S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

# Functional Servicing Report

## 338 & 338.5 CUMBERLAND AVENUE

B.I.Z. Mechanical Inc.

CITY OF HAMILTON

**Revised March 2023**
February 2022

SLA File: 21081

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# 1.0 INTRODUCTION AND BACKGROUND

## 1.1 OVERVIEW

S. Llewellyn & Associates Limited has been retained by B.I.Z. Mechanical Inc. to provide consulting engineering services for the proposed residential development at 338 & 338.5 Cumberland Avenue in the City of Hamilton (see Figure 1.0 for location plan). This report will outline the functional servicing strategy for the proposed development.

The proposed development consists of constructing two townhouse blocks, resulting in 13 residential units, including asphalt roadways, concrete walkways and landscaped areas. There are two existing dwellings and several existing buildings which are proposed to be demolished.

This Functional Servicing Report will provide detailed information of the proposed servicing scheme for this development. Please refer to the Preliminary Site Engineering Plans prepared by S. Llewellyn and Associates Limited and the Site Plan prepared by Urban Solutions for additional information.

## 1.2 BACKGROUND INFORMATION

The following documents were referenced in the preparation of this report:

Ref. 1: MOE Stormwater Management Practices Planning and Design Manual (Ministry of Environment, March 2003)

Ref. 2: Engineering Guidelines for Servicing Land under Development Applications (City of Hamilton, December 2012)

Ref. 3: City of Hamilton Criteria and Guidelines for Stormwater Management Infrastructure (September 2007)

Ref. 4: City of Hamilton Storm Drainage Policy (2004)

Ref. 5: Erosion & Sediment Control Guidelines for Urban Construction (December 2006)

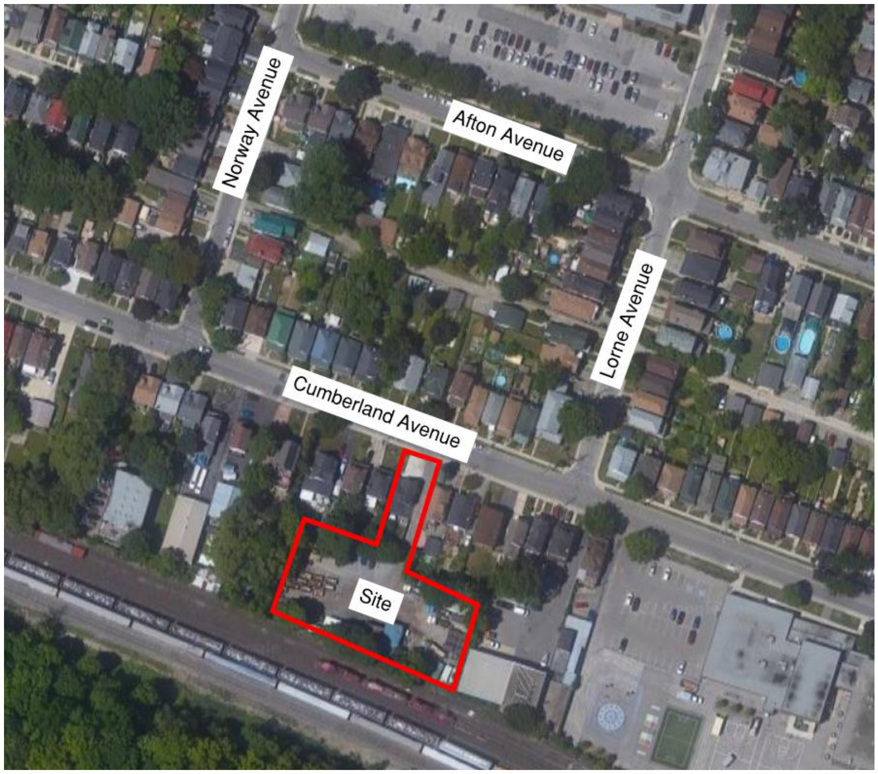


**Figure 1.0 – Location Plan**

## 2.0 STORMWATER MANAGEMENT

The following stormwater management (SWM) criteria will be applied to the site, in accordance with the City of Hamilton:

**Quantity Control**

The stormwater discharge rate from the subject site shall be controlled to the 2-year pre-development condition discharge rate with a runoff co-efficient of 0.45 for all storm events up to and including 100-year event.

**Quality Control**

The stormwater runoff from the proposed site must meet Level 1 (Enhanced) stormwater quality control (80% TSS removal, 90% average annual runoff treatment).

**Erosion Control**

Erosion and sediment control measures will be implemented in accordance with the standards of the City of Hamilton.

## 2.1 EXISTING CONDITIONS

In the existing condition, the 0.307-hectare site contains two dwellings and several existing buildings which are proposed to be demolished. The site is bound by Cumberland Avenue to the north, existing residential lands to the east and west, and existing railway tracks to the south. The site sheet drains north to Cumberland Avenue, where runoff is captured by the existing storm sewer system along Cumberland Avenue.

One catchment area, Catchment 101, has been identified in the existing condition. Catchment 101 represents discharge from the site to the storm sewer system along Cumberland Avenue. See Table 2.1 below and the Existing Condition Drainage Area Plan in Appendix A for details.

| **Table 2.1 – Existing Conditions Catchment Areas** | | | | |
|---|---|---|---|---|
| Catchment ID | Description | Area (ha) | Percent Impervious | Run-off Coefficient |
| 101 | To Cumberland Avenue | 0.307 | 93 | 0.86 |

The existing conditions discharge from the site was calculated using the Rational Method based on the above runoff coefficient (C) and the City of Hamilton storm intensities at a time of concentration of 10 minutes (Tc=10min). An example of the 2-year calculation for Catchment 101 is shown below and a summary can be found in Table 2.2.

$Q_{\text{2-yr (Catchment 101)}}$ = 2.78CiA=2.78 (0.86) (74.10mm/hr) (0.307ha)
= ***54.3 l/s (0.0543 $m^3$/s)***

| **Table 2.2 – Existing Condition Stormwater Discharge** | |
|---|---|
| Storm Event | Catchment 101 Discharge ($m^3$/s) |
| **2-Yr Event** | **0.0543** |
| 5-Yr Event | 0.0756 |
| 10-Yr Event | 0.0897 |
| 25-Yr Event | 0.1071 |
| 50-Yr Event | 0.1207 |
| 100-Yr Event | 0.1333 |

**Allowable Discharge**

An existing 300mmø combined sewer and an existing 600mmø storm relief sewer is located along Cumberland Avenue. The subject site was accounted for in the design of the existing 300mmø combined sewer along Cumberland Avenue, with a runoff coefficient (C) of 0.45 during the 2-year storm event. See below for the allowable discharge calculation and the Drainage Polygon Figure from the City of Hamilton in Appendix A for details.

$Q_{\text{(Allowable)}}$ = 2.78 C i A
= 2.78 (0.45) (74.10 mm/hr) (0.307 ha)
= ***28.5 l/s (0.0285 $m^3$/s)***

## 2.2 PROPOSED CONDITIONS

The proposed development consists of constructing 13 townhouse units including asphalt roadways, concrete walkways and landscaped areas. It is proposed to service the site with a private storm sewer system designed and constructed in accordance with the standards and specifications of the City of Hamilton.

Two catchment areas, Catchment 201 and 202, have been identified in the proposed condition. Catchment 201 represents the drainage area that is captured from the roof of the proposed townhouses, the asphalt roadways, concrete walkways and landscaped areas which will outlet via the private storm sewer and discharge to the existing 600mmø storm sewer along Cumberland Avenue. Catchment 202 represents the uncontrolled drainage area that will sheet drain north to Cumberland Avenue. See Table 4.1 below and the Proposed Condition Drainage Area Plan in Appendix A for details.

| **Table 2.3 – Proposed Condition Catchment Areas** | | | | |
|---|---|---|---|---|
| Catchment ID | Description | Area (ha) | Percent Impervious | Run-off Coefficient |
| 201 | Controlled to Cumberland Avenue | 0.302 | 64 | 0.68 |
| 202 | Uncontrolled to Cumberland Avenue | 0.005 | 0 | 0.25 |

**Water Quantity Control**
It is proposed to apply quantity control measures to the runoff from Catchment 201 by means of a 95mmø orifice plate at the outlet of MH2 to restrict discharge from the site to the allowable discharge rate. See the Preliminary Site Servicing Plan for orifice location.

With the installation of on-site quantity control measures for Catchment 201, it will be required to provide stormwater storage during storm events up to and including the 100-year event. The required storage will be provided on the surface of the asphalt driveway and within an ACO Stormbrixx storage tank beneath the asphalt driveway. Details of the proposed storage tank can be found on the Preliminary Site Servicing Plan. The stage-storage-discharge characteristics can be seen in Table 2.4 below and in Appendix A for details.

| **Table 2.4 – Proposed Condition Stage-Storage-Discharge (Catchment 201)** | | |
|---|---|---|
| Elevation (m) | Storage ($m^3$) | Discharge ($m^3$/s) |
| 97.70 (Bottom of Tank) | 0 | 0.0000 |
| 97.90 (0.2m depth) | 13 | 0.0087 |
| 98.10 (0.4m depth) | 25 | 0.0121 |
| 98.30 (0.6m depth) | 38 | 0.0147 |
| 98.61 (Top of Tank) | 57 | 0.0181 |
| 99.45 (CB Grate) | 57 | 0.0250 |
| 99.50 (5cm Deep) | 58 | 0.0254 |
| 99.55 (10cm Deep) | 60 | 0.0257 |
| 99.60 (15cm Deep) | 65 | 0.0261 |
| 99.65 (20cm Deep) | 74 | 0.0264 |
| 99.70 (25cm Deep) | 88 | 0.0267 |

The maximum discharge rate was calculated using the Rational Method based on the proposed condition runoff coefficients for the 2-year to 100-year storm events. Additionally, the 2-year to 100-year storage volumes for Catchment 201 were calculated using the Modified Rational Method (MRM). The proposed discharge rates and storage volumes are summarized in Table 2.5 below and in Appendix A for details.

**Table 2.5 – Proposed Condition Stormwater Discharge**

| Storm Event | Catchment 201 Controlled Discharge ($m^3/s$) | Catchment 202 Uncontrolled Discharge ($m^3/s$) | Sanitary Discharge ($m^3/s$)[1] | Total Discharge ($m^3/s$) | Allowable Discharge ($m^3/s$) | Required Storage ($m^3$) |
|---|---|---|---|---|---|---|
| 2-Yr | <0.0267 | 0.0003 | 0.00058 | <0.0278 | 0.0285 | 11 |
| 5-Yr | <0.0267 | 0.0004 | | <0.0277 | 0.0285 | 26 |
| 10-Yr | <0.0267 | 0.0004 | | <0.0277 | 0.0285 | 38 |
| 25-Yr | <0.0267 | 0.0005 | | <0.0278 | 0.0285 | 54 |
| 50-Yr | <0.0267 | 0.0006 | | <0.0279 | 0.0285 | 66 |
| 100-Yr | 0.0267 | 0.0006 | | 0.0279 | 0.0285 | 79 |

[1] Refer to Table 3.1 and 3.2 for estimated total Sanitary Demand for the proposed development.

This analysis determined the following:

- The proposed condition discharge rate will not exceed the allowable discharge rate during the 2-year to 100-year design storms, with the installation of a 95mmø orifice plate.

- Catchment 201 will require $79m^3$ of stormwater storage during the 100-year event, which can be accommodated by the on-site surface ponding and the proposed storage tank, having a total storage volume of $88m^3$.

**Water Quality Control**
Water quality control will be achieved through a treatment train approach, designed and constructed as per the standards of the City of Hamilton. See the Preliminary Servicing Plan prepared by S. Llewellyn & Associates Limited for details.

The proposed development is required to achieve an "Enhanced" (80% TSS removal) level of water quality protection. To achieve this criteria, discharge from Catchment 201 will be subject to a treatment train that consists of ADS Flexstorm Pure Permanent Inlet Filters and a HydroStorm oil/grit separator before ultimately discharging to the existing storm sewer system along Cumberland Avenue.

ADS Flexstorm Pure Permanent Inlet Filters have been proposed within the proposed catchbasins in the asphalt parking lot. The installation of the ADS Flexstorm Pure Permanent Inlet Filters will contribute to the removal of TSS and the capture of floatables within the catchbasins. The units also provide scour protection and reduce the resuspension of solids during heavy rain events which would otherwise enter the storm system. The technical information regarding the ADS Flexstorm Pure Permanent Inlet Filters can be found in Appendix B.

The HydroStorm sizing software was used to determine the required size of oil/grit separator unit for the site. It was determined that a HydroStorm HS6 will provide 84% TSS removal and 100% average annual runoff treatment. See HydroStorm unit sizing procedures in Appendix B for details.

With the combination of the proposed HydroStorm Unit and the ADS Flexstorm Pure Permanent Inlet Filters, the requirements for an “Enhanced” level of quality control for the site will be satisfied.

HydroStorm units and ADS Inlet Filters require regular inspection and maintenance as per the manufacture’s specifications to ensure the unit operates properly. See the Maintenance Manuals in Appendix B for details.

## 2.3 SEDIMENT AND EROSION CONTROL

In order to minimize erosion during the grading and site servicing period of construction, the following measures will be implemented:

- Install silt fencing along the outer boundary of the site to ensure that sediment does not migrate to the adjacent properties;

- Install sediment control (silt sacks) in the proposed catchbasins as well as the nearby existing catchbasins to ensure that no untreated runoff enters the existing conveyance system;

- Stabilize all disturbed or landscaped areas with hydro seeding/sodding to minimize the opportunity for erosion.

To ensure and document the effectiveness of the erosion and sediment control structures, an appropriate inspection and maintenance program is necessary. The program will include the following activities:

- Inspection of the erosion and sediment controls (e.g. silt fences, sediment traps, vegetation, etc.) with follow up reports to the governing municipality; and

- The developer and/or their contractor shall be responsible for any costs incurred during the remediation of problem areas.

For details on the proposed erosion and sediment control for the proposed site, see the Preliminary Grading & Erosion Control Plan included in the engineering drawings.

# 3.0 SANITARY SEWER SERVICING

## 3.1 EXISTING CONDITIONS

In the existing condition there is an existing 300mmø combined sewer flowing east along Cumberland Avenue.

## 3.2 SANITARY DEMAND

The proposed development consists of constructing two townhouse blocks, resulting in 13 residential units.

Table 3.1 summarizes the sanitary sewer discharge rates for the proposed residential development. Wastewater generation for the site was calculated based on Table 8.2.1.3.A – Residential Occupancies of the 2020 Ontario Plumbing Code. Additionally, Table 3.2 summarizes the sanitary discharge from the site that has been estimated in accordance with the City of Hamilton Comprehensive Development Guidelines and Financial Policies Manual (Ref. 2).

| **Table 3.1 – Proposed Sanitary Sewer Discharge** | |
|---|---|
| Occupancy Type: | |
| Two-bedroom dwelling | 1100 l/day x 11 units<br>**= 12,100 l/day** |
| Three-bedroom dwelling | 1650 l/day x 2 units<br>**= 3,300 l/day** |
| **Waste Generated (l/day):** | **15,400** |
| **Total Wastewater Estimate (l/s):** | **0.18** |

**Table 3.2- Proposed Sanitary Sewer Discharge**

| Use | Site Area (ha) | Population [A] | Avg. Demand [B] (l/s) | Peaking Factor [C] | Infiltration [D] (l/s) | Peak Flow [E] (l/s) |
|---|---|---|---|---|---|---|
| Residential Units | 0.307 | 20 persons | 0.08 | 5.00 | 0.18 | 0.58 |

[A] Residential Population = (11 x 2bdr units x 2 cap/bed) + (2 x 3bdr units x 2 cap/bed) = 20 persons

[B] Average demand = 360 l/cap/day x persons

[C] Peaking Factor = $5/P^{0.2}$ with P expressed in thousands, 2<M<5

[D] Infiltration flow based on 0.6 l/ha/sec infiltration x site area

[E] Peak Flow = (Average Flow x Peaking Factor) + Infiltration

## 3.3 PROPOSED SANITARY SERVICING AND CAPACITY ANALYSIS

The proposed residential site will be serviced by a 200mmø sanitary sewer, designed, and constructed in accordance with the City of Hamilton standards. Drainage from this sewer will discharge to the existing 300mmø combined sewer located on Cumberland Avenue.

The minimum grade of the proposed 200mmø sanitary sewer will be 1.0%. At this minimum grade, the proposed sanitary sewer will have a capacity of 0.033 $m^3/s$ (33 l/s). Therefore, the proposed 200mmø sanitary sewer at 1.0% grade is adequately sized to service the proposed development.

# 4.0 DOMESTIC AND FIRE WATER SUPPLY SERVICING

## 4.1 EXISTING CONDITIONS

The existing municipal water distribution system consists of a 150mmø watermain located along Cumberland Avenue. Two existing municipal hydrants are located on Cumberland Avenue fronting the site.

## 4.2 DOMESTIC WATER DEMAND

The following is an estimate of the water usage for the proposed development. Water usage for the site was calculated based on the "Fixture Unit Method" as per Table 7.6.3.2.A. forming part of sentences 7.6.3.1(1) to (3) and 7.6.3.4.(2), (3) and (5) of the 2020 Ontario Building Code. See Table 4.1 and Table 4.2 for fixture unit (FU) calculations. Fixture unit calculations will be confirmed upon completion of the Water Usage Assessment, which will be prepared as part of the Site Plan Approval process.

**Table 4.1 - Fixture Unit Calculations**

| Component | FU/ Fixture | No. of Units | Total FU |
|---|---|---|---|
| Dishwasher, domestic | 1.4 | 13 | 18.2 |
| Lavatory (8.3L/min or less) (Private) | 0.7 | 19 | 13.3 |
| Sink, kitchen, domestic (8.3L/min or less) (Public) | 1.4 | 13 | 18.2 |
| Water Closet (6 LPF or less with flush tank) (Private) | 2.2 | 19 | 41.8 |
| Shower head, 9.5 L/min or less per head | 1.4 | 13 | 18.2 |
| Clothes Washer (3.5kg) | 1.4 | 13 | 18.2 |
| | | **Total FU:** | **127.9** |

Total peak water usage for the site was derived below from the fixture unit count as per Table 7.4.10.5 of the Ontario Building Code.

**Total Fixture Unit Count = 127.9 FU**

**Water Usage: 63 IGPM (4.77 L/s)**

## 4.3 FIRE FLOW DEMAND

Fire flow demands for development are governed by a number of guidelines and criteria, such as the Ontario Building Code (OBC), various codes and standards published by the National Fire Protection Association (NFPA) and most recently, the Target Available Fire Flows provided by the City of Hamilton.

The proposed development consists of constructing two townhouse blocks, resulting in 13 residential units. Two existing municipal hydrants are located within close proximity to the site, located at 348 and 318 Cumberland Avenue. It is proposed to install a fire hydrant on the site which will be within the required 90m separation from building face adjacent to a street (as per Sentence 3.2.5.7 of the 2020 Ontario Building Code).

The fire flow for this building was determined to be the greater of the OBC fire flow calculation (OBC section A-3.2.5.7) or the City of Hamilton Target Available Fire Flow.

The result of the OBC fire flow calculation was a minimum flow rate of 9000 L/min (150 L/sec) (see attached OBC fire flow calculation sheet). This is equal to the city of Hamilton target available fire flow of 150 l/s for Residential use with more than 3 units, see City of Hamilton Target Flows (Policy PW19096) attached. Therefore, the minimum required fire flow for this site is **150 l/sec**. See Appendix C for fire flow calculations.

The following hydrant flow test data for the public fire hydrant in closest proximity to the proposed development has been analyzed to determine if the municipal system adjacent to the subject site is adequate to provide the required fire flow, with a minimum pressure of 20 psi. Table 4.2 summarizes the hydrant flow data made available by the City of Hamilton:

| **Table 4.2 – Hydrant Flow Data** | |
|---|---|
| Hydrant ID | HB01H017 |
| Location | 348 Cumberland Ave Hamilton |
| Test Date | 2018-8-11 |
| Static Pressure | 43 psi |
| Residual Pressure During Test Flow | 41 psi |
| Test Flow Rate | 680 IGPM (51.52 l/s) |
| **Theoretical Flow @ 20 psi** | **2543 IGPM (192.68 l/s)** |
| | |
| Hydrant ID | HB01H018 |
| Location | 318 Cumberland Ave Hamilton |
| Test Date | 2018-8-11 |
| Static Pressure | 40 psi |
| Residual Pressure During Test Flow | 38 psi |
| Test Flow Rate | 660 IGPM (50.00 l/s) |
| **Theoretical Flow @ 20 psi** | **2288 IGPM (173.36 l/s)** |

Based on the above hydrant flow test data, the theoretical available flow rate is **173.36 l/s**, while the minimum required fire flow for the proposed development is only **150 l/s**.

Therefore, based on the above analysis, the proposed water distribution system will have the capacity and pressure required to adequately service the subject land.

### 4.4 PROPOSED WATER SERVICING AND ANALYSIS

Proposed water servicing for the site consists of connecting a 150mmø water service off of the existing 150mmø watermain located on Cumberland Avenue. The proposed 150mmø water service will provide domestic and fire water service for the proposed residential development. Water services for the site are to be designed and constructed in accordance with City of Hamilton standards.

## 5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the information provided herein, it is concluded that the proposed development at 338 & 338.5 Cumberland Avenue can be constructed to meet the requirements of the City of Hamilton. Therefore, it is recommended that:

- The development be graded and serviced in accordance with the Preliminary Grading & Servicing Plans prepared by S. Llewellyn & Associates Limited;

- A 95mmø orifice plate be installed as per the Preliminary Site Servicing Plan and this report to provide adequate quantity control;

- An underground storage tank be installed as per the Preliminary Site Servicing Plan to provide stormwater storage;

- A HydroStorm HS6 oil/grit separator and ADS Flexstorm Pure Permanent Inlet Filters be installed as per the Preliminary Site Servicing Plan and this report to provide efficient stormwater quality control;

- Erosion and sediment controls be installed as described in this report to meet City of Hamilton requirements;

We trust the information enclosed herein is satisfactory. Should you have any questions please do not hesitate to contact our office.

Prepared by:

**S. LLEWELLYN & ASSOCIATES LIMITED**

LICENSED PROFESSIONAL ENGINEER
S. J. NELSON
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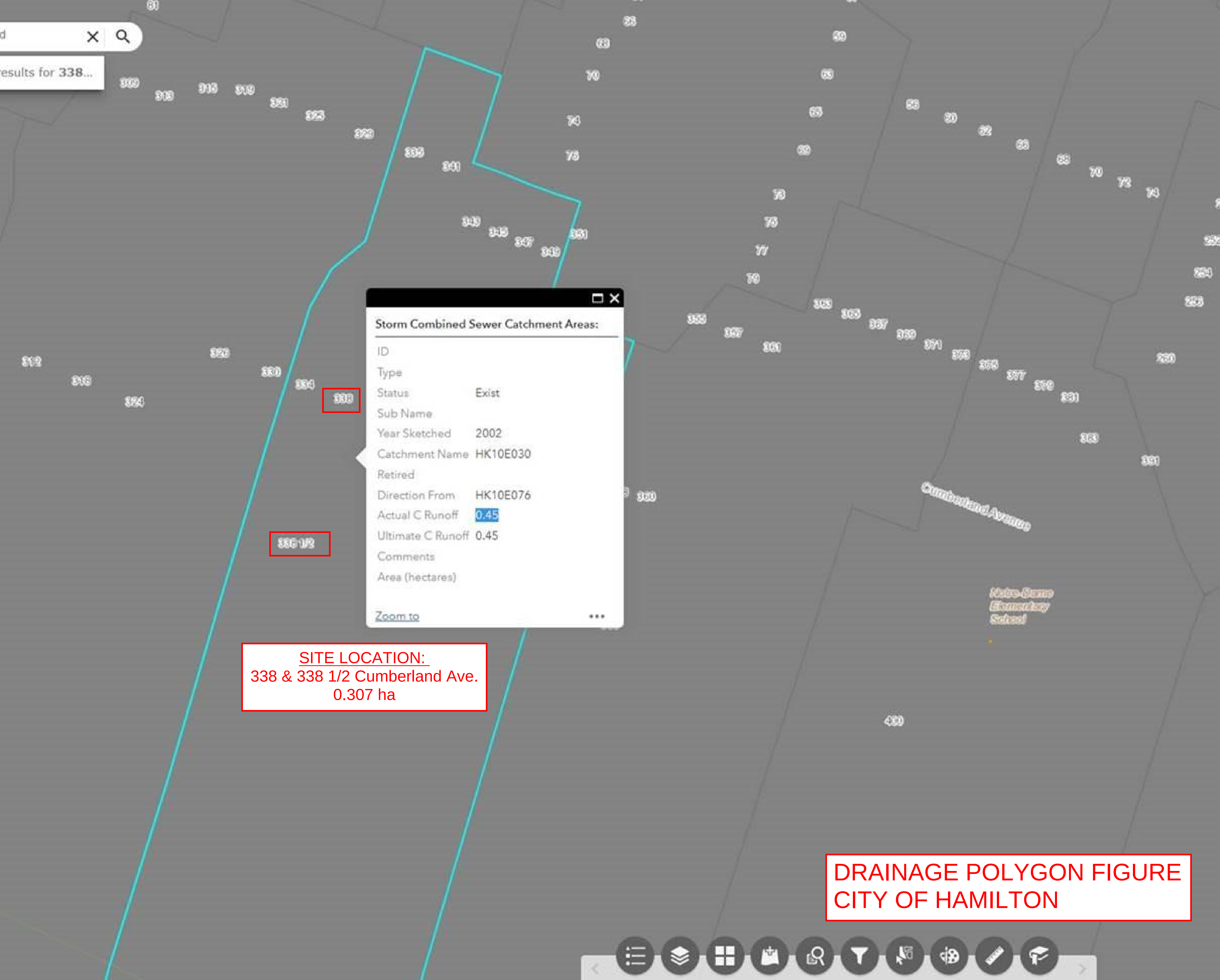
Mar.24/23
PROVINCE OF ONTARIO

Y. Moradiya, B. Eng S. Nelson, P.Eng.

# APPENDIX A

# STORMWATER MANAGEMENT INFORMATION


Storm Combined Sewer Catchment Areas:
ID
Type
Status Exist
Sub Name
Year Sketched 2002
Catchment Name HK10E030
Retired
Direction From HK10E076
Actual C Runoff 0.45
Ultimate C Runoff 0.45
Comments
Area (hectares)
Zoom to
338
338 1/2
Cumberland Avenue
Notre-Dame Elementary School
SITE LOCATION:
338 & 338 1/2 Cumberland Ave.
0.307 ha
DRAINAGE POLYGON FIGURE
CITY OF HAMILTON

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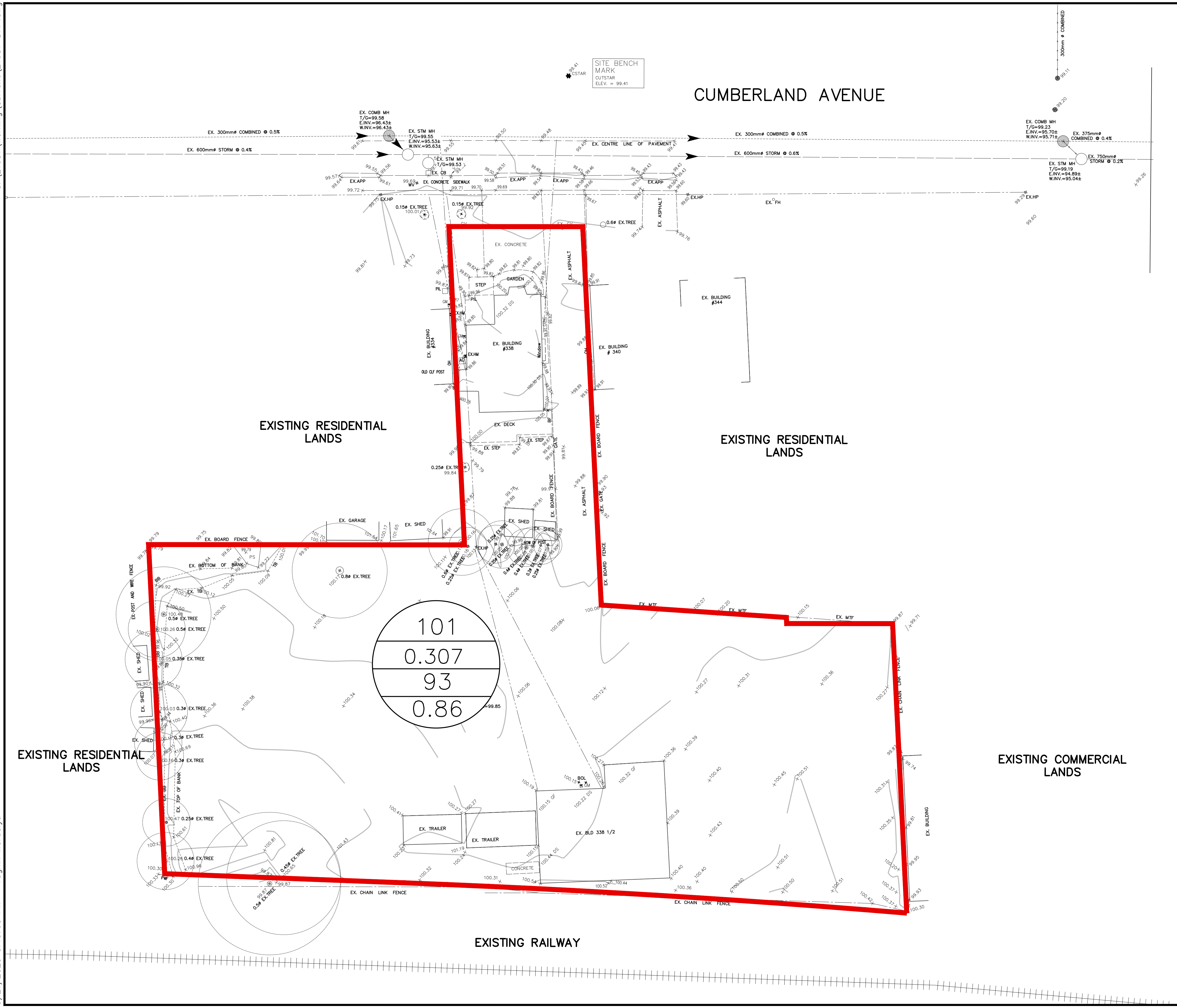


## LEGEND

| | |
|---|---|
| 101 | DRAINAGE AREA I.D. |
| 0.450 | DRAINAGE AREA (ha) |
| 11 | PERCENT IMPERVIOUS |
| 0.32 | RUNOFF COEFFICENT |

# EXISTING CONDITION
# STORM DRAINAGE AREA PLAN

SCALE: 1:400

PROJECT: 338 CUMBERLAND AVENUE, HAMILTON, ON
PROJECT No.: 21081

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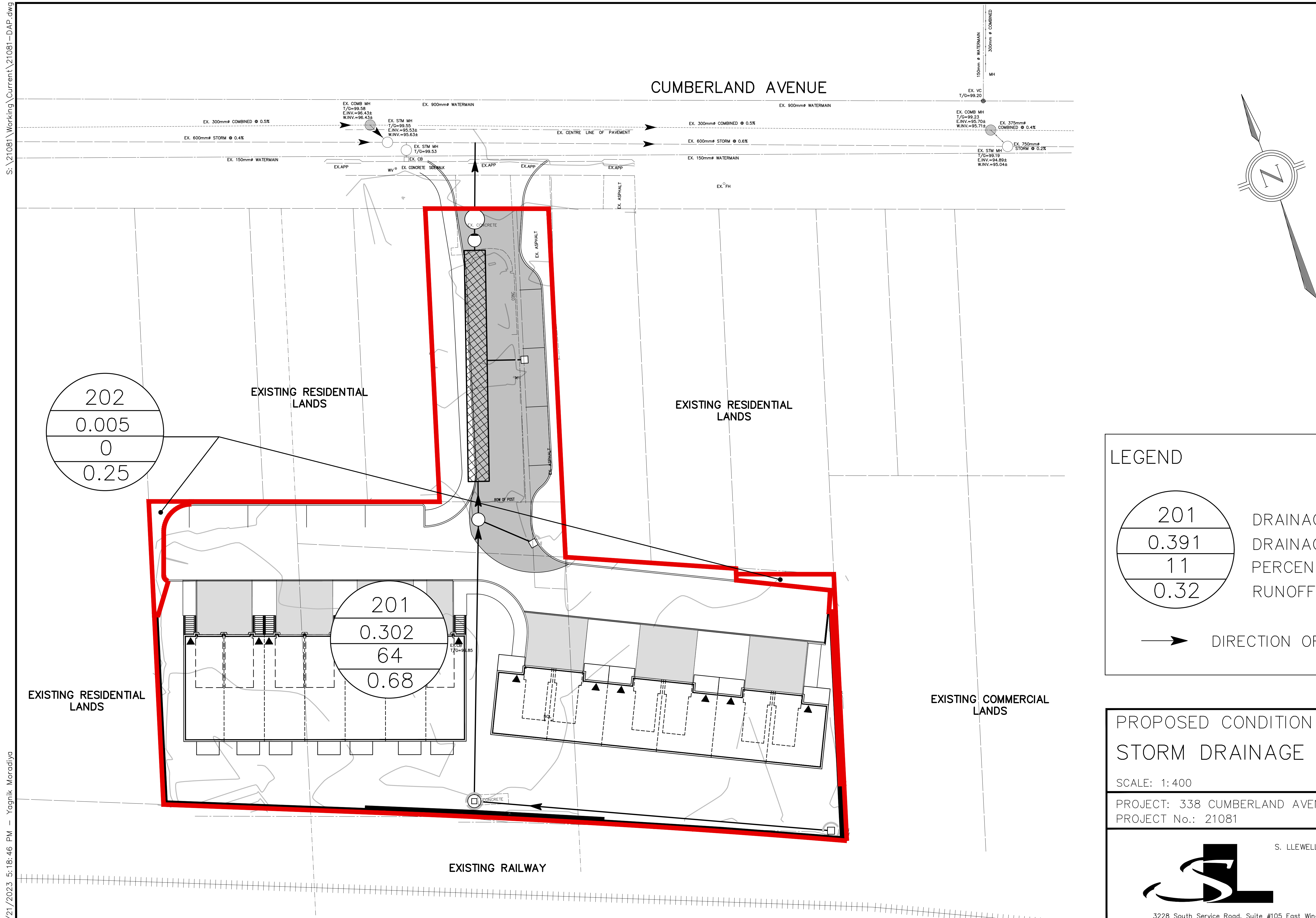


## LEGEND

| 201 | DRAINAGE AREA I.D. |
|---|---|
| 0.391 | DRAINAGE AREA (ha) |
| 11 | PERCENT IMPERVIOUS |
| 0.32 | RUNOFF COEFFICENT |
| → | DIRECTION OF SHEET FLOW |

PROPOSED CONDITION

# STORM DRAINAGE AREA PLAN

SCALE: 1:400

PROJECT: 338 CUMBERLAND AVENUE, HAMILTON, ON
PROJECT No.: 21081


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CONSULTING ENGINEERS

# RUNOFF COEFFICIENT CALCULATIONS

## Pre

| | | C-Value |
|---|---|---|
| Drainage Area #: | 101 | |
| Roof/Building Area (m²): | 297 | 0.95 |
| Asphalt/Conc. Area (m²): | 2551 | 0.90 |
| Gravel Area (m²):l | | 0.80 |
| Grass Area - Pervious (m²): | 224 | 0.25 |
| Total Area (m²): | 3073 | 0.86 |
| Impervious | 2849 | **0.93** |
| Pervious | 224 | **0.07** |
| Site | 3073 | |

## Post (Controlled)

| | | C-Value |
|---|---|---|
| Drainage Area #: | 201 | |
| Roof/Building Area (m²): | 705 | 0.95 |
| Asphalt/Conc. Area (m²): | 1231 | 0.90 |
| Grass Area - Pervious (m²): | 1091 | 0.25 |
| Total Area (m²): | 3027 | 0.68 |
| Impervious | 1936 | **0.64** |
| Pervious | 1091 | **0.36** |
| Site | 3027 | |

## Post (Uncontrolled)

| | | C-Value |
|---|---|---|
| Drainage Area #: | 202 | |
| Roof/Building Area (m²): | 0 | 0.95 |
| Asphalt/Conc. Area (m²): | 0 | 0.90 |
| Grass Area - Pervious (m²): | 46 | 0.25 |
| Total Area (m²): | 46 | 0.25 |
| Impervious | 0 | **0.00** |
| Pervious | 46 | **1.00** |
| Site | 46 | |

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

# STAGE-STORAGE-DISCHARGE CALCULATIONS

Catchment 201
Outlet Device No. 1 (Quantity)

| | |
|---|---|
| Type: | Orifice Plate |
| Diameter (mm) | **95** |
| Area ($m^2$) | 0.00709 |
| Invert Elev. (m) | 97.64 |
| C/L Elev. (m) | 97.69 |
| Disch. Coeff. ($C_d$) | 0.6 |
| Discharge (Q) = | $C_d A ( 2 g H )^{0.5}$ |
| Number of Orifices: | 1 |

| | | SWM Pond Volumes | | | | | | Outlet No. 1 | |
|---|---|---|---|---|---|---|---|---|---|
| | Elevation m | Area $m^2$ | Tank Incremental Volume | Additional Incremental Underground | Additional Incremental Surface $m^3$ | Cumulative Volume $m^3$ | Active Storage Volume $m^3$ | H m | Discharge $m^3/s$ |
| Orifice Invert | 97.64 | 0 | 0 | 0.0 | 0 | 0 | 0 | 0.000 | 0.0000 |
| Bottom of Tank | 97.70 | 63 | 0 | 0.0 | 0 | 0 | 0 | 0.000 | 0.0000 |
| 0.20m Deep | 97.90 | 63 | 13 | 0.0 | 0 | 13 | 13 | 0.213 | 0.0087 |
| 0.40m Deep | 98.10 | 63 | 13 | 0.0 | 0 | 25 | 25 | 0.412 | 0.0121 |
| 0.60m Deep | 98.30 | 63 | 13 | 0.0 | 0 | 38 | 38 | 0.612 | 0.0147 |
| Top of Tank | 98.61 | 63 | 20 | 0.0 | 0 | 57 | 57 | 0.922 | 0.0181 |
| Top of Grate | 99.45 | 0 | 0 | 0.0 | 0 | 57 | 57 | 1.763 | 0.0250 |
| 0.05m Ponding | 99.50 | 16 | 0 | 0.0 | 0 | 58 | 58 | 1.813 | 0.0254 |
| 0.10m Ponding | 99.55 | 60 | 0 | 0.0 | 2 | 60 | 60 | 1.863 | 0.0257 |
| 0.15m Ponding | 99.60 | 145 | 0 | 0.0 | 5 | 65 | 65 | 1.912 | 0.0261 |
| 0.20m Ponding | 99.65 | 235 | 0 | 0.0 | 10 | 74 | 74 | 1.963 | 0.0264 |
| 0.25m Ponding | 99.70 | 317 | 0 | 0.0 | 14 | 88 | 88 | 2.013 | 0.0267 |

## 2-Year Storm - Modified Rational Method
### Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | | |
|---|---|---|
| City/Town/Region: | Hamilton | |
| Return Period: | **2** | Years |
| A = | **646.000** | |
| B = | **6.000** | |
| C= | **0.781** | |
| Tc = | **10** | minutes |
| | 600 | seconds |

**Area of site being investigated (ha) =** **0.31** (Lot Area)
**Composite Runoff Coeff. ( C ) =** **0.68** (Post-development "C")
**Release Rate - $Q_{ALLOW}$ ($m^3/s$) =** **0.0267** (Allowable discharge)

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff | Release | Storage |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | Volume | Volume | Volume |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3/s$) | ($m^3/s$) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 99.290 | 0.0000276 | 0.058 | 0.0 | 0.0576 | 17.27 | 12.02 | 5.26 |
| 10 | 600 | 74.099 | 0.0000206 | 0.043 | 0.0 | 0.0430 | 25.78 | 16.02 | 9.76 |
| 15 | 900 | 59.921 | 0.0000166 | 0.035 | 0.0 | 0.0347 | 31.27 | 20.03 | 11.25 |
| 20 | 1200 | 50.715 | 0.0000141 | 0.029 | 0.0 | 0.0294 | 35.29 | 24.03 | 11.26 |
| 25 | 1500 | 44.206 | 0.0000123 | 0.026 | 0.0 | 0.0256 | 38.45 | 28.04 | 10.42 |
| 30 | 1800 | 39.333 | 0.0000109 | 0.023 | 0.0 | 0.0228 | 41.06 | 32.04 | 9.02 |
| 35 | 2100 | 35.534 | 0.0000099 | 0.021 | 0.0 | 0.0206 | 43.27 | 36.05 | 7.23 |
| 40 | 2400 | 32.480 | 0.0000090 | 0.019 | 0.0 | 0.0188 | 45.20 | 40.05 | 5.15 |
| 45 | 2700 | 29.965 | 0.0000083 | 0.017 | 0.0 | 0.0174 | 46.92 | 44.06 | 2.86 |
| 50 | 3000 | 27.855 | 0.0000077 | 0.016 | 0.0 | 0.0162 | 48.46 | 48.06 | 0.40 |
| 55 | 3300 | 26.055 | 0.0000072 | 0.015 | 0.0 | 0.0151 | 49.86 | 52.07 | -2.21 |
| 60 | 3600 | 24.500 | 0.0000068 | 0.014 | 0.0 | 0.0142 | 51.15 | 56.07 | -4.92 |
| 65 | 3900 | 23.142 | 0.0000064 | 0.013 | 0.0 | 0.0134 | 52.34 | 60.08 | -7.74 |
| 70 | 4200 | 21.944 | 0.0000061 | 0.013 | 0.0 | 0.0127 | 53.45 | 64.08 | -10.63 |
| 75 | 4500 | 20.879 | 0.0000058 | 0.012 | 0.0 | 0.0121 | 54.48 | 68.09 | -13.60 |
| 80 | 4800 | 19.925 | 0.0000055 | 0.012 | 0.0 | 0.0116 | 55.46 | 72.09 | -16.63 |
| 85 | 5100 | 19.064 | 0.0000053 | 0.011 | 0.0 | 0.0111 | 56.38 | 76.10 | -19.71 |
| 90 | 5400 | 18.284 | 0.0000051 | 0.011 | 0.0 | 0.0106 | 57.26 | 80.10 | -22.84 |
| 95 | 5700 | 17.573 | 0.0000049 | 0.010 | 0.0 | 0.0102 | 58.09 | 84.11 | -26.02 |
| 100 | 6000 | 16.923 | 0.0000047 | 0.010 | 0.0 | 0.0098 | 58.88 | 88.11 | -29.23 |
| 105 | 6300 | 16.324 | 0.0000045 | 0.009 | 0.0 | 0.0095 | 59.64 | 92.12 | -32.48 |
| 110 | 6600 | 15.772 | 0.0000044 | 0.009 | 0.0 | 0.0091 | 60.36 | 96.12 | -35.76 |
| 115 | 6900 | 15.261 | 0.0000042 | 0.009 | 0.0 | 0.0088 | 61.06 | 100.13 | -39.06 |
| 120 | 7200 | 14.786 | 0.0000041 | 0.009 | 0.0 | 0.0086 | 61.73 | 104.13 | -42.40 |

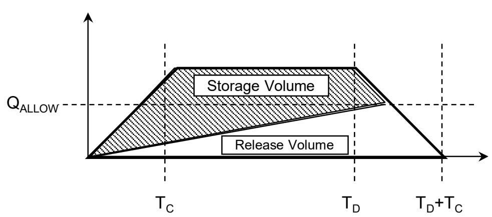
**Max. required storage volume = 11.26 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

Runoff Volume = Area under trapezoidal hydrograph
= $(T_D - T_C)Q_{POST} + (T_C\,Q_{POST})$

Release Volume = Area under triangular outflow hydrograph
= $\frac{1}{2}(T_D + T_C)\,Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



# 5-Year Storm - Modified Rational Method

## Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | | |
|---|---|---|
| City/Town/Region: | **Hamilton** | |
| Return Period: | **5** | Years |
| A = | **1049.500** | |
| B = | **8.000** | |
| C= | **0.803** | |
| Tc = | **10** | minutes |
| | 600 | seconds |

**Area of site being investigated (ha) =** **0.30** (Lot Area)

**Composite Runoff Coeff. ( C ) =** **0.68** (Post-development "C")

**Release Rate - $Q_{ALLOW}$ ($m^3$/s) =** **0.0267** (Allowable discharge)

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff | Release | Storage |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | Volume | Volume | Volume |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3$/s) | ($m^3$/s) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 133.809 | 0.0000372 | 0.076 | 0.0 | 0.0761 | 22.82 | 12.02 | 10.81 |
| 10 | 600 | 103.038 | 0.0000286 | 0.059 | 0.0 | 0.0586 | 35.15 | 16.02 | 19.13 |
| 15 | 900 | 84.628 | 0.0000235 | 0.048 | 0.0 | 0.0481 | 43.30 | 20.03 | 23.28 |
| 20 | 1200 | 72.263 | 0.0000201 | 0.041 | 0.0 | 0.0411 | 49.30 | 24.03 | 25.27 |
| 25 | 1500 | 63.331 | 0.0000176 | 0.036 | 0.0 | 0.0360 | 54.01 | 28.04 | 25.98 |
| 30 | 1800 | 56.548 | 0.0000157 | 0.032 | 0.0 | 0.0322 | 57.87 | 32.04 | 25.83 |
| 35 | 2100 | 51.204 | 0.0000142 | 0.029 | 0.0 | 0.0291 | 61.14 | 36.05 | 25.09 |
| 40 | 2400 | 46.875 | 0.0000130 | 0.027 | 0.0 | 0.0267 | 63.96 | 40.05 | 23.91 |
| 45 | 2700 | 43.290 | 0.0000120 | 0.025 | 0.0 | 0.0246 | 66.45 | 44.06 | 22.40 |
| 50 | 3000 | 40.267 | 0.0000112 | 0.023 | 0.0 | 0.0229 | 68.68 | 48.06 | 20.62 |
| 55 | 3300 | 37.680 | 0.0000105 | 0.021 | 0.0 | 0.0214 | 70.70 | 52.07 | 18.63 |
| 60 | 3600 | 35.439 | 0.0000098 | 0.020 | 0.0 | 0.0201 | 72.54 | 56.07 | 16.47 |
| 65 | 3900 | 33.476 | 0.0000093 | 0.019 | 0.0 | 0.0190 | 74.23 | 60.08 | 14.15 |
| 70 | 4200 | 31.742 | 0.0000088 | 0.018 | 0.0 | 0.0180 | 75.80 | 64.08 | 11.72 |
| 75 | 4500 | 30.197 | 0.0000084 | 0.017 | 0.0 | 0.0172 | 77.26 | 68.09 | 9.17 |
| 80 | 4800 | 28.811 | 0.0000080 | 0.016 | 0.0 | 0.0164 | 78.63 | 72.09 | 6.54 |
| 85 | 5100 | 27.561 | 0.0000077 | 0.016 | 0.0 | 0.0157 | 79.92 | 76.10 | 3.82 |
| 90 | 5400 | 26.426 | 0.0000073 | 0.015 | 0.0 | 0.0150 | 81.13 | 80.10 | 1.03 |
| 95 | 5700 | 25.391 | 0.0000071 | 0.014 | 0.0 | 0.0144 | 82.29 | 84.11 | -1.82 |
| 100 | 6000 | 24.442 | 0.0000068 | 0.014 | 0.0 | 0.0139 | 83.38 | 88.11 | -4.73 |
| 105 | 6300 | 23.570 | 0.0000065 | 0.013 | 0.0 | 0.0134 | 84.43 | 92.12 | -7.69 |
| 110 | 6600 | 22.765 | 0.0000063 | 0.013 | 0.0 | 0.0129 | 85.42 | 96.12 | -10.70 |
| 115 | 6900 | 22.019 | 0.0000061 | 0.013 | 0.0 | 0.0125 | 86.38 | 100.13 | -13.75 |
| 120 | 7200 | 21.325 | 0.0000059 | 0.012 | 0.0 | 0.0121 | 87.30 | 104.13 | -16.83 |

**Max. required storage volume = 25.98 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

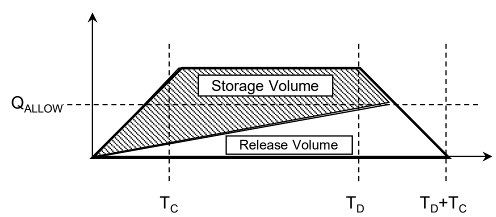
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= $\frac{1}{2}(T_D + T_C)\,Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



# 10-Year Storm - Modified Rational Method

## Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | | |
|---|---|---|
| City/Town/Region: | **Hamilton** | |
| Return Period: | **10** | Years |
| A = | **1343.700** | |
| B = | **9.000** | |
| C= | **0.814** | |
| Tc = | **10** | minutes |
| | 600 | seconds |

**Area of site being investigated (ha) =** **0.30** (Lot Area)

**Composite Runoff Coeff. ( C ) =** **0.68** (Post-development "C")

**Release Rate - $Q_{ALLOW}$ ($m^3/s$) =** **0.0267** (Allowable discharge)

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff Volume | Release Volume | Storage Volume |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | | | |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3/s$) | ($m^3/s$) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 156.803 | 0.0000436 | 0.089 | 0.0 | 0.0892 | 26.75 | 12.02 | 14.73 |
| 10 | 600 | 122.292 | 0.0000340 | 0.070 | 0.0 | 0.0695 | 41.72 | 16.02 | 25.70 |
| 15 | 900 | 101.114 | 0.0000281 | 0.057 | 0.0 | 0.0575 | 51.74 | 20.03 | 31.71 |
| 20 | 1200 | 86.678 | 0.0000241 | 0.049 | 0.0 | 0.0493 | 59.14 | 24.03 | 35.11 |
| 25 | 1500 | 76.152 | 0.0000212 | 0.043 | 0.0 | 0.0433 | 64.94 | 28.04 | 36.91 |
| 30 | 1800 | 68.104 | 0.0000189 | 0.039 | 0.0 | 0.0387 | 69.70 | 32.04 | 37.66 |
| 35 | 2100 | 61.735 | 0.0000171 | 0.035 | 0.0 | 0.0351 | 73.71 | 36.05 | 37.66 |
| 40 | 2400 | 56.557 | 0.0000157 | 0.032 | 0.0 | 0.0322 | 77.17 | 40.05 | 37.12 |
| 45 | 2700 | 52.256 | 0.0000145 | 0.030 | 0.0 | 0.0297 | 80.22 | 44.06 | 36.16 |
| 50 | 3000 | 48.622 | 0.0000135 | 0.028 | 0.0 | 0.0276 | 82.93 | 48.06 | 34.87 |
| 55 | 3300 | 45.506 | 0.0000126 | 0.026 | 0.0 | 0.0259 | 85.38 | 52.07 | 33.32 |
| 60 | 3600 | 42.803 | 0.0000119 | 0.024 | 0.0 | 0.0243 | 87.61 | 56.07 | 31.54 |
| 65 | 3900 | 40.434 | 0.0000112 | 0.023 | 0.0 | 0.0230 | 89.66 | 60.08 | 29.58 |
| 70 | 4200 | 38.338 | 0.0000106 | 0.022 | 0.0 | 0.0218 | 91.55 | 64.08 | 27.47 |
| 75 | 4500 | 36.470 | 0.0000101 | 0.021 | 0.0 | 0.0207 | 93.31 | 68.09 | 25.22 |
| 80 | 4800 | 34.794 | 0.0000097 | 0.020 | 0.0 | 0.0198 | 94.95 | 72.09 | 22.86 |
| 85 | 5100 | 33.279 | 0.0000092 | 0.019 | 0.0 | 0.0189 | 96.50 | 76.10 | 20.40 |
| 90 | 5400 | 31.905 | 0.0000089 | 0.018 | 0.0 | 0.0181 | 97.95 | 80.10 | 17.85 |
| 95 | 5700 | 30.650 | 0.0000085 | 0.017 | 0.0 | 0.0174 | 99.33 | 84.11 | 15.23 |
| 100 | 6000 | 29.501 | 0.0000082 | 0.017 | 0.0 | 0.0168 | 100.64 | 88.11 | 12.53 |
| 105 | 6300 | 28.443 | 0.0000079 | 0.016 | 0.0 | 0.0162 | 101.88 | 92.12 | 9.77 |
| 110 | 6600 | 27.467 | 0.0000076 | 0.016 | 0.0 | 0.0156 | 103.07 | 96.12 | 6.95 |
| 115 | 6900 | 26.562 | 0.0000074 | 0.015 | 0.0 | 0.0151 | 104.20 | 100.13 | 4.08 |
| 120 | 7200 | 25.721 | 0.0000071 | 0.015 | 0.0 | 0.0146 | 105.29 | 104.13 | 1.16 |

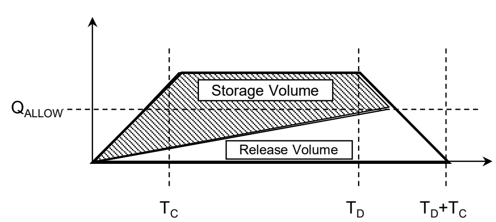
**Max. required storage volume = 37.66 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

Runoff Volume = Area under trapezoidal hydrograph
= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph
= ½ $(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



## 25-Year Storm - Modified Rational Method

### Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | |
|---|---|
| City/Town/Region: | **Hamilton** |
| Return Period: | **25** Years |
| A = | **1719.500** |
| B = | **10.000** |
| C= | **0.823** |
| Tc = | **10** minutes |
| | 600 seconds |

**Area of site being investigated (ha) =** **0.30** (Lot Area)

**Composite Runoff Coeff. ( C ) =** **0.68** (Post-development "C")

**Release Rate - $Q_{ALLOW}$ ($m^3/s$) =** **0.0267** (Allowable discharge)

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff | Release | Storage |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | Volume | Volume | Volume |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3/s$) | ($m^3/s$) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 185.131 | 0.0000514 | 0.105 | 0.0 | 0.1053 | 31.58 | 12.02 | 19.56 |
| 10 | 600 | 146.101 | 0.0000406 | 0.083 | 0.0 | 0.0831 | 49.84 | 16.02 | 33.82 |
| 15 | 900 | 121.590 | 0.0000338 | 0.069 | 0.0 | 0.0691 | 62.22 | 20.03 | 42.19 |
| 20 | 1200 | 104.648 | 0.0000291 | 0.059 | 0.0 | 0.0595 | 71.40 | 24.03 | 47.37 |
| 25 | 1500 | 92.179 | 0.0000256 | 0.052 | 0.0 | 0.0524 | 78.61 | 28.04 | 50.58 |
| 30 | 1800 | 82.586 | 0.0000229 | 0.047 | 0.0 | 0.0470 | 84.52 | 32.04 | 52.48 |
| 35 | 2100 | 74.956 | 0.0000208 | 0.043 | 0.0 | 0.0426 | 89.50 | 36.05 | 53.45 |
| 40 | 2400 | 68.731 | 0.0000191 | 0.039 | 0.0 | 0.0391 | 93.79 | 40.05 | 53.74 |
| 45 | 2700 | 63.545 | 0.0000177 | 0.036 | 0.0 | 0.0361 | 97.55 | 44.06 | 53.49 |
| 50 | 3000 | 59.154 | 0.0000164 | 0.034 | 0.0 | 0.0336 | 100.90 | 48.06 | 52.84 |
| 55 | 3300 | 55.383 | 0.0000154 | 0.031 | 0.0 | 0.0315 | 103.91 | 52.07 | 51.85 |
| 60 | 3600 | 52.106 | 0.0000145 | 0.030 | 0.0 | 0.0296 | 106.65 | 56.07 | 50.58 |
| 65 | 3900 | 49.230 | 0.0000137 | 0.028 | 0.0 | 0.0280 | 109.16 | 60.08 | 49.09 |
| 70 | 4200 | 46.683 | 0.0000130 | 0.027 | 0.0 | 0.0265 | 111.48 | 64.08 | 47.40 |
| 75 | 4500 | 44.411 | 0.0000123 | 0.025 | 0.0 | 0.0253 | 113.63 | 68.09 | 45.54 |
| 80 | 4800 | 42.370 | 0.0000118 | 0.024 | 0.0 | 0.0241 | 115.63 | 72.09 | 43.54 |
| 85 | 5100 | 40.526 | 0.0000113 | 0.023 | 0.0 | 0.0230 | 117.51 | 76.10 | 41.42 |
| 90 | 5400 | 38.851 | 0.0000108 | 0.022 | 0.0 | 0.0221 | 119.28 | 80.10 | 39.18 |
| 95 | 5700 | 37.322 | 0.0000104 | 0.021 | 0.0 | 0.0212 | 120.95 | 84.11 | 36.85 |
| 100 | 6000 | 35.920 | 0.0000100 | 0.020 | 0.0 | 0.0204 | 122.54 | 88.11 | 34.43 |
| 105 | 6300 | 34.630 | 0.0000096 | 0.020 | 0.0 | 0.0197 | 124.04 | 92.12 | 31.92 |
| 110 | 6600 | 33.438 | 0.0000093 | 0.019 | 0.0 | 0.0190 | 125.47 | 96.12 | 29.35 |
| 115 | 6900 | 32.333 | 0.0000090 | 0.018 | 0.0 | 0.0184 | 126.84 | 100.13 | 26.72 |
| 120 | 7200 | 31.306 | 0.0000087 | 0.018 | 0.0 | 0.0178 | 128.15 | 104.13 | 24.02 |

**Max. required storage volume = 53.74 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

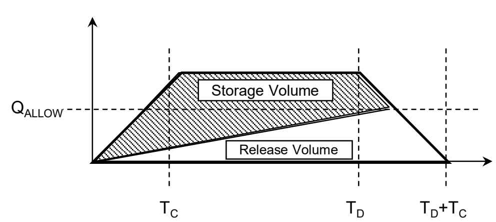
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= $\frac{1}{2}(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



## 50-Year Storm - Modified Rational Method
### Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | |
|---|---|
| City/Town/Region: | **Hamilton** |
| Return Period: | **50** Years |
| A = | **1954.800** |
| B = | **10.000** |
| C= | **0.826** |
| Tc = | **10** minutes |
| | 600 seconds |

**Area of site being investigated (ha) =** **0.30** (Lot Area)
**Composite Runoff Coeff. ( C ) =** **0.68** (Post-development "C")
**Release Rate - $Q_{ALLOW}$ ($m^3/s$) =** **0.0267** (Allowable discharge)

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff | Release | Storage |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | Volume | Volume | Volume |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3/s$) | ($m^3/s$) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 208.762 | 0.0000580 | 0.119 | 0.0 | 0.1187 | 35.61 | 12.02 | 23.59 |
| 10 | 600 | 164.608 | 0.0000457 | 0.094 | 0.0 | 0.0936 | 56.15 | 16.02 | 40.13 |
| 15 | 900 | 136.900 | 0.0000380 | 0.078 | 0.0 | 0.0778 | 70.05 | 20.03 | 50.03 |
| 20 | 1200 | 117.761 | 0.0000327 | 0.067 | 0.0 | 0.0670 | 80.34 | 24.03 | 56.31 |
| 25 | 1500 | 103.682 | 0.0000288 | 0.059 | 0.0 | 0.0589 | 88.42 | 28.04 | 60.39 |
| 30 | 1800 | 92.854 | 0.0000258 | 0.053 | 0.0 | 0.0528 | 95.03 | 32.04 | 62.99 |
| 35 | 2100 | 84.246 | 0.0000234 | 0.048 | 0.0 | 0.0479 | 100.59 | 36.05 | 64.54 |
| 40 | 2400 | 77.224 | 0.0000215 | 0.044 | 0.0 | 0.0439 | 105.37 | 40.05 | 65.32 |
| 45 | 2700 | 71.378 | 0.0000198 | 0.041 | 0.0 | 0.0406 | 109.57 | 44.06 | 65.52 |
| 50 | 3000 | 66.428 | 0.0000185 | 0.038 | 0.0 | 0.0378 | 113.30 | 48.06 | 65.24 |
| 55 | 3300 | 62.178 | 0.0000173 | 0.035 | 0.0 | 0.0354 | 116.66 | 52.07 | 64.60 |
| 60 | 3600 | 58.486 | 0.0000162 | 0.033 | 0.0 | 0.0333 | 119.71 | 56.07 | 63.64 |
| 65 | 3900 | 55.246 | 0.0000153 | 0.031 | 0.0 | 0.0314 | 122.50 | 60.08 | 62.43 |
| 70 | 4200 | 52.378 | 0.0000145 | 0.030 | 0.0 | 0.0298 | 125.08 | 64.08 | 61.00 |
| 75 | 4500 | 49.820 | 0.0000138 | 0.028 | 0.0 | 0.0283 | 127.46 | 68.09 | 59.38 |
| 80 | 4800 | 47.522 | 0.0000132 | 0.027 | 0.0 | 0.0270 | 129.69 | 72.09 | 57.60 |
| 85 | 5100 | 45.447 | 0.0000126 | 0.026 | 0.0 | 0.0258 | 131.78 | 76.10 | 55.68 |
| 90 | 5400 | 43.561 | 0.0000121 | 0.025 | 0.0 | 0.0248 | 133.74 | 80.10 | 53.64 |
| 95 | 5700 | 41.841 | 0.0000116 | 0.024 | 0.0 | 0.0238 | 135.60 | 84.11 | 51.49 |
| 100 | 6000 | 40.264 | 0.0000112 | 0.023 | 0.0 | 0.0229 | 137.35 | 88.11 | 49.24 |
| 105 | 6300 | 38.812 | 0.0000108 | 0.022 | 0.0 | 0.0221 | 139.02 | 92.12 | 46.91 |
| 110 | 6600 | 37.471 | 0.0000104 | 0.021 | 0.0 | 0.0213 | 140.61 | 96.12 | 44.49 |
| 115 | 6900 | 36.229 | 0.0000101 | 0.021 | 0.0 | 0.0206 | 142.13 | 100.13 | 42.00 |
| 120 | 7200 | 35.074 | 0.0000097 | 0.020 | 0.0 | 0.0199 | 143.58 | 104.13 | 39.45 |

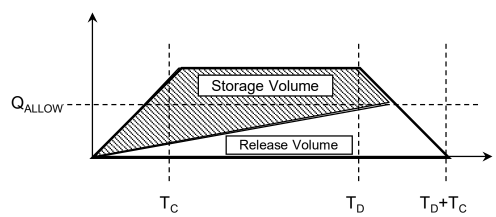
**Max. required storage volume = 65.52 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

Runoff Volume = Area under trapezoidal hydrograph
= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph
= ½ $(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



# 100-Year Storm - Modified Rational Method

## Stormwater Storage Volume

Determination of required storage volume under proposed conditions to control the 100-year proposed conditions runoff to the allowable release rate. Storage volume calculated using the Modified Rational Method.

| *Storm Rainfall Information* | | |
|---|---|---|
| City/Town/Region: | **Hamilton** | |
| Return Period: | **100** | Years |
| A = | **2317.400** | |
| B = | **11.000** | |
| C= | **0.836** | |
| Tc = | **10** | minutes |
| | 600 | seconds |

| | | |
|---|---|---|
| **Area of site being investigated (ha) =** | **0.30** | (Lot Area) |
| **Composite Runoff Coeff. ( C ) =** | **0.68** | (Post development "C") |
| **Release Rate - $Q_{ALLOW}$ ($m^3$/s) =** | **0.0267** | (Allowable discharge) |

Flows from Lot area calculated from area indicated above

Roof flows ($Q_{ROOF}$) added in as a constant flow rate into the orifice controlled system (if applicable)

| Duration ($T_D$) | | Rainfall Intensity | | Post-Development Runoff | | | Runoff Volume | Release Volume | Storage Volume |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Site | Roof | Total "$Q_{POST}$" | | | |
| (min) | (sec) | (mm/hr) | (m/s) | ($m^3$/s) | ($m^3$/s) | ($m^3$) | ($m^3$) | ($m^3$) | ($m^3$) |
| 5 | 300 | 228.222 | 0.0000634 | 0.129 | 0.0 | 0.1293 | 38.80 | 12.02 | 26.78 |
| 10 | 600 | 181.813 | 0.0000505 | 0.103 | 0.0 | 0.1030 | 61.82 | 16.02 | 45.80 |
| 15 | 900 | 152.084 | 0.0000422 | 0.086 | 0.0 | 0.0862 | 77.56 | 20.03 | 57.54 |
| 20 | 1200 | 131.287 | 0.0000365 | 0.074 | 0.0 | 0.0744 | 89.28 | 24.03 | 65.25 |
| 25 | 1500 | 115.860 | 0.0000322 | 0.066 | 0.0 | 0.0657 | 98.48 | 28.04 | 70.45 |
| 30 | 1800 | 103.923 | 0.0000289 | 0.059 | 0.0 | 0.0589 | 106.00 | 32.04 | 73.96 |
| 35 | 2100 | 94.392 | 0.0000262 | 0.053 | 0.0 | 0.0535 | 112.33 | 36.05 | 76.28 |
| 40 | 2400 | 86.591 | 0.0000241 | 0.049 | 0.0 | 0.0491 | 117.76 | 40.05 | 77.71 |
| 45 | 2700 | 80.078 | 0.0000222 | 0.045 | 0.0 | 0.0454 | 122.52 | 44.06 | 78.47 |
| 50 | 3000 | 74.553 | 0.0000207 | 0.042 | 0.0 | 0.0422 | 126.74 | 48.06 | 78.68 |
| 55 | 3300 | 69.801 | 0.0000194 | 0.040 | 0.0 | 0.0396 | 130.53 | 52.07 | 78.46 |
| 60 | 3600 | 65.667 | 0.0000182 | 0.037 | 0.0 | 0.0372 | 133.96 | 56.07 | 77.89 |
| 65 | 3900 | 62.036 | 0.0000172 | 0.035 | 0.0 | 0.0352 | 137.10 | 60.08 | 77.02 |
| 70 | 4200 | 58.818 | 0.0000163 | 0.033 | 0.0 | 0.0333 | 139.99 | 64.08 | 75.91 |
| 75 | 4500 | 55.945 | 0.0000155 | 0.032 | 0.0 | 0.0317 | 142.66 | 68.09 | 74.57 |
| 80 | 4800 | 53.363 | 0.0000148 | 0.030 | 0.0 | 0.0302 | 145.15 | 72.09 | 73.06 |
| 85 | 5100 | 51.030 | 0.0000142 | 0.029 | 0.0 | 0.0289 | 147.48 | 76.10 | 71.38 |
| 90 | 5400 | 48.909 | 0.0000136 | 0.028 | 0.0 | 0.0277 | 149.66 | 80.10 | 69.56 |
| 95 | 5700 | 46.973 | 0.0000130 | 0.027 | 0.0 | 0.0266 | 151.72 | 84.11 | 67.62 |
| 100 | 6000 | 45.197 | 0.0000126 | 0.026 | 0.0 | 0.0256 | 153.67 | 88.11 | 65.56 |
| 105 | 6300 | 43.563 | 0.0000121 | 0.025 | 0.0 | 0.0247 | 155.52 | 92.12 | 63.40 |
| 110 | 6600 | 42.053 | 0.0000117 | 0.024 | 0.0 | 0.0238 | 157.28 | 96.12 | 61.16 |
| 115 | 6900 | 40.653 | 0.0000113 | 0.023 | 0.0 | 0.0230 | 158.95 | 100.13 | 58.83 |
| 120 | 7200 | 39.352 | 0.0000109 | 0.022 | 0.0 | 0.0223 | 160.55 | 104.13 | 56.42 |

**Max. required storage volume = 78.68 $m^3$**

$Q_{POST}$ = (C i A) x 10000 $m^2$/ha (Rational Method)

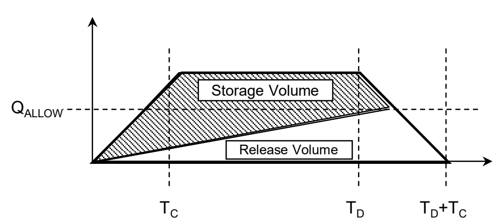
Runoff Volume = Area under trapezoidal hydrograph

= $(T_D - T_C)Q_{POST} + (T_C\, Q_{POST})$

Release Volume = Area under triangular outflow hydrograph

= $\frac{1}{2}(T_D + T_C)\, Q_{ALLOW}$

Storage Volume = Runoff Volume - Release Volume



# APPENDIX B

# QUALITY CONTROL INFORMATION

# Hydroworks Sizing Summary

## 338 & 338.5 Cumberland Avenue
## Hamilton, Ontario

**01-31-2022**

## Recommended Size: HS 6

**A HydroStorm HS 6 is recommended to provide 80 % annual TSS removal based on a drainage area of 0.301 (ha) with an imperviousness of 64 % and Hamilton Airport, Ontario rainfall for the ETV Canada particle size distribution.**

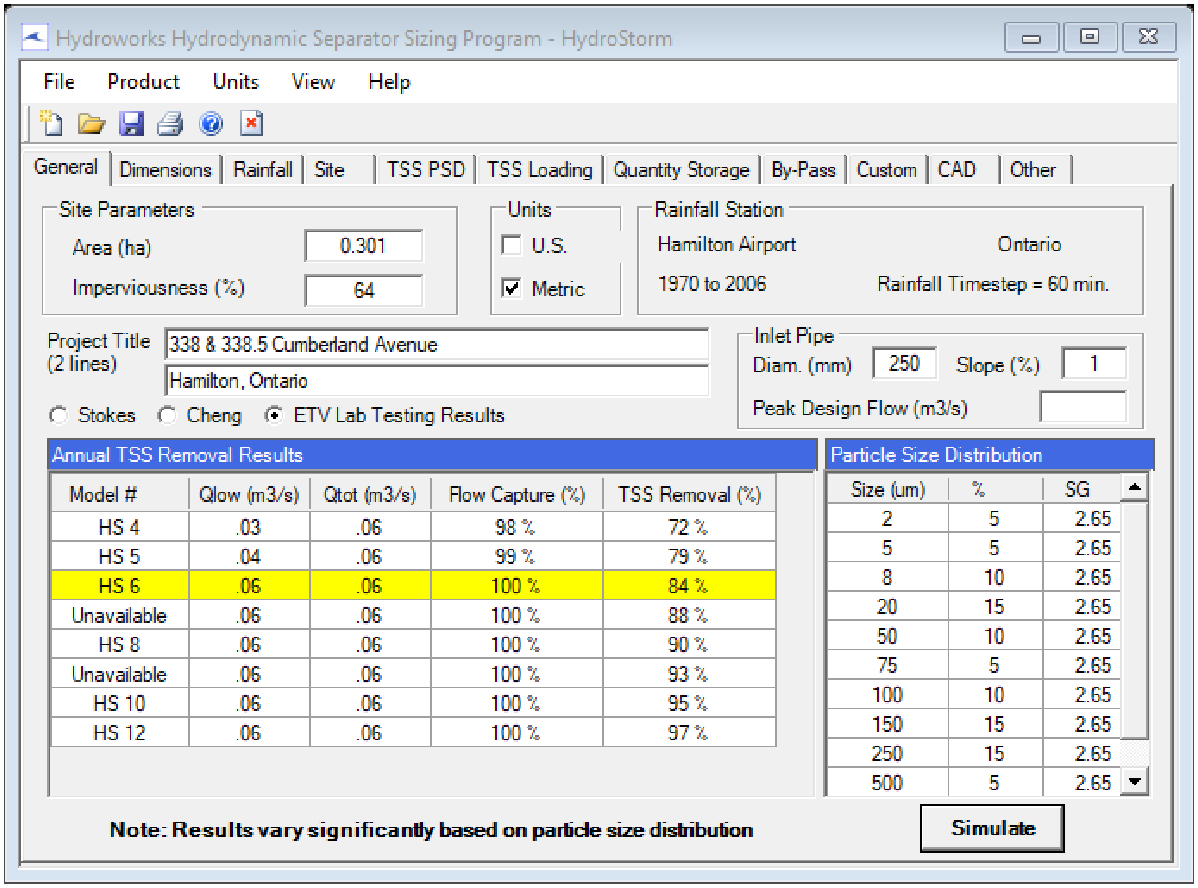
**The recommended HydroStorm HS 6 treats 100 % of the annual runoff and provides 84 % annual TSS removal for the Hamilton Airport rainfall records and ETV Canada particle size distribution.**

**The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of .06 (m3/s) for the given 250 (mm) pipe diameter at 1% slope. The headloss was calculated to be 78 (mm) based on a flow depth of 250 (mm) (full pipe flow).**

**This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.**

**If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.**

## TSS Removal Sizing Summary



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

Site Parameters
Area (ha) 0.301
Imperviousness (%) 64

Units
☐ U.S.
☑ Metric

Rainfall Station
Hamilton Airport Ontario
1970 to 2006 Rainfall Timestep = 60 min.

Project Title (2 lines) 338 & 338.5 Cumberland Avenue
Hamilton, Ontario

Inlet Pipe
Diam. (mm) 250 Slope (%) 1
Peak Design Flow (m3/s)

○ Stokes ○ Cheng ◉ ETV Lab Testing Results

Annual TSS Removal Results

| Model # | Qlow (m3/s) | Qtot (m3/s) | Flow Capture (%) | TSS Removal (%) |
|---|---|---|---|---|
| HS 4 | .03 | .06 | 98 % | 72 % |
| HS 5 | .04 | .06 | 99 % | 79 % |
| HS 6 | .06 | .06 | 100 % | 84 % |
| Unavailable | .06 | .06 | 100 % | 88 % |
| HS 8 | .06 | .06 | 100 % | 90 % |
| Unavailable | .06 | .06 | 100 % | 93 % |
| HS 10 | .06 | .06 | 100 % | 95 % |
| HS 12 | .06 | .06 | 100 % | 97 % |

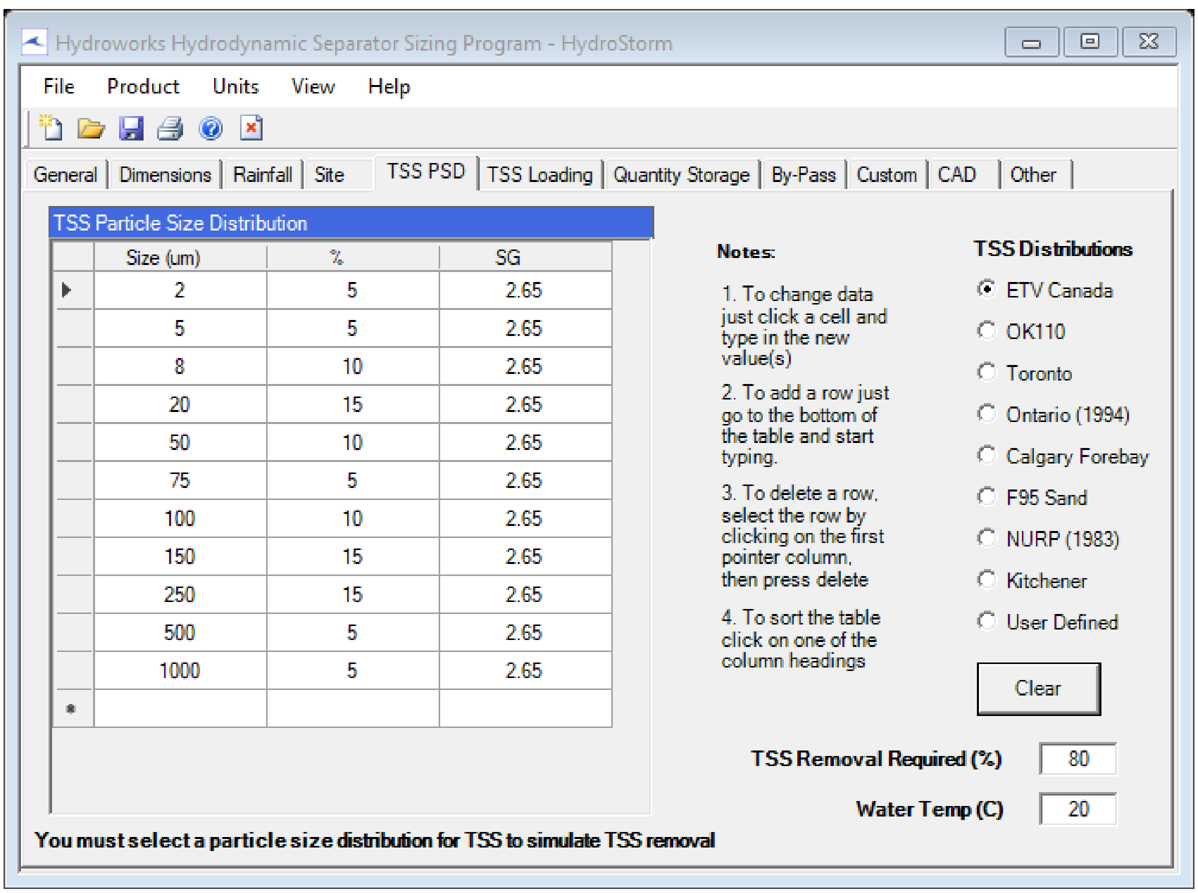
Particle Size Distribution

| Size (um) | % | SG |
|---|---|---|
| 2 | 5 | 2.65 |
| 5 | 5 | 2.65 |
| 8 | 10 | 2.65 |
| 20 | 15 | 2.65 |
| 50 | 10 | 2.65 |
| 75 | 5 | 2.65 |
| 100 | 10 | 2.65 |
| 150 | 15 | 2.65 |
| 250 | 15 | 2.65 |
| 500 | 5 | 2.65 |

**Note: Results vary significantly based on particle size distribution**

Simulate

## TSS Particle Size Distribution



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

TSS Particle Size Distribution

| Size (um) | % | SG |
|---|---|---|
| 2 | 5 | 2.65 |
| 5 | 5 | 2.65 |
| 8 | 10 | 2.65 |
| 20 | 15 | 2.65 |
| 50 | 10 | 2.65 |
| 75 | 5 | 2.65 |
| 100 | 10 | 2.65 |
| 150 | 15 | 2.65 |
| 250 | 15 | 2.65 |
| 500 | 5 | 2.65 |
| 1000 | 5 | 2.65 |

**Notes:**

1. To change data just click a cell and type in the new value(s)
2. To add a row just go to the bottom of the table and start typing.
3. To delete a row, select the row by clicking on the first pointer column, then press delete
4. To sort the table click on one of the column headings

**TSS Distributions**

◉ ETV Canada
○ OK110
○ Toronto
○ Ontario (1994)
○ Calgary Forebay
○ F95 Sand
○ NURP (1983)
○ Kitchener
○ User Defined

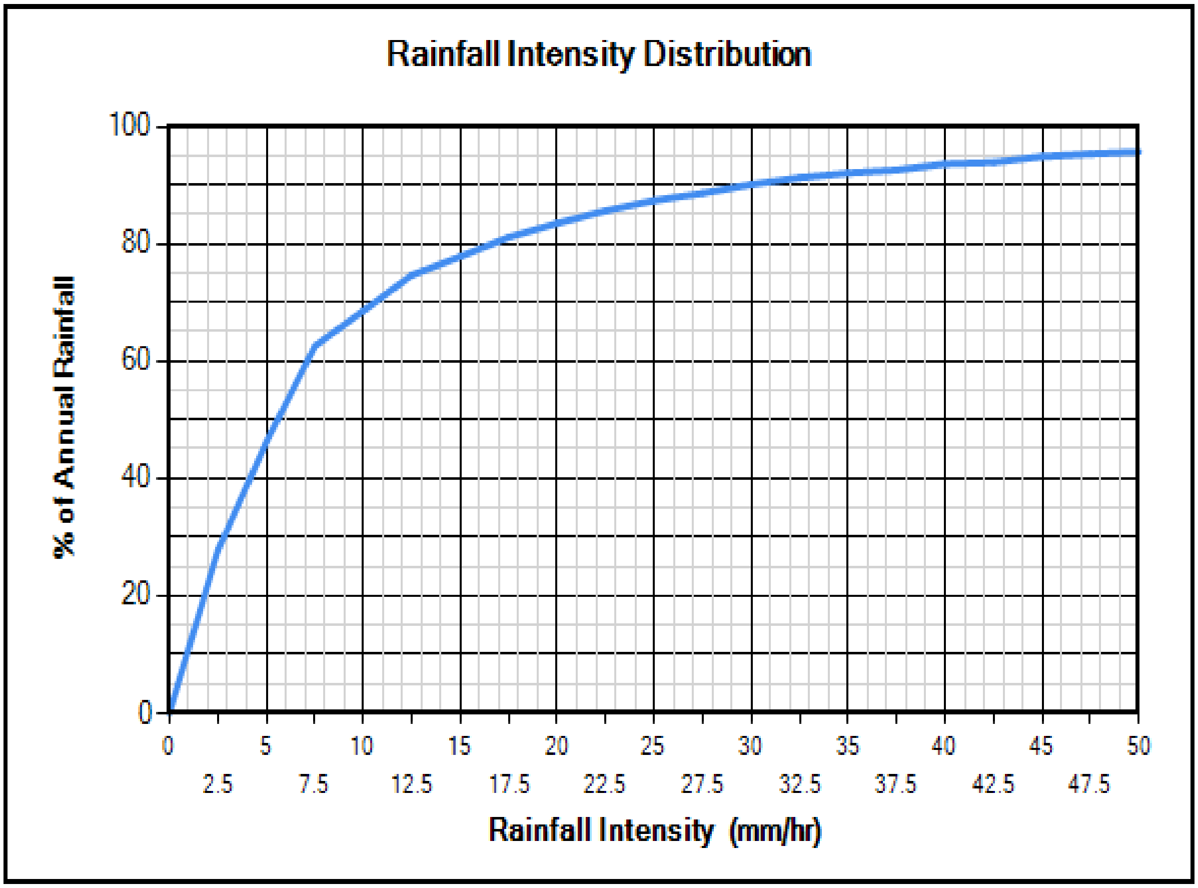
Clear

**TSS Removal Required (%)** 80

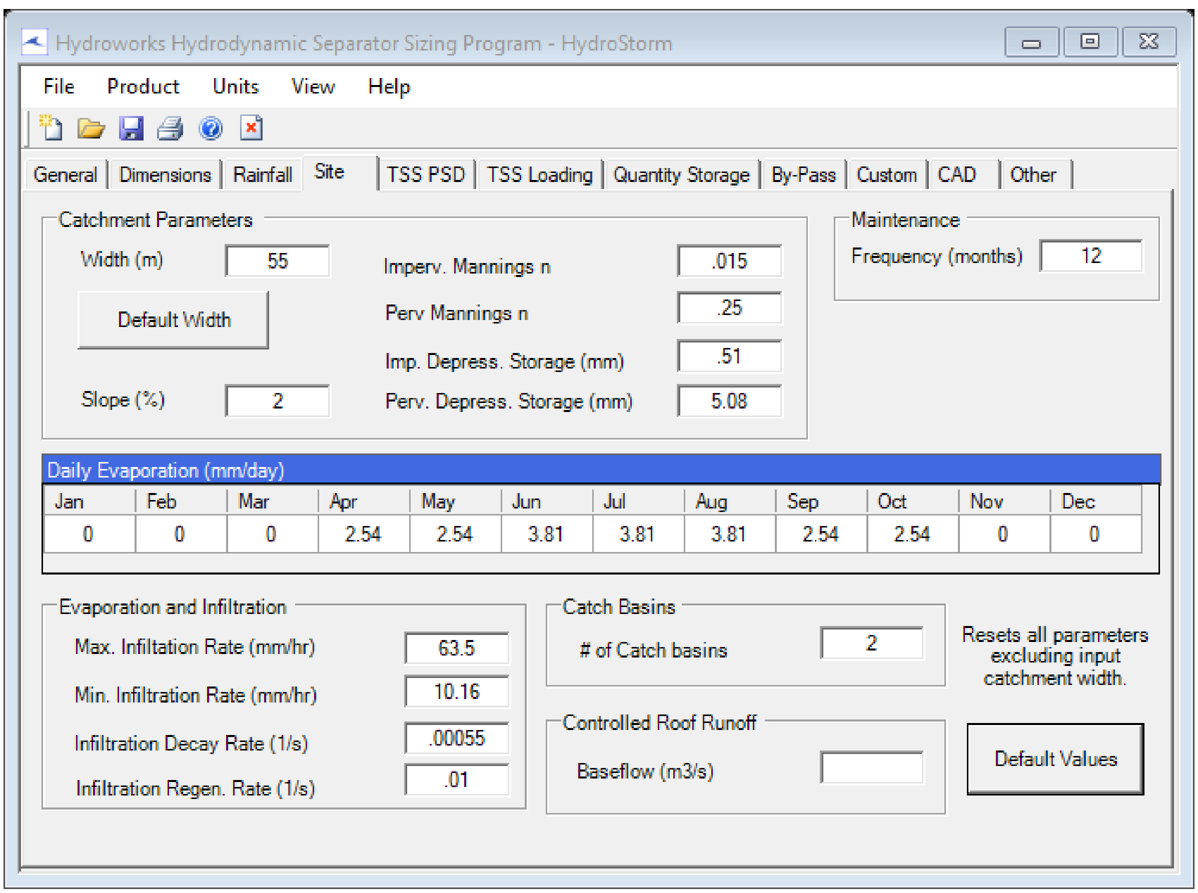
**Water Temp (C)** 20

**You must select a particle size distribution for TSS to simulate TSS removal**

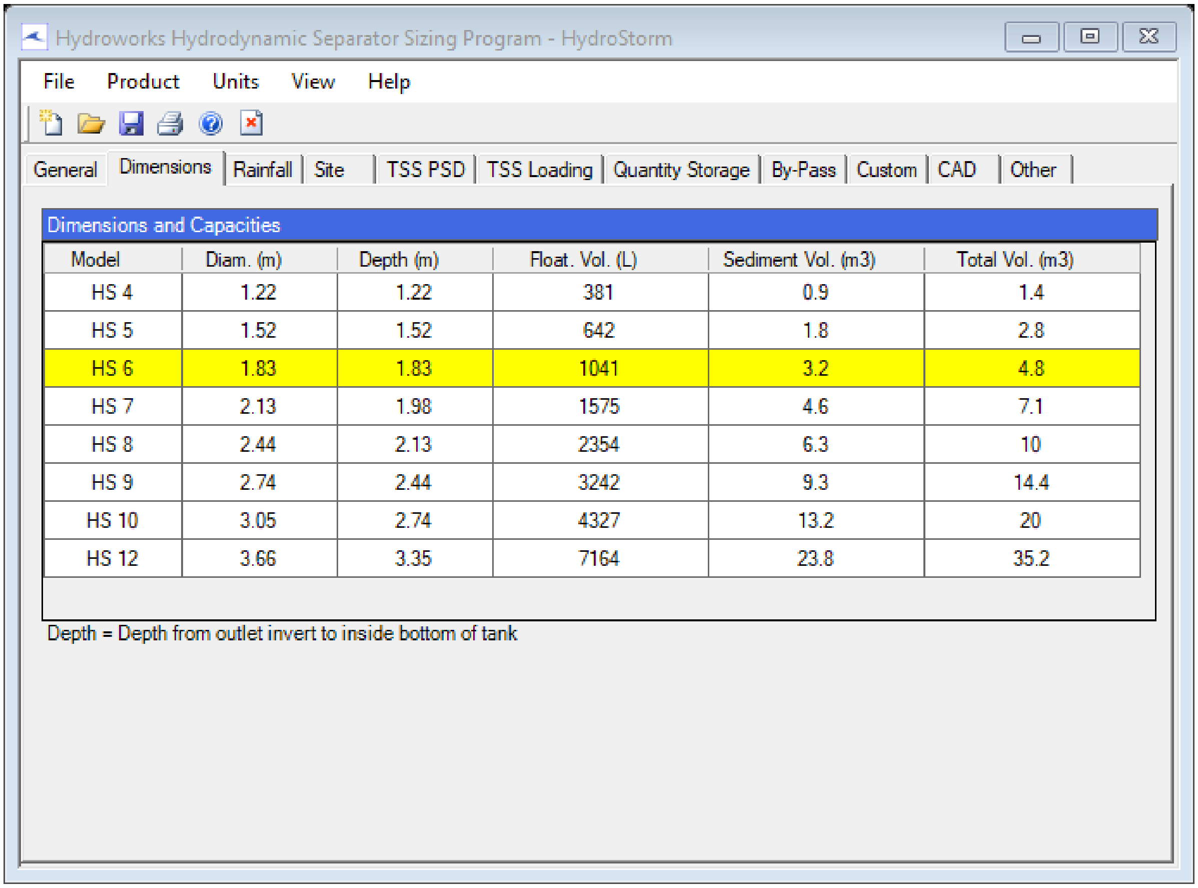
**Rainfall Station - Hamilton Airport, Ontario(1970 to 2006)**




**Site Physical Characteristics**



## Dimensions And Capacities



Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

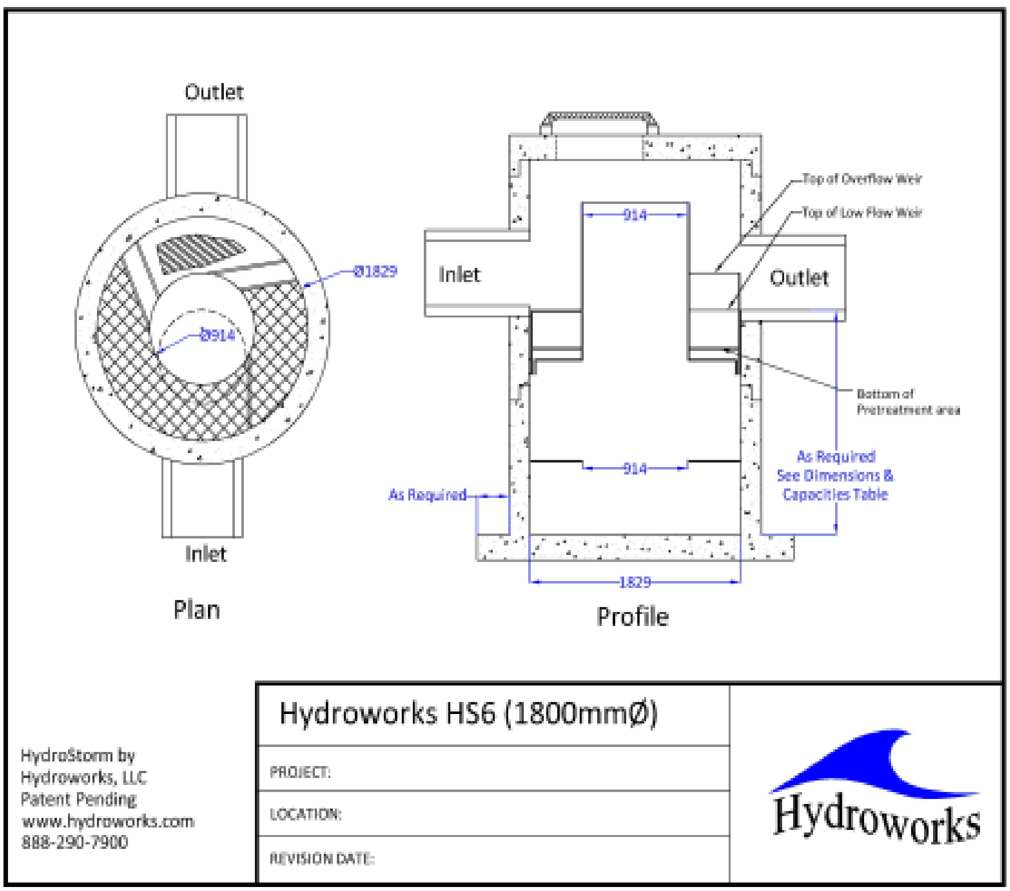
General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

Dimensions and Capacities

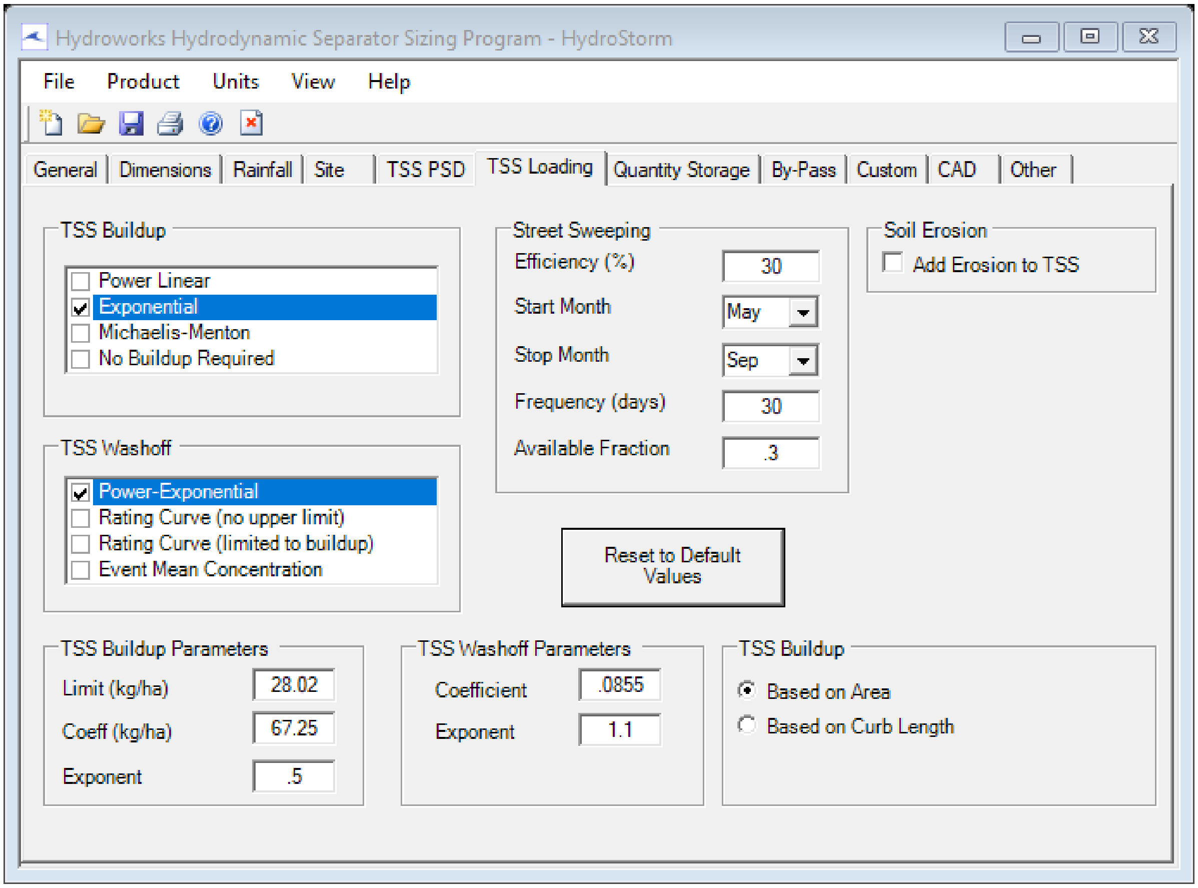
| Model | Diam. (m) | Depth (m) | Float. Vol. (L) | Sediment Vol. (m3) | Total Vol. (m3) |
|---|---|---|---|---|---|
| HS 4 | 1.22 | 1.22 | 381 | 0.9 | 1.4 |
| HS 5 | 1.52 | 1.52 | 642 | 1.8 | 2.8 |
| HS 6 | 1.83 | 1.83 | 1041 | 3.2 | 4.8 |
| HS 7 | 2.13 | 1.98 | 1575 | 4.6 | 7.1 |
| HS 8 | 2.44 | 2.13 | 2354 | 6.3 | 10 |
| HS 9 | 2.74 | 2.44 | 3242 | 9.3 | 14.4 |
| HS 10 | 3.05 | 2.74 | 4327 | 13.2 | 20 |
| HS 12 | 3.66 | 3.35 | 7164 | 23.8 | 35.2 |

Depth = Depth from outlet invert to inside bottom of tank

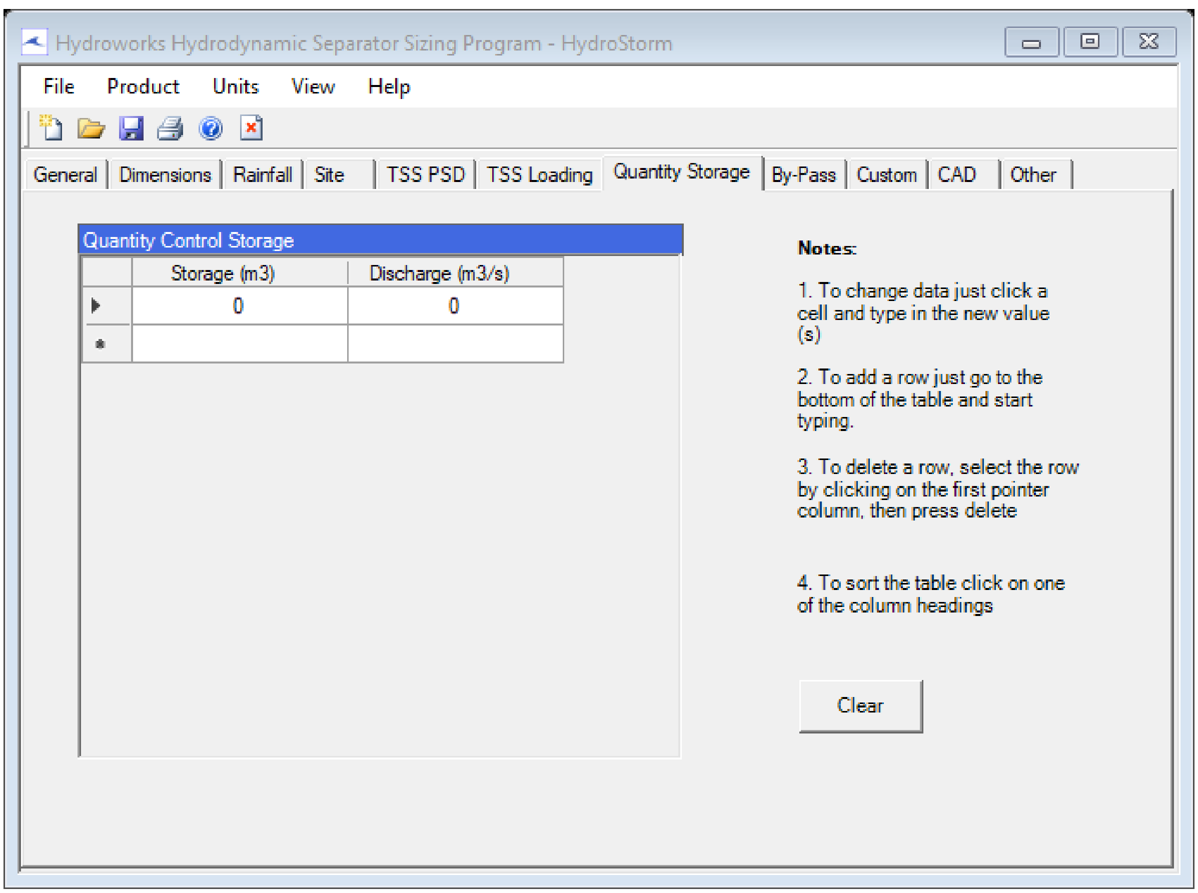
## Generic HS 6 CAD Drawing



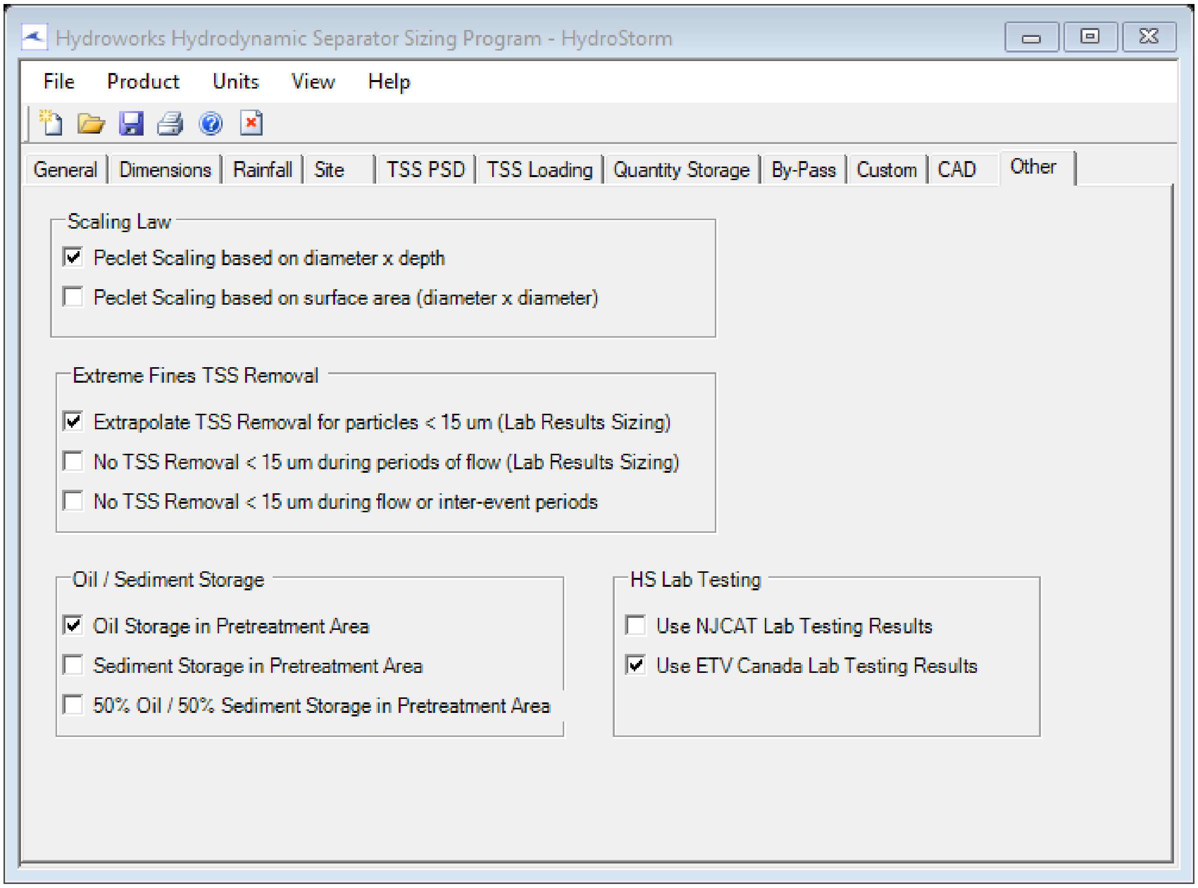
## TSS Buildup And Washoff




## Upstream Quantity Storage



**Other Parameters**




**Hydroworks Sizing Program - Version 5.0**

# FLEXSTORM™ Inlet Filter Specifications and Work Instructions

**Product:** **FLEXSTORM Inlet Filters**

**Manufacturer:** **Inlet & Pipe Protection, Inc** www.inletfilters.com

***A subsidiary of*** **Advanced Drainage Systems (ADS)** www.ads-pipe.com

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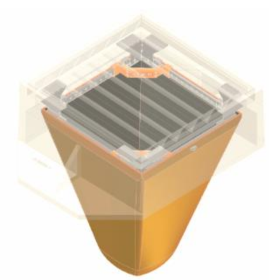
## 1.0 Description of Work:

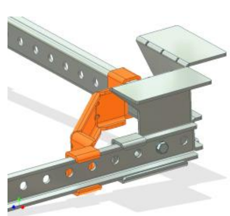
1.1 The work covered shall consist of supplying, installing, and maintaining/cleaning of the FLEXSTORM Inlet Filter assembly. The purpose of the FLEXSTORM Inlet Filter system is to collect silt and sediment from surface storm water runoff at drainage locations shown on the plans or as directed by the Engineer. FLEXSTORM PURE, permanent filters, are capable of removing small particles, hydrocarbons, and other contaminants from drainage "hot spots".

## 2.0 Material:

2.1 The FLEXSTORM Inlet Filter system is comprised of a corrosion resistant steel frame and a replaceable geotextile sediment bag attached to the frame with a stainless steel locking band. The sediment bag hangs suspended from the rigid frame at a distance below the grate that shall allow full water flow into the drainage structure if the bag is completely filled with sediment.

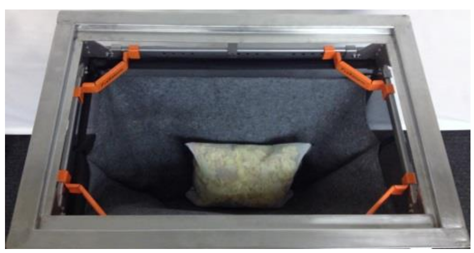



2.2 The FLEXSTORM Inlet Filter frame includes lifting handles in addition to the standard overflow feature. A FLEXSTORM Removal Tool engages the lifting bars or handles to allow manual removal of the assembly without machine assistance. The frame suspension system on most rectangular designs is adjustable in ½" increments up to 5" per side should the casting or drainage structure have imperfections.


2.3 **FLEXSTORM CATCH-IT** Inlet Filters for temporary inlet protection: The FLEXSTORM CATCH-IT framing is galvanized or zinc plated for corrosion resistance. The **“FX”** Woven Polypropylene filter bag is the design standard, although the **“IL”** Nonwoven geotextile is also available if preferred by the engineer. These products are typically used for temporary inlet protection lasting 3 months (short term road work) to 5 years (residential developments).

2.4 **FLEXSTORM PURE** Inlet Filters for permanent inlet protection: The FLEXSTORM PURE framing is comprised of 304 stainless steel with a 25 year life rating. Multiple filter bags are available: **FX, FX+, PC, PC+, LL** and others. The Post Construction **“PC+”** is the design standard consisting of the **“FX”** Woven Polypropylene sediment bag lined with Adsorb-it filter fabric, which is made from recycled polyester fibers. The **“PC+”** includes a replaceable hydrocarbon skimmer pouch strapped to the bottom of the bag for advanced TPH removal.



## 3.0 Filter Bag Specifications and Capabilities:

3.1 Material Properties (taken from manufacturers average roll value):

| FLEXSTORM FILTER BAGS | (22” depth) STD Bag P/N | (12” depth) Short Bag P/N | Clean Water Flow Rate (GPM/SqFt) | Min A.O.S. (US Sieve) |
|---|---|---|---|---|
| FX: Standard Woven Bag | FX | FX-S | 200 | 40 |
| FX+: Woven w/ Oil Skimmer | FXP | FXP-S | 200 | 40 |
| FXO: Woven w/ Oil Boom | FXO | FXO-S | 200 | 40 |
| PC: Post Construction Bag | PC | PC-S | 137 | 140 |
| PC+: PC w/ Oil Skimmer | PCP | PCP-S | 137 | 140 |
| LL: Litter and Leaf Bag | LL | LL-S | High | 3.5 |
| IL: IDOT Non-Woven Bag | IL | IL-S | 145 | 70 |

3.2 Standard Bag Sizes and Capabilities: Bag Sizes are determined by clear opening dimensions of the drainage structure. Once frame design size is confirmed, Small - XL bag ratings can be confirmed to meet design criteria. Ratings below are for standard 22" deep bags.

| Standard Bag Size§ | Solids Storage Capacity (CuFt) | Filtered Flow Rate at 50% Max (CFS) | | | Oil Retention (Oz) | |
|---|---|---|---|---|---|---|
| | | FX | PC | IL | PC* | PCP** |
| Small | 1.6 | 1.2 | 0.8 | 0.9 | 66 | 155 |
| Medium | 2.1 | 1.8 | 1.2 | 1.3 | 96 | 185 |
| Large | 3.8 | 2.2 | 1.5 | 1.6 | 120 | 209 |
| XL | 4.2 | 3.6 | 2.4 | 2.6 | 192 | 370 |

**4.0 Tested Filtration Efficiency and Removal Rates**: Filtration Efficiency, TSS, and TPH testing performed under large scale, real world conditions at accredited third party erosion and sediment control testing laboratory. (See Full Test Reports at www.inletfilters.com )

Inside View of Hopper Agitator

Hopper With Outlet Pipe Leading To Area Inlet

Area Inlet Simulated Showing Influent Discharge From Pipe

4.1 **FLEXSTORM "FX" Filtration Efficiency Test Results:** All testing performed in general accordance with the ASTM D 7351, *Standard Test Method For Determination of Sediment Retention Device Effectiveness in Sheet Flow Application,* with flow diverted into an area inlet. Test Soil used as sediment had the following characteristics with a nominal 7% sediment to water concentration mix. This is representative of a heavy sediment load running off of a construction site.

| Soil Characteristics | Test Method | Value | | Filtration Efficiency of "FX" FLEXSTORM Bag |
|---|---|---|---|---|
| % Gravel | ASTM D 422 | 2 | | **82%** |
| % Sand | | 60 | | |
| % Silt | | 24 | | |
| % Clay | | 14 | | |
| Liquid Limit, % | ASTM D 4318 | 34 | | |
| Plasticity Index, % | | 9 | | |
| Soil Classification | USDA | Sandy Loam | | |
| Soil Classification | USCS | Silty Sand (SM) | | |

4.2 **FLEXSTORM "PC" and "PC+" Test Results:** TSS measured on effluent samples in accordance with SM 2540D and TPH in accordance with EPA 1664A.

| Product Tested | 110 micron Sediment Load | Ave Flow Rate GPM | % TSS Removal | Soil Retention Efficiency |
|---|---|---|---|---|
| **FLEXSTORM PC Sediment Bag** | 1750 mg/L using OK-110 Silica Sand and Clean Water | 23 | **99.28%** | 98.96% |
| | | 48 | **99.32%** | 99.25% |
| | | 70 | **98.89%** | 98.80% |

| Product Tested | Street Sweep Sediment Load | Particle Size of Sediment Load | % TSS Removal | Soil Retention Efficiency |
|---|---|---|---|---|
| **FLEXSTORM PC Sediment Bag** | 2.5% = 100 lbs Sed / 4000 lbs water | .001 mm – 10.0 mm (median 200 micron) | **99.68%** | 95.61% |

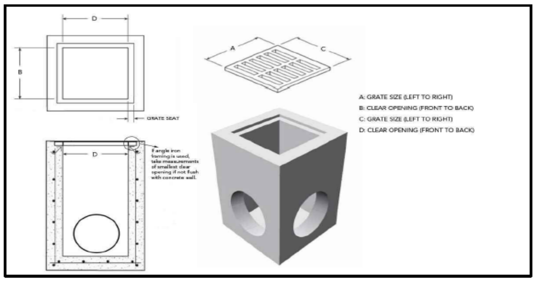
| Product Tested | Hydrocarbon Load | Ave Flow Rate GPM | % TPH Removal | Oil Retention Efficiency |
|---|---|---|---|---|
| **FLEXSTORM PC+** | 243 mg/L using 750 mL (1.45 lb) used motor oil + lube oil and clean water | 19 | **99.04%** | 97.22% |
| **FLEXSTORM PC** | | 20 | **97.67%** | 91.61% |
| **FLEXSTORM PC+** | | 92 | **96.88%** | 99.11% |

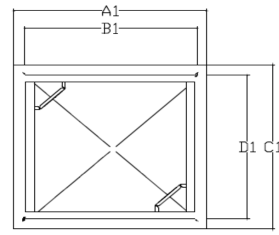
**5.0 Identification of Drainage Structures to Determine FLEXSTORM Item Codes:**

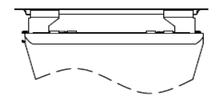
5.1 The Installer (Contactor) shall inspect the plans and/or worksite to determine the quantity of each drainage structure casting type. The foundry casting number or the exact grate size and clear opening size will provide the information necessary to identify the required FLEXSTORM Inlet Filter part number. Inlet Filters are supplied to the field pre-configured to fit the specified drainage structure. Item Codes can be built using the FLEXSTORM Product Configurator at www.inletfilters.com. Detailed Submittal / Specification drawings are linked to each Item Code and available for download by engineers and contractors to include on plans and/or verify field inlet requirements. An example of a typical drawing is shown below.

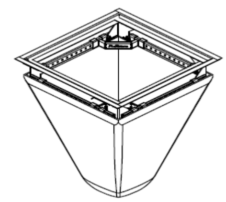
FLEXSTORM P/Ns 62SHDFX & 62SHDFXP

HD4 INLET TYPE: SQUARE/RECT PRECAST OPENING WITH 4 SEAT GRATE SUPPORT





| Pure Frame with FX Bag | | Field Inlet Dimensions | | Flexstorm Framing Dims | | | | Flexstorm Ratings (Flow at 50% Max) | | | Pure Frame with FX+ Bag | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ADS P/N | Flexstorm Item Code | Grate Size (A x C) | Clear Opening (B x D) | B1 | D1 | A1 | C1 | Bag Capacity ($ft^3$) | PC/PC+ Flow Rate (CFS) | Bypass (CFS) | ADS P/N | Flexstorm Item Code |
| 62SHDFX | P-HD4-95-95-80-80-FX | 9 1/2 X 9 1/2 | 8 X 8 | 6.0 | 5.0 | 9.5 | 9.3 | 0.2 | 0.5 | 1.2 | 62SHDFXP | P-HD4-95-95-80-80-FXP |
| 62SHDFX | P-HD4-115-115-105-105-FX | 11.5 x 11.5 | 10.5 x 10.5 | 8.0 | 7.5 | 11.5 | 11.3 | 0.4 | 0.7 | 1.7 | 62SHDFXP | P-HD4-115-115-105-105-FXP |
| 62SHDFX | P-HD4-118-118-105-105-FX | 11.75 x 11.75 | 10.5 x 10.5 | 8.0 | 7.5 | 11.5 | 11.5 | 0.4 | 0.7 | 1.7 | 62SHDFXP | P-HD4-118-118-105-105-FXP |
| 62SHDFX | P-HD4-120-120-105-105-FX | 12 X 12 | 10.5 X 10.5 | 8.5 | 7.5 | 12.0 | 11.8 | 0.4 | 0.7 | 1.7 | 62SHDFXP | P-HD4-120-120-105-105-FXP |
| 62SHDFX | P-HD4-134-134-116-116-FX | 13.375 X 13.375 | 11 5/8 X 11 5/8 | 9.5 | 8.5 | 13.0 | 13.1 | 0.5 | 0.8 | 1.9 | 62SHDFXP | P-HD4-134-134-116-116-FXP |
| 62SHDFX | P-HD4-130-130-120-120-FX | 13 x 13 | 12 x 12 | 9.5 | 9.0 | 13.0 | 12.8 | 0.5 | 0.8 | 2.0 | 62SHDFXP | P-HD4-130-130-120-120-FXP |
| 62SHDFX | P-HD4-144-144-133-133-FX | 14.375 x 14.375 | 13.25 x 13.25 | 10.5 | 10.5 | 14.0 | 14.1 | 0.7 | 0.9 | 2.3 | 62SHDFXP | P-HD4-144-144-133-133-FXP |
| 62SHDFX | P-HD4-145-145-133-133-FX | 14.5 X 14.5 | 13.25X 13.25 | 11.0 | 10.5 | 14.5 | 14.3 | 0.7 | 0.9 | 2.3 | 62SHDFXP | P-HD4-145-145-133-133-FXP |
| 62SHDFX | P-HD4-159-159-143-143-FX | 15.87 X 15.87 | 14.25 X 14.25 | 12.0 | 11.5 | 15.5 | 15.6 | 0.9 | 1.0 | 2.5 | 62SHDFXP | P-HD4-159-159-143-143-FXP |
| 62SHDFX | P-HD4-178-178-160-160-FX | 17.75 x 17.75 | 16 x 16 | 14.0 | 13.0 | 17.5 | 17.5 | 1.2 | 1.1 | 2.9 | 62SHDFXP | P-HD4-178-178-160-160-FXP |

NOTES:

1. RATINGS SHOWN ARE FOR STANDARD 22" BAG DEPTH; "SHORT" 12" DEPTH BAGS ARE AVAILABLE WITH -S SUFFIX; RATINGS REDUCED BY ~50%.

2. THE FOLLOWING REQUIRES ADDITIONAL REVIEW

-GRATES WITH EXTENDED BOTTOMS

-ANY OBSTRUCTED INLET OPENINGS

FLEXSTORM INLET FILTERS PURE



ALL PRODUCTS MANUFACTURED BY INLET & PIPE PROTECTION, INC
A DIVISION OF ADS, INC.
WWW.INLETFILTERS.COM
(866) 287-8655 PH
(630) 355-3477 FX
INFO@INLETFILTERS.COM

| SIZE | FRAME TYPE | DWG NO | REV |
|---|---|---|---|
| C | HD4 | HD4-62SHD-FX | A |
| SCALE | | SHEET 1 OF 1 | |

## 6.0 Installation Into Standard Grated Drainage Structures:

6.1 Remove the grate from the casting or concrete drainage structure. Clean the ledge (lip) of the casting frame or drainage structure to ensure it is free of stone and dirt. Drop in the FLEXSTORM Inlet Filter through the clear opening and be sure the suspension hangers rest firmly on the inside ledge (lip) of the casting. Replace the grate and confirm it is elevated no more than 1/8", which is the thickness of the steel hangers. For Curb Box Inlet Filters: Insert FLEXSTORM CATCH IT Inlet Filter as described above, pull the rear curb guard flap up and over the open curb box until tight, align magnets to ensure firm attachment to the top portion of the curb box casting. If the curb back opening is not magnetic, slide a typical rock sack or 2 x 4 through the 2-ply rear curb box flap to create a dam which will direct runoff into the sediment bag.

**7.0 Maintenance Guidelines:** The frequency of maintenance will vary depending on the application (during construction, post construction, or industrial use), the area of installation (relative to grade and runoff exposure), and the time of year relative to the geographic location (infrequent rain, year round rain, rain and snow conditions). The FLEXSTORM Operation & Maintenance Plan (as shown in 7.5) or other maintenance log should be kept on file.

7.1 Frequency of Inspections: Construction site inspection should occur following each ½" or more rain event. Post Construction inspections should occur three times per year (every four months) in areas with year round rainfall and three times per year (every three months) in areas with rainy seasons before and after snowfall season. Industrial application site inspections (loading ramps, wash racks, maintenance facilities) should occur on a regularly scheduled basis no less than three times per year.

7.2 General Maintenance for standard sediment bags: Upon inspection, the FLEXSTORM Inlet Filter should be emptied if the sediment bag is more than half filled with sediment and debris, or as directed by the Engineer. Remove the grate, engage the lifting bars or handles with the FLEXSTORM Removal Tool, and lift the FLEXSTORM Inlet Filter from the drainage structure. Machine assistance is not required. Dispose of the sediment or debris as directed by the Engineer. As an alternative, an industrial vacuum may be used to collect the accumulated sediment if available. Remove any caked on silt from the sediment bag and reverse flush the bag for optimal filtration. Replace the bag if the geotextile is torn or punctured to ½" diameter or greater on the lower half of the bag. If properly maintained, the Woven sediment bag will last a minimum of 4 years in the field.

7.3 Inspection and Handling of the FLEXSTORM PC / PC+ post construction sediment bag: The PC+ sediment bags will collect oil until saturated. Both the Adsorb-it filter liner and the skimmer pouch will retain oil. The volume of oils retained will depend on sediment bag size. Unlike other passive oil sorbent products, Adsorb-it filter fabric has the ability to remove hydrocarbons at high flow rates while retaining 10- 20 times its weight in oil (weight of fabric is 12.8 oz / sq yd). The average 2' x 2' PC Bag contains approx .8 sq yds, or 10 oz of fabric. At 50% saturation, the average Adsorb-it lined PC filter will retain approximately 75 oz (4.2 lbs) of oil. Once the bag has become saturated with oils, it can be centrifuged or passed through a wringer to recover the oils, and the fabric reused with 85% to 90% efficacy. If it is determined, per Maintenance Contracts or Engineering Instructions, that the saturated PC sediment bags will be completely replaced, it is the responsibility of the service technician to place the filter medium and associated debris in an approved container and dispose of in accordance with EPA regulations. Spent Adsorb-it can be recycled for its fuel value through waste to energy incineration with a higher BTU per pound value than coal. The oil skimmers start white in color and will gradually turn brown/black as they become saturated, indicating time for replacement. The average skimmer pouch will absorb approximately 62 oz (4 lbs) of oil before requiring replacement. To remove the pouch simply unclip it from the swivel strap sewn to the bottom of the bag. Dispose of all oil contaminated products in accordance to EPA guidelines. The ClearTec Rubberizer media used in the pouch, since a solidifier, will not leach under pressure and can be disposed of in most landfills, recycled for industrial applications, or burned as fuel.

7.4 Sediment Bag Replacement: When replacing a Sediment Bag, remove the bag by loosening or cutting off the clamping band. Take the new sediment bag, which is equipped with a stainless steel worm drive clamping band, and use a drill or screw driver to tighten the bag around the frame channel. Ensure the bag is secure and that there is no slack around the perimeter of the band. For Oil absorbent boom bags, simply replace the oil boom or pouch when saturated by sliding it through the mesh support sleeve.

7.5 Operation & Maintenance Plan. (Download at www.inletfilters.com or www.ads-pipe.com )

# FLEXSTORM OPERATION AND MAINTENANCE PLAN

## OPERATION & MAINTENANCE PLAN

**Installation Instructions:**

1. Remove grate from the drainage structure
2. Clean stone and dirt from ledge (lip) of drainage structure
3. Drop the FLEXSTORM inlet filter through the clear opening such that the hangers rest firmly on the lip of the structure.
4. Replace the grate and confirm it is not elevated more than 1/8", the thickness of the steel hangers.

**Frequency of Inspections:**

1. Inspection should occur following any rain event >½".
2. Post construction inspections should occur 4 times per year. In snowfall affected regions additional inspections should take place before and after snowfall season.
3. Industrial application site inspections (loading ramps, wash racks, maintenance facilities) should occur on a regularly scheduled basis no less than 3 times/year.

**Maintenance Guidelines:**

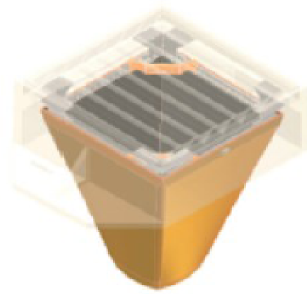
1. Empty the sediment bag if more than half filled with sediment and debris, or as directed.
2. Remove the grate, engage the lifting bars with the FLEXSTORM Removal Tool, and lift from drainage structure.
3. Dispose of sediment or debris as directed by the Engineer or Maintenance contract.
4. An industrial vacuum can be used to collect sediment.
5. Remove caked on silt from sediment bag and flush with Medium spray with optimal filtration.
6. Replace bag if torn or punctured to >½" diameter on lower half of bag.

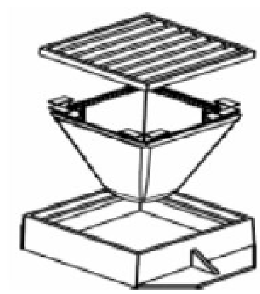
**Post Construction PC Bag Maintenance:**

1. At 50% saturation the average 2'x2' Adsorb-it lined PC filter will retain approximately 75 oz (4.2 lbs) of oil and should be serviced. To recover the oils the filter can be centrifuged or passed through a wringer.
2. Oil skimmer pouches start to turn black when saturated, indicating time for replacement. Each ClearTec Rubberizer pouch will absorb ~62oz (4 lbs) of oil before needing replacement.
3. Dispose of all oil contaminated products in accordance with EPA guidelines. ClearTec Rubberizer, since a solidifier, will not leach under pressure and can be disposed of in most landfills, recycled for industrial applications, or burned as fuel.

**Sediment Bag Replacement:**

1. Remove the bag by loosening or cutting off clamping bag.
2. Take new sediment bag and secure worm drive clamping band to the frame channel.
3. Ensure Bag is secure and there is no slack around perimeter.





**STRUCTURE ID#/LOCATION:**

| DATE | TASK PERFORMED | INSPECTOR |
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# VERIFICATION STATEMENT

## GLOBE Performance Solutions

Verifies the performance of

## Hydroworks® HydroStorm (HS) Hydrodynamic Separator

Developed by Hydroworks, LLC
Clark, NJ, USA

In accordance with

## ISO 14034:2016

### Environmental management — Environmental technology verification (ETV)

John D. Wiebe, PhD
Executive Chairman
GLOBE Performance Solutions

May 15, 2018
Vancouver, BC, Canada

GLOBE PERFORMANCE SOLUTIONS

Verification Body
GLOBE Performance Solutions
404 – 999 Canada Place | Vancouver, B.C | Canada |V6C 3E2

# Technology description and application

The Hydroworks® HydroStorm (HS) Hydrodynamic Separator is a concrete cylindrical device with an annular pre-treatment channel, an inner chamber, and lower collection sump. A schematic of the HS 4 test unit is shown in Figure 1. The pre-treatment channel extends below the outlet pipe invert and contains three intermediate low-flow weirs (flush with the outlet invert), and two downstream higher bypass weirs that extend above the outlet invert. The higher weirs bypass high flows to prevent oil and solids from being scoured out of the separator.

As water enters the unit through one or more inlets, coarser solids immediately start to settle below a horizontal grate extending from the inlet to two sets of lower weirs near the outlet pipe. The grating is positioned over the pre-treatment channel to help displace the inflow turbulence and protect the captured sediment from scour. Openings are located on the horizontal plate upstream of each weir to allow the flow to be conveyed into the inner chamber and lower sump. The weirs are positioned to create a counter clockwise rotation of water in the inner chamber to minimize turbulence and maximize settling. After water spirals down the inner chamber to the main settling chamber towards the floor of the separator where it deposits suspended sediments, it flows upwards between the wall of the unit and the outer edge of the disk extended from the inner chamber and through an arced opening at the bottom of the pre-treatment disk, downstream of the bypass weirs, where it is conveyed into the outlet pipe. An annular secondary horizontal plate with 32% of open-perforations is located within the lower sump to protect the collected sediment from scour. Oil and light liquids enter the inner chamber through the holes, reaching the bottom of the pre-treatment area and rises to the top of the water level where they are trapped.

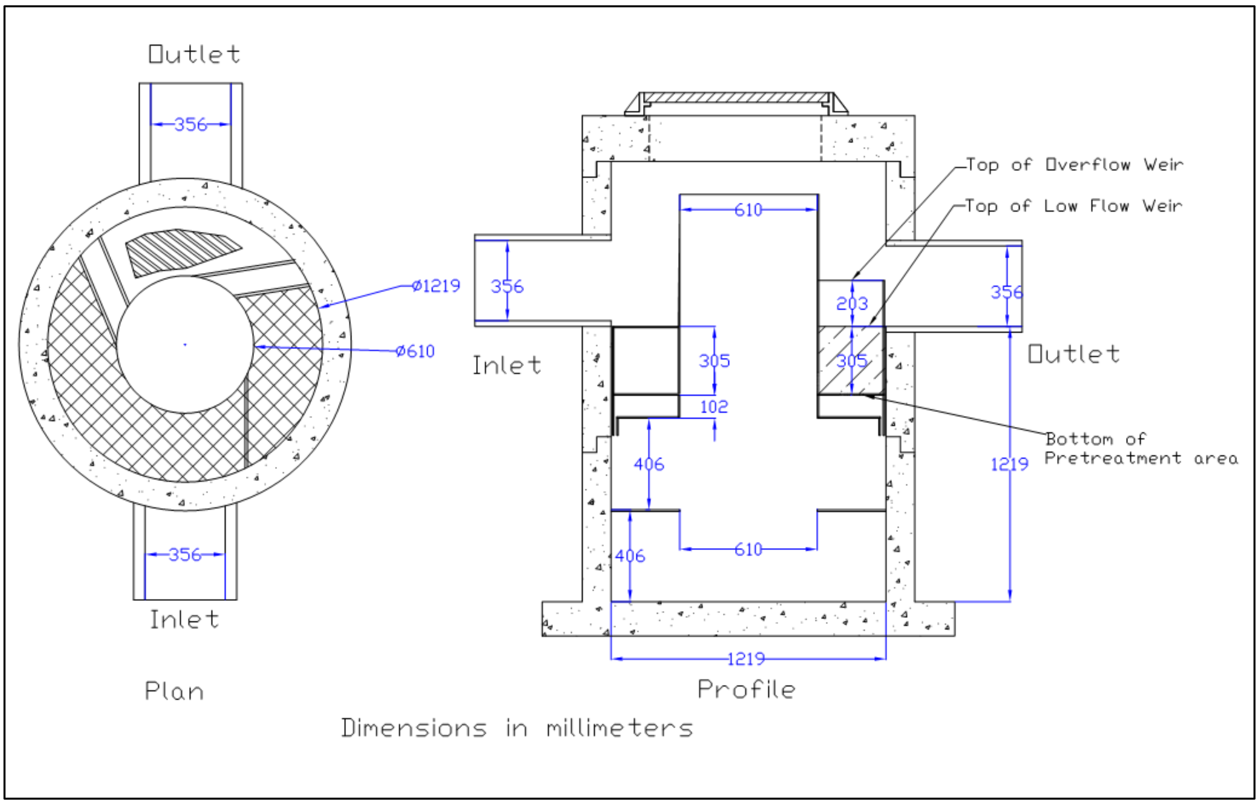


Figure 1: Schematic of the Hydroworks® HS4 Hydrodynamic Separator treatment unit tested as part of this verification.

# Performance conditions

The data and results published in this Technology Fact Sheet were obtained from the testing program conducted on the Hydroworks® HS4 Hydrodynamic Separator, in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators (Version 3.0, June 2014)*. The Procedure was prepared by the Toronto and Region Conservation Authority (TRCA) for the Canadian Environmental Technology Verification Program. A copy of the Procedure may be accessed on the Canadian ETV website at www.etvcanada.ca.

# Performance claim(s)

Capture test[1]:

During the capture test, the Hydroworks® HS Hydrodynamic Separator, with a false floor set to 50% of the manufacturer's recommended maximum sediment storage depth and a constant influent test sediment concentration of 200 mg/L, removes 69, 64, 60, 56, 46, 41, and 36 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, and 1400 L/min/m$^2$, respectively.

Scour test[1]:

During the scour test, the Hydroworks® HS Hydrodynamic Separator, with 10.2 cm (4 inches) of test sediment pre-loaded onto a false floor reaching 50% of the manufacturer's recommended maximum sediment sump storage depth and sediment loaded onto the pre-treatment channel emulating depositional pattern of the 40 L/min/m$^2$ capture test, generate corrected effluent concentrations of 22.4, 28.5, 20.0, 19.1, and 24.4 mg/L at 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m$^2$, respectively.

Light liquid re-entrainment test[1]:

During the light liquid re-entrainment test, the Hydroworks® HS Hydrodynamic Separator with surrogate low-density polyethylene beads preloaded within the inner chamber, representing a floating light liquid volume equal to a depth of 50.8 mm over the sedimentation area, retains 100, 99.9, 95.4, 95.7, and 97.5 percent of loaded beads by mass during the 5-minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m$^2$, respectively.

# Performance results

The test sediment consisted of ground silica (1 – 1000 micron) with a specific gravity of 2.65, uniformly mixed to meet the particle size distribution specified in the testing procedure. The *Procedure for Laboratory Testing of Oil Grit Separators* requires that the three sample average of the test sediment particle size distribution (PSD) meet the specified PSD percent less than values within a boundary threshold of 6%. The comparison of the average test sediment PSD to the CETV specified PSD in Figure 2indicates that the test sediment used for the capture and scour tests met this condition.

[1] The claim can be applied to other units smaller or larger than the tested unit as long as the untested units meet the scaling rule specified in the Procedure for Laboratory of Testing of Oil Grit Separators (Version 3.0, June 2014)

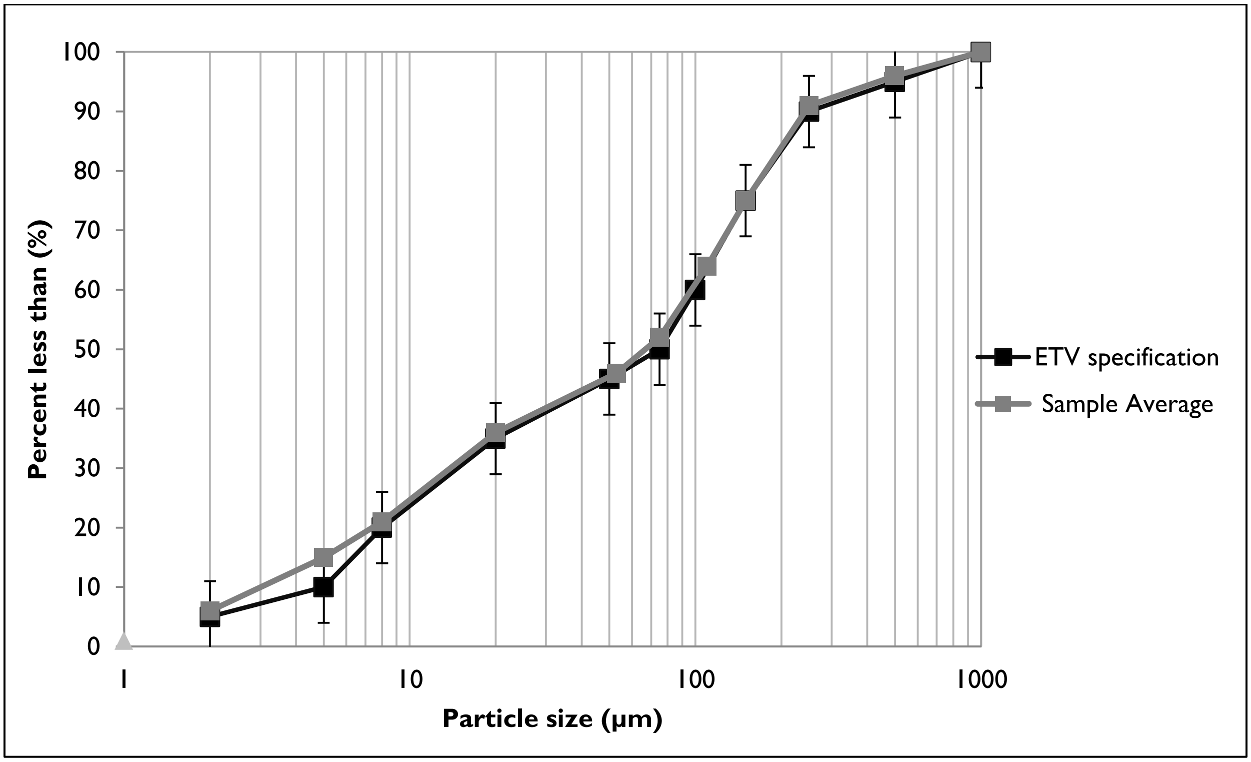


Figure 2. The three sample average particle size distribution (PSD) of the test sediment used for the capture and scour test compared to the specified PSD.

The capacity of the device to retain sediment was determined at seven surface loading rates using the modified mass balance method. This method involved measuring the mass and particle size distribution of the injected and retained sediment for each test run. Performance was evaluated with a false floor at 0.15 m from the bottom, simulating the technology filled to 50% of the manufacturer's recommended maximum sediment storage depth. The test was carried out with clean water that maintained a sediment concentration below 20 mg/L. Based on these conditions, removal efficiencies for individual particle size classes and for the test sediment as a whole were determined for each of the tested surface loading rates (Table 1).

In some instances, the removal efficiencies were above 100% for certain particle size fractions. These discrepancies are not unique to any one test laboratory and may be attributed to errors relating to the blending of sediment, collection of representative samples for laboratory submission, and laboratory analysis of PSD. Due to these errors, caution should be exercised in applying the removal efficiencies by particle size fraction for the purposes of sizing the tested device (see Bulletin # CETV 2016-11-0001). The results for "all particle sizes by mass balance" (see Table 1 and 2) are based on measurements of the total injected and retained sediment mass, and are therefore not subject to blending, sampling or PSD analysis errors.

Table 1. Removal efficiencies (%) of the HS4 unit at specified surface loading rates.

| Particle size fraction (µm) | Surface loading rate (L/min/m²) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 40 | 80 | 200 | 400 | 600 | 1000 | 1400 |
| >500 | 73 | 100* | 98 | 67 | 100* | 100* | 26 |
| 250 - 500 | 100 | 100* | 92 | 64 | 100* | 98 | 48 |
| 150 - 250 | 100* | 75 | 89 | 72 | 89 | 60 | 69 |
| 105 - 150 | 94 | 100* | 100* | 100* | 78 | 99 | 91 |
| 75 - 105 | 96 | 76 | 79 | 95 | 68 | 54 | 46 |
| 53 - 75 | 87 | 100* | 100* | 100* | 56 | 69 | 65 |
| 20 - 53 | 71 | 54 | 46 | 44 | 19 | 14 | 10 |
| 8 - 20 | 38 | 23 | 15 | 8 | 2 | 2 | 2 |
| 5 – 8 | 13 | 6 | 1 | 1 | 0 | 0 | 0 |
| <5 | 8 | 0 | 0 | 0 | 0 | 0 | 0 |
| **All particle sizes by mass balance** | **68.6** | **64.0** | **60.0** | **56.1** | **46.1** | **41.2** | **35.7** |

* Removal efficiencies were calculated to be above 100%. Calculated values ranged between 103 and 194% (average 128%). See text and Bulletin # CETV 2016-11-0001 for more information.

Figure 3 compares the particle size distribution (PSD) of the three sample average of the test sediment to the PSD of the sediment retained by the HS4 unit at each of the tested surface loading rates. As expected, the capture efficiency for fine particles in the unit was generally found to decrease as surface loading rates increased.

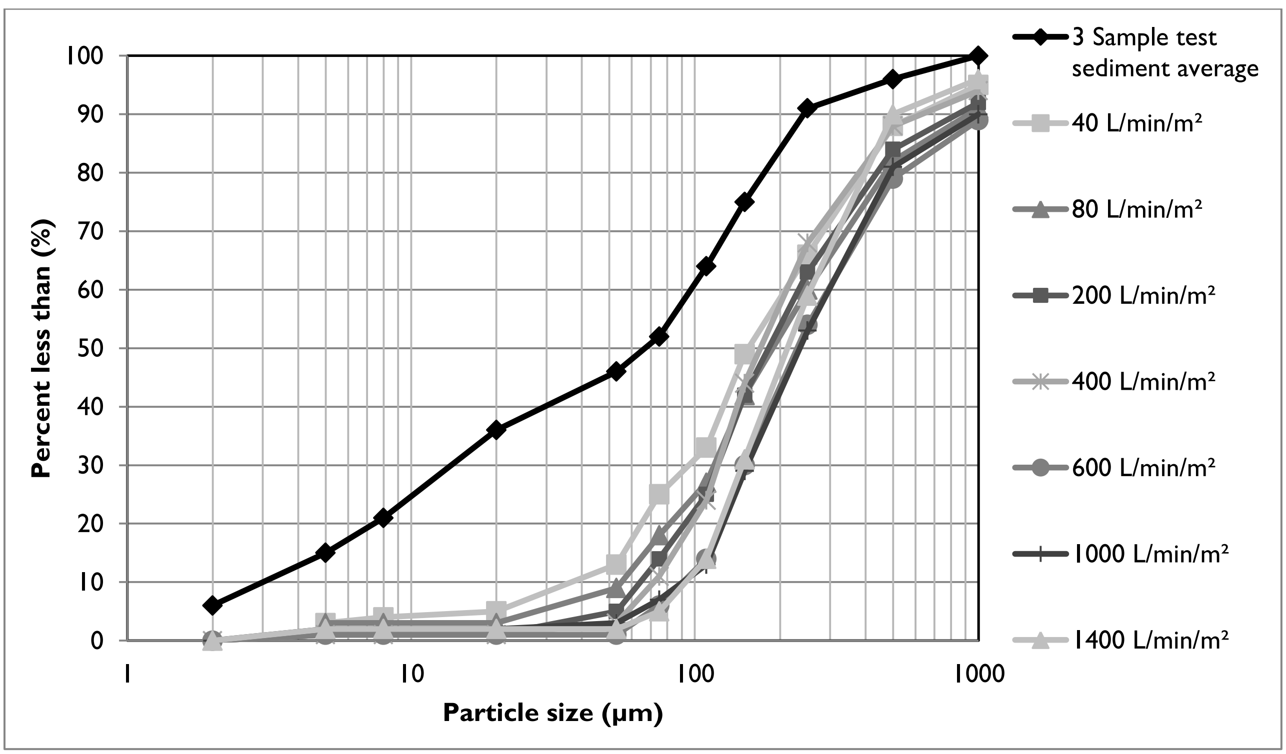


Figure 3. Particle size distribution of sediment retained in the HS4 unit in relation to the injected test sediment average.

For the sediment scour and re-suspension test, two tests were conducted. The first test was conducted with the secondary plate used in the capture tests. The second used a perforated secondary plate. Since sediment during the capture tests was found to settle in the pre-treatment channel, and in roughly the same quantities on the secondary plate and collection sump, all three of these surfaces were preloaded with sediment during the first test. The pre-treatment channel only captures coarse sediment. Therefore, this area was pre-loaded with sediment having a PSD similar to the PSD of the sediment that settled in this area during the 40 L/min/m² SLR sediment capture test. The pre-loaded sediment in the pre-treatment channel was shaped and leveled to correspond with sedimentation patterns and depths observed by the laboratory technician during the 40 L/min/m² SLR capture test. It should be noted that the actual sediment preloaded in this area was finer than the PSD of sediment captured in the same area during the 40 L/min/m² SLR capture test, particularly for particle sizes less than the median size. Both the sump and secondary plate were pre-loaded with the 1-1000 µm sediment mix to a depth of 10.2 cm. The preloaded sediment in the lower sump was placed on a false floor to mimic a device filled to 50% of the manufacturer's maximum recommended sediment storage depth.

After pre-loading the sediment, clean water was run through the device at five SLRs over a 25 minute period. At each SLR, five effluent samples were collected over a four minute interval (one per minute) with the first sample collected at the beginning of each flow rate, and the last collected just prior to the one minute transition to the next flow rate or end of the test. Effluent samples were analyzed for Suspended Sediment Concentration (SSC) and PSD by methods prescribed in the *Procedure*. The effluent samples were subsequently adjusted based on the background concentration of the influent water and the smallest 5% of particles captured during the 40 L/min/m² sediment capture test (7 um), as per the method described in Bulletin # CETV 2016-09-0001.

Measurements of sediment depths in the sump after the first test showed that most of the sediment from the secondary plate was carried into the lower sump. During this process, the fine sediment was likely re-suspended and carried out of the unit with the flow. The average adjusted effluent suspended sediment concentrations for each SLR ranged from 11.3 mg/L at the 200 L/min/m2 SLR to 196.7 mg/L at the 1400 L/min/m2 SLR. Effluent SSCs declined after the 1400 L/min/m2 SLR because the unit begins to bypass flow at this rate. It should be noted that this was a very conservative test as sediment was preloaded in three areas, rather than in the lower sump alone, and the preloaded sediment on the pre-treatment channel and secondary plate had a finer PSD than the sediment found to settle in these areas during the lowest SLR capture test.

The second sediment scour test was conducted on an identical unit but with a 32% open-area perforated secondary plate of the same size and orientation as the solid plate used in the first test. The perforated plate was intended to allow most of the sediment to settle in the lower sump, while still protecting against sediment scour, and not affecting the capacity of the unit to capture sediment. A second capture test was run at the 600 L/min/m² SLR to confirm that the perforated plate would have the same flow characteristics and removal efficiencies as the solid plate. Results of this comparison presented in Table 2 show that removal efficiencies were not affected and that the collection sump was receiving the majority of sediment transported into the lower chamber. Based on the observed sediment deposition zones, the second repeat test with the perforated plate had sediment preloaded in the pre-treatment channel and the lower collection sump only (*i.e.* the major deposition zones). The collection sump was preloaded with 10.2 cm of the 1- 1000 µm test sediment mix, as in the first test, and the pre-treatment channel was preloaded in much the same way as the first test, but with a sediment PSD that more closely mimicked the PSD of sediment observed to settle in this area during the 40 L/min/m² sediment capture test.

Table 2: Injected mass captured at the 600 L/min/m$^2$ SLR for two different configurations of the secondary plate

| Secondary Plate type | Target Surface Loading Rate (L/min/m$^2$) | Tested Flow Rate (L/min) | Removal Efficiency (%) | Pre-treatment Channel (%) | Secondary Plate (%) | Outlet Dispersion Plate (%) | Collection Sump (%) |
|---|---|---|---|---|---|---|---|
| Solid Plate | 600 | 736.2 | 46.1 | 24.7 | 8.5 | 3.1 | 9.9 |
| Perforated Plate | 600 | 740.9 | 45.9 | 25.8 | 2.7 | 3.0 | 14.5 |

Results of the second test are presented in Table 3. Background concentrations were maintained below 10.5 mg/L. The average adjusted effluent suspended sediment concentrations ranged from 19.1 to 28.5 mg/L. Since the commercially available unit will have a perforated secondary plate, these concentrations are the appropriate values to consider for approvals. The verifier acknowledges that the sediment capture removal efficiencies were not all tested with the perforated plate (see variance notes below), but that the repeat test results at the 600 L/min/m$^2$ SLR and a statement from the independent test laboratory were sufficient to provide reasonable confidence that the added perforations in the secondary plate would have negligible influence on sediment removal efficiencies.

Table 3. Scour test adjusted effluent sediment concentrations

| Run | Surface loading rate (L/min/m$^2$) | Run time (min) | Background sample concentration (mg/L)[a] | Average adjusted effluent suspended sediment concentration (mg/L)[b] |
|---|---|---|---|---|
| 1 | 200 | 5 | 3.6 | 22.4 |
| 2 | 800 | 5 | 8.9 | 28.5 |
| 3 | 1400 | 5 | 7.6 | 20.0 |
| 4 | 2000 | 5 | 10.4 | 19.1 |
| 5 | 2600 | 5 | 6.0 | 24.4 |

[a] Background concentrations shown here are approximate values based on graphical interpolation

[b] The adjusted effluent suspended sediment concentration represents the actual measured effluent concentration minus the background concentration. For more information see Bulletin # CETV 2016-09-0001. Adjusted concentrations were only calculated for the average of the five samples collected per surface loading rate.

The results of the light liquid re-entrainment test used to evaluate the unit's capacity to prevent re-entrainment of light liquids are reported in Table 4. The test involved preloading 58.3 L (corresponding to a 5 cm depth over the collection sump area of 1.17m$^2$) of surrogate low-density polyethylene beads (Dow Chemical Dowlex™ 2517) within the inner chamber and running clean water through the device continuously at five surface loading rates (200, 800, 1400, 2000, and 2600 L/min/m$^2$). Each flow rate was maintained for 5 minutes with approximately 1 minute transition time between flow rates (30 minutes total). The effluent flow was screened to capture all re-entrained pellets throughout the test. Results showed maximum re-entrainment of 4.6% at 1400 L/min/m$^2$, which is the highest SLR without bypass. Re-entrainment decreased at subsequent SLRs as bypass volumes increased.

Table 4. Light liquid re-entrainment test results for the HS4

| Surface Loading Rate (L/min/m²) | Time Stamp (min) | Amount of Beads Re-entrained | | | |
|---|---|---|---|---|---|
| | | Mass (g) | Volume (L) | % of Pre-loaded Mass Re-entrained | % of Pre-loaded Mass Retained |
| 200 | 1:00 – 6:00 | 0 | 0 | 0.00 | 100 |
| 800 | 7:00 – 12:00 | 49 | 0.1 | 0.1 | 99.9 |
| 1400 | 13:00 – 18:00 | 1523 | 2.7 | 4.6 | 95.4 |
| 2000 | 19:00 – 24:00 | 1445 | 2.5 | 4.3 | 95.7 |
| 2600 | 25:00 – 30:00 | 847 | 1.5 | 2.5 | 97.5 |
| Interim Collection Net | | 39 | 0.1 | 0.1 | 99.9 |
| Total Re-entrained | | 3902 | 6.8 | 11.7 | -- |
| Total Retained | | 29,497 | 51.5 | -- | 88.3 |
| Total Loaded | | 33,399 | 58.3 | -- | -- |

# Variances from testing Procedure

The following deviations from the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014) have been noted:

1. The Procedure stipulates that the tested device "must be a full scale, commercially available device with the same configuration and components that would be typical for an actual installation." As noted above, the sediment capture tests were conducted with a solid secondary plate. The solid secondary plate was later modified to a 32% open area perforated plate to reduce sediment settling on the plate, while continuing to provide scour prevention. As described above, the scour test was repeated with the perforated secondary plate, but the sediment capture test was only repeated at the 600 L/min/m² SLR (i.e. one of seven tested SLRs). Removal efficiency results for the repeat test showed very close correspondence with the earlier test using the solid plate and much of the sediment that previously settled on the secondary plate was deposited in the lower collection sump (see Table 2). The independent laboratory provided the following statement regarding the potential for the added perforations to affect sediment removal efficiencies: "Taking into account the close proximity of the plate to the collection sump, as well as our knowledge of sediment transport, it is expected that the deposited sediment would have settled in the lower sump, with no impact on removal efficiency, if the plate was removed." While the verifier acknowledges that stronger evidence would have been provided by additional repeat testing at a lower and higher SLR, the close correlation between the original and repeat test, combined with the statement from the lab were sufficient to provide reasonable confidence that adding the perforations would not likely have changed the capture test results significantly.

2. The repeat test at the 600 L/min/m² SLR had background concentrations exceeding the 20 mg/L threshold during the last half of the test. The exceedances occurred in 4 of the 8 samples collected, reaching a maximum of 28.4 mg/L. The experimental apparatus is a closed loop system. Therefore, the sediment in the background samples consists of fine particles not captured by the device, and would therefore not likely bias the mass balance results.

3. It was necessary to change flow meters during the sediment scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. When the flow capacity of the selected meter was reached, the flow was shut down over a period of approximately 10 seconds and all flow data saved. The next data acquisition file was executed and flow increased at a rate that corresponded to reaching each previous target flow after a period of 1-minute. This procedure was approved by CETV prior to testing, in recognition that most particles susceptible to scour at low flows would not be in the sump at higher flows. Similarly, re-entrainment of the oil beads was not expected to be significantly affected by the flow meter change.

4. As part of the capture test, evaluation of the 40 and 80 L/min/$m^2$ surface loading rate was split into 3 and 2 parts, respectively, due to the long duration needed to feed the required minimum of 11.3 kg of test sediment into the unit. At the end of the first and second parts of the test, the flow rates were gradually shutdown to prevent capture of particles that would have been washed out under normal circumstances. The amended procedure was reviewed and approved by the verifier prior to testing.

# Verification

The verification was completed by the Verification Expert, Toronto and Region Conservation Authority, contracted by GLOBE Performance Solutions, using the International Standard ***ISO 14034:2016 Environmental management -- Environmental technology verification (ETV)***. Data and information provided by Hydroworks, LLC to support the performance claim included the following: Performance test report prepared by Alden Research Laboratory, Inc., and dated February 2018. This report is based on testing completed in accordance with the *Procedure for Laboratory Testing of Oil-Grit Separators* (Version 3.0, June 2014).

# What is ISO14034:2016 Environmental management – Environmental technology verification (ETV)?

ISO 14034:2016 specifies principles, procedures and requirements for environmental technology verification (ETV), and was developed and published by the *International Organization for Standardization (ISO)*. The objective of ETV is to provide credible, reliable and independent verification of the performance of environmental technologies. An environmental technology is a technology that either results in an environmental added value or measures parameters that indicate an environmental impact. Such technologies have an increasingly important role in addressing environmental challenges and achieving sustainable development.

**For more information on the Hydroworks® HS Hydrodynamic Separator please contact:**

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Email: info@hydroworks.com
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**Limitation of verification**

GLOBE Performance Solutions and the Verification Expert provide the verification services solely on the basis of the information supplied by the applicant or vendor and assume no liability thereafter. The responsibility for the information supplied remains solely with the applicant or vendor and the liability for the purchase, installation, and operation (whether consequential or otherwise) is not transferred to any other party as a result of the verification.

Hydroworks® HydroStorm

Operations & Maintenance Manual

Version 1.0

Please call Hydroworks at 888-290-7900 or email us at support@hydroworks.com if you have any questions regarding the Inspection Checklist. Please fax a copy of the completed checklist to Hydroworks at 888-783-7271 for our records.

## Introduction

The HydroStorm is a state of the art hydrodynamic separator. Hydrodynamic separators remove solids, debris and lighter than water (oil, trash, floating debris) pollutants from stormwater. Hydrodynamic separators and other water quality measures are mandated by regulatory agencies (Town/City, State, Federal Government) to protect storm water quality from pollution generated by urban development (traffic, people) as part of new development permitting requirements.

As storm water treatment structures fill up with pollutants they become less and less effective in removing new pollution. Therefore, it is important that storm water treatment structures be maintained on a regular basis to ensure that they are operating at optimum performance. The HydroStorm is no different in this regard and this manual has been assembled to provide the owner/operator with the necessary information to inspect and coordinate maintenance of their HydroStorm.

## Hydroworks® HydroStorm Operation

The Hydroworks HydroStorm (HS) separator is a unique hydrodynamic by-pass separator. It incorporates a protected submerged pretreatment zone to collect larger solids, a treatment tank to remove finer solids, and a dual set of weirs to create a high flow bypass. High flows are conveyed directly to the outlet and do not enter the treatment area, however, the submerged pretreatment area still allows removal of coarse solids during high flows.

Under normal or low flows, water enters an inlet area with a horizontal grate. The area underneath the grate is submerged with openings to the main treatment area of the separator. Coarse solids fall through the grate and are either trapped in the pretreatment area or conveyed into the main treatment area depending on the flow rate. Fines are transported into the main treatment area. Openings and weirs in the pretreatment area allow entry of water and solids into the main treatment area and cause water to rotate in the main treatment area creating a vortex motion. Water in the main treatment area is forced to rise along the walls of the separator to discharge from the treatment area to the downstream pipe.

The vortex motion forces solids and floatables to the middle of the inner chamber. Floatables are trapped since the inlet to the treatment area is submerged. The design maximizes the retention of settled solids since solids are forced to the center of the inner chamber by the vortex motion of water while water must flow up the walls of the separator to discharge into the downstream pipe.

A set of high flow weirs near the outlet pipe create a high flow bypass over both the pretreatment area and main treatment chamber. The rate of flow into the treatment area is regulated by the number and size of openings into the treatment chamber and the height of by-pass weirs. High flows flow over the weirs directly to the outlet pipe preventing the scour and resuspension of any fines collected in the treatment chamber.

A central access tube is located in the structure to provide access for cleaning. The arrangement of the inlet area and bypass weirs near the outlet pipe facilitate the use of multiple inlet pipes.

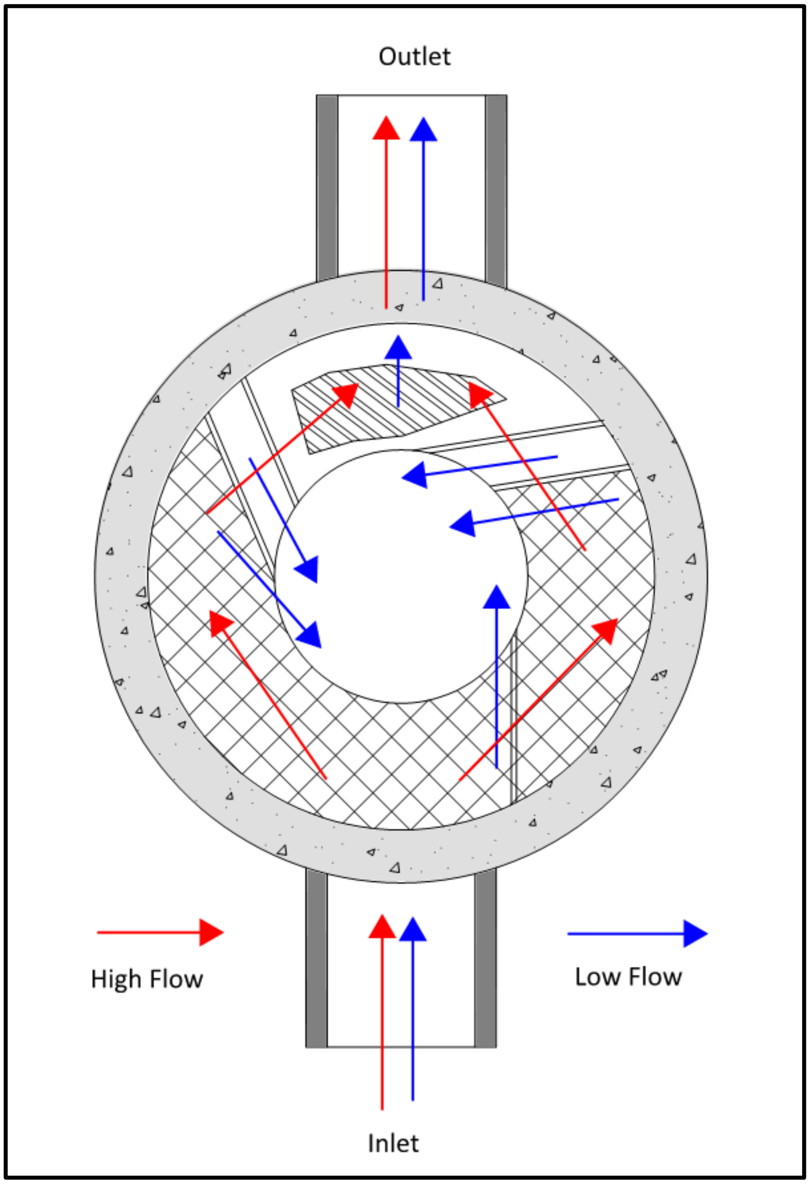


**Figure 1. Hydroworks HydroStorm Operation – Plan View**

Figure 2 is a profile view of the HydroStorm separator showing the flow patterns for low and high flows.

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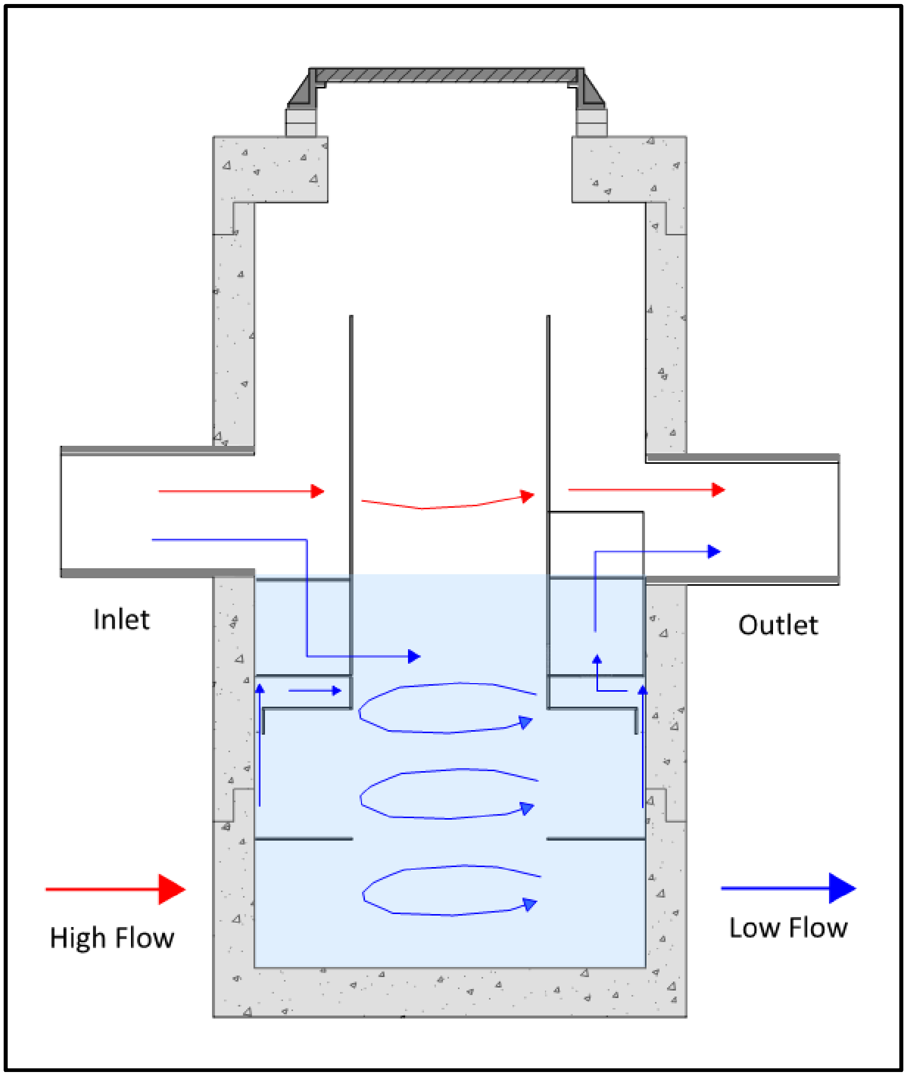


**Figure 2. Hydroworks HydroStorm Operation – Profile View**

The HS 4i is an inlet version of the HS 4 separator. There is a catch-basin grate on top of the HS 4i. A funnel sits sits underneath the grate on the frame and directs the water to the inlet side of the separator to ensure all lows flows are properly treated. The whole funnel is removed for inspection and cleaning.

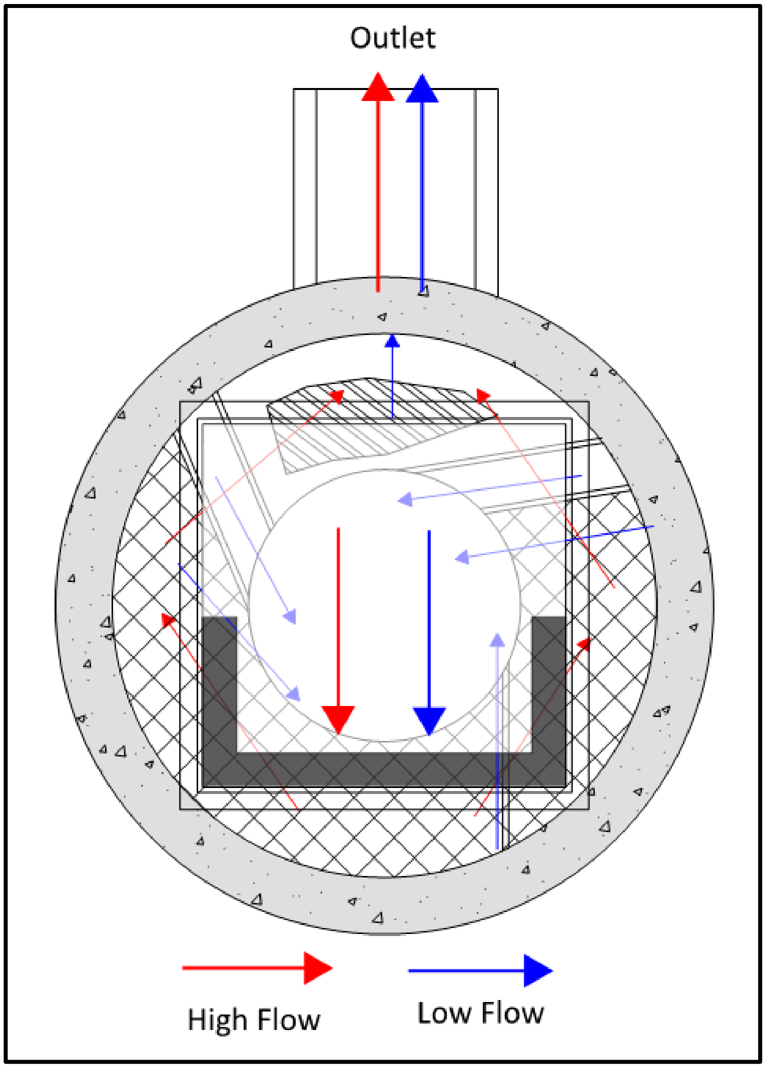


**Figure 3. Hydroworks HS 4i Funnel**

## Inspection

### Procedure

Floatables

A visual inspection can be conducted for floatables by removing the covers and looking down into the center access tube of the separator. Separators with an inlet grate (HS 4i or custom separator) will have a plastic funnel located under the grate that must be removed from the frame prior to inspection or maintenance. If you are missing a funnel please contact Hydroworks at the numbers provided at the end of this document.

TSS/Sediment

Inspection for TSS build-up can be conducted using a Sludge Judge®, Core Pro®, AccuSludge® or equivalent sampling device that allows the measurement of the depth of TSS/sediment in the unit. These devices typically have a ball valve at the bottom of the tube that allows water and TSS to flow into the tube when lowering the tube into the unit. Once the unit touches the bottom of the device, it is quickly pulled upward such that the water and TSS in the tube forces the ball valve closed allowing the user to see a full core of water/TSS in the unit. The unit should be inspected for TSS through each of the access covers. Several readings (2 or 3) should be made at each access cover to ensure that an accurate TSS depth measurement is recorded.

## Frequency

Construction Period

The HydroStorm separator should be inspected every four weeks and after every large storm (over 0.5” (12.5 mm) of rain) during the construction period.

Post-Construction Period

The Hydroworks HydroStorm separator should be inspected during the first year of operation for normal stabilized sites (grassed or paved areas). If the unit is subject to oil spills or runoff from unstabilized (storage piles, exposed soils) areas the HydroStorm separator should be inspected more frequently (4 times per year). The initial annual inspection will indicate the required future frequency of inspection and maintenance if the unit was maintained after the construction period.

## Reporting

Reports should be prepared as part of each inspection and include the following information:

1. Date of inspection
2. GPS coordinates of Hydroworks unit
3. Time since last rainfall
4. Date of last inspection
5. Installation deficiencies (missing parts, incorrect installation of parts)
6. Structural deficiencies (concrete cracks, broken parts)
7. Operational deficiencies (leaks, blockages)
8. Presence of oil sheen or depth of oil layer
9. Estimate of depth/volume of floatables (trash, leaves) captured
10. Sediment depth measured
11. Recommendations for any repairs and/or maintenance for the unit
12. Estimation of time before maintenance is required if not required at time of inspection

A sample inspection checklist is provided at the end of this manual.

## Maintenance

### Procedure

The Hydroworks HydroStorm unit is typically maintained using a vacuum truck. There are numerous companies that can maintain the HydroStorm separator. Maintenance with a vacuum truck involves removing all of the water and sediment together. The water is then separated from the sediment on the truck or at the disposal facility.

A central access opening (24” or greater) is provided to the gain access to the lower treatment tank of the unit. This is the primary location to maintain by vacuum truck. The pretreatment area can also be vacuumed and/or flushed into the lower treatment tank of the separator for cleaning via the central access once the water level is lowered below the pretreatment floor.

In instances where a vacuum truck is not available other maintenance methods (i.e. clamshell bucket) can be used, but they will be less effective. If a clamshell bucket is used the water must be decanted prior to cleaning since the sediment is under water and typically fine in nature. Disposal of the water will depend on local requirements. Disposal options for the decanted water may include:

1. Discharge into a nearby sanitary sewer manhole
2. Discharge into a nearby LID practice (grassed swale, bioretention)
3. Discharge through a filter bag into a downstream storm drain connection

The local municipality should be consulted for the allowable disposal options for both water and sediments prior to any maintenance operation. Once the water is decanted the sediment can be removed with the clamshell bucket.

Disposal of the contents of the separator depend on local requirements. Maintenance of a Hydroworks HydroStorm unit will typically take 1 to 2 hours based on a vacuum truck and longer for other cleaning methods (i.e. clamshell bucket).

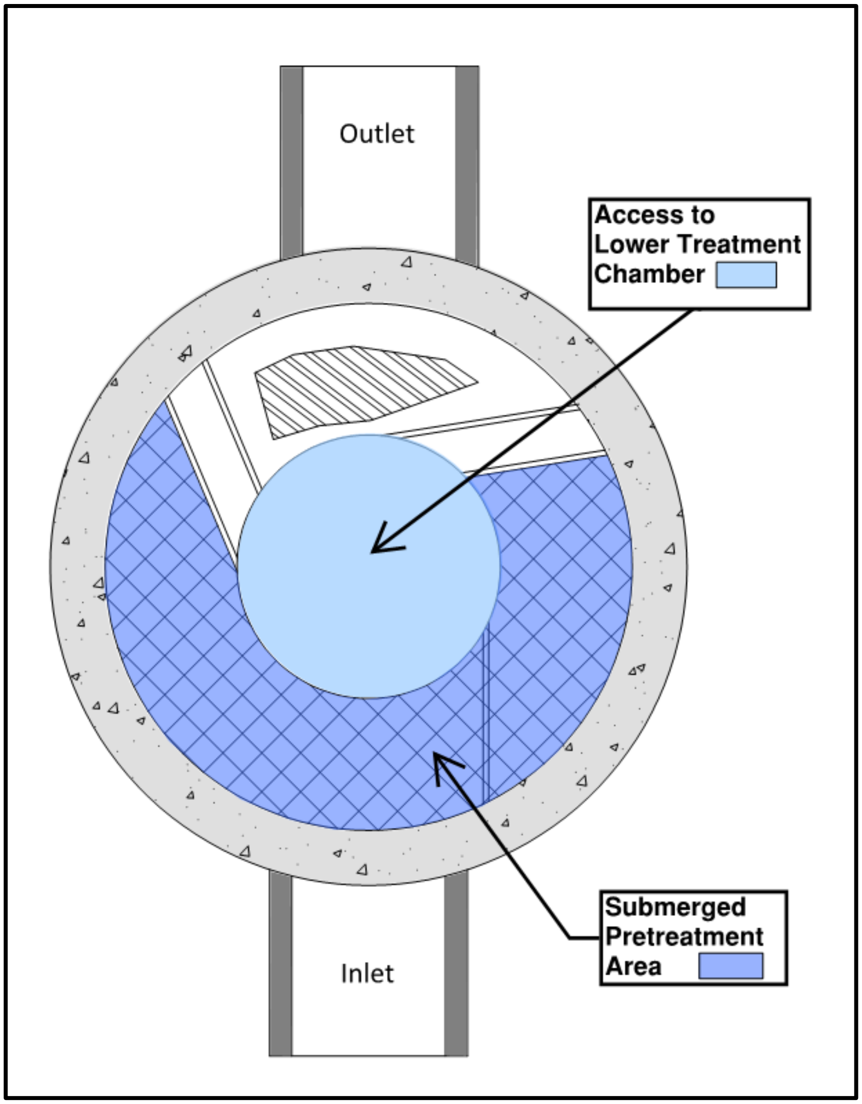


**Figure 3. Maintenance Access**

**Frequency**

<u>Construction Period</u>

A HydroStorm separator can fill with construction sediment quickly during the construction period. The HydroStorm must be maintained during the construction period when the depth of TSS/sediment reaches 24” (600 mm). It must also be maintained during the construction period if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the area of the separator

The HydroStorm separator should be maintained at the end of the construction period, prior to operation for the post-construction period.

Post-Construction Period

The HydroStorm was independently tested by Alden Research Laboratory in 2017. A HydroStorm HS 4 was tested for scour with a 50% sediment depth of 0.5 ft. Therefore, maintenance for sediment accumulation is required if the depth of sediment is 1 ft or greater in separators with standard water (sump) depths (Table 1).

There will be designs with increased sediment storage based on specifications or site-specific criteria. A measurement of the total water depth in the separator through the central access tube should be taken and compared to water depth given in Table 1. The standard water depth from Table 1 should be subtracted from the measured water depth and the resulting extra depth should be added to the 1 ft to determine the site-specific sediment maintenance depth for that separator.

For example, if the measured water depth in the HS-7 is 7 feet, then the sediment maintenance depth for that HS-7 is 2 ft (= 1 + 7 – 6) and the separator does not need to be cleaned for sediment accumulation until the measure sediment depth is 2 ft.

The HydroStorm separator must also be maintained if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the water surface of the separator.

**Table 1 Standard Dimensions for Hydroworks HydroStorm Models**

| Model | Diameter (ft) | Total Water Depth (ft) | Sediment Maintenance Depth for Table 1 Total Water Depth(ft) |
|---|---|---|---|
| HS-3 | 3 | 3 | 1 |
| HS-4 | 4 | 4 | 1 |
| HS-5 | 5 | 4 | 1 |
| HS-6 | 6 | 4 | 1 |
| HS-7 | 7 | 6 | 1 |
| HS-8 | 8 | 7 | 1 |
| HS-9 | 9 | 7.5 | 1 |
| HS-10 | 10 | 8 | 1 |
| HS-11 | 11 | 9 | 1 |
| HS-12 | 12 | 9.5 | 1 |

# HYDROSTORM INSPECTION SHEET

**Date** ______________________________

**Date of Last Inspection** ______________________________

**Site** ______________________________

**City** ______________________________

**State** ______________________________

**Owner** ______________________________

**GPS Coordinates** ______________________________

**Date of last rainfall** ______________________________

| **Site Characteristics** | **Yes** | **No** |
|---|---|---|
| Soil erosion evident | ☐ | ☐ |
| Exposed material storage on site | ☐ | ☐ |
| Large exposure to leaf litter (lots of trees) | ☐ | ☐ |
| High traffic (vehicle) area | ☐ | ☐ |

| **HydroStorm** | **Yes** | **No** |
|---|---|---|
| Obstructions in the inlet or outlet | ☐ * | ☐ |
| Missing internal components | ☐ ** | ☐ |
| Improperly installed inlet or outlet pipes | ☐ *** | ☐ |
| Internal component damage (cracked, broken, loose pieces) | ☐ ** | ☐ |
| Floating debris in the separator (oil, leaves, trash) | ☐ | ☐ |
| Large debris visible in the separator | ☐ * | ☐ |
| Concrete cracks/deficiencies | ☐ *** | ☐ |
| Exposed rebar | ☐ ** | ☐ |
| Water seepage (water level not at outlet pipe invert) | ☐ *** | ☐ |
| Water level depth below outlet pipe invert ________ " | | |

**Routine Measurements**

| | | | | |
|---|---|---|---|---|
| Floating debris depth | **< 0.5" (13mm)** | ☐ | **>0.5" 13mm)** | ☐ * |
| Floating debris coverage | **< 50% of surface area** | ☐ | **> 50% surface area** | ☐ * |
| Sludge depth | **< 12" (300mm)** | ☐ | **> 12" (300mm)** | ☐ ***** |

* Maintenance required

** Repairs required

*** Further investigation is required

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**Other Comments:**

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# Hydroworks® HydroStorm

## One Year Limited Warranty

Hydroworks, LLC warrants, to the purchaser and subsequent owner(s) during the warranty period subject to the terms and conditions hereof, the Hydroworks HydroStorm to be free from defects in material and workmanship under normal use and service, when properly installed, used, inspected and maintained in accordance with Hydroworks written instructions, for the period of the warranty. The standard warranty period is 1 year.

The warranty period begins once the separator has been manufactured and is available for delivery. Any components determined to be defective, either by failure or by inspection, in material and workmanship will be repaired, replaced or remanufactured at Hydroworks' option provided, however, that by doing so Hydroworks, LLC will not be obligated to replace an entire insert or concrete section, or the complete unit. This warranty does not cover shipping charges, damages, labor, any costs incurred to obtain access to the unit, any costs to repair/replace any surface treatment/cover after repair/replacement, or other charges that may occur due to product failure, repair or replacement.

This warranty does not apply to any material that has been disassembled or modified without prior approval of Hydroworks, LLC, that has been subjected to misuse, misapplication, neglect, alteration, accident or act of God, or that has not been installed, inspected, operated or maintained in accordance with Hydroworks, LLC instructions and is in lieu of all other warranties expressed or implied. Hydroworks, LLC does not authorize any representative or other person to expand or otherwise modify this limited warranty.

The owner shall provide Hydroworks, LLC with written notice of any alleged defect in material or workmanship including a detailed description of the alleged defect upon discovery of the defect. Hydroworks, LLC should be contacted at 136 Central Ave., Clark, NJ 07066 or any other address as supplied by Hydroworks, LLC. (888-290-7900).

This limited warranty is exclusive. There are no other warranties, express or implied, or merchantability or fitness for a particular purpose and none shall be created whether under the uniform commercial code, custom or usage in the industry or the course of dealings between the parties. Hydroworks, LLC will replace any goods that are defective under this warranty as the sole and exclusive remedy for breach of this warranty.

Subject to the foregoing, all conditions, warranties, terms, undertakings or liabilities (including liability as to negligence), expressed or implied, and howsoever arising, as to the condition, suitability, fitness, safety, or title to the Hydroworks HydroStorm are hereby negated and excluded and Hydroworks, LLC gives and makes no such representation, warranty or undertaking except as expressly set forth herein. Under no circumstances shall Hydroworks, LLC be liable to the Purchaser or to any third party for product liability claims; claims arising from the design, shipment, or installation of the HydroStorm, or the cost of other goods or services related to the purchase and installation of the HydroStorm. For this Limited Warranty to apply, the HydroStorm must be installed in accordance with all site conditions required by state and local codes; all other applicable laws; and Hydroworks' written installation instructions.

Hydroworks, LLC expressly disclaims liability for special, consequential or incidental damages (even if it has been advised of the possibility of the same) or breach of expressed or implied warranty. Hydroworks, LLC shall not be liable for penalties or liquidated damages, including loss of production and profits; labor and materials; overhead costs; or other loss or expense incurred by the purchaser or any third party. Specifically excluded from limited warranty coverage are damages to the HydroStorm arising from ordinary wear and tear; alteration, accident, misuse, abuse or neglect; improper maintenance, failure of the product due to improper installation of the concrete sections or improper sizing; or any other event not caused by Hydroworks, LLC. This limited warranty represents Hydroworks' sole liability to the purchaser for claims related to the HydroStorm, whether the claim is based upon contract, tort, or other legal basis.

# APPENDIX C

# FIRE FLOW INFORMATION

# OBC FIRE FLOW WATER SUPPLY

S. LLEWELLYN & ASSOCIATES LIMITED
CONSULTING ENGINEERS

| | |
|---|---|
| **Project:** | **338 & 338.5 Cumberland Avenue** |
| Project Number: | 21081 |
| Date: | Feb-22 |

Type of Development: **Residential (Greater than 3 Units)**

**Required Fire Water Supply (Q) per OBC:** **$Q = K\ V\ S_{tot}$** *(OBC Tables and Figures attached)*

Where:

Q = Minimim supply of water in litres
K = Water suppy coefficient from Table 1
V = total building volume in cubic meters
$S_{tot}$ = total of spatial coefficient values from property line exposures on all sides

$S_{tot} = 1.0 + [S_{side1} + S_{side2} + S_{side3} + \ldots]$ from Figure 1. Max. 2.0

## Water Supply Coefficient (K)

Building Group/Division Classification: **C (Residential occupancy, building that exceeds 3-stories in height )**

From Table 1, **K =** **16**

## Building Volume (V)

Building Footprint Area: **695** $m^2$
Building Height: **15** m (basement floor to underside of roof deck)
***Building Volume (V):*** ***10425*** **$m^3$** (conservatively assume attic has same footprint)

## Spatial Coefficient (S)

See Figure 1 for Spatial Coefficients

| Side | Dist (m) | $S_{coeff}$ |
|---|---|---|
| North | **>10m** | **0** |
| South | **>10m** | **0** |
| East | **2** | **0.5** |
| West | **3.5** | **0.5** |
| | Total | **1** |

Therefore, $S_{tot}$ = **2.0**

## Required Water Supply

**$Q = K\ V\ S_{tot}$ =** **333600 L**

***From Table 2, the minimum required water supply flow rate =*** ***9000 l/min or*** 150 l/s

**City of Hamilton Target flow for Residential (Greater than 3 Units) =** **150 l/s <-- governs**

# OBC Tables and Figures

| Table 1 | | | | | |
|---|---|---|---|---|---|
| Water Supply Coefficient - K | | | | | |
| Type of Construction | Classification by Group or Division in Accordance with Table 3.1.2.1. of the Building Code | | | | |
| | A-2<br>B-1<br>B-2<br>B-3<br>C<br>D | A-4<br>F-3 | A-1<br>A-3 | E<br>F-2 | F-1 |
| Building is of noncombustible construction with fire separations and fire-resistance ratings provided in accordance with Subsection 3.2.2., including loadbearing walls, columns and arches. | 10 | 12 | 14 | 17 | 23 |
| Building is of noncombustible construction or of heavy timber construction conforming to Article 3.1.4.6. Floor assemblies are fire separations but with no fire-resistance rating. Roof assemblies, mezzanines, loadbearing walls, columns and arches do not have a fire-resistance rating. | 16 | 19 | 22 | 27 | 37 |
| Building is of combustible construction with fire separations and fire-resistance ratings provided in accordance with Subsection 3.2.2., including loadbearing walls, columns and arches.<br>Noncombustible construction may be used in lieu of fire-resistance rating where permitted in Subsection 3.2.2. | 18 | 22 | 25 | 31 | 41 |
| Building is of combustible construction. Floor assemblies are fire separations but with no fire-resistance rating. Roof assemblies, mezzanines, loadbearing walls, columns and arches do not have a fire-resistance rating. | 23 | 28 | 32 | 39 | 53 |
| Column 1 | 2 | 3 | 4 | 5 | 6 |

| Table 2 | |
|---|---|
| Part 3 Buildings under the Building Code | Required Minimum Water Supply Flow Rate, L/min |
| One-storey building with building area not exceeding 600 m² | 1 800 |
| All other buildings | 2 700 (if Q ≤ 108 000 L)(1)<br>3 600 (if Q > 108 000 L and ≤ 135 000 L)(1)<br>4 500 (if Q > 135 000 L and ≤ 162 000 L)(1)<br>5 400 (if Q > 162 000 L and ≤ 190 000 L)(1)<br>6 300 (if Q > 190 000 L and ≤ 270 000 L)(1)<br>9 000 (if Q > 270 000 L)(1) |

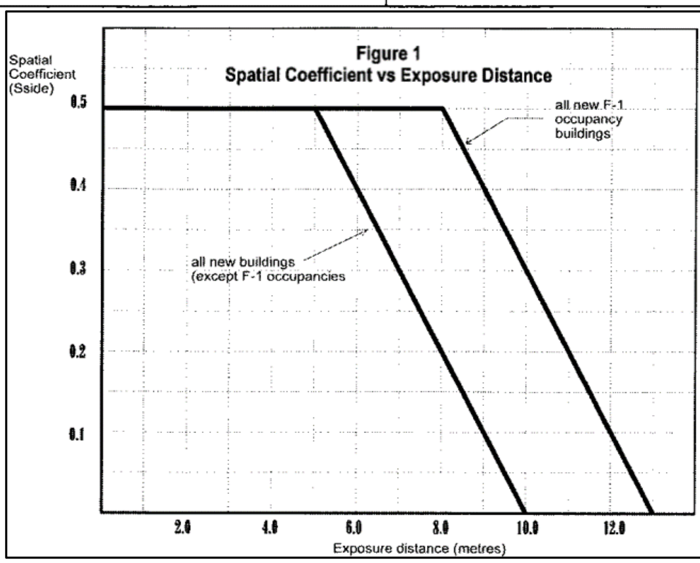


**Figure 1**
**Spatial Coefficient vs Exposure Distance**

# City of Hamilton Target Flows (Policy PW19096)

Table 1: Target Available Fire Flow

| Land Use | Target AFF (L/s) |
|---|---|
| Commercial | 150 |
| Small ICI (<1,800 m²)[1] | 100 |
| Industrial | 250 |
| Institutional | 150 |
| Residential Multi (greater than 3 units) | 150 |
| Residential Medium (3 or less units) | 125 |
| Residential Single | 75 |
| Residential Single (Dead End) | 50 |