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June 07, 2021

Project Number: 1474

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Attention: **Steve Pichette, P.Eng**

Subject: **BCDC Phase 2 – Preliminary Water Balance & Water Quality Controls**

Introduction

Phase 2 of the Barrhaven Conservancy Development (aka Conservancy East) is located in Barrhaven, Ontario, north of the Jock River, south of the Fraser Clarke Creek and east of the Foster Creek. The proposed development is approximately 59.26 ha that will primarily comprise of single and townhouse residential lots. As a part of the City of Ottawa's review of the proposed development draft plan submitted in December 2020, it was requested that a preliminary water balance for the site be completed, and that additional information is provided to show how the development will meet the water quality requirements (80% TSS removal). As such the following memo outlines how the proposed development will match/exceed the existing water budget and meet the water quality requirements for the site; both of which will be achieved through the use of LIDs.

Modified Etobicoke Filtration Systems (MEFS)

It is proposed that Modified Etobicoke Filtration Systems (MEFS) will be implemented on all roads within the development. The MEFS takes the idea of using the right of way (ROW) to implement Low Impact Developments (LID) solutions, a concept originally proposed by James Li and John Tran in the development of the Etobicoke Exfiltration Systems (EES), but with some modifications made to the design to better suit the conditions observed at the proposed BCDC Phase 2 site. Figure 1 provides detailed drawings of the proposed MEFS.

The primary difference between the EES and the MEFS is that the EES provide storage volume solely below the proposed storm sewer, which then exfiltrates to the soils underneath the system, while the MEFS filters runoff through the granular storage volume around (above, below and beside) the storm sewer before it is conveyed to the downstream Maintenance Hole (MH). One other major difference between the EES and MEFS is that while the MEFS does provide some stormwater infiltration it is primarily a stormwater filtration solution. This is due to the BCDC Phase 2 development site consisting primarily of tight clay soils, providing low infiltration potential.

As shown in Figure 1, the MEFS will consist of catch basins with deep sumps (1 m) and will have two lead pipes, located at different elevations, with both equipped with goss traps. The lower lead pipe, a 150 mm non-ridged PVC pipe, will direct the first flush flows to a perforated 200 mm PVC pipe located near the top of the 2.5 m wide by 1.35 m deep, clear stone MEFS trench, which will then disperse and filter the runoff throughout the granular material in the trench. Once this filtered water reaches the bottom of the trench it can exfiltrate back to the surrounding soils or be collected by another 200 mm perforated pipe that drains to a downstream stormwater maintenance hole which then directs the flow into the stormwater sewer system. The second (higher) catch basin lead pipe, is a typical and conventional 200 mm pipe and will connect directly to the storm sewer.

Under this configuration, the first lead pipe will capture the first flush runoff from the development and direct it to the MEFS trench, where it will percolate and filter through the granular, with a portion of this volume retained within the trench to infiltrate. During high flow events (100-year storm) or when the filtration trench volume is already utilized, water will slightly back up in the catchbasin before reaching the second lead pipe, at which point it will pass flows directly to the storm sewer. Refer to Figure 1, for the detailed drawings of the proposed filtration system.

Water Quality Treatment

An analysis of various potential stormwater quality treatment options was investigated for this site. These included options and combinations of options such as street sweeping, curb cuts with grass swales, curb cuts with infiltration trenches, catch basin inserts, deep sump catch basins, below ground infiltration/ filtration trenches such as the Etobicoke systems or variations of it, and end of pipe alternatives such as oil and grit separators, and JellyFish filters. Each of these options has an expected total suspended sediment (TSS) removal capability, varying from 5% to 88%. When used in a treatment train approach the combination of TSS removal methods improves the overall performance. A summary of quality control options is provided in Attachment A.

Table 1 provides a summary of the TSS removal methods that were considered. Various options and combinations of options have been assessed and shown to meet or exceed the required 80% TSS target. However, with the proposed use of the MEFS which will provide a combination of filtration and infiltration (which is a vital component to meet the site's water budget requirements - further discussion below), Option 6 was selected for this project.

As such, stormwater quality treatment will be provided through the combined use of deep sump catch basins, goss traps on the lead pipes and MEFS. As per the available literature, deep sump catch basins can remove/ retain 25% of the total suspended sediments (TSS) and the MEFS 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 MEFS, the use of deep sump catch basins will provide pre-treatment to the MEFS, especially from being overloaded during construction periods and will reduce cleanout/maintenance frequency, further increasing its longevity. In addition to this, it is proposed that the catch basin lead pipes, both the upper and lower pipes, be protected with goss traps. This will prevent floatable pollutants, including oils, from being discharged to the stormwater collection system. The characteristics of the MEFS are described in the previous section of this memo and presented in Figure 1.

Table 1: Quality Control Options - Treatment Train to get 80% TSS Removal
Selection and comparison of Options

Method	TSS Removal	Opt. 1	Opt. 2	Opt. 3	Opt. 4	Opt. 5	Opt. 6	Opt. 7	Opt. 8
Street Sweeping (Monthly)	5%								
Street Sweeping (Weekly)	10%								
Street Sweeping (Weekly with Elgin Eagle)*	88%	X							
Curb Cut with Grass Swales	75%			X					
Curb Cut with Infiltration Trenches	80%		X						
Catch basin Inserts (CB Shield)*	27%				X	X		X	X
Deep Sump Catch Basin	25%				X		X		X
Infiltration/ Filtration Trenches**	80%				X	X	X		
OGS*	50%			X					X
JellyFish*	85%							X	
Overall Performance		**88.00%**	**80.00%**	**87.50%**	**89.10%**	**85.40%**	**85.00%**	**89.10%**	**72.60%**

Treatment Train Overall Performance = 1 - (1- TSS Removal Rate Method 1) x (1- TSS Removal Rate Method 2) x (1- TSS Removal Rate Method 3 x …)

*) TSS Removal as documented by ETV Canada

**) includes the use of Etobicoke infiltration or filtration systems or other permutations of the same

Water Balance

A pre-and post-development water balance has been completed for the site based on the Ministry of the Environment, Conservation and Parks (MECP) SWM design guidelines; the following section outlines the approach and results of this analysis for the various site conditions.

Pre-Development

Based on the Soil Survey Complex mapping from the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) the site primarily consists of Carsonby - Silty Clay (Type C) Soils. This was confirmed through onsite field investigations and boreholes which also reported Silty Clays through the majority of the site, refer to Paterson Groups report title "Geotechnical Investigation – Proposed Residential development – Conservancy Lands East", 24 September 2019, for full details. The existing site's water budget parameters have been based on Table 3.1 - Hydrologic Cycle Component Values of the MECP's SWM Manual, assuming Pasture and shrub conditions and a Type C hydrologic soil type, with a soil infiltration factor of 0.1 (tight clays) applied. Under pre-development conditions, the site has a total imperviousness of approximately 2%.

To determine the total water budget for the site, the proposed development lands have been broken 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 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 this analysis it was found that this site on average, 57.1% of the annual precipitation will return to the atmosphere through evaporation and evapotranspiration, 16.6% will infiltrate and 26.3% will runoff. For the total site drainage area of 59.26 ha, the site will infiltrate 92,215 m³/yr. or 156 mm/yr. of the total annual precipitation of 940 mm/yr.

Post-Development-Without LIDs

Under post-development conditions, the site has been broken into 3 subcomponents based on the proposed land use type: Town Homes, Single Homes and Park Lands. Note that the impervious area associated with the proposed roads has been included in the various development types outlined above. Based on the development conceptual plan, the 59.26 ha site will have a total imperviousness of 64%. 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 Lawns and Type C hydrologic soil type. This analysis also assumes that the pervious surfaces within the development will be covered with imported topsoil, and as such a soil infiltration factor of 0.2 (reflective of a mix of clay and loam) was applied.

As completed under pre-development conditions, each of the land use 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 7.6% will infiltrate and 55.4% will runoff. Based on the total development area of 59.26 ha, the site will infiltrate 42,561 m³/yr. or 71.8 mm/yr. of the total annual rainfall of 940 mm/yr.: 49,654 m³/yr. or 83.8 mm/yr. short of the pre-development conditions.

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, the Modified Etobicoke Filtration Systems (MEFS) are proposed to be implemented throughout this site in all locations physically and practically possible.

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 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 particular rainfall events. 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 determine the runoff (in mm) generated from a given TIMP and XIMP, for any of these storms. For events with less than 5 mm of rainfall, the runoff volume can be computed by simply removing the initial abstraction (IA), from the total rainfall, over the impervious surfaces as the pervious surfaces will not generate any runoff.

It is noted that for the proposed development, with 65% total imperviousness (TIMP) and 52% directly connected imperviousness (XIMP), a 5 mm event would generate approximately 1.78 mm of runoff volume. For a typical ROW of 20 m and 30 m deep residential lots, this represents a volume of 0.142 m^3/m (1.78 mm * 80 m^2/m). Noting that for the current application, 16.5 m ROW widths and 21 m deep lots are being proposed, the runoff generated per linear meter of roads is reduced to 0.104 m^3/m (1.78 mm * 58.5 m^2/m). With the proposed 2.5 m wide MEFS clear stone trenches (40% porosity) either of these volumes can be retained within the vertical space between the bottom of the trench and the invert of the lower perforated pipe. For the larger of the two-volume to exfiltrate to the soils underneath the trench within a 48-to-72-hour period, the soils' effective infiltration rates would need to be 0.8 mm/hr to 1.2 mm/hr. These required rates are much lower than those reported by Paterson Group of 9 mm/hr - 25 mm/hr, based on the soil types observed on site.

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 MEFS. Interpolating the values in the tables derived by JLR (Table B2-5), combined with the SWMHYMO results provided in Appendix C, it is found that if the MEFS is designed to capture and infiltrate the runoff for storms up to the 5 mm event (64th percentile) a runoff volume of 1.78 mm, the MEFS would provide the means to maintain and exceed the existing on-site infiltration. The results of this analysis are summarized in Appendix B Table B2-4 and show that if LIDs were designed to retain and infiltrate the runoff from 5 mm storms or less, some additional 70,703 m^3/yr. (119 mm/yr.) of runoff volume would be infiltrated. This volume offsets the deficit of 49,654 m^3/yr. (83.8 mm/yr.) that was calculated under post-development conditions without any LIDs implemented, shown above, and exceeds the pre-development inflation rate by 21,049 m^3/yr. (35.5mm/yr.)

Note that this analysis assumes that these LID measures will infiltrate the runoff volume for storms up to a 5 mm event, this does not mean that these LIDs will only be sized to capture and treat the 5 mm event. These measures will be sized to filter events greater than the 5 mm event, but only need to capture and infiltrate up to the 5 mm event to meet the existing water budget. It is important to note that the relatively low capture (retention/infiltration) rate of up to the 5 mm event is driven by the naturally low infiltration rates of the existing underlying soils (Silty Clays). The design capture event could be further increased but this would also greatly increase the drawdown times within the MEFS; these details can be refined at detailed design.

Development Water Budget Scenario Summary

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

Table 2:Pre-Development Water Balance

Drainage Area (ha)		59.26	Imperviousness:	2%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	556,997	318,216	92,215	146,566
mm	940	537	156	247
%	100%	57.1%	16.6%	26.3%

Table 3:Post Development Water Balance – Without LIDs

Drainage Area (ha)		59.26	Imperviousness:	64%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	556,997	206,259	42,561	308,177
mm	940	348	72	520
%	100%	37.1%	7.6%	55.3%

Table 4:Post Development Water Balance – With LIDs

Drainage Area (ha)		59.26	Imperviousness:	64%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	556,997	206,259	113,264	237,474
mm	940	348	191	401
%	100%	37.1%	20.3%	42.6%

Based on this analysis of pre-development conditions this site will evaporate 57.1%, infiltrate 16.6% and runoff 26.3% of all annual rainfall. Under Post-development conditions without LID, this site will evaporate 37.1%, infiltrate 7.6% and runoff 55.3% of all annual rainfall. Under post-development conditions with LIDs, this site will evaporate 37.1%, infiltrate 20.3% and runoff 42.6% of all annual rainfall, exceeding existing pre-development infiltration rates.

Jock River Corridor Restoration Area.

As a part of this development, restoration works will be completed within the Jock River corridor. With 18.27 ha of wetland and habitat features implemented east of Borrisokane, and 5.54 ha of habitat features implemented west of Borrisokane. A Pre & post-development water budget analysis was completed for these lands as well. Full details of this water budget analysis have been provided in attachment C tables B3-1 to B3-4.

Tables 5 - 8 summarize the annual average water balance under existing conditions and post-development (naturalized wetland) conditions for these two proposed lands, as m³/year, mm/year and % of total annual rainfall.

Table 5: Pre Development Water Balance - Naturalization work East Borrisokane Road

Drainage Area (ha)		18.27	Imperviousness:	0%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	171,738	99,206	29,013	43,519
mm	940	543	159	238
%	100%	57.8%	16.9%	25.3%

Table 6: Post Development Water Balance - Naturalization work East Borrisokane Road

Drainage Area (ha)		18.27	Imperviousness:	0%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	171,738	104,837	37,745	29,156
mm	940	574	207	160
%	100%	61.0%	22.0%	17.0%

Table 7: Post Development Water Balance - Naturalization work West Borrisokane Road

Drainage Area (ha)		5.54	Imperviousness:	0%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	52,076	30,082	8,798	13,196
mm	940	543	159	238
%	100%	57.8%	16.9%	25.3%

Table 8: Post Development Water Balance - Naturalization work West Borrisokane Road

Drainage Area (ha)		5.54	Imperviousness:	0%
Annual Average Volume	Precipitation	Evapotranspira-tion	Infiltration	Runoff
m^3	52,076	30,359	11,939	9,778
mm	940	548	216	177
%	100%	58.3%	22.9%	18.8%

Based on this analysis of pre-development conditions the east lands will evaporate 57.8%, infiltrate 16.9% and runoff 25.3% of all annual rainfall. Under Post-development (naturalization) conditions, this site will evaporate 61.0%, infiltrate 22.0% and runoff 17.0% of all annual rainfall. Exceeding both the pre-development evaporation and infiltration targets, while also reducing the total runoff to the Jock River.

Based on this analysis of pre-development conditions the west lands will evaporate 57.8%, infiltrate 16.9% and runoff 25.3% of all annual rainfall. Under Post-development (naturalization) conditions, this site will evaporate 58.3%, infiltrate 22.9% and runoff 18.8% of all annual rainfall. Exceeding both the pre-development evaporation and infiltration targets, while also reducing the total runoff to the Jock River.

Conclusion

Phase 2 of the Barrhaven Conservancy Development will meet and exceed the quality control requirements of 80% TSS removal, through the implementation of a stormwater quality treatment train, which will combine the use of deep sump catch basins, goss traps on the lead pipes and MEFS. This combined treatment train approach is expected to provide 85% TSS removal, exceeding the site's water quality requirements.

A preliminary water balance analysis of the existing site was completed to determine pre-development infiltration rates. A post-development analysis for the site, where no LIDs were implemented, showed that the percentage of annual rainfall infiltrated would decrease by 8.9%. Implementing LIDs in the way of Modified Etobicoke Filtration Systems that are designed to capture and infiltrate up to the 5 mm event would offset this deficit and exceed pre-development conditions. 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 MEFS.

As a part of this development, restoration works will be completed within the Jock River corridor. With 18.27 ha of wetland and habitat features implemented east of Borrisokane, and 5.54 ha of habitat features implemented west of Borrisokane. A Pre & post-development water budget analysis was completed for these lands as well. From this analysis, it was found that for both sites, the naturalization works will exceed both pre-development evaporation and infiltration targets, while also reducing the total annual runoff to the Jock River.

Yours truly,
J.F Sabourin and Associates Inc.

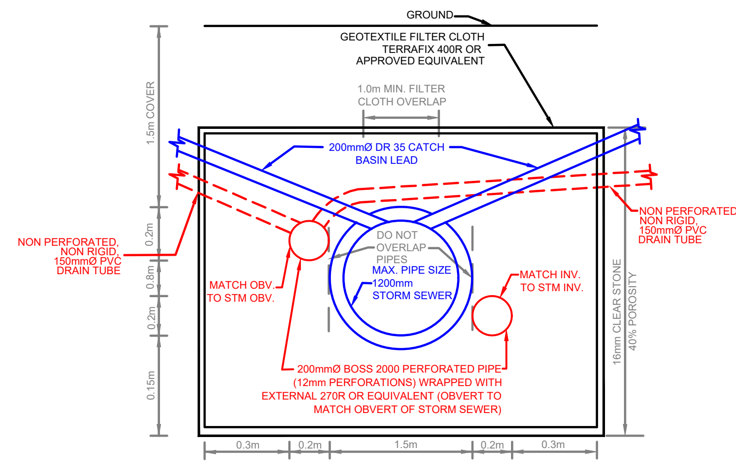
Jonathon Burnett, P.Eng
Water Resources Engineer

cc: J.F Sabourin, M.Eng, P.Eng
Director of Water Resources Projects

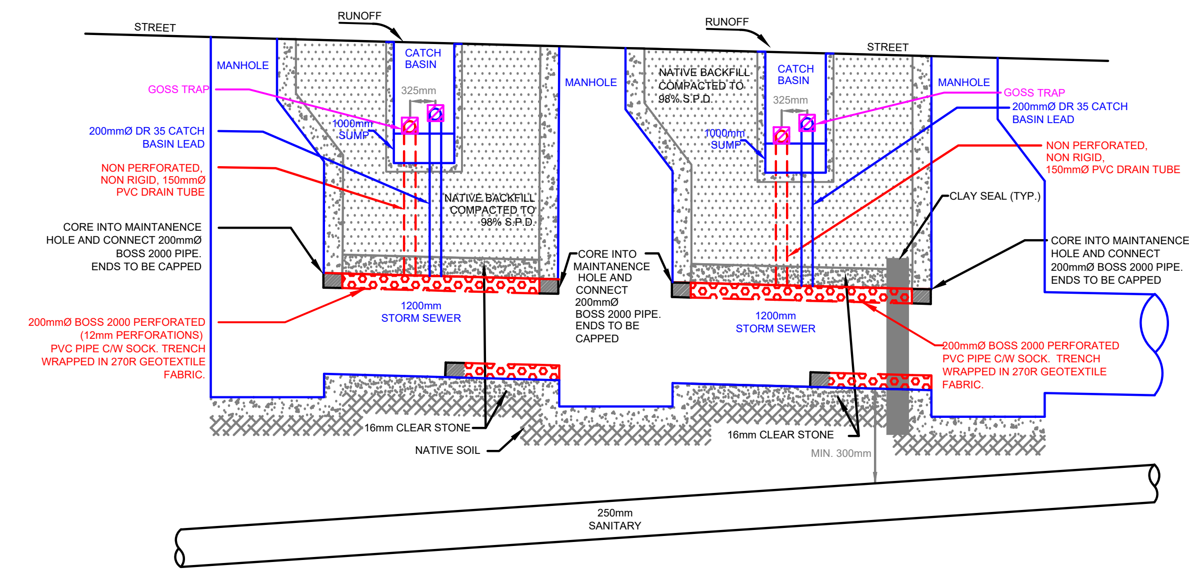
Figures

Tables

Attachments

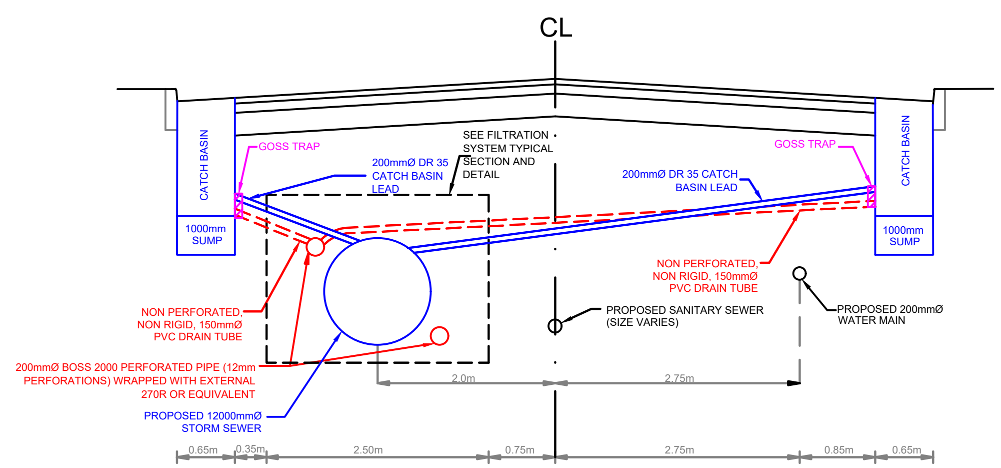


FILTRATION SYSTEM DETAIL
TYPICAL SECTION
N.T.S.

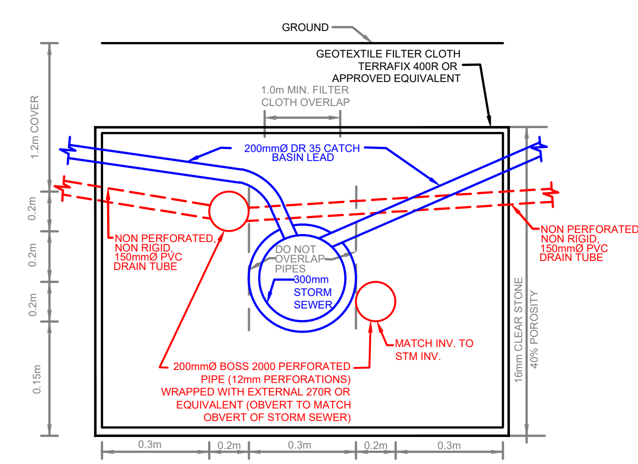


FILTRATION SYSTEM DETAIL
TYPICAL PROFILE
N.T.S.

SCENARIO 1 - DOWNSTREAM FILTRATION SYSTEM



FILTRATION SYSTEM
LOCATION CROSS SECTION (TYP)
N.T.S.



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TYPICAL SECTION
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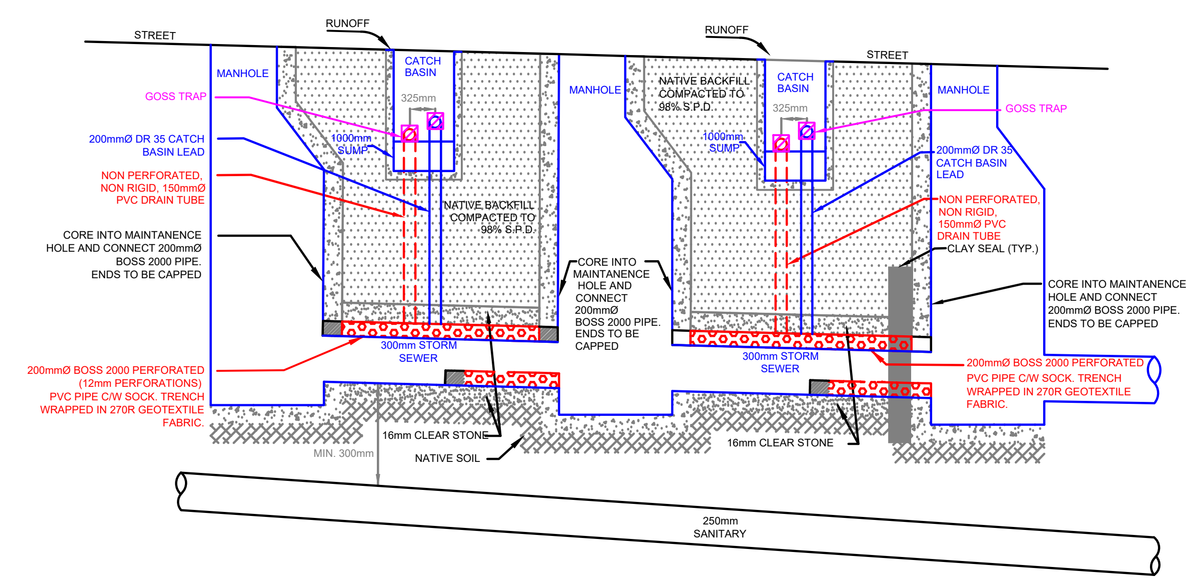

FILTRATION SYSTEM DETAIL
TYPICAL PROFILE
N.T.S.

SCENARIO 2 - UPSTREAM FILTRATION SYSTEM

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BARRHAVEN CONSERVANCY
FILTRATION SYSTEM DETAILS
CITY OF OTTAWA

PROJECT No.:	16-891
SCALE:	NTS
DATE:	FEBRUARY 2021
FIGURE:	5

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Attachment A

Quality Control Alternatives – Summary

P1474(05)-20: 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)	88%	Elgin Eagle Waterless Sweeper (per pass as tested by ETV Canada)
Street Sweeping (Weekly with Elgin Eagle)*		

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

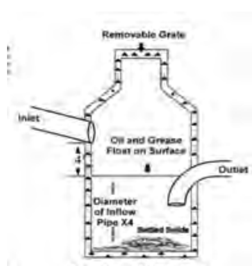

FIGURE 2.2 Cartridge type CBI (Contech Engineered Solutions, 2017).


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

BCDC Phase 2 - Pre Development Water Balance

Table B1-1: Pre 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)	Topography Factor	Infiltration Factor* Soils Factor	Infiltration Factor* Cover Factor	Infiltration Factor* Total	Infiltration (mm/yr.)	Runoff (mm/yr.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Pre-Development	Moderately Rooted Crops	59.26	2%	58.07	1.19	Silty Clay	C	940	543	397	0.2	0.1	0.1	0.4	158.8	238	315,320	92,215	138,323
Total		**59.26**		**58.07**	**1.19**												**315,320**	**92,215**	**138,323**

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.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff
Pre-Development	Moderately Rooted Crops	59.26	2%	58.07	1.19	940	244	696	0	696	2,896	0	8,244
Total		**59.26**		**58.07**	**1.19**						**2,896**	**0**	**8,244**

*Evapotranosptation rate based on continuous hydrologic SWMHYMO model simulations using 39 years of historical rainfall data from the Ottawa Airport, for 100% impervious surfaces with City default impervious Initial Abstraction parameters applied

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 (m^3/yr.)	Impervious Runoff Volume (m^3/yr.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Pre-Development	Moderately Rooted Crops	59.26	2%	58.07	1.19	138,323	8,244	318,216	**92,215**	146,566
Total		**59.26**		**58.07**	**1.19**		**Total**	**318,216**	**92,215**	**146,566**

BCDC Phase 2 - 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.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
											Topography Factor	Soils Factor	Cover Factor	Total					
Post Development	Town Homes	3.924	86%	0.56	3.36	Silty Clay	C	940	536	404	0.2	0.2	0.1	0.5	202	202	3,008	1,133	1,133
	Park	4.967	29%	3.55	1.42	Silty Clay	C	940	536	404	0.2	0.2	0.1	0.5	202	202	19,009	7,164	7,164
	Single Homes	50.364	66%	16.96	33.40	Silty Clay	C	940	536	404	0.2	0.2	0.1	0.5	202	202	90,918	34,264	34,264
Total		**59.26**		**21.07**	**38.19**												**112,934**	**42,561**	**42,561**

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.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Post Development	Town Homes	3.924	86%	0.56	3.36	940	244	696	0	696	8,219	0	23,392
	Park	4.967	29%	3.55	1.42	940	244	696	0	696	3,472	0	9,881
	Single Homes	50.364	66%	16.96	33.40	940	244	696	0	696	81,634	0	232,343
Total		**59.26**		**21.07**	**38.19**						**93,325**	**0**	**265,616**

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 (m^3/yr.)	Impervious Runoff Volume (m^3/yr.)	Evapo-transpiration (m^3/Year)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Post Development	Town Homes	3.924	86%	0.56	3.36	1133	23392	11,227	1,133	24,526
	Park	4.967	29%	3.55	1.42	7164	9881	22,481	7,164	17,045
	Single Homes	50.364	66%	16.96	33.40	34264	232343	172,552	34,264	266,606
Total		**59.26**		**21.07**	**38.19**			**206,259**	**42,561**	**308,177**

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 (m^3/yr.)	Site Infiltration Surplus (m^3/yr.)
Post Development LID System	59.3	100%	59.26	520	5.0	1.78	64%	119	70,703	21,049

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

BCDC Phase 2 - Jock River Corridor Restoration Area - Pre & Post Development Water Balance

B3-1: BCDC Phase 2 - Pre Development Water Balance where naturalization work will take place east of Borrisokane Road - 18.27 ha

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* Topography Factor	Infiltration Factor* Soils Factor	Infiltration Factor* Cover Factor	Infiltration Factor* Total	Infiltration (mm/yr.)	Runoff (mm/yr.)	Evapo-transpiration (m^3/yr.)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Pre-Development	Moderately Rooted Crops	18.27	0%	18.27	0.00	Silty Clay	C	940	543	397	0.2	0.1	0.1	0.4	158.8	238	99,206	29,013	43,519
Total		**18.27**		**18.27**	**0.00**												**99,206**	**29,013**	**43,519**

B3-2: BCDC Phase 2 - Pre Development Water Balance where naturalization work will take place west of Borrisokane Road- 5.54 ha

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* Topography Factor	Infiltration Factor* Soils Factor	Infiltration Factor* Cover Factor	Infiltration Factor* Total	Infiltration (mm/yr.)	Runoff (mm/yr.)	Evapo-transpiration (m^3/yr.)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Pre-Development	Moderately Rooted Crops	5.54	0%	5.54	0.00	Silty Clay	C	940	543	397	0.2	0.1	0.1	0.4	158.8	238	30,082	8,798	13,196
Total		**5.54**		**5.54**	**0.00**												**30,082**	**8,798**	**13,196**

B3-3: BCDC Phase 2 - Post Development Water Balance where naturalization work will take place east of Borrisokane Road - 18.27 ha

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* Topography Factor	Infiltration Factor* Soils Factor	Infiltration Factor* Cover Factor	Infiltration Factor* Total	Infiltration (mm/yr.)	Runoff (mm/yr.)	Evapo-transpiration (m^3/yr.)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Wetland	Water	3.02	100%	0.00	3.02	Silty Clay	C	940	700	240	0.3	0.1	0.1	0.5	120	120	21,140	3,624	3,624
Wetland	Meadows	4.24	0%	4.24	0.00	Silty Clay	C	940	546	394	0.2	0.2	0.1	0.5	197	197	23,150	8,353	8,353
Wetland	Sand Banks	0.22	0%	0.22	0.00	Silty Clay	C	940	546	394	0.1	0.4	0.1	0.6	236.4	158	1,201	520	347
Wetland	Trees/ Forest	10.79	0%	10.79	0.00	Silty Clay	C	940	550	390	0.2	0.2	0.2	0.6	234	156	59,345	25,249	16,832
Total		**18.27**		**15.25**	**3.02**												**104,837**	**37,745**	**29,156**

*Evaporation rate taken from Hydrologic Atlas of Canada - Mean Annual Lake Evaporation - 700mm

B3-4: BCDC Phase 2 - Post Development Water Balance where naturalization work will take place west of Borrisokane Road- 5.54 ha

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* Topography Factor	Infiltration Factor* Soils Factor	Infiltration Factor* Cover Factor	Infiltration Factor* Total	Infiltration (mm/yr.)	Runoff (mm/yr.)	Evapo-transpiration (m^3/yr.)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
Wetland	Meadows	2.77	0%	2.77	0.00	Silty Clay	C	940	546	394	0.2	0.2	0.1	0.5	197	197	15,124	5,457	5,457
Wetland	Trees/ Forest	2.77	0%	2.77	0.00	Silty Clay	C	940	550	390	0.2	0.2	0.2	0.6	234	156	15,235	6,482	4,321
Total		**5.54**		**5.54**	**0.00**												**30,359**	**11,939**	**9,778**

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