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Attention: **Kevin Murphy, P.Eng**

Subject: **7000 Campeau Drive: Preliminary Water Balance & Water Quality Controls**

Introduction

The proposed residential development at 7000 Campeau Drive in Kanata, Ontario, consists of four individual parcels equating to approximately 71 ha. These lands are a part of the Kanata Golf and Country Club and are currently zoned as Parks and Open Space (O1A). The proposed development will consist of single detached homes, front drive towns, back-to-back towns & stacked towns. The proposed development will be serviced by four (4) stormwater management (SWM) dry ponds to meet quantity control requirements, with Etobicoke Exfiltration Systems (EES) implemented throughout all roads within the proposed development (or ultimately to the extent required by detailed analysis) to meet the sites water quality and water balance requirements. The following memo provides an overview of the proposed EES and how they will be implemented to meet both the water quality and water budget requirements for this site.

Etobicoke Exfiltration Systems (EES)

The Etobicoke Exfiltration System, a concept originally proposed by James Li and John Tran, considers the addition of a granular trench located below (and/or around) the main storm sewer system, which allows runoff captured by the developments minor system to exfiltrate back into the ground via these trenches. The EES works by connecting the bottom of the Maintenance Hole (MH) on the upstream side of the trench to the trench via two perforated pipes. These pipes then allow runoff that enters the MH to be dispersed and filtered throughout the granular material in the trench, where it can then exfiltrate back into the soil. If the volume or rate of runoff exceeds the capacity of the EES, the water level in each maintenance hole increases to the point at which the excess flow is carried downstream by the conventional storm sewer system, where it can either enter the next EES, if there is available capacity, or continue unimpeded downstream through the minor system network.

With this configuration, developments can help restore the deficit in groundwater contributions due to the increase in impervious area, while also reducing the total annual runoff volume from the development. As runoff from the development first needs to fill the volume in the trench below the storm sewer before passing downstream, this system also does an effective job at capturing the first flush and providing water quality treatment.

For this development, it is proposed that Etobicoke Exfiltration Systems (EES) will be implemented underneath storm sewers within the right-of-way (ROW) to meet both the water budget (groundwater infiltration) and water quality requirements. For this analysis it has been assumed that each system will consist of two 200 mm diameter perforated pipes surrounded by a 0.9 m deep by 2.5 m wide clear stone trench; note that the specific trench details may be subject to change at detailed design. Detailed drawings of the proposed EES units are provided in Figure 1. Note that there are no LID measures proposed on private property (residential rear yards) or within parklands.

Water Quality Treatment

To ensure that the proposed development will meet the water quality requirements (Enhanced water quality treatment – 80% TSS removal), a treatment train approach is proposed, which will use a combination of deep sump catch basins, goss traps on the lead pipes and EES. As per the available literature, deep sump catch basins can remove/retain 25% of the total suspended sediments (TSS) and the EES can remove at least 80% of TSS. While it may be argued that the objective to remove 80% TSS could be achieved solely by the EES, the use of deep sump catch basins will provide pre-treatment to the EES, preventing the system from being overloaded during construction periods and will reduce cleanout/maintenance frequency, further increasing the longevity of the EES. In addition to this, it is proposed that the catch basin lead pipes will be protected with goss traps. This will prevent floatable pollutants, including oils, from being discharged to the stormwater collection system, although goss traps do provide some form of TSS removal, it has not been included in the total treatment train performance calculation provided below. Based on the below calculations, it is found that the proposed treatment train will provide 85% TSS removal, exceeding The Ministry of the Environment Conservation and Park's (MECP) requirement of 80% TSS removal.

$$Total\ TSS\ removal = 1 - [(1 - Deep\ Sump\ TSS\ Removal) \times (1 - EES\ TSS\ Removal)]$$

$$Total\ TSS\ removal = 1 - [(1 - 0.25) \times (1 - 0.80)]$$

$$Total\ TSS\ removal = 85\%$$

Note that based on "Table 3.2 Water Quality Storage Requirements based on Receiving Waters" per the MECP's Stormwater Management Planning and Design Manual, to achieve 80% TSS removal via infiltration for a site at 65% imperviousness will require 33.33 m^3/ha of infiltration volume to be provided, as documented below in the "Conceptual EES Sizing" section of this report the proposed EES will provide approximately 104.8 m^3/ha, well above the required volume specified by MECP's to meet the site water quality requirement. One additional benefit of the EES worth noting is that, as this water quality treatment system is implemented underground, it results in considerably lower runoff temperatures to the receiving watercourses when compared to similar developments that use the conventional end of pipe treatment systems like wet ponds to provide water quality control.

Water Balance

A pre-and post-development water balance has been completed for the site based on the subsoil sampling infiltration rates determined by Paterson Group as a part of their on-site geotechnical investigations, full details outlined in their April 2021 memo titled "Subsoil Infiltration Review Proposed Residential Development Kanata Lakes Golf Club - 7000 Campeau Drive – Ottawa"; the following section outlines the approach and results of this analysis for the various site conditions.

Pre-Development

Based on Paterson's subsoil sampling, the site primarily consists of Silty Clay, with pockets of bedrock, fill and glacial till. Paterson also provided approximate minimum infiltration rates based on the soil types observed. These rates were compared with the F_c rates outlined in "Table A6-geotechnical investigations" of the SWMHYMO manual, to determine the appropriate SCS soil classification (A-D) for each soil type present within the site. The site's existing water budget parameters have been based on "Table 3.1 - Hydrologic Cycle Component Values" of the MECP's SWM Manual, assuming Urban Lawn (Golf Course) conditions with a soil infiltration factor of 0.2 (medium combinations of clay and loam) applied. Under pre-development conditions, the site has a total imperviousness of approximately 6%.

To determine the total water budget for the site, the proposed development lands have been broken into individual soil types (Silty Clay, Bedrock etc.) and then into pervious and impervious areas. The annual evaporation, runoff and infiltration volumes were calculated for the impervious and pervious lands separately and summated to provide the overall water balance for the site. Based on continuous hydrologic SWMHYMO model simulations using 39 years of historical rainfall data from the Ottawa Airport, City default impervious Initial Abstraction (IA) parameters and an impervious drying time of 45 minutes, it was found that for 100% impervious surfaces, on average, 26% of the annual precipitation will be lost due to evaporation with runoff making up the remaining 74%, these values have been adopted in the water balance calculations for impervious surfaces.

Tables B1-1 to B1-3 outline the calculations of each of these components. Based on the analysis of pre-development conditions for this site, it was found that on average, 54% of the annual precipitation will return to the atmosphere through evaporation and evapotranspiration, 21% will infiltrate and 25% will runoff. For the total site drainage area of 71.03 ha, the site will infiltrate 137,955 m^3/yr. or 194 mm/yr. of the total annual precipitation of 940 mm/yr. This annual infiltration rate has been established as the minimum target for annual infiltration rates under post-development conditions.

Post-Development - Without LIDs

Under post-development conditions, the proposed development lands have been broken into individual soil types (Silty Clay, Bedrock etc.) and then into pervious and impervious areas. Based on the development conceptual plan, the 71.03 ha site will have a total imperviousness of 64% (Runoff Coefficient = 0.7). Note that the percent imperviousness assumed for the development includes the impervious area from the proposed roads within the development. The site's water budget parameters have been updated based on Table 3.1 - Hydrologic Cycle Component Values of the MECP's SWM Manual, assuming Urban Lawn (residential development) conditions with a soil infiltration factor of 0.2 (medium combinations of clay and loam) applied.

As completed under pre-development conditions, each of the soil types have been broken into pervious and impervious areas, and these resulting values summated. Tables B2-1 to B2-3 outline the calculations of each of these components. Based on this analysis it was found that, under post-development conditions (without any LID measures in place), this site on average will evaporate 37.0% of its annual precipitation while 8% will infiltrate and 55% will runoff. Based on the total development area of 71.03 ha, the site will infiltrate 52,176 m³/yr. or 73 mm/yr. of the total annual rainfall of 940 mm/yr. This is 85,780 m³/yr. or 121 mm/yr. short of the pre-development conditions. The results observed above are typical for most subdivisions that proposed development without LIDs; annual evapotranspiration rates decrease due to the reduction in vegetated lands, annual infiltrated rates also decrease due to the reduction in pervious surfaces, which in turn results in an increase in annual average runoff volume.

Post-Development – With LIDs

As indicated above, the increase in the impervious area due to the proposed development will result in a decrease in annual infiltration volume. To offset this deficit, it is proposed that LID measures will be implemented throughout the site to capture a portion of the additional runoff and allow it to infiltrate back into the soil. As indicated above, EES are proposed to be implemented throughout this site to offset this deficit.

As a part of the “Barrhaven South Urban Expansion Area Master Servicing Study” completed by J.L. Richards and Associates Inc. (JLR), a detailed historical rainfall analysis was completed to correlate the volume of a single rainfall event in Ottawa to an annual event percentile; for example, based on JLR’s study a 22 mm rainfall event correlates to the 95th percentile of all annual rainfall events in the Ottawa region. Similarly, the 85th, 75th and 65th percentile events correspond to 11.4 mm, 7.5 mm and 5.1 mm rainfall events. Using JLR’s data, further extrapolation/interpolation can be applied to determine the annual percentiles for any particular rainfall event. JLR’s analysis helps determine how much of the annual rainfall volume will be dealt with but is missing a key piece of information; the runoff volume (in mm) generated by such rainfall events, which then can be used to conceptually size LID measures. To provide this missing information, a series of conceptual SWMHYMO models were prepared for various total imperviousness (TIMP) ranging from 40% to 95% with various degrees of directly connected imperviousness (XIMP), all with City Standard parameters. These models were run for the 5 mm, 10 mm, 15 mm, 20 mm, 22 mm, 25 mm and 30 mm design storms. From the results obtained (provided in Attachment C) it is possible to approximate the runoff (in mm) generated from a given TIMP and XIMP, for any of these storms.

It is important to consider that although the 3 mm event equates to approximately 50% of all annual rainfall events, it does not equate to 50% of the total annual runoff; as initial abstraction for pervious surfaces is generally assumed to be 4.67 mm, and a single large rainfall event produces far more runoff than a series of small rainfall events of the same total volume that occur over several days. To account for this in the water budget runoff/infiltration calculations the runoff volume determined for the specific event at a specific imperviousness (per the lookup tables provided in Attachment C) is divided by the design storm capacity, and then multiplied by the annual rainfall percentile and annual runoff volume, to approximate the total infiltrated volume. Using these look-up tables it is found that for a proposed development with a 65% total imperviousness (TIMP) and 55% directly connected imperviousness (XIMP), the 22 mm event would generate approximately 10.03 mm of runoff volume (averaged of 60% and 50% XIMP).

As a part of this preliminary water budget analysis, it is assumed that 100% of the total drainage area within the development will be treated via EES. It has also been assumed that the EES units will be sized to capture and infiltrate up to the 22 mm rainfall event (95% percentile) to meet water quality requirements as outlined above, which is based on the SWMHYMO modelling equates to 10.03mm of runoff. The results of this analysis are summarized in Appendix B Table B2-4 and show that if EES were designed to retain and infiltrate the runoff from the 22 mm storms or less, some additional 160,446 m³/yr. (226 mm/yr.) of runoff volume would be infiltrated. This is an increase in annual infiltration volume of 74,666 m³/yr. (105 mm/yr.) from the pre-development target established above.

Water Budget Scenario Summary

Tables 2-4 summarize the annual average water balance under existing conditions and post-development conditions with and without LID measures in place, as m³/year, mm/year and % of total annual rainfall.

Table 1:Pre-Development Water Balance

Drainage Area (ha)		71.03	Imperviousness:	6%
Annual Average Volume	Precipitation	Evapotranspiration	Infiltration	Runoff
m³	667,663	364,081	137,955	165,626
mm	940	513	194	233
%	100%	54%	21%	25%

Table 2:Post Development Water Balance – Without LIDs

Drainage Area (ha)		71.03	Imperviousness:	64%
Annual Average Volume	Precipitation	Evapotranspiration	Infiltration	Runoff
m³	667,663	245,442	52,176	370,046
mm	940	346	73	521
%	100%	37%	8%	55%

Table 3:Post Development Water Balance – With LIDs

Drainage Area (ha)		71.03	Imperviousness:	64%
Annual Average Volume	Precipitation	Evapotranspiration	Infiltration	Runoff
m³	667,663	245,442	212,622	209,600
mm	940	346	299	295
%	100%	37%	32%	31%

Based on this analysis of pre-development conditions this site will evaporate 54%, infiltrate 21% and runoff 25% of all annual rainfall. Under Post-development conditions without LID, this site will evaporate 37%, infiltrate 8% and runoff 55% of all annual rainfall. Under post-development conditions with LIDs, this site will evaporate 37%, infiltrate 32% and runoff 31% of all annual rainfall, exceeding existing pre-development infiltration rates.

Conceptual EES Sizing

To confirm that the proposed EES can be physically implemented within the development a preliminary sizing analysis has been completed. The EES will be sized to capture runoff from the 22 mm event (95th Percentile rainfall event), which equates to a runoff volume of 10.03 mm based on an average site imperviousness of 65%. Multiplying the 10.03 mm of runoff over the 71.03 ha development results in a total runoff volume of 7,124 m³, which will need to be captured and exfiltrated by the EES.

Based on the latest development plan there is a total of 8,275 linear metres of the proposed road within this development. For now, it is proposed that all EES within the development will be 2.5 m wide with clear stone trenches (40% porosity). To exceed the required volume (7,124 m³) the EES will need to be 0.9 m deep, providing a total EES exfiltration/storage volume of 7,448 m³. Note that this conceptual volumetric analysis of the EES is conservative as it does not consider the volume provided in the system due to the perforated pipes that distribute the runoff throughout the trench. Additionally as outlined above in the Water Budget Scenario Summary section designing the EES units to capture and exfiltrate all runoff up to the 22mm event, exceeds the sites existing annual infiltration volumes. Note that the dimensions assumed as a part of this analysis are conceptual and may differ at detailed design based on site-specific conditions present at each location. A full breakdown of the required storage volume and conceptual EES dimensions have been provided below in Table 4.

Table 4: Conceptual EES sizing

Parameter	Value	Unit
LID Design Rainfall Event	22	mm
Site Total Drainage Area	71.028	ha
Average Site imperviousness	64.3	%
Runoff Volume[1]	10.03	mm
Site Runoff Volume	**7,124**	**m³**
Total Length of EES system (Road)	8275	m
EES Width	2.5	m
EES Depth	0.9	m
Void Ratio	0.4	-
Total LID Volume	**7,448**	**m³**
Total LID Volume	**104.8**	**m³/ha**

1 Refer to "TIMP vs Runoff Volume Summary Tables" in Attachment C for the relationship between design storm imperviousness and runoff

EES Drawdown Times

Assuming all EES units will have a maximum depth of 900 mm with an assumed porosity of 0.4. Based on the minimum site soil infiltration rate of 5 mm/hr determined by Paterson, and assuming only bottom infiltration (conservative assumption), this equates to a full EES having a drawdown time of approximately 72 hours (3 Days). Note that the above soil infiltration rate is the minimum of the values approximated, and the infiltration rates and required dimension of each of the EES units can be reviewed on a location basis at detailed design, the primary goal is to ensure that the required exfiltration volume is provided throughout the site.

It is important to note that based on the “Planning and Design Manual of the Etobicoke Exfiltration System for Stormwater Management” Report by John Ran and James Li, the two EES pilot sites in Etobicoke, had soil infiltration rates of less than 15mm/hr, yet appeared to still meet the site's objectives. One of the pilot sites had a field measured hydraulic conductivity of 1 x 10-7 cm/sec (approximately 7.2 mm/hr) yet peer-reviewed results concluded that the total rate of exfiltration for that system was equivalent to 30 mm/hr.

Conclusion

Based on the above it is determined that the proposed 7000 Campeau development will meet and exceed the quality control requirements of 80% TSS removal, through the implementation of a treatment train of deep sumps, goss traps and Etobicoke Exfiltration Systems (EES) sized to retain and infiltrate up to the 22 mm event (95^{th} percental). A preliminary water balance analysis of the existing site was completed to determine pre-development infiltration rates. A post-development analysis, where no LIDs were implemented, showed that the percentage of annual rainfall infiltrated would decrease by 13%. Implementing EES that are designed to capture and infiltrate up to the 22 mm event would offset this deficit and exceed pre-development conditions by 11%. Based on a conceptual size of the EES, assuming that EES are implemented on all proposed roads throughout this development, it was found that each of the EES trenches would need to be 2.5 m wide and 0.9 m deep. Based on this analysis it has been shown that the proposed development will be able to meet and exceed the existing annual infiltration volumes through the use of EES.

Yours truly,
J.F Sabourin and Associates Inc.

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Figures
Figure 1: Etobicoke Exfiltration Systems Drawing Details

Tables
Table 1: Pre-Development Water Balance
Table 2: Post Development Water Balance – Without LIDs
Table 3: Post Development Water Balance – With LIDs
Table 4: Conceptual EES sizing

Attachments
Attachment A: Quality Control Alternatives – Summary
Attachment B: Water Budget Calculations
Attachment C: TIMP vs Runoff Volume Summary Tables

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Attachment A

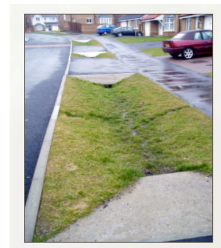
Quality Control Alternatives – Summary

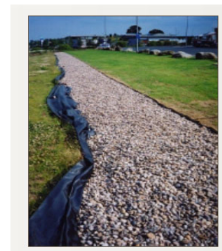
Quality Control Alternatives - Summary of Technologies/ Methods

Prepared by: JFSA (J.F. Sabourin), January 28, 2021

Method/ Approach	TSS Removal (%)	Notes
Street Sweeping (Monthly)	0-10%	Depends on method and frequency (ref Massachusetts, 2008)
Street Sweeping (Weekly)		
Street Sweeping (Weekly with Elgin Eagle)*	88%	Elgin Eagle Waterless Sweeper (per pass as tested by ETV Canada)

Method/ Approach	TSS Removal (%)	Notes
Curb Cut with Grass Swales	+/- 75%	Based on several references
	80%+	if combined with with infiltration trench





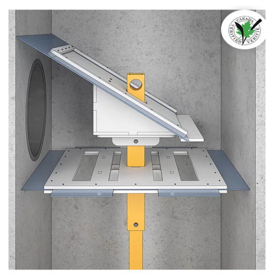
Method/ Approach	TSS Removal (%)	Notes
Catchbasin Inserts	11% to 90%	(1) Cartrige Type, disposible; (2) Bag Type,; (3) Basket Type


FIGURE 2.2 Cartridge type CBI (Contech Engineered Solutions, 2017).

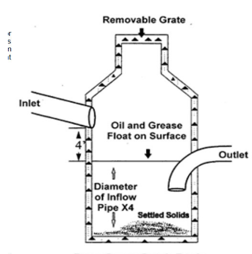

FIGURE 2.3 Bag type CBI (ADS, 2016).


FIGURE 2.4 Basket type CBI (Environmental XPRT, n.d.).

Method/ Approach	TSS Removal (%)	Notes
Catchbasin Inserts (CB Shield)*	27%	CB Shield (as tested by ETV Canada)



Method/ Approach	TSS Removal (%)	Notes
Deep Sump Catch Basin	25%	if sump deep enough and goss trap added to outlet



Method/ Approach	TSS Removal (%)	Notes
Infiltration/ Filtration Trenches**	82% to 85%	as per LSRCA and other references
OGS*	50%	
JellyFish*	85%	

*) TSS Removal as documented by ETV Canada

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Attachment B

Water Budget Calculations

7000 Campeau Drive - Pre Development Water Balance

Table B1-1: Pre Development Conditions - Pervious Areas

Soil Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Soil Type	Hydrologic Soil Group	Precipitation (mm/Year)	Evapo-transpiration (mm/Year)	Surplus (mm/Year)	Infiltration Factor*				Infiltration (mm/yr.)	Runoff (mm/yr.)	Infiltration Volume (m³/yr.)	Runoff Volume (m³/yr.)
											Topography Factor	Soils Factor	Cover Factor	Total				
Silty Clay	Golf Course	42.14	3%	40.74	1.39	Silty Clay	B	940	525	415	0.2	0.2	0.1	0.5	207.5	208	84,542	84,542
Bedrock	Golf Course	19.07	5%	18.16	0.91	Bedrock	C	940	536	404	0.2	0.2	0.1	0.5	202	202	36,689	36,689
Fill-Silty Clay	Golf Course	4.61	18%	3.80	0.81	Fill-Silty Clay	C	940	536	404	0.2	0.2	0.1	0.5	202	202	7,684	7,684
Fill-Silty Sand	Golf Course	3.39	23%	2.61	0.79	Fill-Silty Sand	A	940	515	425	0.2	0.2	0.1	0.5	212.5	213	5,538	5,538
Glacial Till	Golf Course	1.81	4%	1.73	0.08	Glacial Till	C	940	536	404	0.2	0.2	0.1	0.5	202	202	3,503	3,503
Total		**71.03**	**6%**	**67.05**	**3.98**												**137,955**	**137,955**

Table B1-2: Pre Development Conditions - Impervious Areas

Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Precipitation (mm/Year)	Evaporation* (mm/Year)	Surplus (mm/Year)	Infiltration (mm/yr.)	Runoff (mm/yr.)	Infiltration Volume (m³/yr.)	Runoff Volume (m³/yr.)
Silty Clay	Golf Course	42.14	3%	40.74	1.39	940	244	696	0	696	0	9,690
Bedrock	Golf Course	19.07	5%	18.16	0.91	940	244	696	0	696	0	6,330
Fill-Silty Clay	Golf Course	4.61	18%	3.80	0.81	940	244	696	0	696	0	5,620
Fill-Silty Sand	Golf Course	3.39	23%	2.61	0.79	940	244	696	0	696	0	5,481
Glacial Till	Golf Course	1.81	4%	1.73	0.08	940	244	696	0	696	0	550
Total		**71.03**	**6%**	**67.05**	**3.98**						**0**	**27,671**

* Value based on average annual simulated rates using continuous simulations of 39 years of Ottawa rainfall data and City of Ottawa default model paraments (26% of annual precipitation)

Table B1-3: Pre Development Conditions - Water Budget Summary

Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Pervious Runoff Volume (m³/yr.)	Impervious Runoff Volume (m³/yr.)	Runoff Volume (m³/yr.)	Infiltration Volume (m³/yr.)
Silty Clay	Golf Course	42.14	3%	40.74	1.39	84,542	9,690	94,231	84,542
Bedrock	Golf Course	19.07	5%	18.16	0.91	36,689	6,330	43,019	36,689
Fill-Silty Clay	Golf Course	4.61	18%	3.80	0.81	7,684	5,620	13,305	7,684
Fill-Silty Sand	Golf Course	3.39	23%	2.61	0.79	5,538	5,481	11,019	5,538
Glacial Till	Golf Course	1.81	4%	1.73	0.08	3,503	550	4,052	3,503
Total		**71.03**	**6%**	**67.05**	**3.98**			**165,626**	**137,955**

7000 Campeau Drive - Post Development Water Balance

Table B2-1: Post Development Conditions - Pervious Areas

Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Soil Type	Hydrologic Soil Group	Precipitation (mm/Year)	Evapo-transpiration (mm/Year)	Surplus (mm/Year)	Infiltration Factor*				Infiltration (mm/yr.)	Runoff (mm/yr.)	Infiltration Volume (m³/yr.)	Runoff Volume (m³/yr.)
											Topography Factor	Soils Factor	Cover Factor	Total				
Silty Clay	Residential	42.14	64%	15.04	27.09	Silty Clay	B	940	525	415	0.2	0.2	0.1	0.5	207.5	208	31,213	31,213
Bedrock	Residential	19.07	64%	6.81	12.26	Bedrock	C	940	536	404	0.2	0.2	0.1	0.5	202	202	13,754	13,754
Fill-Silty Clay	Residential	4.61	64%	1.65	2.97	Fill-Silty Clay	C	940	536	404	0.2	0.2	0.1	0.5	202	202	3,326	3,326
Fill-Silty Sand	Residential	3.39	64%	1.21	2.18	Fill-Silty Sand	A	940	515	425	0.2	0.2	0.1	0.5	212.5	213	2,575	2,575
Glacial Till	Residential	1.81	64%	0.65	1.17	Glacial Till	C	940	536	404	0.2	0.2	0.1	0.5	202	202	1,307	1,307
Total		**71.03**		**25.36**	**45.67**												**52,176**	**52,176**

Table B2-2: Post Development Conditions - Impervious Areas

Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Precipitation (mm/Year)	Evaporation* (mm/Year)	Surplus (mm/Year)	Infiltration (mm/yr.)	Runoff (mm/yr.)	Infiltration Volume (m³/yr.)	Runoff Volume (m³/yr.)
Silty Clay	Residential	42.14	64%	15.04	27.09	940	244	696	0	696	0	188,570
Bedrock	Residential	19.07	64%	6.81	12.26	940	244	696	0	696	0	85,357
Fill-Silty Clay	Residential	4.61	64%	1.65	2.97	940	244	696	0	696	0	20,640
Fill-Silty Sand	Residential	3.39	64%	1.21	2.18	940	244	696	0	696	0	15,189
Glacial Till	Residential	1.81	64%	0.65	1.17	940	244	696	0	696	0	8,114
Total		**71.03**		**25.36**	**45.67**						**0**	**317,870**

* Value based on average annual simulated rates using continuous simulations of 39 years of Ottawa rainfall data and City of Ottawa default model paraments (26% of annual precipitation)

Table B2-3: Post Development Conditions - Water Budget Summary

Condition	Land Use	Total Area (ha)	Total Imp (%)	Pervious Area (ha)	Impervious Area (ha)	Pervious Runoff Volume (m³/yr.)	Impervious Runoff Volume (m³/yr.)	Runoff Volume (m³/yr.)	Infiltration Volume (m³/yr.)
Silty Clay	Residential	42.14	64%	15.04	27.09	31,213	188,570	219,784	31,213
Bedrock	Residential	19.07	64%	6.81	12.26	13,754	85,357	99,111	13,754
Fill-Silty Clay	Residential	4.61	64%	1.65	2.97	3,326	20,640	23,966	3,326
Fill-Silty Sand	Residential	3.39	64%	1.21	2.18	2,575	15,189	17,764	2,575
Glacial Till	Residential	1.81	64%	0.65	1.17	1,307	8,114	9,421	1,307
Total		**71.03**		**25.36**	**45.67**			**370,046**	**52,176**

Table B2-4: Post Development Conditions - LID Infiltration Requirements

Description	Total Runoff Area (ha)	Area treated by LID (%)	Total Treated Area (ha)	Average Site Runoff (mm/yr.)	LID Storm Design Capacity (mm)	LID Runoff Capture Capacity[1] (mm)	Annual Rainfall Percentile Capture[2]	Captured Runoff (mm/yr.)	LID Infiltrated Volume (m³/yr.)	Site Infiltration Surplus (m³/yr.)
LID System	71.0	100%	71.03	521	22.0	10.03	95%	226	160,446	74,666

1 Refer to "TIMP vs Runoff Volume Summary Tables" in Attachment C

2 Refer table B2-5 Ottawa Airport Annual Rainfall Percentiles J.L. Richard - Barrhaven South MSS (2021)

Table B2-5: Ottawa Airport Annual Rainfall Percentiles
J.L. Richard - Barrhaven South MSS (2021)

Event Percentile	Rainfall Depth (mm)
0	0
50	2.9
55	3.4
60	4.2
65	5.1
70	6.2
75	7.5
80	9.1
85	11.4
90	15.1
95	21.6
99	37.1

MOE SWM Manual
Table 3.1: Hydrologic Cycle Component Values

	Water Holding Capacity mm	Hydrologic Soil Group	Precipitation mm	Evapo-transpiration mm	Runoff mm	Infiltration* mm
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)						
Fine Sand	50	A	940	515	149	276
Fine Sandy Loam	75	B	940	525	187	228
Silt Loam	125	C	940	536	222	182
Clay Loam	100	CD	940	531	245	164
Clay	75	D	940	525	270	145
Moderately Rooted Crops (corn and cereal grains)						
Fine Sand	75	A	940	525	125	291
Fine Sandy Loam	150	B	940	539	160	241
Silt Loam	200	C	940	543	199	199
Clay Loam	200	CD	940	543	218	179
Clay	150	D	940	539	241	160
Pasture and Shrubs						
Fine Sand	100	A	940	531	102	307
Fine Sandy Loam	150	B	940	539	140	261
Silt Loam	250	C	940	546	177	217
Clay Loam	250	CD	940	546	197	197
Clay	200	D	940	543	218	179
Mature Forests						
Fine Sand	250	A	940	546	79	315
Fine Sandy Loam	300	B	940	548	118	274
Silt Loam	400	C	940	550	156	234
Clay Loam	400	CD	940	550	176	215
Clay	350	D	940	549	196	196

Notes: Hydrologic Soil Group A represents soils with low runoff potential and Soil Group D represents soils with high runoff potential. The evapotranspiration values are for mature vegetation. Streamflow is composed of baseflow and runoff.

* *This is the total infiltration of which some discharges back to the stream as base flow. The infiltration factor is determined by summing a factor for topography, soils and cover.*

Infiltration Factor*		Value
Topography	Flat Land, average slope < 0.6 m/km	0.3
	Rolling Land, average slope 2.8 m to 3.8 m/km	0.2
	Hilly Land, average slope 28 m to 47 m/km	0.1
Soils	Tight impervious clay	0.1
	Medium combinations of clay and loam	0.2
	Open Sandy loam	0.4
Cover	Cultivated Land	0.1
	Woodland	0.2

Ottawa. ON
Paris. ON
Gatineau. QC
Montréal. QC
Québec. QC

Attachment C

TIMP vs Runoff Volume Summary Tables

TIMP vs Runoff Volume Summary Tables

Runoff Volume (mm) Generated for 5 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	3.26	2.93	2.63	2.50	2.42	2.39	2.39	2.43	2.48	2.54	2.62
90.0%	3.09	2.78	2.47	2.16	1.86	1.69	1.60	1.51	1.43	1.38	1.36
85.0%	2.91	2.62	2.33	2.04	1.75	1.46	1.17	0.97	0.82	0.73	0.66
80.0%	2.74	2.47	2.19	1.92	1.65	1.37	1.10	0.82	0.55	0.30	0.15
75.0%	2.57	2.31	2.06	1.80	1.54	1.29	1.03	0.77	0.51	0.26	0.03
70.0%	2.40	2.16	1.92	1.68	1.44	1.20	0.96	0.72	0.48	0.24	0.02
65.0%	2.23	2.01	1.78	1.56	1.34	1.11	0.89	0.67	0.45	0.22	0.02
60.0%	2.06	1.85	1.65	1.44	1.23	1.03	0.82	0.62	0.41	0.21	0.02
55.0%	1.89	1.70	1.51	1.32	1.13	0.94	0.75	0.57	0.38	0.19	0.02
50.0%	1.71	1.54	1.37	1.20	1.03	0.86	0.69	0.51	0.34	0.17	0.02
45.0%	1.54	1.39	1.23	1.08	0.93	0.77	0.62	0.46	0.31	0.15	0.02
40.0%	1.37	1.23	1.10	0.96	0.82	0.69	0.55	0.41	0.27	0.14	0.01

Runoff Volume (mm) Generated for 22 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	19.41	18.62	18.40	18.36	18.41	18.52	18.63	18.75	18.87	19.00	19.12
90.0%	18.39	17.40	16.86	16.55	16.39	16.32	16.29	16.30	16.34	16.43	16.53
85.0%	17.37	16.35	15.63	15.15	14.81	14.56	14.41	14.32	14.26	14.23	14.22
80.0%	16.34	15.33	14.53	13.94	13.47	13.12	12.84	12.62	12.47	12.35	12.29
75.0%	15.32	14.30	13.55	12.86	12.32	11.87	11.51	11.21	10.95	10.73	10.58
70.0%	14.30	13.27	12.58	11.89	11.26	10.76	10.32	9.95	9.64	9.37	9.14
65.0%	13.28	12.30	11.60	10.95	10.31	9.75	9.27	8.85	8.48	8.14	7.88
60.0%	12.26	11.34	10.62	10.03	9.43	8.84	8.31	7.84	7.46	7.08	6.78
55.0%	11.24	10.38	9.64	9.10	8.55	8.01	7.46	6.96	6.53	6.13	5.81
50.0%	10.21	9.42	8.72	8.17	7.68	7.18	6.68	6.19	5.69	5.29	4.93
45.0%	9.19	8.46	7.83	7.24	6.79	6.34	5.90	5.45	5.02	4.56	4.16
40.0%	8.17	7.50	6.93	6.38	5.91	5.52	5.13	4.73	4.33	3.93	3.58

Runoff Volume (mm) Generated for 10 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	8.01	7.32	7.02	6.88	6.83	6.85	6.90	6.97	7.06	7.16	7.28
90.0%	7.59	6.83	6.24	5.92	5.65	5.48	5.36	5.29	5.24	5.24	5.25
85.0%	7.17	6.45	5.73	5.20	4.90	4.58	4.34	4.15	3.99	3.88	3.80
80.0%	6.74	6.07	5.39	4.72	4.24	3.91	3.62	3.33	3.08	2.87	2.72
75.0%	6.32	5.69	5.06	4.43	3.79	3.33	2.96	2.69	2.42	2.15	1.90
70.0%	5.90	5.31	4.72	4.13	3.54	2.95	2.48	2.09	1.80	1.54	1.32
65.0%	5.48	4.93	4.38	3.84	3.29	2.74	2.19	1.68	1.32	0.96	0.73
60.0%	5.06	4.55	4.05	3.54	3.03	2.53	2.02	1.52	1.01	0.61	0.31
55.0%	4.64	4.17	3.71	3.25	2.78	2.32	1.85	1.39	0.93	0.46	0.05
50.0%	4.21	3.79	3.37	2.95	2.53	2.11	1.69	1.26	0.84	0.42	0.04
45.0%	3.79	3.41	3.03	2.66	2.28	1.90	1.52	1.14	0.76	0.38	0.04
40.0%	3.37	3.03	2.70	2.36	2.02	1.69	1.35	1.01	0.67	0.34	0.03

Runoff Volume (mm) Generated for 25 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	22.29	21.52	21.32	21.30	21.38	21.49	21.60	21.72	21.85	21.98	22.10
90.0%	21.16	20.17	19.65	19.37	19.23	19.18	19.16	19.19	19.28	19.39	19.48
85.0%	20.02	18.99	18.29	17.83	17.50	17.29	17.17	17.09	17.05	17.03	17.04
80.0%	18.88	17.89	17.07	16.49	16.05	15.72	15.45	15.26	15.14	15.04	14.98
75.0%	17.75	16.79	15.94	15.29	14.75	14.33	13.99	13.69	13.45	13.27	13.14
70.0%	16.61	15.69	14.89	14.16	13.58	13.08	12.67	12.31	12.01	11.75	11.53
65.0%	15.47	14.59	13.84	13.10	12.48	11.95	11.47	11.07	10.70	10.41	10.16
60.0%	14.33	13.49	12.81	12.12	11.44	10.89	10.40	9.95	9.55	9.19	8.89
55.0%	13.20	12.40	11.77	11.14	10.50	9.89	9.40	8.91	8.51	8.11	7.79
50.0%	12.06	11.29	10.72	10.16	9.58	9.00	8.45	7.98	7.52	7.14	6.79
45.0%	10.92	10.20	9.68	9.17	8.65	8.13	7.62	7.10	6.67	6.26	5.88
40.0%	9.79	9.13	8.64	8.18	7.72	7.27	6.81	6.34	5.88	5.45	5.11

Runoff Volume (mm) Generated for 15 mm event

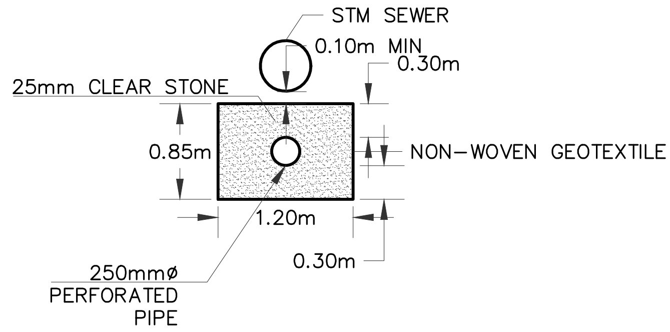
TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	12.76	11.96	11.67	11.58	11.58	11.62	11.71	11.83	11.95	12.08	12.19
90.0%	12.09	11.08	10.54	10.18	9.96	9.81	9.74	9.72	9.72	9.75	9.78
85.0%	11.42	10.31	9.68	9.16	8.78	8.49	8.28	8.12	8.00	7.93	7.88
80.0%	10.74	9.67	8.85	8.35	7.85	7.44	7.14	6.87	6.66	6.49	6.36
75.0%	10.07	9.06	8.16	7.54	7.08	6.61	6.20	5.85	5.56	5.30	5.11
70.0%	9.40	8.46	7.52	6.83	6.31	5.87	5.43	5.00	4.65	4.33	4.08
65.0%	8.73	7.86	6.98	6.18	5.59	5.13	4.72	4.32	3.91	3.52	3.22
60.0%	8.06	7.25	6.45	5.64	4.99	4.44	4.01	3.64	3.27	2.89	2.55
55.0%	7.39	6.65	5.91	5.17	4.43	3.89	3.39	2.97	2.62	2.28	1.97
50.0%	6.71	6.04	5.37	4.70	4.03	3.36	2.88	2.43	1.97	1.66	1.38
45.0%	6.04	5.44	4.83	4.23	3.63	3.02	2.42	1.97	1.55	1.15	0.79
40.0%	5.37	4.83	4.30	3.76	3.22	2.69	2.15	1.61	1.14	0.78	0.45

Runoff Volume (mm) Generated for 30 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	27.14	26.38	26.22	26.24	26.34	26.45	26.57	26.69	26.82	26.95	27.08
90.0%	25.86	24.85	24.36	24.14	24.03	23.99	24.03	24.12	24.21	24.31	24.39
85.0%	24.57	23.49	22.82	22.39	22.12	21.96	21.86	21.80	21.77	21.79	21.85
80.0%	23.28	22.20	21.43	20.87	20.47	20.16	19.95	19.81	19.70	19.63	19.58
75.0%	22.00	20.94	20.12	19.48	18.98	18.59	18.26	18.02	17.83	17.70	17.59
70.0%	20.71	19.73	18.86	18.19	17.62	17.16	16.77	16.43	16.14	15.93	15.77
65.0%	19.42	18.51	17.64	16.94	16.34	15.82	15.39	15.02	14.67	14.38	14.14
60.0%	18.14	17.29	16.45	15.74	15.14	14.59	14.11	13.70	13.31	13.01	12.71
55.0%	16.85	16.08	15.30	14.58	13.96	13.43	12.92	12.48	12.06	11.72	11.41
50.0%	15.56	14.86	14.16	13.45	12.86	12.29	11.81	11.36	10.94	10.53	10.21
45.0%	14.28	13.64	13.01	12.39	11.74	11.24	10.73	10.29	9.87	9.45	9.12
40.0%	12.99	12.44	11.88	11.31	10.74	10.20	9.75	9.29	8.87	8.49	8.14

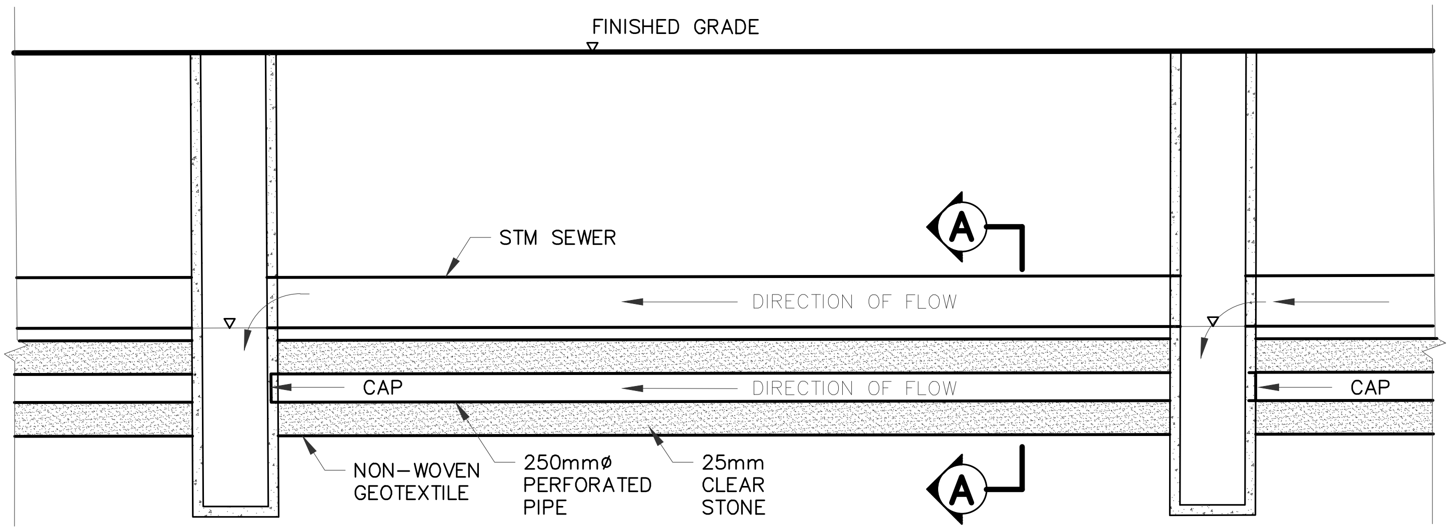
Runoff Volume (mm) Generated for 20 mm event

TIMP	XIMP = % of TIMP										
	1.00	0.90	0.80	0.70	0.60	0.50	0.40	0.30	0.20	0.10	0.01
95.0%	17.51	16.70	16.46	16.41	16.44	16.53	16.65	16.76	16.89	17.02	17.14
90.0%	16.59	15.58	15.02	14.70	14.51	14.43	14.39	14.40	14.42	14.48	14.57
85.0%	15.67	14.60	13.89	13.39	13.04	12.79	12.60	12.49	12.43	12.39	12.37
80.0%	14.74	13.62	12.91	12.28	11.81	11.44	11.16	10.92	10.73	10.60	10.51
75.0%	13.82	12.68	11.98	11.31	10.74	10.30	9.91	9.59	9.35	9.11	8.93
70.0%	12.90	11.79	11.04	10.42	9.80	9.28	8.84	8.44	8.11	7.83	7.61
65.0%	11.98	10.89	10.10	9.52	8.95	8.37	7.87	7.44	7.06	6.72	6.44
60.0%	11.06	9.99	9.24	8.63	8.10	7.57	7.03	6.55	6.13	5.75	5.44
55.0%	10.14	9.12	8.40	7.74	7.25	6.76	6.28	5.79	5.30	4.91	4.56
50.0%	9.21	8.29	7.57	6.94	6.40	5.96	5.52	5.08	4.63	4.19	3.79
45.0%	8.29	7.46	6.73	6.17	5.60	5.15	4.76	4.36	3.97	3.57	3.21
40.0%	7.37	6.63	5.90	5.40	4.89	4.38	3.99	3.65	3.29	2.94	2.62



SECTION DETAIL A

SCALE: N.T.S.



PROFILE

SCALE: N.T.S.

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7000 CAMPEAU DRIVE

CITY OF OTTAWA

EXFILTRATION TRENCH DETAIL

SCALE:	NTS	PROJECT No.:	1061
DATE:	APRIL 2021	FIGURE:	1