,297	10,865
TOTAL POST-DEVELOPMENT	**218,900**		**89,288**		**67,744**	**129,612**		**30,533**		**23,873**	**98,277**	**23,873**
										% Change from Pre to Post	255	12
										Effect of development	2.6 times increase in runoff	12% decrease in infiltration

** figures from Tables 1 ,2 and 4

To balance pre- to post-,
the infiltration target (m^3/a)= **3,313**