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March 05, 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, 57.5% of the annual precipitation will return to the atmosphere through evaporation and evapotranspiration, 16.4% will infiltrate and 26.1% will runoff. For the total site drainage area of 59.26 ha, the site will infiltrate 91,518 m^3/yr. or 154 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 m^3/yr. or 71.8 mm/yr. of the total annual rainfall of 940 mm/yr.: 48,957 m^3/yr. or 82.6 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 48,957 m^3/yr. (82.6 mm/yr.) that was calculated under post-development conditions without any LIDs implemented, shown above.

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.

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 m^3/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	319,958	91,518	145,521
mm	940	540	154	246
%	100%	57.5%	16.4%	26.1%

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 57.4%, infiltrate 16.4% and runoff 26.1% 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.

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, where no LIDs were implemented, showed that the percentage of annual rainfall infiltrated would decrease by 8.8%. 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.

Yours truly,
J.F Sabourin and Associates Inc.

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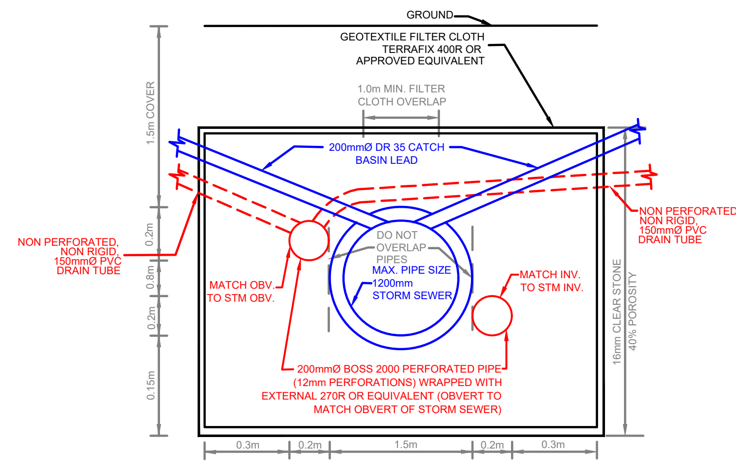
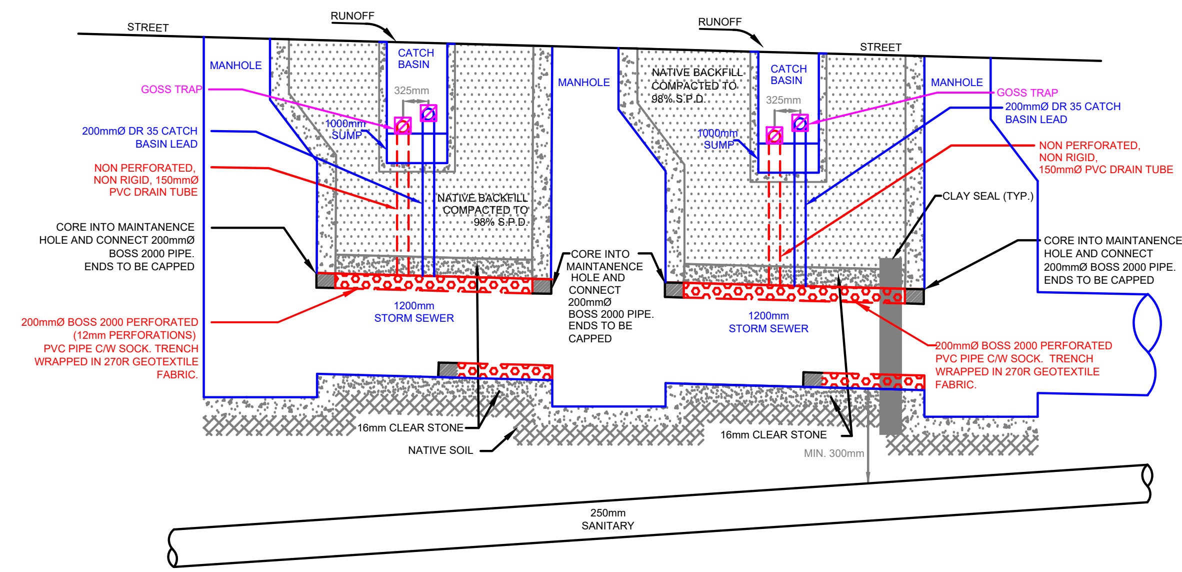
Figures
Figure 1: Modified Etobicoke Filtration Systems Drawing Details

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

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

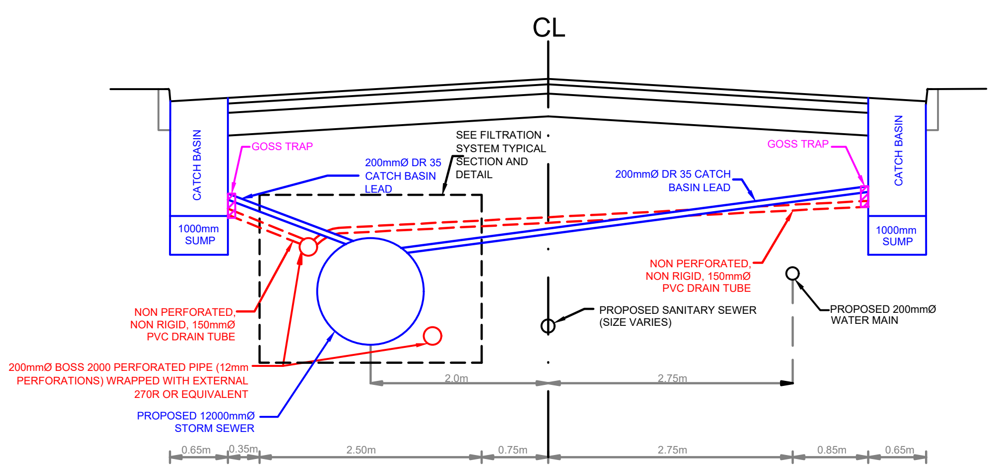


FILTRATION SYSTEM DETAIL
TYPICAL SECTION
N.T.S.

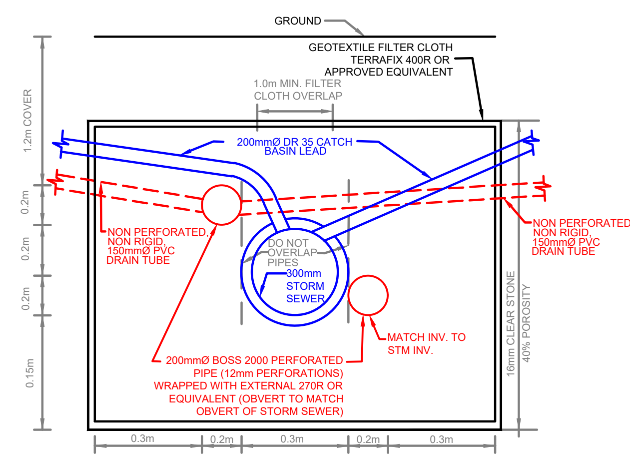


FILTRATION SYSTEM DETAIL
TYPICAL PROFILE
N.T.S.

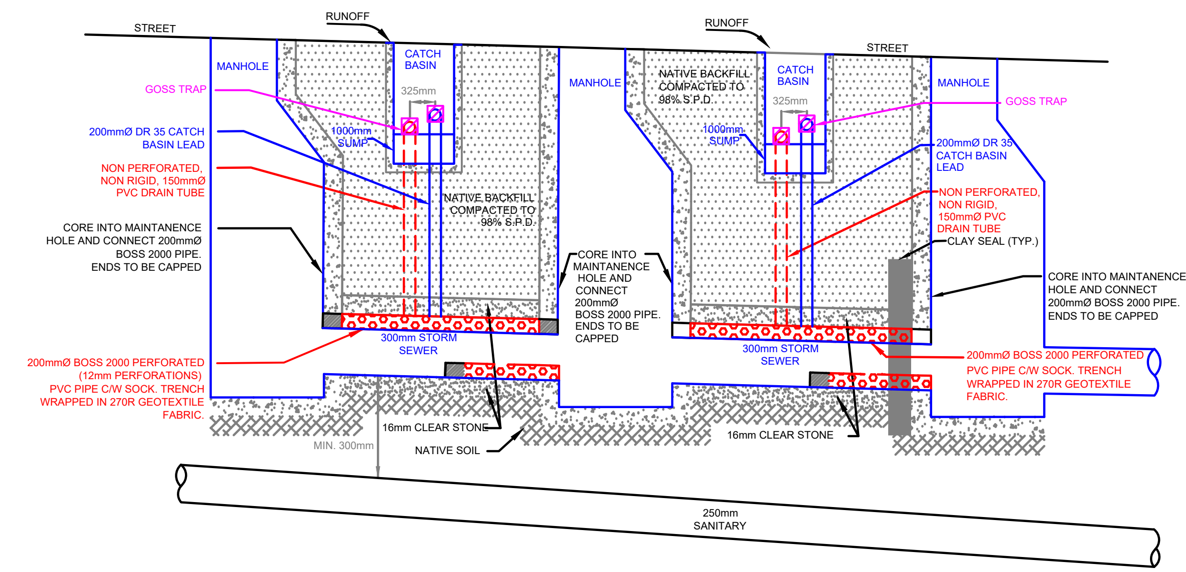
SCENARIO 1 - DOWNSTREAM FILTRATION SYSTEM



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



FILTRATION SYSTEM DETAIL
TYPICAL SECTION
N.T.S.



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

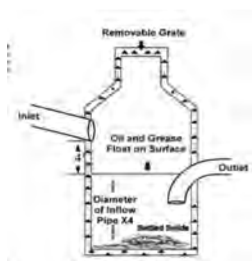
FIGURE 2.2 Cartridge type CBI (Contech Engineered Solutions, 2017).

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



Deep Sump Catch Basin

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)	Infiltration Factor*				Infiltration (mm/yr.)	Runoff (mm/yr.)	Infiltration Volume (m^3/yr.)	Runoff Volume (m^3/yr.)
											Topography Factor	Soils Factor	Cover Factor	Total				
Pre-Development	Natural	59.26	2%	58.07	1.19	Silty Clay	C	940	546	394	0.2	0.1	0.1	0.4	157.6	236	91,518	137,277
Total		**59.26**		**58.07**	**1.19**												**91,518**	**137,277**

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 (m^3/yr.)	Runoff Volume (m^3/yr.)
Pre-Development	Natural	59.26	2%	58.07	1.19	940	244	696	0	696	0	8,244
Total		**59.26**		**58.07**	**1.19**						**0**	**8,244**

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.)	Runoff Volume (m^3/yr.)	Infiltration Volume (m^3/yr.)
Pre-Development	Natural	59.26	2%	58.07	1.19	137,277	8,244	145,521	**91,518**
Total		**59.26**		**58.07**	**1.19**		**Total**	**145,521**	**91,518**

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.)	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	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	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	34,264	34,264
Total		**59.26**		**21.07**	**38.19**												**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.)	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	0	23,392
	Park	4.967	29%	3.55	1.42	940	244	696	0	696	0	9,881
	Single Homes	50.364	66%	16.96	33.40	940	244	696	0	696	0	232,343
Total		**59.26**		**21.07**	**38.19**						**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.)	Runoff Volume (m^3/yr.)	Infiltration Volume (m^3/yr.)
Post Development	Town Homes	3.924	86%	0.56	3.36	1133	23392	24526	1133
	Park	4.967	29%	3.55	1.42	7164	9881	17045	7164
	Single Homes	50.364	66%	16.96	33.40	34264	232343	266606	34264
Total		**59.26**		**21.07**	**38.19**			**308,177**	**42,561**

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	21,746

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

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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 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 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 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

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 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 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