UNITED PROPERTY RESOURCE CORPORATION

Norval United Church

Stormwater Management Report

December 16, 2022 Confidential

Norval United Church

Stormwater Management Report

UNITED PROPERTY RESOURCE CORPORATION

Confidential

Project No.: 221-05336
Date: December 16, 2022

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2022-12-16

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Date

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1 INTRODUCTION

1.1 Scope

WSP Canada Inc. (WSP) has been retained by United Property Recourse Corporation to prepare a Stormwater Management (SWM) Report to support the Zoning By-law Amendment (ZBA) of the proposed development (the "Site") located at 14015 Danby Road in the Town of Halton Hills (hereafter the "Project").

This SWM report examines the potential water quantity and water quality impacts of the proposed development and summarizes how each will be addressed in conformance with the requirements of the Town of Halton Hills, Conservation of Halton (CH) and other applicable stormwater management criteria.

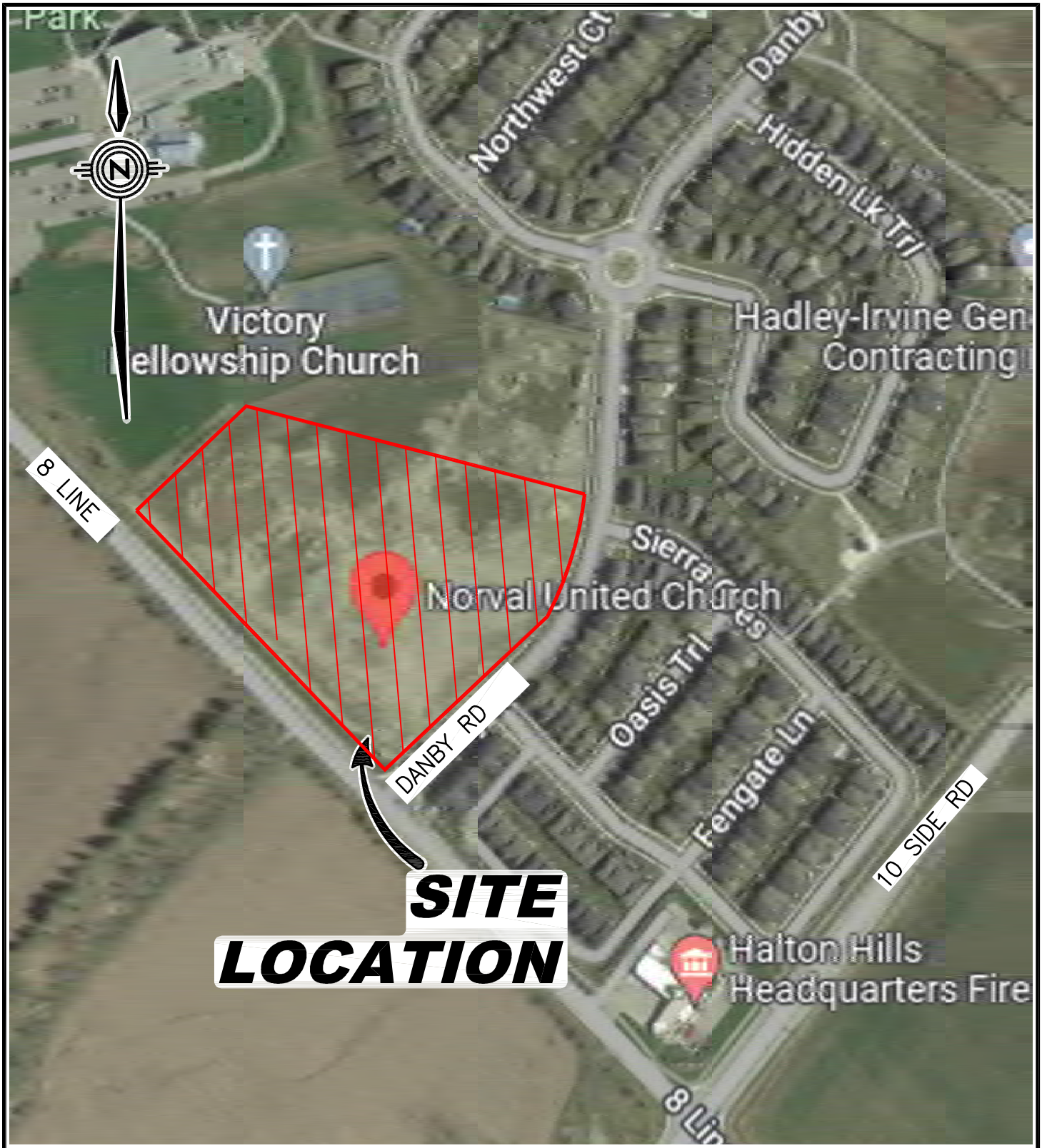
1.2 Site Location

The proposed development has a project area of 2.0 ha, located at the existing Norval United Church at 14015 Danby Road in the Town of Halton Hills, Region of Halton. The site generally trapezoid in shape and has Victory Fellowship Church to the North, Eight Line to the West, and Danby Road to the South and East. The location of the proposed development is illustrated in **Figure 1**. The site lies within the Sixteen Miles Creek sub-watershed, which is under the jurisdiction of CH.

1.3 Stormwater Management Plan Objectives

In accordance with the applicable Town of Halton Hills and CH's SWM guidelines, the objectives of this stormwater management plan are as follows:

- Determine site specific stormwater management requirements to ensure that the development project is in conformance with the Town and CH guidelines.
- Evaluate various stormwater management practices that meet the requirements of the relevant SWM design criteria and recommend a preferred strategy.
- Prepare a stormwater management report documenting the strategy along with the technical information necessary for sizing of the proposed stormwater management features.



@2022 Google - Map data @2022

CLIENT

KPMB ARCHITECTS & TOWN OF HALTON HILLS

TITLE

NORVAL UNITED CHURCH,
CITY OF HALTON HILLS

SITE LOCATION

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Date DEC 2022	Proj. No. 221-05336-00
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FIGURE 1.dwg Site Location C:\Users\calz077846\ACCDocs\WSP Canada projects (AMER)\LDO\Files\221-05336 Norval United Church\SWM\Figures\ Dec 14, 2022 - 3:54pm

1.4 Design Criteria

The CH issued the Stormwater Management Engineering Submission Guidelines document in November 2021 to identify CH's regulatory and technical requirements for any SWM submission within its jurisdiction as well as to outline its key expectations for SWM designs. A summary of the stormwater management criteria applicable to this project is as follows:

Water Balance

The Guidelines recommend that the levels shall be maintained as close to current levels as possible to reduce impacts on surface water and groundwater systems. According to the Guidelines, the water balance/infiltration strategies should consider both site scale and feature-based scale.

Currently, due to the absence of criteria specified in higher-level studies, the proponent is recommended to retain the minimum 5 mm rainfall event. More details "refer to Requirements for completion of hydrogeological studies to facilitate Conservation Halton's reviews and consult with CH staff".

Water Quality

Under the Guidelines, the site is required to target a long-term removal of 80% of total suspended solids (TSS) on an annual loading basis, and ensure water discharged to the municipal storm sewers is in compliance with all town requirements pertaining to water quality control.

Erosion Control

In the absence of higher-level studies establishing erosion control requirements, a site-specific erosion study may be required, however for a small infill/redevelopment sites < 2 ha, erosion control in the form of stormwater detention is normally not required, provided a on-site minimum runoff retention from a small design rainfall event (typically 5 mm) is achieved

Water Quantity Control and Discharge to Municipal Infrastructure

As indicated in the Guidelines, "in the absence of current higher-level studies, control post-development flows to pre-development levels for 1:2-year through 1:100-year storm events." The runoff from the 2-year up to 100-year design storms must not exceed the existing 2-year to 100-year return period events release rate to the municipal storm sewer system. For a conservative purpose of this SWM report, runoff

from the 2-year up to 100-year design storms must not exceed the 5-year pre-development flow rate.

2 EXISTING CONDITIONS

2.1 General

The project is a development located at the northeast corner of Eight Line – Danby intersection. The 2.0 ha site is occupied by the Norval United Church and an existing surface parking lot. The existing overland flow route flows from the northeast towards the southeast corner of the site and flows east along Danby Road.

The existing runoff coefficient is estimated to be C = 0.63 as site consists of 69% impervious pavement and 31% at-grade landscaping.

The existing condition of the site is shown in **Figure 2**.

2.2 Rainfall Information

The rainfall intensity for the site was calculated using the following equation:

$$I = A/(B + T)^C$$

Where,

I = rainfall intensity in mm/hour

T = time of concentration in minutes

A, B, and C = constant parameters (see below)

The parameters (A, B, C) recommended for use by the Town of Halton Hills are summarized in **Table 2-1**.

Table 2-1: Rainfall Parameters

Return Period (Years)	2	5	10	25	50	100
A	586.10	946.46	1173.48	1368.91	1622.45	1777.2
B	6.0	7.0	8.0	8.0	9.0	9.0
C	0.760	0.788	0.794	0.789	0.797	0.795

Source: Southwest Georgetown Subwatershed Study, Vision Georgetown, Subwatershed Strategy Report

Gauge: AES for Toronto International Airport, Fergus Shand Dam and Heart Lake

An initial time of concentration, T_C, of 10 minutes (or 0.167 hours) is recommended for this site.

2.3 Allowable Flow Rates

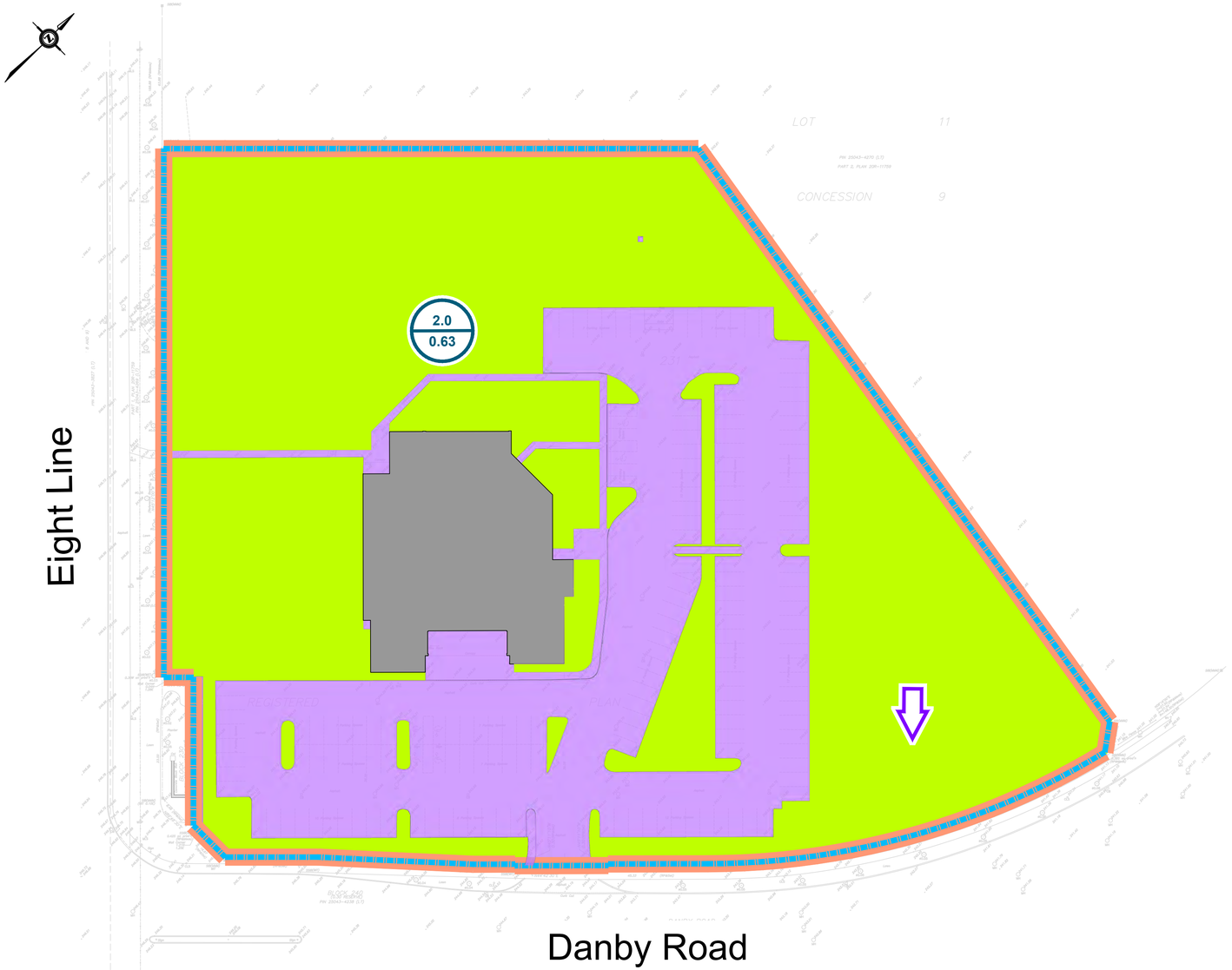
The site is located in an area of suburban development. As noted in **Section 1.4**, relevant policies from the Town require the discharge rate from this site to be controlled to the allowable rate for discharge to municipal sewers. The allowable release rate is the 5-year pre-development flow rate to the municipal storm sewer system. The calculated runoff coefficient for the 2.0 ha site under existing conditions is C = 0.63. The pre-development peak flow rates from the site are summarized in **Table 2.2.** Detailed calculations are contained within **Appendix A**.

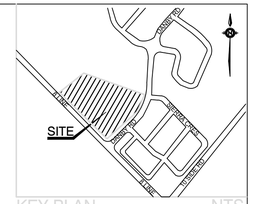
Table 2-2: Pre-Development Peak Flow Rates

Return Period (Years)	Rainfall Intensity, I (mm/hr)	Pre-Development Peak Flow Rates[1] (L/s)	Allowable Release Rate[2] (L/s)
2	71.3	250.6	**356.9**
5	101.5	356.9	
10	118.2	415.8	
25	139.9	492.1	
50	155.2	545.9	
100	171.1	601.5	

[1] Based off a runoff coefficient C = 0.63, an area of 2.0 ha for the site, and a T_c of 10 minutes

[2] 5-year peak flow based off a runoff coefficient C = 0.63, and a site area of 2.0 ha and a T_c of 10 minutes





LEGEND

- PROPERTY BOUNDARY
- CONTROLLED DRAINAGE AREA
- 2.0 / 0.63 — DRAINAGE AREA (ha) / AVERAGE RUNOFF COEFFICIENT
- Impervious Roof
- At-Grade Impervious
- AT-GRADE LANDSCAPING
- OVERLAND FLOW DIRECTION

CLIENT
KPMB ARCHITECTS & TOWN OF HORTON HILLS

TITLE
NORVAL UNITED CHURCH,
TOWN OF HALTON HILLS

EXISTING CONDITIONS

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3 POST-DEVELOPMENT CONDITIONS

3.1 General

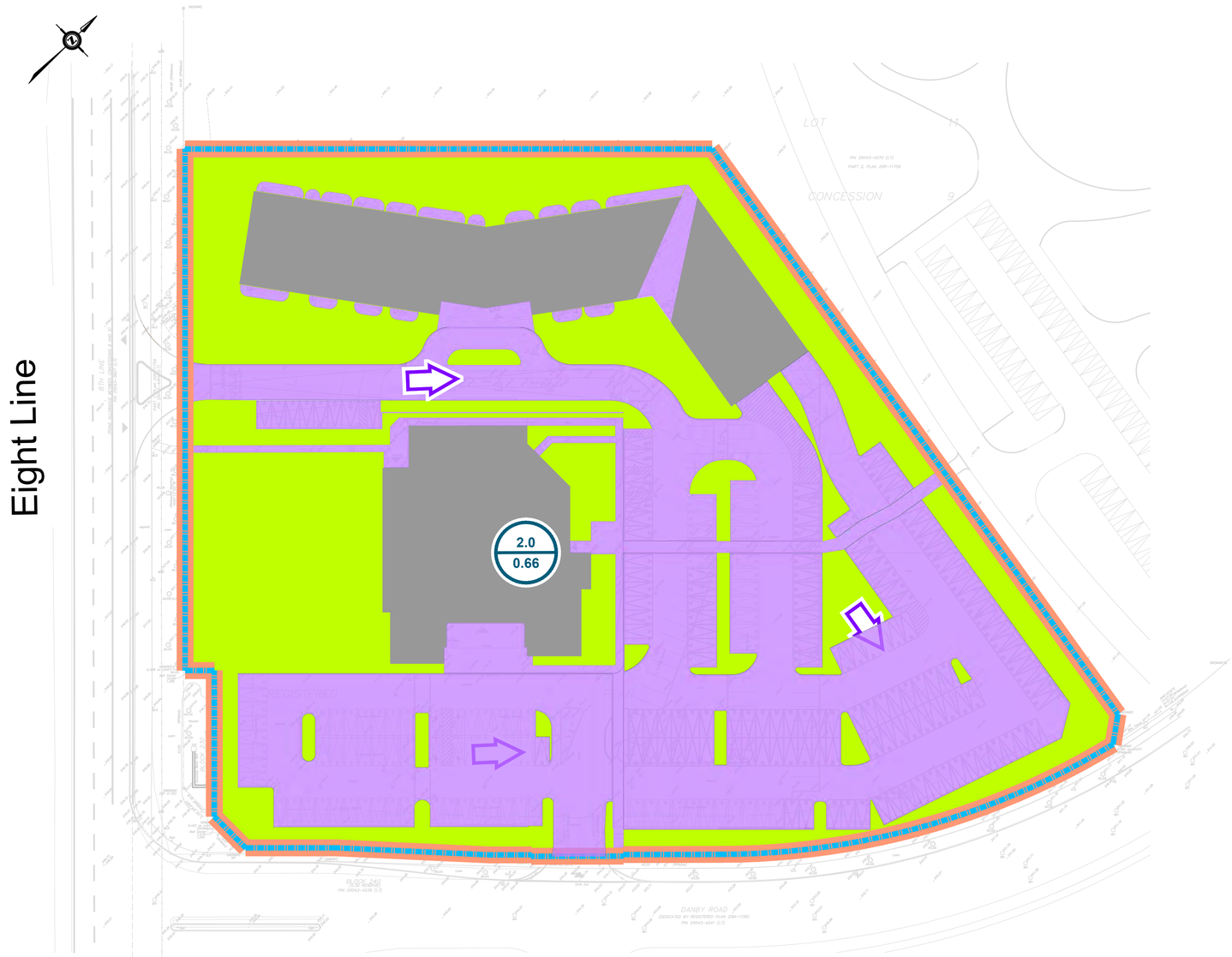
The proposed development consists of construction of a new condominium at the north side of the site, behind the existing building. Access to the site will be provided by two entrances, the first off of Danby Road, and the second off of Eighth Line.

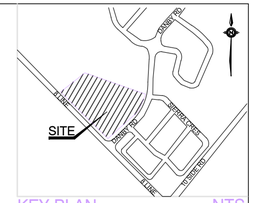
Runoffs generated from the development area will be collected and directed to a stormwater tank located under the proposed parking space, and drain to the existing storm sewer on Danby Road. **Figure 3** illustrates the proposed conditions.

The subject development area has a weighted runoff coefficient of 0.66 under post-development conditions. For detailed servicing and grading please refer to Civil drawings SS-1 and SG-1. An area breakdown of the purposed development is provided below in **Table 3-1**.

Table 3-1: Proposed Conditions Area Breakdown

Surface Type	Area (m^2)	Runoff Coefficient, C	% Coverage
Impervious Roof Coverage	3,504	0.90	17%
Landscaping	7,308	0.25	36%
At-grade Impervious	9,225	0.90	46%
Total Site	**20,038**	**0.66**	**100%**





LEGEND

- PROPERTY BOUNDARY
- CONTROLLED DRAINAGE AREA
- 2.0 / 0.66 — DRAINAGE AREA (ha) / AVERAGE RUNOFF COEFFICIENT
- Impervious Roof
- At-Grade Impervious
- At-Grade Landscaping
- OVERLAND FLOW DIRECTION

CLIENT
KPMB ARCHITECTS & TOWN OF HORTON HILLS

TITLE
NORVAL UNITED CHURCH,
TOWN OF HALTON HILLS

PROPOSED CONDITIONS

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FIGURE 3.dwg FG3 C:\Users\cala0779846\ACCDocs\WSP Canada projects (AMER)\LDO\Files\221-05336 Norval United Church\SWM\Figures\ Dec 14, 2022 - 10:54am

3.2 Water Balance

The site shall target the retention of the 5 mm rainfall event for the purposes of water balance. A volume of 53 m^3 shall be retained for reuse within the stormwater cistern, below the outlet. The reuse methods for the captured stormwater will be assessed in conjunction with the mechanical design of the building's water supply systems. The overall proposed reuse options include irrigation and flushing of toilets and any additional non-potable demand in the communal building areas. It is assumed that sufficient opportunities exist within the development to reuse the full volume of retained stormwater within a reasonable drawdown time.

As noted in **Section 1.4**, due to the absence of criteria in high-level studies, the Guidelines recommend referring to the Requirements for completion of hydrogeological studies to facilitate Conservation Halton's reviews and consult with CH staff. The detailed annual water balance analysis will be provided later by the Hydrogeological design team under a separate cover.

3.3 Water Quality Control

Stormwater runoff from the site will require water quality treatment. This will provide pre-treatment for the water balance volume and ensure excessive sediment does not accumulate within the tank. The standard for water quality treatment is 80% TSS removal on a long-term average annual loading basis. A water quality unit, Imbrium Jellyfish Filter model JF6-6-1, has been sized to provide treatment to the 0.9 ha of at-grade impervious area. Details are included under **Appendix B**.

3.4 Erosion Control

As mentioned in **Section 1.4**, this development is has an overall small footprint, and the 5 mm water balance volume has been retained, thus no further erosion control measures are recommended at this stage beyond the erosion and sediment controls implemented during construction. If required, conservation and municipality staff may provide additional site-specific controls upon revision.

3.5 Water Quantity Control

As noted in **Section 2.3**, the site discharge to the Danby storm sewer and have an allowable discharge rate of 356.9 L/s. This is equivalent to the peak runoff rate under

pre-development conditions during a 5-year design storm event using a runoff coefficient of 0.63.

A model of the site was constructed in HydroCAD and used to determine the required storage volume in the stormwater cistern and to calculate the discharge rates achieved by the proposed flow controls under all storm events. The modified rational method (an inherent subroutine of the HydroCAD software) has been used for the modelling exercise.

An emergency overflow will be provided at the top of the cistern, with discharge to the street level and the adjacent right of way. This will prevent flow from backing up into the building pipework if the primary outlet is blocked, or if a storm event in excess of the 100-year return period occurs.

The runoff from the site will be collected into a stormwater cistern underneath the surface parking lot. The cistern was modelled with a base area of 260.0 m^2 and a height of 1.0 m providing 260.0 m^3 of storage.

The potential reuse volume for water balance is contained below the outlet invert (0.2m) and is assumed full at the onset of the storm, and shall provide a volume of 53 m^3 to satisfy the water balance criteria. A 400 mm orifice tube is proposed as the outlet control and provides sufficient flow restriction to control release rates to the target rate set by the Town.

A summary of the modelling results is provided below in **Table 3-2**. Full HydroCAD modelling output is provided in **Appendix C.**

Table 3-2: Summary of Modelling Results

Return Period (Years)	Allowable Release Rate (L/s)	Peak Cistern Discharge Rate (L/s)	Utilized Storage (m^3) (of 260 m^3)	Water Depth in Cistern (m)
2	**356.9**	162.9	137.5	0.529
5		226.5	168.1	0.646
10		259.6	188.1	0.724
25		298.1	214.9	0.827
50		326.0	236.6	0.910
100		351.8	258.5	0.994

The modelling results demonstrate that the post-development peak flow rates for all events up to the 100-year storm are lower than the target release rate established in

accordance with the Guidelines. The maximum required storage volume to control the 100-year post-development runoff is 258.5 m^3. Note that this total utilized storage volume includes the previously quoted sump storage volume, and the sump has been modelled as full at the beginning of the storm event.

The storm duration producing the highest combination of peak flows from the cistern has been iteratively determined to be t_d = 18 minutes (for the 100-year event) according to the modified rational method process.

4 EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION PERIOD

During construction, there is potential for short-term sediment wash-off from the site. To protect the downstream receiving sewer system and other natural features, on-site sediment control measures are necessary during construction.

As sediment and erosion control strategies focus on minimizing adverse environmental impacts by restricting the mobilization and transport of sediment, the following general practices will be observed:

- Sediment and erosion control works, as shown on the project's erosion and sedimentation control plans which will be provided during the detailed design stage, must be in place prior to the commencement of construction, and not removed until the end of the construction period, when the site has been stabilized.
- Construction phasing must be scheduled to minimize the extent and period to which disturbed soils are exposed to weathering. As such, all disturbed areas must be stabilized as quickly as possible. Stabilization of disturbed areas may be accomplished by sodding, seeding, mulching, hydroseeding, planting, or covering of constructed slopes with an appropriate material such as geotextile or jute mesh.
- Access to the construction site must be minimized.
- A continuous siltation fence must be constructed along the perimeter of the proposed development. The silt fence must be in place prior to the commencement of construction, and must be removed at the end of the construction period.

5 CONCLUSIONS

A stormwater management plan has been prepared to support the ZBA for the proposed development of the Norval United Church in The Town of Norval. The key points are summarized below.

Water Balance

The overall proposed reuse options include irrigation and flushing of toilets and any additional non-potable demand in the communal building areas.

Water Quality

A water quality unit, Imbrium Jellyfish Filter model JF6-6-1, is sized to provide treatment for the at-grade impervious area, and shall treat runoff from these areas to an 80%TSS removal on an average annual basis.

Erosion Control

The site achieves retention of the 5 mm rainfall event, thus no further erosion controls beyond erosion and sediment controls implemented during construction

Water Quantity

Runoff from the controlled catchments on-site will be directed to a stormwater cistern. Post-development flows in the site have been controlled to below 356.9 L/s, in compliance with the target release rate to the municipal storm sewer system by use of a 260.0 m^3 stormwater cistern fitted with a 400 mm orifice tube outlet.

The proposed SWM strategy described in this report addresses all stormwater management-related impacts from the project and satisfies the intent of the Town of Halton Hill Stormwater Management Guidelines.

BIBLIOGRAPHY

- Conservation Halton Guidelines for Stormwater Management Engineering Submissions. Retrieved December 14, 2022, https://www.conservationhalton.ca/wp-content/uploads/2022/05/CH_GSWMES_Nov2021_Final.pdf
- Southwest Georgetown Subwatershed Study VISION GEORGETOWN, Subwatershed Strategy Report. Retried December 14, 2022, https://www.haltonhills.ca/en/residents/resources/Documents/RPT-2017-05-29-SW-Georgetown-Sections-1-7-60297831-with-Figures.pdf

APPENDIX

A

Stormwater Management Calculations

Project:	Norval United Church	No.:	211-05336	
By:	LZ	Date:	2022-12-15	Page:
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Subject: Stormwater Management Calculations - Existing Discharge Rate

Calculation of existing runoff rate is undertaken using the Rational Method: **Q = 2.78 CIA**

Where: Q = Peak flow rate (litres/second)
C = Runoff coefficient
I = Rainfall intensity (mm/hour)
A = Catchment area (hectares)

Catchment Area, A	**2.00**	hectares
* Runoff Coefficient, C	0.63	

$$I = A/(B + t)^C$$

Rainfall intensity calculated in accordance with the Town Requirements:

Where: A, B and C = Parameters defined in requirements
I = Rainfall intensity (mm/hour)
T = Time of concentration (mins)

Return Period (Years)	2	5	10	25	50	100
A	586.1	946.46	1173.48	1368.91	1622.45	1777.2
B	6	7	8	8	9	9
C	-0.76	-0.788	-0.794	-0.789	-0.797	-0.795
T (mins) **	10	10	10	10	10	10
T (hrs)	10.000	10.000	10.000	10.000	10.000	10.000
I (mm/hr)	71.3	101.5	118.2	139.9	155.2	171.1
Q (litres/sec)	**250.6**	356.9	415.8	492.1	545.9	601.5
Q (m3/sec)	0.251	0.357	0.416	0.492	0.546	0.601

Allowable release rate to municipal storm sewer system is therefore 356.9 litres/second.

Source: Toronto International Airport
Gauge: AES for Toronto International Airport, Fergus Shand Dam and Heart Lake

Subject: Stormwater Management Calculations - Water Balance Calculations

The Town require a site "to retain water on-site to the extent practicable,
to achieve the same level of annual volume of overland runoff allowable from the development site under pre-development conditions".

In this case, the minimum on-site runoff retention will require the site to retain all runoff from 5 mm storm event through evapotranspiration or rainwater reuse.

The current area measurements and land use types for the site are as follows:

Land Use	Area (m^2)	Runoff C	Impervious	CN
Impervious Roof Area	3,504.3	0.90	100%	98
Soft/Pervious Landscaping	7,308.5	0.25	0%	74
At-Grade Impervious	9,224.7	0.90	100%	98
Green Roof	-	0.45	0%	98
Total Site Area:	20,038	0.66	64%	-

Surface Type	Area (m^2)	IA (m)	Volume Abstracted (m^3)	5 mm Volume (m^3)	Water Balance (m^3)
Impervious Roof Area	3,504	0.0010	3.50	17.52	14.02
Soft/Pervious Landscaping	7,308	0.0050	36.54	36.54	0.00
At-Grade Impervious	9,225	0.0010	9.22	46.12	36.90
Green Roof	-	0.0050	0.00	0.00	0.00
Total Site Area:	20,038		49.27	100.19	50.92

For the purposes of the water balance calculation it is assumed that green roofs can accept 10 mm of rainfall without producing any runoff. This is supported by EPA analysis of green roof manufacturer data sheets (dry unit weights versus saturated unit weights).

It is assumed that the remaining hard surfaces on the site can abstract 1 mm of rainfall, and that all soft landscaped areas can absorb 5 mm

Therefore, volume of runoff during a 5 mm storm event: 50.92 m^3

Subject: Stormwater Management Calculations - Water Quality - Typical Sediment Loading Analysis

Analysis based on typical EMC TSS values provoded in the following documents:

(1) "Evaluation of an Extensive Greenroof, York University, Toronto, Ontario", Final Report, STEP Program, TRCA, July 2006.

(2) "Wet Weather Flow Management Master Plan, Area 1; Combined System Sewershed", Final Report, July 2003, City of Toronto.

Typical Residential Site:

Surface	Area (m^2)	TSS Loading EMC (mg/l)	TSS Removal (%)	Remaining TSS Load (mg/l)
Total Site Area [1]	**20,038**	**91.0**	**80%**	**18.2**

[1] From WWFMP report for typical residential development area.

Proposed Site

Surface	Area (m^2)	TSS Loading EMC (mg/l)	TSS Removal (%)	Remaining TSS Load (mg/l)
Impervious Roof Areas [1]	3,504	6.3	0%	6.3
Soft Landscaped Areas [2]	7,308	2.2	0%	2.2
Impervious At-Grade Areas [3]	9,225	91.0	0%	91.0
Green Roof [4]	0	2.2	0%	2.2
Totals [5]	**20,038**	**43.8**	**0%**	**43.8**

[1] From STEP program report for impervious roof.

[2] From STEP program report, landscaping assumed to have same loading as green roof.

[3] From WWFMP report for typical residential development area.

[4] From STEP program report for green roof.

[5] TSS Loadings weighted based on area coverage.

The average residential site treated for 80% TSS removal has an AEMC loading of 15.9 mg/L.
The weighted average for this site without any TSS treatment is no more than 18.2 mg/L.
Therefore, no quality control treatment is recommended.

APPENDIX

B

Stormwater Management Calculations

STANDARD OFFLINE
Jellyfish Filter Sizing Report

Project Information

Date	Friday, December 16, 2022
Project Name	8 Line and Danby Rd.
Project Number	
Location	Georgetown

Jellyfish Filter Design Overview

This report provides information for the sizing and specification of the Jellyfish Filter. When designed properly in accordance to the guidelines detailed in the Jellyfish Filter Technical Manual, the Jellyfish Filter will exceed the performance and longevity of conventional horizontal bed and granular media filters.

Please see ***www.ImbriumSystems.com*** *for more information.*

Jellyfish Filter System Recommendation

The Jellyfish Filter model JF6-6-1 is recommended to meet the water quality objective by treating a flow of 28.6 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 18 years of TORONTO CENTRAL rainfall data for this site. This model has a sediment capacity of 370 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF6-6-1	6	1	1.8	28.6	370

The Jellyfish Filter System

The patented Jellyfish Filter is an engineered stormwater quality treatment technology featuring unique membrane filtration in a compact stand-alone treatment system that removes a high level and wide variety of stormwater pollutants. Exceptional pollutant removal is achieved at high treatment flow rates with minimal head loss and low maintenance costs. Each lightweight Jellyfish Filter cartridge contains an extraordinarily large amount of membrane surface area, resulting in superior flow capacity and pollutant removal capacity.

Maintenance

Regular scheduled inspections and maintenance is necessary to assure proper functioning of the Jellyfish Filter. The maintenance interval is designed to be a minimum of 12 months, but this will vary depending on site loading conditions and upstream pretreatment measures. Quarterly inspections and inspections after all storms beyond the 5-year event are recommended until enough historical performance data has been logged to comfortably initiate an alternative inspection interval.

Please see ***www.ImbriumSystems.com*** *for more information.*

Thank you for the opportunity to present this information to you and your client.

Performance

Jellyfish efficiently captures a high level of Stormwater pollutants, including:

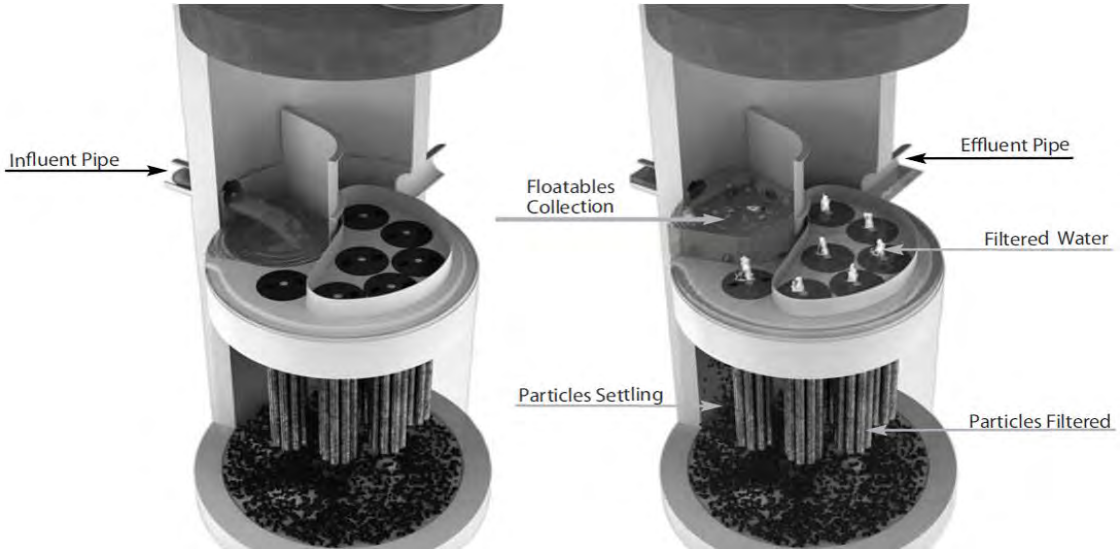
- ☑ 89% of the total suspended solids (TSS) load, including particles less than 5 microns
- ☑ 77% TP removal & 51% TN removal
- ☑ 90% Total Copper, 81% Total Lead, 70% Total Zinc
- ☑ Particulate-bound pollutants such as nutrients, toxic metals, hydrocarbons and bacteria
- ☑ Free oil, Floatable trash and debris

Field Proven Peformance

The Jellyfish filter has been field-tested on an urban site with 25 TARP qualifying rain events and field monitored according to the TARP field test protocol, demonstrating:

- A median TSS removal efficiency of 89%, and a median SSC removal of 99%;
- The ability to capture fine particles as indicated by an effluent d50 median of 3 microns for all monitotred storm events, and a median effluent turbidity of 5 NTUs;
- A median Total Phosphorus removal of 77%, and a median Total Nitrogen removal of 51%.

Jellyfish Filter Treatment Functions



Pre-treatment and Membrane Filtration

Jellyfish® Filter

Project Information

Date:	Friday, December 16, 2022
Project Name:	8 Line and Danby Rd.
Project Number:	
Location:	Georgetown

Designer Information

Company:	WSP Canada Group Ltd.
Contact:	Lanxin Zhang
Phone #:	

Notes

Rainfall

Name:	TORONTO CENTRAL
State:	ON
ID:	100
Record:	1982 to 1999
Co-ords:	45°30'N, 90°30'W

Drainage Area

Total Area:	0.9225 ha
Imperviousness:	100%

Upstream Detention

Peak Release Rate:	n/a
Pretreatment Credit:	n/a

Design System Requirements

Flow Loading	90% of the Average Annual Runoff based on 18 years of TORONTO CENTRAL rainfall data:	**24 L/s**
Sediment Loading	Treating 90% of the average annual runoff volume, 5488 m³, with a suspended sediment concentration of 60 mg/L.	**329 kg***

** Indicates that sediment loading is the limiting parameter in the sizing of this Jellyfish system*

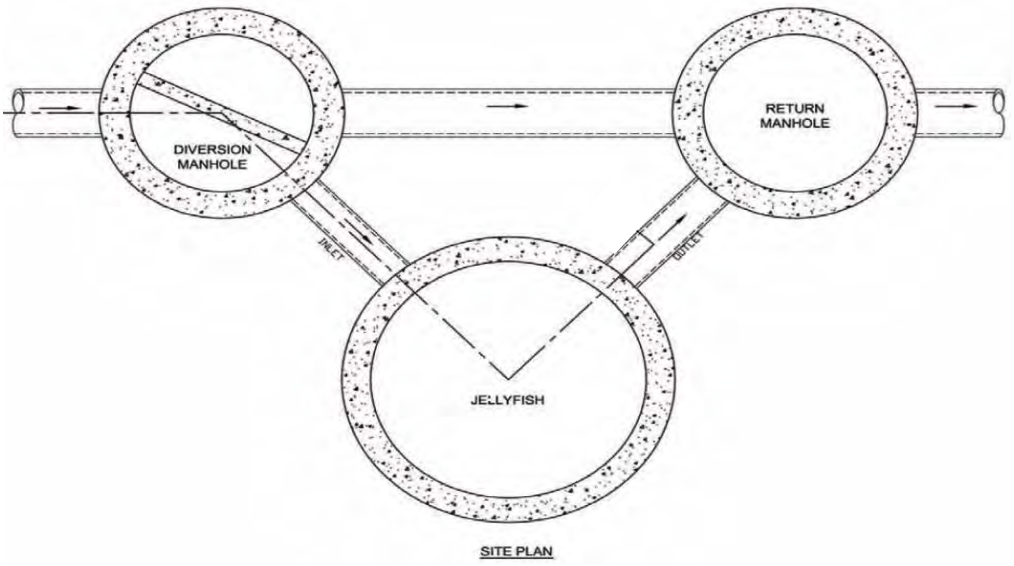
Recommendation

The Jellyfish Filter model JF6-6-1 is recommended to meet the water quality objective by treating a flow of 28.6 L/s, which meets or exceeds 90% of the average annual rainfall runoff volume based on 18 years of TORONTO CENTRAL rainfall data for this site. This model has a sediment capacity of 370 kg, which meets or exceeds the estimated average annual sediment load.

Jellyfish Model	Number of High-Flo Cartridges	Number of Draindown Cartridges	Manhole Diameter (m)	Wet Vol Below Deck (L)	Sump Storage (m³)	Oil Capacity (L)	Treatment Flow Rate (L/s)	Sediment Capacity (kg)
JF4-1-1	1	1	1.2	2313	0.34	379	7.6	85
JF4-2-1	2	1	1.2	2313	0.34	379	12.6	142
JF6-3-1	3	1	1.8	5205	0.79	848	17.7	199
JF6-4-1	4	1	1.8	5205	0.79	848	22.7	256
JF6-5-1	5	1	1.8	5205	0.79	848	27.8	313
JF6-6-1	**6**	**1**	**1.8**	**5205**	**0.79**	**848**	**28.6**	**370**
JF8-6-2	6	2	2.4	9252	1.42	1469	35.3	398
JF8-7-2	7	2	2.4	9252	1.42	1469	40.4	455
JF8-8-2	8	2	2.4	9252	1.42	1469	45.4	512
JF8-9-2	9	2	2.4	9252	1.42	1469	50.5	569
JF8-10-2	10	2	2.4	9252	1.42	1469	50.5	626
JF10-11-3	11	3	3.0	14456	2.21	2302	63.1	711
JF10-12-3	12	3	3.0	14456	2.21	2302	68.2	768
JF10-12-4	12	4	3.0	14456	2.21	2302	70.7	796
JF10-13-4	13	4	3.0	14456	2.21	2302	75.7	853
JF10-14-4	14	4	3.0	14456	2.21	2302	78.9	910
JF10-15-4	15	4	3.0	14456	2.21	2302	78.9	967
JF10-16-4	16	4	3.0	14456	2.21	2302	78.9	1024
JF10-17-4	17	4	3.0	14456	2.21	2302	78.9	1081
JF10-18-4	18	4	3.0	14456	2.21	2302	78.9	1138
JF10-19-4	19	4	3.0	14456	2.21	2302	78.9	1195
JF12-20-5	20	5	3.6	20820	3.2	2771	113.6	1280
JF12-21-5	21	5	3.6	20820	3.2	2771	113.7	1337
JF12-22-5	22	5	3.6	20820	3.2	2771	113.7	1394
JF12-23-5	23	5	3.6	20820	3.2	2771	113.7	1451
JF12-24-5	24	5	3.6	20820	3.2	2771	113.7	1508
JF12-25-5	25	5	3.6	20820	3.2	2771	113.7	1565
JF12-26-5	26	5	3.6	20820	3.2	2771	113.7	1622
JF12-27-5	27	5	3.6	20820	3.2	2771	113.7	1679

Jellyfish Filter Design Notes

- Typically the Jellyfish Filter is designed in an offline configuration, as all stormwater filter systems will perform for a longer duration between required maintenance services when designed and applied in off-line configurations. Depending on the design parameters, an optional internal bypass may be incorporated into the Jellyfish Filter, however note the inspection and maintenance frequency should be expected to increase above that of an off-line system. Speak to your local representative for more information.



Jellyfish Filter Typical Layout

- Typically, 18 inches (457 mm) of driving head is designed into the system, calculated as the difference in elevation between the top of the diversion structure weir and the invert of the Jellyfish Filter outlet pipe. Alternative driving head values can be designed as 12 to 24 inches (305 to 610mm) depending on specific site requirements, requiring additional sizing and design assistance.
- Typically, the Jellyfish Filter is designed with the inlet pipe configured 6 inches (150 mm) above the outlet invert elevation. However, depending on site parameters this can vary to an optional configuration of the inlet pipe entering the unit below the outlet invert elevation.
- The Jellyfish Filter can accommodate multiple inlet pipes within certain restrictions.
- While the optional inlet below deck configuration offers 0 to 360 degree flexibility between the inlet and outlet pipe, typical systems conform to the following:

Model Diameter (m)	Minimum Angle Inlet / Outlet Pipes	Minimum Inlet Pipe Diameter (mm)	Minimum Outlet Pipe Diameter (mm)
1.2	62º	150	200
1.8	**59º**	**200**	**250**
2.4	52º	250	300
3.0	48º	300	450
3.6	40º	300	450

- The Jellyfish Filter can be built at all depths of cover generally associated with conventional stormwater conveyance systems. For sites that require minimal depth of cover for the stormwater infrastructure, the Jellyfish Filter can be applied in a shallow application using a hatch cover. The general minimum depth of cover is 36 inches (915 mm) from top of the underslab to outlet invert.
- If driving head caclulations account for water elevation during submerged conditions the Jellyfish Filter will function effectively under submerged condtions.
- Jellyfish Filter systems may incorporate grated inlets depending on system configuration.
- For sites with water quality treatment flow rates or mass loadings that exceed the design flow rate of the largest standard Jellyfish Filter manhole models, systems can be designed that hydraulically connect multiple Jellyfish Filters in series or alternatively Jellyfish Vault units can be designed.

STANDARD SPECIFICATION
STORMWATER QUALITY – MEMBRANE FILTRATION TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

Specifies requirements for construction and performance of an underground stormwater quality membrane filtration treatment device that removes pollutants from stormwater runoff through the unit operations of sedimentation, floatation, and membrane filtration.

1.2 REFERENCE STANDARDS

ASTM C 891: Specification for Installation of Underground Precast Concrete Utility Structures
ASTM C 478: Specification for Precast Reinforced Concrete Manhole Sections
ASTM C 443: Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets
ASTM D 4101: Specification for Copolymer steps construction

CAN/CSA-A257.4-M92
Joints for Circular Concrete Sewer and Culvert Pipe, Manhole Sections and Fittings Using Rubber Gaskets

CAN/CSA-A257.4-M92
Precast Reinforced Circular Concrete Manhole Sections, Catch Basins and Fittings

Canadian Highway Bridge Design Code

1.3 SHOP DRAWINGS

Shop drawings for the structure and performance are to be submitted with each order to the contractor. Contractor shall forward shop drawing submittal to the consulting engineer for approval. Shop drawings are to detail the structure's precast concrete and call out or note the fiberglass (FRP) internals/components.

1.4 PRODUCT SUBSTITUTIONS

No product substitutions shall be accepted unless submitted 10 days prior to project bid date, or as directed by the engineer of record. Submissions for substitutions require review and approval by the Engineer of Record, for hydraulic performance, impact to project designs, equivalent treatment performance, and any required project plan and report (hydrology/hydraulic, water quality, stormwater pollution) modifications that would be required by the approving jurisdictions/agencies. Contractor to coordinate with the Engineer of Record any applicable modifications to the project estimates of cost, bonding amount determinations, plan check fees for changes to approved documents, and/or any other regulatory requirements resulting from the product substitution.

1.5 HANDLING AND STORAGE

Prevent damage to materials during storage and handling.

PART 2 – PRODUCTS

2.1 GENERAL

2.1.1 The device shall be a cylindrical or rectangular, all concrete structure (including risers), constructed from precast concrete riser and slab components or monolithic precast structure(s), installed to conform to ASTM C 891 and to any required state highway, municipal or local specifications; whichever is more stringent. The device shall be watertight.

2.1.2 Cartridge Deck The cylindrical concrete device shall include a fiberglass deck. The rectangular concrete device shall include a coated aluminum deck. In either instance, the insert shall be bolted and sealed watertight inside the precast concrete chamber. The deck shall serve as: (a) a horizontal divider between the lower treatment zone and the upper treated effluent zone; (b) a deck for attachment of filter cartridges such that the membrane filter elements of each cartridge extend into the lower treatment zone; (c) a platform for maintenance workers to service the filter cartridges (maximum manned weight = 450 pounds (204 kg)); (d) a conduit for conveyance of treated water to the effluent pipe.

2.1.3 Membrane Filter Cartridges Filter cartridges shall be comprised of reusable cylindrical membrane filter elements connected to a perforated head plate. The number of membrane filter elements per cartridge shall be a minimum of eleven 2.75-inch (70-mm) diameter elements. The length of each filter element shall be a minimum 15 inches (381 mm). Each cartridge shall be fitted into the cartridge deck by insertion into a cartridge receptacle that is permanently mounted into the cartridge deck. Each cartridge shall be secured by a cartridge lid that is threaded onto the receptacle, or similar mechanism to secure the cartridge into the deck. The maximum treatment flow rate of a filter cartridge shall be controlled by an orifice in the cartridge lid, or on the individual cartridge itself, and based on a design flux rate (surface loading rate) determined by the maximum treatment flow rate per unit of filtration membrane surface area. The maximum design flux rate shall be 0.21 gpm/ft² (0.142 lps/m²).

Each membrane filter cartridge shall allow for manual installation and removal. Each filter cartridge shall have filtration membrane surface area and dry installation weight as follows (if length of filter cartridge is between those listed below, the surface area and weight shall be proportionate to the next length shorter and next length longer as shown below):

Filter Cartridge Length (in / mm)	Minimum Filtration Membrane Surface Area (ft2 / m2)	Maximum Filter Cartridge Dry Weight (lbs / kg)
15	106 / 9.8	10.5 / 4.8
27	190 / 17.7	15.0 / 6.8
40	282 / 26.2	20.5 / 9.3
54	381 / 35.4	25.5 / 11.6

2.1.4 Backwashing Cartridges The filter device shall have a weir extending above the cartridge deck, or other mechanism, that encloses the high flow rate filter cartridges when placed in their respective cartridge receptacles within the cartridge deck. The weir, or other mechanism, shall collect a pool of filtered water during inflow events that backwashes the high flow rate cartridges when the inflow

event subsides. All filter cartridges and membranes shall be reusable and allow for the use of filtration membrane rinsing procedures to restore flow capacity and sediment capacity; extending cartridge service life.

2.1.5 Maintenance Access to Captured Pollutants The filter device shall contain an opening(s) that provides maintenance access for removal of accumulated floatable pollutants and sediment, removal of and replacement of filter cartridges, cleaning of the sump, and rinsing of the deck. Access shall have a minimum clear vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

2.1.6 Bend Structure The device shall be able to be used as a bend structure with minimum angles between inlet and outlet pipes of 90-degrees or less in the stormwater conveyance system.

2.1.7 Double-Wall Containment of Hydrocarbons The cylindrical precast concrete device shall provide double-wall containment for hydrocarbon spill capture by a combined means of an inner wall of fiberglass, to a minimum depth of 12 inches (305 mm) below the cartridge deck, and the precast vessel wall.

2.1.8 Baffle The filter device shall provide a baffle that extends from the underside of the cartridge deck to a minimum length equal to the length of the membrane filter elements. The baffle shall serve to protect the membrane filter elements from contamination by floatables and coarse sediment. The baffle shall be flexible and continuous in cylindrical configurations, and shall be a straight concrete or aluminum wall in rectangular configurations.

2.1.9 Sump The device shall include a minimum 24 inches (610 mm) of sump below the bottom of the cartridges for sediment accumulation, unless otherwise specified by the design engineer. Depths less than 24 inches may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

2.2 PRECAST CONCRETE SECTIONS

All precast concrete components shall be manufactured to a minimum live load of HS-20 truck loading or greater based on local regulatory specifications, unless otherwise modified or specified by the design engineer, and shall be watertight.

2.3 JOINTS All precast concrete manhole configuration joints shall use nitrile rubber gaskets and shall meet the requirements of ASTM C443, Specification C1619, Class D or engineer approved equal to ensure oil resistance. Mastic sealants or butyl tape are not an acceptable alternative.

2.4 GASKETS Only profile neoprene or nitrile rubber gaskets in accordance to CSA A257.3-M92 will be accepted. Mastic sealants, butyl tape or Conseal CS-101 are not acceptable gasket materials.

2.5 FRAME AND COVER Frame and covers must be manufactured from cast-iron or other composite material tested to withstand H-20 or greater design loads, and as approved by the

local regulatory body. Frames and covers must be embossed with the name of the device manufacturer or the device brand name.

2.6 DOORS AND HATCHES If provided shall meet designated loading requirements or at a minimum for incidental vehicular traffic.

2.7 CONCRETE All concrete components shall be manufactured according to local specifications and shall meet the requirements of ASTM C 478.

2.8 FIBERGLASS The fiberglass portion of the filter device shall be constructed in accordance with the following standard: ASTM D-4097: Contact Molded Glass Fiber Reinforced Chemical Resistant Tanks.

2.9 STEPS Steps shall be constructed according to ASTM D4101 of copolymer polypropylene, and be driven into preformed or pre-drilled holes after the concrete has cured, installed to conform to applicable sections of state, provincial and municipal building codes, highway, municipal or local specifications for the construction of such devices.

2.10 INSPECTION All precast concrete sections shall be inspected to ensure that dimensions, appearance and quality of the product meet local municipal specifications and ASTM C 478.

PART 3 – PERFORMANCE

3.1 GENERAL

3.1.1 Verification – The stormwater quality filter must be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV).

3.1.2 Function - The stormwater quality filter treatment device shall function to remove pollutants by the following unit treatment processes; sedimentation, floatation, and membrane filtration.

3.1.3 Pollutants - The stormwater quality filter treatment device shall remove oil, debris, trash, coarse and fine particulates, particulate-bound pollutants, metals and nutrients from stormwater during runoff events.

3.1.4 Bypass - The stormwater quality filter treatment device shall typically utilize an external bypass to divert excessive flows. Internal bypass systems shall be equipped with a floatables baffle, and must avoid passage through the sump and/or cartridge filtration zone.

3.1.5 Treatment Flux Rate (Surface Loading Rate) – The stormwater quality filter treatment device shall treat 100% of the required water quality treatment flow based on a maximum design treatment flux rate (surface loading rate) across the membrane filter cartridges of 0.21 gpm/ft² (0.142 lps/m²).

3.2 FIELD TEST PERFORMANCE

At a minimum, the stormwater quality filter device shall have been field tested and verified with a minimum 25 TARP qualifying storm events and field monitoring shall have been conducted according to the TARP 2009 NJDEP TARP field test protocol, and have received NJCAT verification.

3.2.1 Suspended Solids Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median TSS removal efficiency of 85% and a minimum median SSC removal efficiency of 95%.

3.2.2 Runoff Volume – The stormwater quality filter treatment device shall be engineered, designed, and sized to treat a minimum of 90 percent of the annual runoff volume determined from use of a minimum 15-year rainfall data set.

3.2.3 Fine Particle Removal - The stormwater quality filter treatment device shall have demonstrated the ability to capture fine particles as indicated by a minimum median removal efficiency of 75% for the particle fraction less than 25 microns, an effluent d_{50} of 15 microns or lower for all monitored storm events.

3.2.4 Turbidity Reduction - The stormwater quality filter treatment device shall have demonstrated the ability to reduce the turbidity from influent from a range of 5 to 171 NTU to an effluent turbidity of 15 NTU or lower.

3.2.5 Nutrient (Total Phosphorus & Total Nitrogen) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Phosphorus removal of 55%, and a minimum median Total Nitrogen removal of 50%.

3.2.6 Metals (Total Zinc & Total Copper) Removal - The stormwater quality filter treatment device shall have demonstrated a minimum median Total Zinc removal of 55%, and a minimum median Total Copper removal of 85%.

3.3 INSPECTION and MAINTENANCE

The stormwater quality filter device shall have the following features:

3.3.1 Durability of membranes are subject to good handling practices during inspection and maintenance (removal, rinsing, and reinsertion) events, and site specific conditions that may have heavier or lighter loading onto the cartridges, and pollutant variability that may impact the membrane structural integrity. Membrane maintenance and replacement shall be in accordance with manufacturer's recommendations.

3.3.2 Inspection which includes trash and floatables collection, sediment depth determination, and visible determination of backwash pool depth shall be easily conducted from grade (outside the structure).

3.3.3 Manual rinsing of the reusable filter cartridges shall promote restoration of the flow capacity and sediment capacity of the filter cartridges, extending cartridge service life.

3.3.4 The filter device shall have a minimum 12 inches (305 mm) of sediment storage depth, and a minimum of 12 inches between the top of the sediment storage and bottom of the filter cartridge tentacles, unless otherwise specified by the design engineer. Variances may have an impact on the total performance and/or longevity between cartridge maintenance/replacement of the device.

3.3.5 Sediment removal from the filter treatment device shall be able to be conducted using a standard maintenance truck and vacuum apparatus, and a minimum one point of entry to the sump that is unobstructed by filter cartridges.

3.3.6 Maintenance access shall have a minimum clear height that provides suitable vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of the receptacles and deck for the entire length of the cartridge.

3.3.7 Filter cartridges shall be able to be maintained without the requirement of additional lifting equipment.

PART 4 – EXECUTION

4.1 INSTALLATION

4.1.1 PRECAST DEVICE CONSTRUCTION SEQUENCE

The installation of a watertight precast concrete device should conform to ASTM C 891 and to any state highway, municipal or local specifications for the construction of manholes, whichever is more stringent. Selected sections of a general specification that are applicable are summarized below.

4.1.1.1 The watertight precast concrete device is installed in sections in the following sequence:

- aggregate base
- base slab
- treatment chamber and cartridge deck riser section(s)
- bypass section
- connect inlet and outlet pipes
- concrete riser section(s) and/or transition slab (if required)
- maintenance riser section(s) (if required)
- frame and access cover

4.1.2 The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

4.1.3 Adjustment of the stormwater quality treatment device can be performed by lifting the upper sections free of the excavated area, re-leveling the base, and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary to restore original condition and watertight seals. Once the stormwater quality treatment device has been constructed, any/all lift holes must be plugged watertight with mortar or non-shrink grout.

4.1.4 Inlet and Outlet Pipes Inlet and outlet pipes should be securely set into the device using approved pipe seals (flexible boot connections, where applicable) so that the structure is watertight, and such that any pipe intrusion into the device does not impact the device functionality.

4.1.5 Frame and Cover Installation Adjustment units (e.g. grade rings) should be installed to set the frame and cover at the required elevation. The adjustment units should be laid in a full bed of mortar with successive units being joined using sealant recommended by the manufacturer. Frames for the cover should be set in a full bed of mortar at the elevation specified.

4.2 MAINTENANCE ACCESS WALL
In some instances the Maintenance Access Wall, if provided, shall require an extension attachment and sealing to the precast wall and cartridge deck at the job site, rather than at the precast facility. In this instance, installation of these components shall be performed according to instructions provided by the manufacturer.

4.3 FILTER CARTRIDGE INSTALLATION Filter cartridges shall be installed in the cartridge deck only after the construction site is fully stabilized and in accordance with the manufacturer's guidelines and recommendations. Contractor to contact the manufacturer to schedule cartridge delivery and review procedures/requirements to be completed to the device prior to installation of the cartridges and activation of the system.

PART 5 – QUALITY ASSURANCE

5.1 FILTER CARTRIDGE INSTALLATION Manufacturer shall coordinate delivery of filter cartridges and other internal components with contractor. Filter cartridges shall be delivered and installed complete after site is stabilized and unit is ready to accept cartridges. Unit is ready to accept cartridges after is has been cleaned out and any standing water, debris, and other materials have been removed. Contractor shall take appropriate action to protect the filter cartridge receptacles and filter cartridges from damage during construction, and in accordance with the manufacturer's recommendations and guidance. For systems with cartridges installed prior to full site stabilization and prior to system activation, the contractor can plug inlet and outlet pipes to prevent stormwater and other influent from entering the device. Plugs must be removed during the activation process.

5.2 INSPECTION AND MAINTENANCE

5.2.1 The manufacturer shall provide an Owner's Manual upon request.

5.2.2 After construction and installation, and during operation, the device shall be inspected and cleaned as necessary based on the manufacturer's recommended inspection and maintenance guidelines and the local regulatory agency/body.

5.3 REPLACEMENT FILTER CARTRIDGES When replacement membrane filter elements and/or other parts are required, only membrane filter elements and parts approved by the manufacturer for use with the stormwater quality filter device shall be installed.

END OF SECTION

STANDARD PERFORMANCE SPECIFICATION
STORMWATER QUALITY – MEMBRANE FILTRATION TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground stormwater quality membrane filtration treatment device that removes pollutants from stormwater runoff through the unit operations of sedimentation, floatation, and membrane filtration.

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV)

1.3 SUBMITTALS

1.3.1 All submittals, including sizing reports & shop drawings, shall be submitted upon request with each order to the contractor then forwarded to the Engineer of Record for review and acceptance. Shop drawings shall detail all OGS components, elevations, and sequence of construction.

1.3.2 Alternative devices shall have features identical to or greater than the specified device, including: filtration surface area, treatment chamber diameter, treatment chamber wet volume, sediment storage volume, and oil storage volume.

1.3.3 Unless directed otherwise by the Engineer of Record, filtration treatment device product substitutions or alternatives submitted within ten days prior to project bid shall not be accepted. All alternatives or substitutions submitted shall be signed and sealed by a local registered Professional Engineer, based on the exact same criteria detailed in Section 3, in entirety, subject to review and approval by the Engineer of Record.

PART 2 – PRODUCTS

2.1 GENERAL

2.1.1 Maintenance Access to Captured Pollutants The filter device shall contain an opening(s) that provides maintenance access for removal of accumulated floatable pollutants and sediment, removal of and replacement of filter cartridges, cleaning of the sump, and rinsing of the internal components. Access shall have a minimum clear vertical clear space over all of the filter cartridges. Filter cartridges shall be able to be lifted straight vertically out of their installed placement for the entire length of the cartridge.

2.1.2 Pollutant Storage: The Filter device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants.

PART 3 – PERFORMANCE

3.1 GENERAL

3.1.1 Verification – The stormwater quality filter treatment device shall have been field tested in accordance with either TARP Tier II Protocol (TARP, 2003) and New Jersey Tier II Stormwater Test Requirements – Amendments to TARP Tier II Protocol (NJDEP, 2009) or Washington State Technology Assessment Protocol – Ecology (TAPE), 2011 or later version. The field test shall have been verified in accordance with ISO 14034:2016 Environmental Management – Environmental Technology Verification (ETV). See Section 3.2 of this specification for field test performance requirements.

3.2 FIELD TEST PERFORMANCE

The field test (as specified in section 3.1.1)shall have monitored a minimum of twenty (20) TARP or TAPE qualifying storm events, and report at **minimum** the following results:

3.2.1 Suspended Solids Removal - The stormwater quality filter treatment device shall have ISO 14034 ETV verified load based median TSS removal efficiency of at least 85% and load based median SSC removal efficiency of at least 98%.

3.2.2 Runoff Volume – The stormwater quality filter treatment device shall be engineered, designed, and sized to treat a minimum of 90 percent of the annual runoff volume determined from use of a minimum 15-year rainfall data set.

3.2.3 Fine Particle Removal - The stormwater quality filter treatment device shall have demonstrated the ability to capture fine particles as indicated by a minimum median removal efficiency of 75% for the particle fraction less than 25 microns, and an effluent d_{50} of 15 microns or lower for all monitored storm events.

3.2.4 Turbidity Reduction - The stormwater quality filter treatment device shall have demonstrated the ability to reduce turbidity such that effluent turbidity is 15 NTU or lower.

3.2.5 Nutrients & Metals – The stormwater quality filter treatment device shall have ISO 14034 ETV Verified minimum load based removal efficiencies for the following:

3.2.5.1 Total Phosphorus (TP) Removal - Median TP removal efficiency of at least 49%.

3.2.5.2 Total Nitrogen (TN) Removal - Median TN removal efficiency of at least 39%.

3.2.5.3 Total Zinc (Zn) Removal - Median Zn removal efficiency of at least 69%.

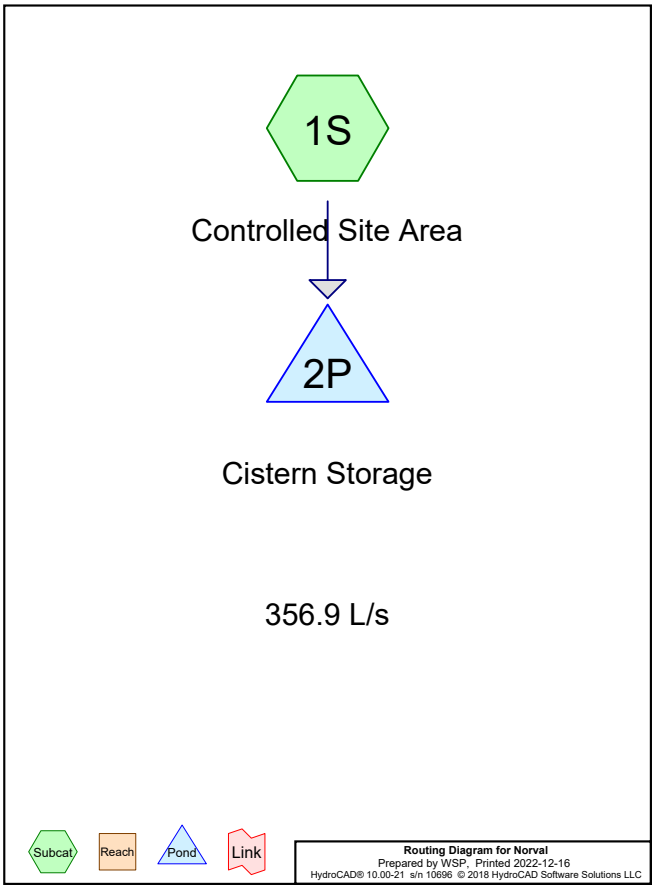
3.2.5.4 Total Copper (Cu) Removal - Median Cu removal efficiency of at least 91%.

END OF SECTION

APPENDIX

C

Hydrological Model Output (HydroCAD)



Area Listing (all nodes)

Area (sq-meters)	C	Description (subcatchment-numbers)
9,225.0	0.90	At-Grade Impervious (1S)
3,504.0	0.90	Impervious Roof Area (1S)
7,308.0	0.25	Landscaping (1S)
20,037.0	**0.66**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-meters)	Soil Group	Subcatchment Numbers
0.0	HSG A	
0.0	HSG B	
0.0	HSG C	
0.0	HSG D	
20,037.0	Other	1S
20,037.0		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-meters)	HSG-B (sq-meters)	HSG-C (sq-meters)	HSG-D (sq-meters)	Other (sq-meters)	Total (sq-meters)	Ground Cover	Su Nu
0.0	0.0	0.0	0.0	9,225.0	9,225.0	At-Grade Impervious	
0.0	0.0	0.0	0.0	3,504.0	3,504.0	Impervious Roof Area	
0.0	0.0	0.0	0.0	7,308.0	7,308.0	Landscaping	
0.0	**0.0**	**0.0**	**0.0**	**20,037.0**	**20,037.0**	**TOTAL AREA**	

Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=10 mm
Tc=10.0 min C=0.66 Runoff=0.1923 m³/s 207.7 m³

Pond 2P: Cistern Storage Peak Elev=0.527 m Storage=137.1 m³ Inflow=0.1923 m³/s 207.7 m³
Outflow=0.1617 m³/s 207.2 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 207.7 m³ Average Runoff Depth = 10 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

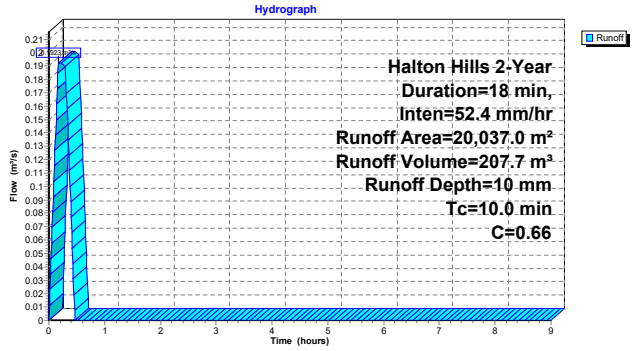
Runoff = 0.1923 m³/s @ 0.17 hrs, Volume= 207.7 m³, Depth= 10 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 2-Year Duration=18 min, Inten=52.4 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 10 mm for 2-Year event
Inflow = 0.1923 m³/s @ 0.17 hrs, Volume= 207.7 m³
Outflow = 0.1617 m³/s @ 0.33 hrs, Volume= 207.2 m³, Atten= 16%, Lag= 9.4 min
Primary = 0.1617 m³/s @ 0.33 hrs, Volume= 207.2 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.527 m @ 0.33 hrs Surf.Area= 260.0 m² Storage= 137.1 m³ (85.1 m³ above start)

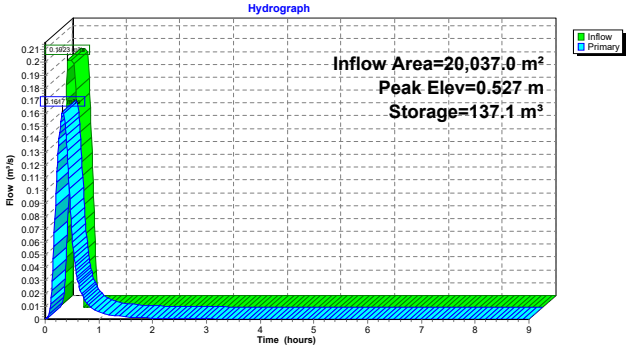
Plug-Flow detention time= 24.5 min calculated for 155.2 m³ (75% of inflow)
Center-of-Mass det. time= 16.0 min (30.0 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.1616 m³/s @ 0.33 hrs HW=0.527 m (Free Discharge)
↑**1=Orifice/Grate Tube** (Orifice Controls 0.1616 m³/s @ 1.47 m/s)

Pond 2P: Cistern Storage



Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=15 mm
Tc=10.0 min C=0.66 Runoff=0.2752 m³/s 297.2 m³

Pond 2P: Cistern Storage Peak Elev=0.643 m Storage=167.1 m³ Inflow=0.2752 m³/s 297.2 m³
Outflow=0.2248 m³/s 296.7 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 297.2 m³ Average Runoff Depth = 15 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

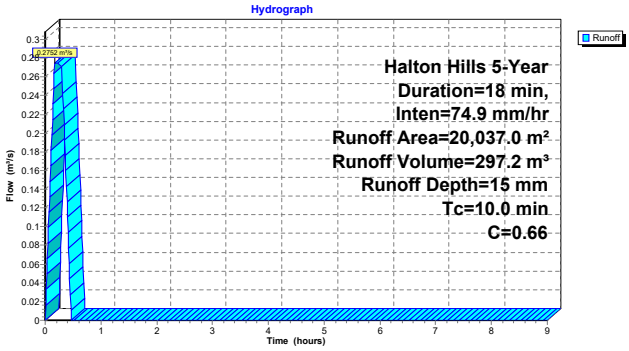
Runoff = 0.2752 m³/s @ 0.17 hrs, Volume= 297.2 m³, Depth= 15 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 5-Year Duration=18 min, Inten=74.9 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 15 mm for 5-Year event
Inflow = 0.2752 m³/s @ 0.17 hrs, Volume= 297.2 m³
Outflow = 0.2248 m³/s @ 0.33 hrs, Volume= 296.7 m³, Atten= 18%, Lag= 9.6 min
Primary = 0.2248 m³/s @ 0.33 hrs, Volume= 296.7 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.643 m @ 0.33 hrs Surf.Area= 260.0 m² Storage= 167.1 m³ (115.1 m³ above start)

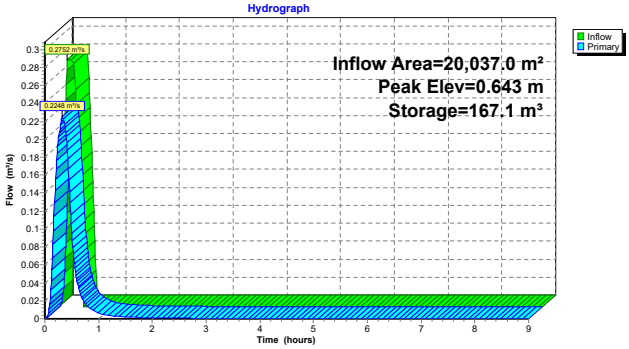
Plug-Flow detention time= 18.9 min calculated for 244.7 m³ (82% of inflow)
Center-of-Mass det. time= 13.5 min (27.5 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.2248 m³/s @ 0.33 hrs HW=0.643 m (Free Discharge)
└**1=Orifice/Grate Tube** (Orifice Controls 0.2248 m³/s @ 1.79 m/s)

Pond 2P: Cistern Storage



Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=17 mm
Tc=10.0 min C=0.66 Runoff=0.3244 m³/s 350.3 m³

Pond 2P: Cistern Storage Peak Elev=0.721 m Storage=187.5 m³ Inflow=0.3244 m³/s 350.3 m³
Outflow=0.2587 m³/s 349.8 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 350.3 m³ Average Runoff Depth = 17 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

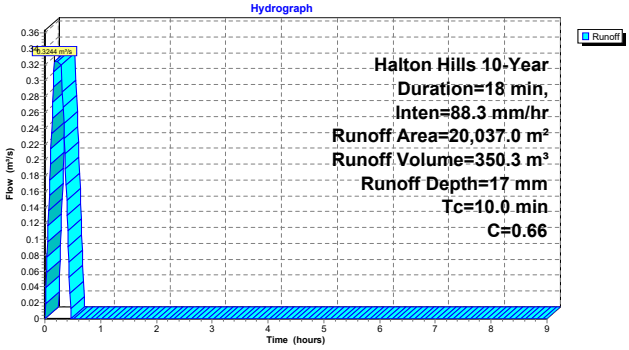
Runoff = 0.3244 m³/s @ 0.17 hrs, Volume= 350.3 m³, Depth= 17 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 10-Year Duration=18 min, Inten=88.3 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 17 mm for 10-Year event
Inflow = 0.3244 m³/s @ 0.17 hrs, Volume= 350.3 m³
Outflow = 0.2587 m³/s @ 0.33 hrs, Volume= 349.8 m³, Atten= 20%, Lag= 9.8 min
Primary = 0.2587 m³/s @ 0.33 hrs, Volume= 349.8 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.721 m @ 0.33 hrs Surf.Area= 260.0 m² Storage= 187.5 m³ (135.5 m³ above start)

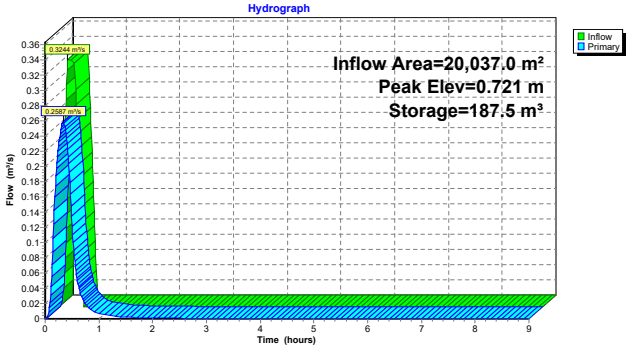
Plug-Flow detention time= 16.8 min calculated for 297.5 m³ (85% of inflow)
Center-of-Mass det. time= 12.8 min (26.8 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.2585 m³/s @ 0.33 hrs HW=0.721 m (Free Discharge)
1=Orifice/Grate Tube (Orifice Controls 0.2585 m³/s @ 2.06 m/s)

Pond 2P: Cistern Storage



Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=21 mm
Tc=10.0 min C=0.66 Runoff=0.3846 m³/s 415.4 m³

Pond 2P: Cistern Storage Peak Elev=0.825 m Storage=214.5 m³ Inflow=0.3846 m³/s 415.4 m³
Outflow=0.2975 m³/s 414.9 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 415.4 m³ Average Runoff Depth = 21 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

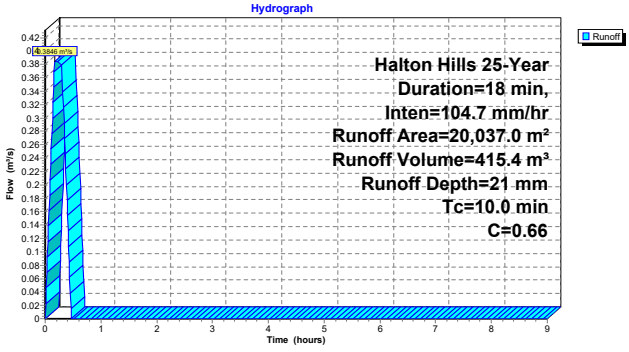
Runoff = 0.3846 m³/s @ 0.17 hrs, Volume= 415.4 m³, Depth= 21 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 25-Year Duration=18 min, Inten=104.7 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 21 mm for 25-Year event
Inflow = 0.3846 m³/s @ 0.17 hrs, Volume= 415.4 m³
Outflow = 0.2975 m³/s @ 0.34 hrs, Volume= 414.9 m³, Atten= 23%, Lag= 10.1 min
Primary = 0.2975 m³/s @ 0.34 hrs, Volume= 414.9 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.825 m @ 0.34 hrs Surf.Area= 260.0 m² Storage= 214.5 m³ (162.5 m³ above start)

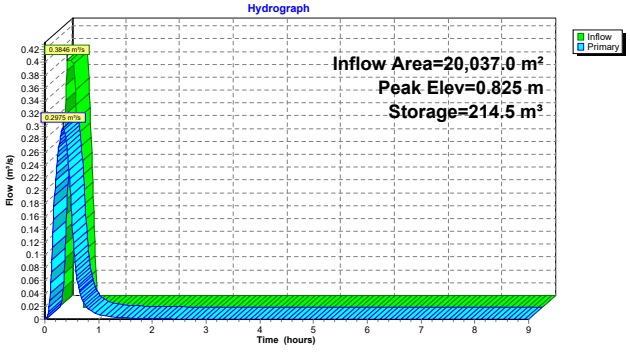
Plug-Flow detention time= 15.5 min calculated for 362.5 m³ (87% of inflow)
Center-of-Mass det. time= 12.2 min (26.2 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.2974 m³/s @ 0.34 hrs HW=0.825 m (Free Discharge)
1=Orifice/Grate Tube (Orifice Controls 0.2974 m³/s @ 2.37 m/s)

Pond 2P: Cistern Storage



Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=23 mm
Tc=10.0 min C=0.66 Runoff=0.4310 m³/s 465.4 m³

Pond 2P: Cistern Storage Peak Elev=0.910 m Storage=236.5 m³ Inflow=0.4310 m³/s 465.4 m³
Outflow=0.3258 m³/s 464.9 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 465.4 m³ Average Runoff Depth = 23 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

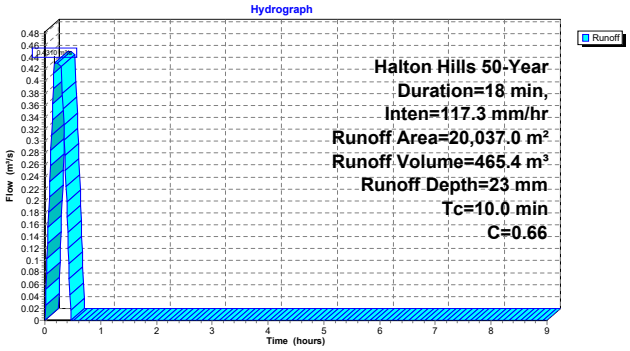
Runoff = 0.4310 m³/s @ 0.17 hrs, Volume= 465.4 m³, Depth= 23 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 50-Year Duration=18 min, Inten=117.3 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 23 mm for 50-Year event
Inflow = 0.4310 m³/s @ 0.17 hrs, Volume= 465.4 m³
Outflow = 0.3258 m³/s @ 0.34 hrs, Volume= 464.9 m³, Atten= 24%, Lag= 10.2 min
Primary = 0.3258 m³/s @ 0.34 hrs, Volume= 464.9 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.910 m @ 0.34 hrs Surf.Area= 260.0 m² Storage= 236.5 m³ (184.5 m³ above start)

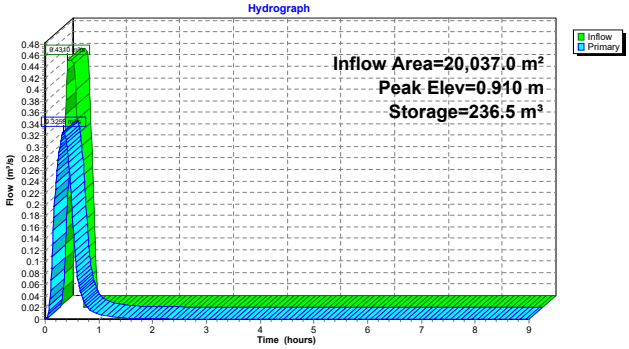
Plug-Flow detention time= 14.9 min calculated for 412.5 m³ (89% of inflow)
Center-of-Mass det. time= 12.0 min (26.0 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.3258 m³/s @ 0.34 hrs HW=0.910 m (Free Discharge)
↑**1=Orifice/Grate Tube** (Orifice Controls 0.3258 m³/s @ 2.59 m/s)

Pond 2P: Cistern Storage



Time span=0.00-9.00 hrs, dt=0.01 hrs, 901 points
Runoff by Rational method, Rise/Fall=1.0/1.0 xTc
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Controlled Site Area Runoff Area=20,037.0 m² 0.00% Impervious Runoff Depth=26 mm
Tc=10.0 min C=0.66 Runoff=0.4752 m³/s 513.2 m³

Pond 2P: Cistern Storage Peak Elev=0.994 m Storage=258.5 m³ Inflow=0.4752 m³/s 513.2 m³
Outflow=0.3518 m³/s 512.7 m³

Total Runoff Area = 20,037.0 m² Runoff Volume = 513.2 m³ Average Runoff Depth = 26 mm
100.00% Pervious = 20,037.0 m² 0.00% Impervious = 0.0 m²

Summary for Subcatchment 1S: Controlled Site Area

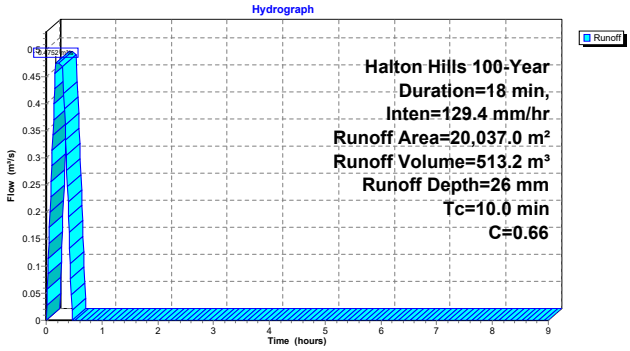
Runoff = 0.4752 m³/s @ 0.17 hrs, Volume= 513.2 m³, Depth= 26 mm

Runoff by Rational method, Rise/Fall=1.0/1.0 xTc, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Halton Hills 100-Year Duration=18 min, Inten=129.4 mm/hr

Area (m²)	C	Description
9,225.0	0.90	At-Grade Impervious
3,504.0	0.90	Impervious Roof Area
7,308.0	0.25	Landscaping
20,037.0	0.66	Weighted Average
20,037.0		100.00% Pervious Area

Tc (min)	Length (meters)	Slope (m/m)	Velocity (m/sec)	Capacity (m³/s)	Description
10.0					**Direct Entry,**

Subcatchment 1S: Controlled Site Area



Summary for Pond 2P: Cistern Storage

Inflow Area = 20,037.0 m², 0.00% Impervious, Inflow Depth = 26 mm for 100-Year event
Inflow = 0.4752 m³/s @ 0.17 hrs, Volume= 513.2 m³
Outflow = 0.3518 m³/s @ 0.34 hrs, Volume= 512.7 m³, Atten= 26%, Lag= 10.4 min
Primary = 0.3518 m³/s @ 0.34 hrs, Volume= 512.7 m³

Routing by Stor-Ind method, Time Span= 0.00-9.00 hrs, dt= 0.01 hrs
Starting Elev= 0.200 m Surf.Area= 260.0 m² Storage= 52.0 m³
Peak Elev= 0.994 m @ 0.34 hrs Surf.Area= 260.0 m² Storage= 258.5 m³ (206.5 m³ above start)

Plug-Flow detention time= 14.5 min calculated for 460.2 m³ (90% of inflow)
Center-of-Mass det. time= 11.9 min (25.9 - 14.0)

Volume	Invert	Avail.Storage	Storage Description
#1	0.000 m	260.0 m³	**1.00 mW x 260.00 mL x 1.00 mH Prismatoid**

Device	Routing	Invert	Outlet Devices
#1	Primary	0.200 m	**400 mm Vert. Orifice/Grate Tube** C= 0.820

Primary OutFlow Max=0.3517 m³/s @ 0.34 hrs HW=0.994 m (Free Discharge)
1=Orifice/Grate Tube (Orifice Controls 0.3517 m³/s @ 2.80 m/s)

Pond 2P: Cistern Storage