

STORMWATER MANAGEMENT REPORT

233 DUNLOP STREET WEST
CITY OF BARRIE, COUNTY OF SIMCOE



PEARSON
ENGINEERING LTD.

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(Revised October 2019)

November 2018

12081.01



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STORMWATER MANAGEMENT REPORT

233 DUNLOP STREET WEST - BARRIE

1. INTRODUCTION

PEARSON Engineering Ltd. has been retained by MDM Developments (Client) to prepare a Stormwater Management (SWM) Report in support of the proposed 8-storey residential building with ground floor commercial space located at 233, 237, 241, and 245 Dunlop Street West in the City of Barrie (City), County of Simcoe (County).

The subject property is approximately 0.72 ha in size and currently contains one residential lot and three vacant lots. The existing site drains to the south sloping towards Bunkers Creek at the rear of the property. It is proposed to construct a mixed-use residential and commercial building with an adjacent asphalt parking area. The location of the site can be seen on Figure 1.

1.1. TERMS OF REFERENCE

The intent of this SWM Report is to:

- Identify the existing site characteristics including any external drainage conditions;
- Illustrate the design of the stormwater conveyance and detention system, capable of accommodating both minor and major storm flows from the site;
- Incorporate the appropriate Best Management Practices for controlling on-site erosion and sedimentation during construction while ultimately ensuring that the post-development release of stormwater is of adequate quality; and
- Summarize this design in a technically comprehensive and concise manner.

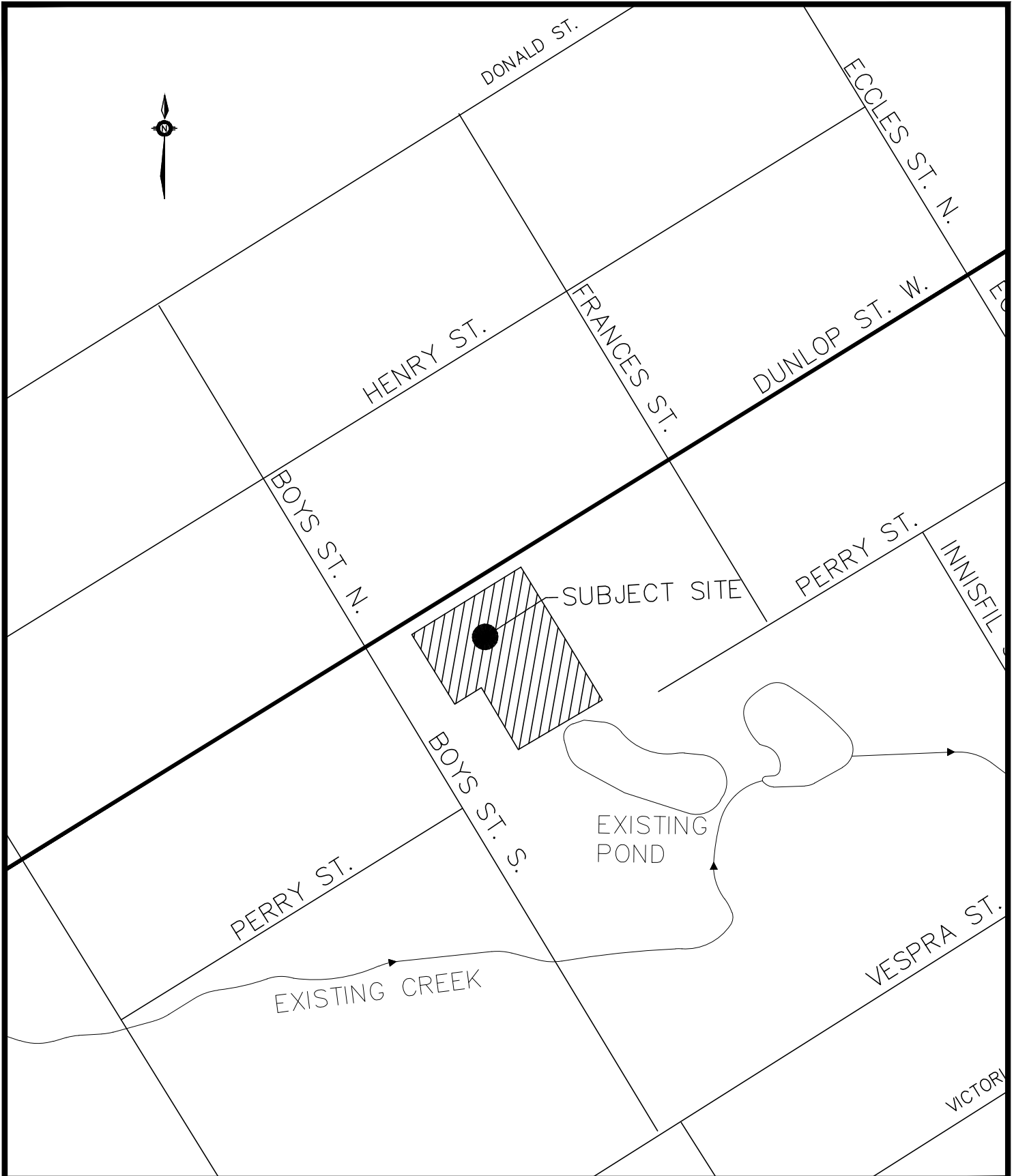
2. STORMWATER MANAGEMENT

A key component of the development is the need to address environmental and related SWM issues. These are examined in a framework aimed at meeting the City, Lake Simcoe Region Conservation Authority (LSRCA) and the Ministry of the Environment, Conservation, and Parks (MECP) requirements. SWM parameters have evolved from an understanding of the location and sensitivity of the site's natural systems. This report focuses on the necessary measures to satisfy the MECP's SWM requirements.

It is understood the objectives of the SWM plan are to:

- Protect life and property from flooding and erosion.
- Maintain water quality for ecological integrity, recreational opportunities etc.
- Protect and maintain groundwater flow regime(s).
- Protect aquatic and fishery communities and habitats.
- Maintain and protect significant natural features.
- Incorporate Low Impact Development (LID) practices to promote infiltration and reduce phosphorus levels to downstream watercourses.

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233 DUNLOP STREET WEST
BARRIE, ONTARIO

LOCATION PLAN



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DESIGNED BY	MWD	HORIZ SCALE	1:750	PROJECT #	12081.01
DRAWN BY	MJWP	VERT SCALE		DRAWING #	FIG-1
CHECKED BY	MWD	DATE	NOV 2018	REVISION #	0



2.1. ANALYSIS METHODOLOGY

The design of the SWM Facilities for this site has been conducted in accordance with:

- The Ministry of the Environment Stormwater Management Planning and Design Manual, March 2003
- City of Barrie, Storm Drainage and Stormwater Management Policies and Design Guidelines, December 2017
- Lake Simcoe Region Conservation Authority Technical Guidelines for Stormwater Management Submissions, September 2016

In order to design the facilities to meet these requirements, it is essential to select the appropriate modeling methodology for the storm system design. Given the size of the site, the Modified Rational Method is appropriate for the design for the SWM system.

2.2. EXISTING DRAINAGE CONDITIONS

The existing Project site currently consists of vacant and residential lots. The majority of the site's stormwater flows from north to south overland at approximately 1 to 2%. The rear of the property slopes down to the existing creek corridor at approximately 30 to 50%. The flows that are conveyed overland to Bunkers Creek will ultimately outlet to Kempenfelt Bay. Details of existing storm drainage conditions are shown on Drawing STM-1 in Appendix F.

According to the *Soil Map of Simcoe County, Report No.29 of the Ontario Soil Survey, Ministry of Agriculture and Food*, the project site is comprised of Wauseon Sandy Loam. This soil is characterized as outwash sand underlain by calcareous clay or silty clay loam, as well as having poor drainage. This material is characterized in the Hydrologic Soil Group CD.

Given the size of the site, the Modified Rational Method will be used to determine the pre-development peak flows. IDF curve parameters were taken from the City of Barrie Stormwater Management Guidelines to determine the storm intensity values. The pre-development peak flows for the site can be seen in Table 1 below. Detailed calculations can be found in Appendix A.

Table 1: Pre-Development Peak Flows

	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Total Flow (m ³ /s)	0.02	0.03	0.03	0.04	0.05	0.06

2.3. PROPOSED DRAINAGE CONDITIONS

The post-development storm drainage for the project will generally follow pre-development conditions. The proposed drainage from the rooftop area will be conveyed through a 300 mm diameter storm sewer to Brentwood ST-30 underground storage chambers in the parking lot area south of the proposed building designed to infiltrate the roof runoff. The majority of the parking lot has been graded to direct stormwater towards two proposed permeable paver areas in the south portion of the parking lot. Underground storage chambers will be provided for quantity control and will be designed as an off-line system. Stormwater will flow through an OGS treatment unit before draining to the south through an outlet structure with a headwall, ultimately draining to Bunkers Creek. A small portion north of the proposed building will drain uncontrolled to Dunlop Street West and the environmentally protected land to the south of the proposed development will continue to drain southerly to Bunkers Creek.



The proposed storm sewer was sized for the 5-year storm event using the rational method. In the event of a storm greater than the 5-year event, the storm sewer will surcharge, forcing stormwater to the surface. A 1.0 m wide major storm control weir is located in the southwest corner of the parking lot which will convey storms greater than the 25-year storm southerly via overland flow. In the event of a storm greater than the 100-year storm or if the orifice tube becomes blocked, the site has been graded to allow stormwater to be conveyed southerly towards Bunker's Creek without negatively impacting the proposed building. The proposed post-development storm drainage patterns can be found on drawing STM-2.

2.4. STORMWATER QUANTITY CONTROL

The proposed development will increase the imperviousness of the site and as such the post-development peak flows will increase. It is important to quantify the increase in stormwater runoff rates and attenuate these increases. The calculated post-development runoff coefficient of 0.73 is greater than the pre-development runoff coefficient of 0.16.

Considerations were taken to reduce post-development peak flows to pre-development values. Given the size of the site, the Modified Rational Method will be used to determine the SWM release rates. A 75 mm diameter orifice tube is proposed upstream of the OGS unit, causing stormwater to back up into the subsurface storage units. Calculations in Appendix A demonstrate that 163 m³ is required to control the 100-year storm event to pre-development values. Underground storage chambers containing a total of 132 m³ are proposed, with the remaining 35 m³ through above grade parking lot storage located around CB1 and CB2.

Table 2 below summarizes post-development peak flows, and by comparing with Table 1 it can be seen that the post-development flows for all storm events are smaller than or equal to the pre-development peak flows.

Table 2: Post-Development Peak Flows

	2 Year Storm	5 Year Storm	10 Year Storm	25 Year Storm	50 Year Storm	100 Year Storm
Controlled Area (m ³ /s)	0.01	0.02	0.02	0.03	0.03	0.04
Uncontrolled Area (m ³ /s)	0.01	0.01	0.01	0.01	0.01	0.02
Total Flow (m³/s)	0.02	0.03	0.03	0.04	0.05	0.06

2.5. VOLUME CONTROL

Since the project site meets the definition of Major Development as per LSRCA Guidelines, considerations were taken to meet the volume control criteria detailed in section 2.2.2. The LSRCA guidelines state that the 25 mm storm event from the total impervious area of the site is to be retained and treated, with flexible alternatives if this criteria cannot be met. As the site is located within a highly vulnerable aquifer, storm runoff from the parking lot area cannot be infiltrated.

Therefore, it is proposed to provide on-site storage to achieve infiltration of the 25 mm storm event over the site's impervious area, which results in a total volume of approximately 69.6 m³. This storage will be provided within 31.0 m³ of Brentwood underground infiltration tanks and 87.3 m³ of storage located within the proposed permeable pavers, resulting in a total of 118.3 m³ of storage. Refer to Appendix A for calculations. The Brentwood system information can be found in Appendix D.



2.6. STREAM EROSION CONTROL

As the site is located near an existing watercourse, considerations were taken to protect against stream erosion. As per LSRCA Guidelines, erosion control is typically completed for sites located upstream of a known erosion site, if the site drains to a first or second order headwater stream, or as part of Master Drainage Plan for a Secondary Planning Area.

However, as the site is less than 2 hectares, no additional erosion control is proposed.

2.7. STORMWATER QUALITY CONTROL

The Ministry of the Environment, Conservation, and Parks (MECP) in March 2003 issued a "Stormwater Management Planning and Design Manual". This manual has been adopted by a variety of agencies including the City of Barrie. The development's Stormwater Quality Control objective is to provide Enhanced Protection quality control as stated in the MECP manual. To achieve enhanced protection, permanent and temporary control of erosion and sediment transport are proposed using a treatment train approach and are discussed in the following sections.

2.7.1. PERMANENT QUALITY CONTROL

The development's active parking facilities pose a risk to stormwater quality through the collection of grit, salt, sand and oils on the paved surfaces. Stormwater from the parking lot area will be receive pretreatment from the proposed permeable pavers by filtering through and draining into a perforated pipe located within the pavers. Stormwater flows from the landscaped areas west of the proposed building and parking lot will flow via grassed swales to the south towards Bunkers Creek. As the site is located within a highly vulnerable aquifer, infiltration of road runoff is prohibited as road salts used in the winter will negatively impact groundwater quality. As such, the permeable paver areas around CB1 and CB2 have been designed with an impermeable liner, and the permeable pavers located along the eastern edge of the property have been graded to ensure no parking lot drainage is conveyed towards them.

Prior to draining to Bunkers Creek, stormwater within the storm sewer system will flow through an oil/grit separator unit. A CDS PMSU20_15_4 treatment unit is the proposed OGS to treat the storm water released from this site to the MOE's Enhanced Level Protection standard. This MOE standard stipulates a Total Suspended Solids (TSS) removal of at least 80%. The OGS unit will treat the post development flows to the required MOE quality standard, with a TSS removal rate of approximately 81%. Regular inspections and proper maintenance of the proposed OGS unit will ensure the TSS removal rate will be achieved as well as protect the downstream watercourse from oil, grease, and heavy metals. Detailed information regarding the OGS unit can be seen in Appendix E.

2.7.2. QUALITY CONTROL DURING CONSTRUCTION

During construction, earth grading and excavation will create the potential for soil erosion and sedimentation. It is imperative that effective environmental and sedimentation controls are in place and maintained throughout the duration of construction activities to ensure the stormwater runoff's quality.

Therefore, the following recommendations shall be implemented and maintained during construction to achieve acceptable stormwater runoff quality:

- Installation of silt fence along the entire perimeter of the site to reduce sediment migration onto surrounding properties;
- Installation of a construction entrance mat to minimize transportation of sediment onto roadways;



- Restoration of exposed surfaces with vegetative and non-vegetative material as soon as construction schedules permit. The duration in which surfaces are disturbed/exposed shall not exceed 30 days;
- Reduce stormwater drainage velocities where possible; and
- Minimize the amount of existing vegetation removed.

The Environmental Protection and Removals Plan has been included in Appendix F.

3. PHOSPHORUS BUDGET

3.1. PHOSPHOROUS BUDGET TOOL

Local conservation authorities have determined the importance of reducing phosphorus levels in water courses in this area. The reduction was based on conservative values derived by the LSRCA using data contained within the MECP's Lake Simcoe Phosphorous Loading Development Tool. As such, best efforts are to be employed in order to reduce phosphorus levels to pre-development levels or better. The existing site generates approximately 0.16 kg of phosphorus annually and the proposed Project will generate approximately 0.54 kg of phosphorus annually if uncontrolled. Best efforts will be used in order to reduce the phosphorus loading as much as is reasonably possible.

To minimize the amount of phosphorus discharged from the site, a treatment train approach is to be utilized. Rooftop runoff will be conveyed to an underground infiltration system, which will infiltrate the equivalent of the first 25 mm over the total rooftop area. Stormwater from the parking areas will flow through the permeable pavers and into a perforated pipe, which will connect to the proposed storm sewer system. A catch basin within the permeable pavers complete with sump will settle larger particles. Stormwater will then flow through an OGS unit and outlet on the slope on the southern side of the site before entering Bunkers Creek through a vegetated buffer strip. According to the LSRCA Standards, the typical phosphorus reduction is 45% for permeable pavers, 60% for underground infiltration chambers, 25% for underground storage chambers, and 65% for the vegetated filter strip.

Additionally, while LSRCA guidelines state that the OGS unit receives 0% phosphorous removal, it will assist in the capture of sediment and therefore inherently provide some reduction in phosphorous levels. The following Table 3 details the anticipated phosphorus loadings for the pre and post-development conditions.

Table 3: Phosphorus Loadings

	Total P (kg)
Pre-Development	0.16
Uncontrolled Post-Development	0.54
Controlled Post-Development	0.08

Detailed calculations can be found in Appendix B.



3.2. PHOSPHOROUS OFFSETTING POLICY

The LSRCA has implemented a Phosphorous Offsetting Policy in September 2017 which has a goal that all new development must reduce 100% of the phosphorous leaving the property. A fee of \$87,500 per annual kg is required for anything above a net 0 kg of phosphorous running off the site. Therefore, the required fee for the proposed development is as follows:

$$\text{LSPOP Fee} = \$35,000 \times 2.5 \times 0.08 \text{ kg} = \mathbf{\$7,000}$$

Refer to Appendix B for detailed phosphorous budget calculations.

4. WATER BALANCE

Since the post-development state will increase the imperviousness of the site, considerations were taken in regard to groundwater recharge. A water budget was completed as per LSRCA guidelines. Under pre-development conditions, the project site had an annual recharge volume of 850 m³. With the increased imperviousness of the site, this recharge will be reduced to 232 m³, resulting in a deficit volume of 618 m³.

In order to infiltrate an additional 618 m³ annually, a yearly rainfall depth of 538.5 mm from the rooftop is required to be infiltrated resulting in a storage volume of 9 m³. This percentage of annual rainfall occurs for rain events of 7 mm or less. However, it is proposed to provide retention for the first 5 mm of rainfall over the site area as per City of Barrie Guidelines resulting in a required storage volume of 31 m³. A summary of water balance calculations can be seen in Table 4 below. Detailed water balance calculations have been provided in Appendix C.

Table 4: Water Balance Calculations Summary

Characteristic	Site		
	Pre-Development	Post-Development	Change (Pre to Post)
Inputs (Volumes)			
Precipitation (m ³ /yr)	4780	4780	0.0%
Run-On (m ³ /yr)	0	0	0.0%
Other Inputs (m ³ /yr)	0	0	0.0%
Total Inputs (m³/yr)	4780	4780	0.0%
Outputs (Volumes)			
Precipitation Surplus (m ³ /yr)	1606	3936	145.1%
Net Surplus (m ³ /yr)	1606	3936	145.1%
Evapotranspiration (m ³ /yr)	3174	844	-73.4%
Infiltration (m ³ /yr)	850	232	-77.3%
Rooftop Infiltration (m ³ /yr)	0	0	0.0%
Total Infiltration (m ³ /yr)	850	232	0.0%
Runoff Pervious Areas (m ³ /yr)	567	154	-65.9%
Runoff Impervious Areas (m ³ /yr)	189	3550	1428.6%
Total Runoff (m ³ /yr)	756	3705	308.2%
Total Outputs (m³/yr)	4780	4780	0.0%

Note: Tabulated values taken from calculation sheets in Appendix C.



5. MAINTENANCE

5.1. PERMEABLE PAVERS

Permeable pavement requires regular inspection and maintenance to ensure that it functions properly. The limiting factor for permeable pavers is clogging within the aggregate layers, filler, or underdrain. The pavers themselves can be reused. Annual inspections of permeable pavement should be conducted in the spring to ensure continued infiltration performance. These inspections should check for spilling or deterioration and investigate whether water is draining between storms. The pavement reservoir should drain completely within 48 hours of the end of the storm event.

5.2. BRENTWOOD STORAGE CHAMBERS

The Brentwood Chambers are proposed to provide 31 m³ of underground storage volume for infiltration and 117 m³ of underground storage for quantity control. The chambers should be inspected every six months during the first year to ensure that the storm tanks are free of any debris. In subsequent years, the chambers should be inspected annually, or more if deemed necessary for this specific site.

If the average depth of sediment accumulates throughout the length of the chamber, a cleanout should be performed. Maintenance should be executed using the JetVac process and a vacuum pump truck to evacuate sediment and debris from the system and is to be performed in dry weather. Material removed from the unit will be disposed of in a similar manner to that of other stormwater management facilities. The owner should keep a Record of Maintenance Book to log inspection results and cleanout frequency. The maintenance manual from the manufacturer is included in Appendix D.

5.3. OIL/GRIT SEPARATOR UNIT

The OGS unit should be inspected on a monthly basis during the rainy season to ensure that the unit is cleaned out at the appropriate time. Where site conditions may cause a rapid accumulation of pollutants, more frequent inspections should be carried out. It is recommended that the OGS unit be cleaned out at the end of the rainy season. The CDS PMSU20_15_4 system should be cleaned when the sump has reached 75% capacity, or the sediment depth has accumulated to a depth of 650 mm. Maintenance is to be performed in dry weather. Material removed from the unit will be disposed of in a similar manner to other stormwater management facilities.

When oils are encountered in the unit, they should be immediately removed upon discovery using a small portable pump and/or adsorbent pads and the remaining water should be decanted to the sanitary sewer system for treatment at the local sewage treatment facility. Contact the supplier for a listing of recommended Oil Sorbents. Any sludge or sediment in the bottom of the unit should be removed and disposed of appropriately. Servicing should be performed immediately after any oil/containment spills in the area. Regular maintenance of the OGS unit will ensure satisfactory and long-term treatment.

5.4. ORIFICE TUBE

The orifice tube controlling flows towards Bunkers Creek is located just downstream of MH1 and should be inspected monthly during the first year of operation and in the spring and fall thereafter. Any standing water observed during inspection of the catchbasin manhole that does not drain away may indicate a blocked orifice tube. The orifice tube should be kept clear of debris and any offending debris should be removed. Access to the orifice tube can be achieved through MH1.



6. CONCLUSIONS

Quantity control for the development is provided in the Brentwood underground storage units and surface ponding allowing post development peak flows to be released at pre-development values through an orifice tube.

A treatment train approach is implemented consisting of permeable pavers and an oil/grit separator to obtain quality control for the site and reduce phosphorus levels leaving the site.

Water balance for the site is achieved by infiltration of runoff from the rooftop.

All of which is respectfully submitted,

PEARSON ENGINEERING LTD.

Taylor Arkell, P.Eng.
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APPENDIX A

STORMWATER MANAGEMENT CALCULATIONS

233 Dunlop Street West Calculation of Runoff Coefficients

Runoff Coefficient	=	0.15	0.08	0.95	0.95	0.60	0.95		Weighted Runoff Coefficient
Surface Cover	=	Grass	Forest	Asphalt	Building	Gravel	Concrete		
PRE DEVELOPMENT	Total Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)		
1	5124	4104	806	54	159	0	0		0.17
Pre Total	5124	4104	806	54	159	0	0		0.17

POST DEVELOPMENT	Total Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)	Area (m ²)		
1	1220	0	0	0	1220	0	0		0.95
2	725	57	0	581	0	0	87		0.89
3	2186	216	0	1882	0	0	88		0.87
4	433	433	0	0	0	0	0		0.15
5	560	413	0	54	0	0	94		0.36
Post Total	5124	1118	0	2517	1220	0	269		0.78

233 Dunlop Street West Pre-Development Peak Flows

Storm (yrs)	City of Barrie Coeff A	Coeff B	Coeff C	Modified Rational Method $Q = C_i C_i A / 360$
2	678.085	4.699	0.781	
5	853.608	4.699	0.766	
10	975.865	4.699	0.760	
25	1146.275	4.922	0.757	
50	1236.152	4.699	0.751	
100	1426.408	5.273	0.759	

Where:

- Q - Flow Rate (m^3/s)
- C_i - Peaking Coefficient
- C - Rational Method Runoff Coefficient
- I - Storm Intensity (mm/hr)
- A - Area (ha.)

Area Number	1
Area	0.51 ha
Runoff Coefficient	0.17
Time of Concentration	10 min
Return Rate	2 year
Peaking Coefficient (C_i)	1.0
Rainfall Intensity	83.1 mm/hr
Pre-Development Peak Flow	0.02 m^3/s

Return Rate	5 year
Peaking Coefficient (C_i)	1.0
Rainfall Intensity	108.9 mm/hr
Pre-Development Peak Flow	0.03 m^3/s

Return Rate	10 year
Peaking Coefficient (C_i)	1.0
Rainfall Intensity	126.5 mm/hr
Pre-Development Peak Flow	0.03 m^3/s

Return Rate	25 year
Peaking Coefficient (C_i)	1.1
Rainfall Intensity	148.2 mm/hr
Pre-Development Peak Flow	0.04 m^3/s

Return Rate	50 year
Peaking Coefficient (C_i)	1.2
Rainfall Intensity	164.2 mm/hr
Pre-Development Peak Flow	0.05 m^3/s

Return Rate	100 year
Peaking Coefficient (C_i)	1.25
Rainfall Intensity	180.2 mm/hr
Pre-Development Peak Flow	0.06 m^3/s

233 Dunlop Street West Post-Development Peak Flows

Storm (yrs)	City of Barrie Coeff A	Coeff B	Coeff C	Modified Rational Method $Q = C_i C_i A / 360$
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2	678.085	4.699	0.781
5	853.608	4.699	0.766
10	975.865	4.699	0.760
25	1146.275	4.922	0.757
50	1236.152	4.699	0.751
100	1426.408	5.273	0.759

Where:

Q - Flow Rate (m³/s)
 C_i - Peaking Coefficient
 C - Rational Method Runoff Coefficient
 I - Storm Intensity (mm/hr)
 A - Area (ha.)

Area Number	Areas to Quantity Control 1, 2 & 3	Total Uncontrolled Flows 4 & 5
Area	0.41 ha	0.10 ha
Runoff Coefficient	0.90	0.27
Time of Concentration	10 min	10 min
Return Rate	2 year	2 year
Peaking Coefficient (C _i)	1.00	1.00
Rainfall Intensity	83.1	83.1
Post-Development Peak Flow	0.09 m ³ /s	0.01 m ³ /s
Return Rate	5 year	5 year
Peaking Coefficient (C _i)	1.00	1.00
Rainfall Intensity	108.9	108.9
Post-Development Peak Flow	0.11 m ³ /s	0.01 m ³ /s
Return Rate	10 year	10 year
Peaking Coefficient (C _i)	1.00	1.00
Rainfall Intensity	126.5	126.5
Post-Development Peak Flow	0.13 m ³ /s	0.01 m ³ /s
Return Rate	25 year	25 year
Peaking Coefficient (C _i)	1.10	1.10
Rainfall Intensity	148.2	148.2
Post-Development Peak Flow	0.17 m ³ /s	0.01 m ³ /s
Return Rate	50 year	50 year
Peaking Coefficient (C _i)	1.20	1.20
Rainfall Intensity	164.2	164.2
Post-Development Peak Flow	0.19 m ³ /s	0.01 m ³ /s
Return Rate	100 year	100 year
Peaking Coefficient (C _i)	1.25	1.25
Rainfall Intensity	180.2	180.2
Post-Development Peak Flow	0.21 m ³ /s	0.02 m ³ /s

233 Dunlop Street West Stage-Storage-Discharge Table

Elevation (m)	Area (m ²)	Volume (m ³)	Cum. Vol. (m ³)	Orifice Head (m)	Orifice Flow (m ³ /s)	Weir Head (m)	Weir Flow (m ³ /s)	Total Flow (m ³ /s)
225.84	174	0	0	0.35	0.009	0.000	0.000	0.009
225.90	174	10	10	0.41	0.010	0.000	0.000	0.010
226.00	174	17	28	0.51	0.011	0.000	0.000	0.011
226.10	174	17	45	0.61	0.012	0.000	0.000	0.012
226.20	174	17	63	0.71	0.013	0.000	0.000	0.013
226.30	174	17	80	0.81	0.014	0.000	0.000	0.014
226.40	174	17	97	0.91	0.015	0.000	0.000	0.015
226.50	174	17	115	1.01	0.016	0.000	0.000	0.016
226.60	174	17	132	1.11	0.017	0.000	0.000	0.017
226.70	0	0	132	1.21	0.017	0.000	0.000	0.017
226.80	0	0	132	1.31	0.018	0.000	0.000	0.018
226.90	0	0	132	1.41	0.019	0.000	0.000	0.019
227.00	0	0	132	1.51	0.019	0.000	0.000	0.019
227.10	0	0	132	1.61	0.020	0.000	0.000	0.020
227.20	0	0	132	1.71	0.020	0.000	0.000	0.020
227.30	0	0	132	1.81	0.021	0.000	0.000	0.021
227.40	0	0	132	1.91	0.022	0.000	0.000	0.022
227.50	0	0	132	2.01	0.022	0.000	0.000	0.022
227.55	0	0	132	2.06	0.022	0.000	0.000	0.022
227.60	49	1	133	2.11	0.023	0.000	0.000	0.023
227.65	145	5	138	2.16	0.023	0.000	0.000	0.023
227.70	258	10	148	2.21	0.023	0.000	0.000	0.023
227.75	474	18	167	2.26	0.024	0.050	0.019	0.043

Orifice	
Diameter	75 mm
Invert Elevation	225.45
Orifice Constant	0.80
Orifice Centroid	225.49
Orifice Flow Formula	$0.80\pi(D/2000)^2 \times (2 \times 9.81 \times H)^{0.5}$

Major Storm Control Weir	
Width	1.00 m
Invert of Weir	227.70 m
Weir Flow Formula	$1.7WH^{1.5}$

233 Dunlop Street West
Quantity Control Volume Calculations

DATE: 26-Sep-19
FILE: 12081.01
CONTRACT/PROJECT: 233 DUNLOP STREET WEST
COMPLETED BY: MJWP

Modified Rational Method Parameters

Pre Development Area (ha)	Post Development Area (ha)	Time of Concentration (min)	Time Increments (min)	Pre Development Runoff Coefficient	Post Development Runoff Coefficient
0.51	0.41	10	1	0.17	0.90

Note: Refer to page Calculation of Runoff Coefficients for detailed calculations of Modified Rational Method parameters.

Pre-Development Runoff Rate

	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
C	0.17	0.17	0.17	0.17	0.17	0.17
C _i	1.00	1.00	1.00	1.10	1.20	1.25
I	83.11	108.92	126.55	148.15	164.22	180.15
A	0.51	0.51	0.51	0.51	0.51	0.51
Q	0.02	0.03	0.03	0.04	0.05	0.06

Note: Q= 0.00278CC_iA

Rainfall Station	Barrie
------------------	--------

SWM Pond Design Input

Storm (yrs)	Chicago Storm Coefficient	Chicago Storm Coefficient	Chicago Storm Coefficient	Allowable Outflow	Post Development Runoff Coefficient
	A	B	C	(m3/s)	
2	678.085	4.899	0.781	0.01	0.90
5	853.608	4.699	0.766	0.02	0.90
10	975.865	4.699	0.760	0.02	0.90
25	1146.275	4.922	0.757	0.03	0.99
50	1236.152	4.699	0.751	0.03	1.00
100	1426.408	5.273	0.759	0.04	1.00

Results

Storm Event	Storage (m³)	Time (min)
2	68	66
5	100	86
10	117	88
25	147	81
50	156	72
100	163	63

Note: Storage volume calculated as per Hydrology Handbook, Second Edition, American Society of Civil Engineers, 1996

Time (min)	2 Year					Difference	5 Year					Difference	10 Year					Difference	25 Year					Difference	50 Year					Difference	100 Year					Difference
	Intensity mm/hr	Inflow m³/s	Outflow m³/s	Storage m³	Intensity mm/hr		Inflow m³/s	Outflow m³/s	Storage m³	Intensity mm/hr	Inflow m³/s		Outflow m³/s	Storage m³	Intensity mm/hr	Inflow m³/s	Outflow m³/s		Storage m³	Intensity mm/hr	Inflow m³/s	Outflow m³/s	Storage m³		Intensity mm/hr	Inflow m³/s	Outflow m³/s	Storage m³	Intensity mm/hr		Inflow m³/s	Outflow m³/s	Storage m³			
1	174.18	0.18	0.01	6	8	225.07	0.23	0.02	9	10	260.01	0.27	0.02	10	12	298.22	0.34	0.03	12	15	334.55	0.38	0.03	12	17	353.96	0.41	0.04	11	18						
2	153.52	0.16	0.01	14	6	198.85	0.20	0.02	19	8	264.99	0.30	0.02	22	9	296.30	0.30	0.03	27	12	336.34	0.34	0.03	29	13	316.38	0.36	0.04	29	14						
3	137.71	0.14	0.01	20	5	178.75	0.18	0.02	27	7	206.87	0.21	0.02	31	8	239.26	0.27	0.03	39	10	266.91	0.31	0.03	43	11	286.90	0.33	0.04	44	12						
4	125.19	0.13	0.01	25	4	162.79	0.17	0.02	34	6	188.54	0.19	0.02	39	6	218.67	0.25	0.03	49	8	243.52	0.28	0.03	54	9	263.10	0.30	0.04	56	10						
5	114.99	0.12	0.01	29	4	149.77	0.15	0.02	39	5	173.57	0.18	0.02	46	6	201.77	0.23	0.03	57	7	224.41	0.26	0.03	63	8	243.43	0.28	0.04	66	9						
6	106.50	0.11	0.01	33	3	138.93	0.14	0.02	44	4	161.10	0.17	0.02	51	5	187.63	0.21	0.03	64	6	208.47	0.24	0.03	71	7	226.85	0.26	0.04	75	8						
7	99.33	0.10	0.01	36	3	129.73	0.13	0.02	48	4	155.52	0.15	0.02	56	4	175.59	0.20	0.03	70	6	194.94	0.22	0.03	78	6	212.68	0.24	0.04	82	7						
8	93.16	0.09	0.01	39	2	121.83	0.12	0.02	52	3	141.42	0.15	0.02	60	4	165.20	0.19	0.03	76	4	183.29	0.21	0.03	84	5	200.41	0.23	0.04	89	6						
9	87.81	0.09	0.01	41	2	114.96	0.12	0.02	55	3	133.51	0.14	0.02	64	3	156.14	0.18	0.03	81	4	173.15	0.20	0.03	89	5	189.66	0.22	0.04	95	5						
10	83.11	0.09	0.01	43	2	108.92	0.11	0.02	58	3	126.55	0.13	0.02	67	3	148.15	0.17	0.03	85	4	164.22	0.19	0.03	94	4	180.15	0.21	0.04	100	5						
11	78.94	0.08	0.01	45	2	103.57	0.11	0.02	61	2	120.37	0.12	0.02	71	3	141.05	0.16	0.03	89	4	156.30	0.18	0.03	98	4	171.69	0.20	0.04	105	4						
12	75.23	0.08	0.01	47	2	98.78	0.10	0.02	63	2	114.85	0.12	0.02	73	3	134.69	0.15	0.03	93	3	149.22	0.17	0.03	102	4	164.09	0.19	0.04	109	4						
13	71.88	0.07	0.01	48	1	94.48	0.10	0.02	65	2	109.89	0.11	0.02	76	2	128.97	0.16	0.03	96	3	142.84	0.16	0.03	106	3	157.23	0.18	0.04	113	4						
14	68.86	0.07	0.01	50	1	90.58	0.09	0.02	67	2	105.39	0.11	0.02	78	2	123.77	0.14	0.03	99	3	137.07	0.16	0.03	109	3	151.00	0.17	0.04	117	3						
15	66.12	0.07	0.01	51	1	87.04	0.09	0.02	69	2	101.30	0.10	0.02	80	2	119.04	0.13	0.03	102	3	131.81	0.15	0.03	112	3	145.31	0.17	0.04	120	3						
16	63.61	0.07	0.01	52	1	83.80	0.09	0.02	71	2	97.56	0.10	0.02	82	2	114.71	0.13	0.03	105	2	127.00	0.15	0.03	115	3	140.09	0.16	0.04	123	3						
17	61.31	0.06	0.01	53	1	80.82	0.08	0.02	73	1	94.12	0.10	0.02	84	2	110.72	0.13	0.03	107	2	122.58	0.14	0.03	117	2	135.29	0.16	0.04	126	3						
18	59.19	0.06	0.01	54	1	78.08	0.08	0.02	74	1	90.95	0.09	0.02	86	2	107.05	0.12	0.03	109	2	118.50	0.14	0.03	120	2	130.86	0.15	0.04	129	2						
19	57.23	0.06	0.01	55	1	75.55	0.08	0.02	75	1	88.02	0.09	0.02	88	2	103.64	0.12	0.03	112	2	114.72	0.13	0.03	122	2	126.75	0.15	0.04	131	2						
20	55.41	0.06	0.01	56	1	73.19	0.08	0.02	77	1	85.30	0.09	0.02	89	1	100.48	0.11	0.03	114	2	111.22	0.13	0.03	124	2	122.92	0.14	0.04	133	2						
21	53.72	0.06	0.01	57	1	71.00	0.07	0.02	78	1	82.77	0.09	0.02	91	1	97.53	0.11	0.03	115	2	107.95	0.12	0.03	126	2	119.35	0.14	0.04	135	2						
22	52.14	0.05	0.01	58	1	68.95	0.07	0.02	79	1	80.40	0.08	0.02	92	1	94.78	0.11	0.03	117	2	104.90	0.12	0.03	128	2	116.02	0.13	0.04	137	2						
23	50.67	0.05	0.01	59	1	67.04	0.07	0.02	80	1	78.18	0.08	0.02	93	1	92.19	0.10	0.03	119	2	102.04	0.12	0.03	130	2	112.89	0.13	0.04	139	2						
24	49.28	0.05	0.01	60	1	65.24	0.07	0.02	81	1	76.10	0.08	0.02	95	1	89.77	0.10	0.03	120	1	99.36	0.11	0.03	131	2	109.95	0.13	0.04	141	2						
25	47.98	0.05	0.01	61	1	63.55	0.07	0.02	82	1	74.15	0.08	0.02	96	1	87.49	0.10	0.03	122	1	96.84	0.11	0.03	133	1	107.18	0.12	0.04	143	2						
26	46.76	0.05	0.01	60	1	61.96	0.06	0.02	83	1	72.31	0.07	0.02	97	1	85.34	0.10	0.03	123	1	94.46	0.11	0.03	134	1	104.57	0.12	0.04	144	1						
27	45.60	0.05	0.01	61	1	60.46	0.06	0.02	84	1	70.57	0.07	0.02	98	1	83.31	0.09	0.03	124	1	92.21	0.11	0.03	136	1	102.10	0.12	0.04	145	1						
28	44.51	0.05	0.01	62	0	59.04	0.06	0.02	85	1	68.92	0.07	0.02	99	1	81.39	0.09	0.03	126	1	90.09	0.10	0.03	137	1	99.76	0.11	0.04	147	1						
29	43.47	0.04	0.01	62	0	57.69	0.06	0.02	86	1	67.36	0.07	0.02	100	1	79.56	0.09	0.03	127	1	88.07	0.10	0.03	138	1	97.55	0.11	0.04	148	1						
30	42.49	0.04	0.01	62	0	56.41	0.06	0.02	86	1	65.88	0.07	0.02	101	1	77.83	0.09	0.03	128	1	86.16	0.10	0.03	139	1	95.44	0.11	0.04	149	1						
31	41.56	0.04	0.01	63	0	55.20	0.06	0.02	87	1	64.47	0.07	0.02	101	1	76.19	0.09	0.03	129	1	84.34	0.10	0.03	140	1	93.44	0.11	0.04	150	1						
32	40.67	0.04	0.01	63	0	54.04	0.06	0.02	88	1	63.13	0.06	0.02	102	1	74.62	0.08	0.03	130	1	82.61	0.09	0.03	141	1	91.53	0.11	0.04	151	1						
33	39.83	0.04	0.01	64	0	52.94	0.05	0.02	88	1	61.86	0.06	0.02	103	1	73.13	0.08	0.03	131	1	80.96	0.09	0.03	142	1	89.71	0.10	0.04	152	1						
34	39.02	0.04	0.01	64	0	51.89	0.05	0.02	89	1	60.64	0.06	0.02	104	1	71.70	0.08	0.03	132	1	79.38	0.09	0.03	143	1	87.97	0.10	0.04	153	1						
35	38.25	0.04	0.01	64	0	50.89	0.05	0.02	90	1	59.47	0.06	0.02	104	1	70.33	0.08	0.03	133	1	77.87	0.09	0.03	144	1	86.31	0.10	0.04	154	1						
36	37.51	0.04	0.01	65	0	49.92	0.05	0.02	90	1	58.36	0.06	0.02	105	1	69.03	0.08	0.03	134	1	76.43	0.09	0.03	145	1	84.71	0.10	0.04	155	1						
37	36.81	0.04	0.01	65	0	49.01	0.05	0.02	91	1	57.29	0.06	0.02	106	1	67.78	0.08	0.03	134	1	75.05	0.09	0.03	146	1	83.19	0.10	0.04	156	1						
38	36.13	0.04	0.01	65	0	48.12	0.05	0.02	91	0	56.27	0.06	0.02	106	1	66.58	0.08	0.03	135	1	73.73	0.08	0.03	146	1	81.73	0.09	0.04	156	1						
39	35.49	0.04	0.01	66	0	47.28	0.05	0.02	92	0	55.29	0.06	0.02	107	1	65.43	0.07	0.03	136	1	72.46	0.08	0.03	147	1	80.32	0.09	0.04	157	1						
40	34.87	0.04	0.01	66	0	46.47	0.05	0.02	92	0	54.35	0.06	0.02	107	1	64.32	0.07	0.03	137	1	71.24	0.08	0.03	148	1	78.97	0.09	0.04	158	1						
41	34.21	0.04	0.01	66	0	45.68	0.05	0.02	92	0	53.44	0.06	0.02	108	1	63.26	0.08	0.03	137	1	70.26	0.08	0.03	148	1	77.65	0.09	0.04	159	1						
42	33.69	0.03	0.01	66	0	44.93	0.05	0.02	93	0	52.57	0.06	0.02	108	0	62.24	0.07	0.03	138	1	68.93	0.08	0.03	149	1	76.42	0.09	0.04	159	0						
43	33.14	0.03	0.01	66	0	44.21	0.05	0.02	93	0	51.73	0.05	0.02	109	0	61.25	0.07	0.03	1																	

233 Dunlop Street West Permeable Pavers Sizing Calculations

Infiltration volumes from MOE Stormwater Management Planning and Design Manual to size Permeable Pavers
Table 3.2 Water Quality Storage Requirements are as follows:

Design Area 2 Total	=	0.07	ha	
Total Imperviousness	=	80%		
Storage Volume	=	38.2	m ³ /ha	(Enhanced 80% long-term S.S. removal)
Area 2 Storage Volume Required	=	0.07	x	38.2
	=	2.8	m ³	
Design Area 3 Total	=	0.22	ha	
Total Imperviousness	=	86%		
Storage Volume	=	40.0	m ³ /ha	(Enhanced 80% long-term S.S. removal)
Area 3 Storage Volume Required	=	0.22	x	40.0
	=	8.7	m ³	

Required storage volume calculated over 25 mm of the total impervious area on the site:

Storage Volume	=	2,786	x	0.025
Area Storage Volume Required	=	69.6	m ³	

Note: The 25 mm storm event is being infiltrated from the rooftop area and therefore the roof area was neglected for these purposes.

Find Storage Volume provided in Permeable Pavers:

Area of West Pavers (A ₁)	=	89.6	m ²	
Depth of Trench (d)	=	0.40	m	
Storage Volume (V)	=	0.4 (A x d)		
	=	14.3	m ³	
Area of South Pavers (A ₂)	=	118.8	m ²	
Depth of Trench (d)	=	0.40	m	
Storage Volume (V)	=	0.4 (A x d)		
	=	19.0	m ³	
Area of East Pavers (A ₃)	=	337.5	m ²	
Depth of Trench (d)	=	0.40	m	
Storage Volume (V)	=	0.4 (A x d)		
	=	54.0	m ³	
Total Area Storage Volume	=	Required 69.6	m ³	Provided 87.3 m ³

Use Equation 4.12 to find Area of Permeable Pavers:

Area Design Volume (V)	=	69.6	m ³	
Depth of Controlling Filter Medium (d)	=	0.40	m	
Coefficient of Permeability of the Controlling Filter Media (k)	=	45.0	mm/hr	
Design Drawdown Time (t)	=	24	hr	
Surface Area Of Filter (A)	=	$\frac{1000Vd}{kdt}$		
	=	64.5	m ²	
Total Area Surface Area	=	Required 64.5	m ²	Provided 545.9 m ²

Q= 0.0028*C*I*A (cms)
C=RUNOFF COEFFICIENT
I-RAINFALL INTENSITY= A/(Time+B)^C
A=AREA (ha)

233 Dunlop Street West
Storm Sewer Design
5-Year Storm Event

DATE: 2-Oct-19
FILE: 12081.01
CONTRACT/PROJECT: 233 DUNLOP ST. W.

Areas	MANHOLE		LENGTH (m)	INCREMENT			TOTAL CA	FLOW TIME (min)		I (mm/h)	TOTAL Q (cms)	S (%)	D (mm)	Q FULL (cms)	V FULL (m/s)
	FROM	TO		C	A	CA		TO	IN						
Area 1	ROOF	CBMH1	2.1	0.95	0.12	0.12	0.12	10.00	0.03	108.92	0.04	1.0	300	0.10	1.37
-	CBMH1	STM TANKS	4.6	0.00	0.00	0.00	0.12	10.03	0.03	108.78	0.04	5.0	300	0.22	3.06
	STM TANKS	CB1	5.9	0.00	0.00	0.00	0.12	10.05	0.03	108.64	0.03	5.1	300	0.22	3.09
Area 2	CB1	MH2	25.2	0.89	0.07	0.06	0.18	10.08	0.31	108.46	0.05	1.0	300	0.10	1.37
-	MH2	MH1	16.7	0.00	0.00	0.00	0.18	10.39	0.20	106.76	0.05	1.0	300	0.10	1.37
Area 3	CB2	MH1	9.9	0.87	0.22	0.19	0.19	10.00	0.07	108.92	0.06	2.7	300	0.16	2.25
	MH1	STM OGS	2.0	0.00	0.00	0.00	0.37	10.59	0.02	105.67	0.02*	1.0	300	0.10	1.37
	STM OGS	OUTLET	12.6	0.00	0.00	0.00	0.37	10.62	0.11	105.54	0.02*	2.0	300	0.14	1.94

* denotes 100 year flow through orifice tube taken from SSD.



APPENDIX B

PHOSPHOROUS BUDGET CALCULATIONS

233 Dunlop Street West Phosphorus Budget Tool

	High Intensity Residential	Low Intensity Residential	Pasture	Forest
Phosphorus Export (kg/ha/year)	1.32	1.82	0.07	0.05

Pre-Development Condition

	High Intensity Residential	Low Intensity Residential	Pasture	Forest
Area (ha):	0.00	0.07	0.36	0.08
Total P (kg):	0.00	0.13	0.03	0.00
Total Pre-Development P (kg):		0.16		

Post-Development Condition (Uncontrolled)

	High Intensity Residential	Low Intensity Residential	Pasture	Forest
Total Area				
Area (ha):	0.40	0.00	0.11	0.00
Total P (kg):	0.53	0.00	0.01	0.00
Total Post-Development P (kg):		0.54		

Post Development Condition (Controlled)

	High Intensity Residential	Low Intensity Residential	Pasture	Forest
Untreated Area				
Area (ha):	0.00	0.00	0.10	0.00
Total P (kg):	0.00	0.00	0.01	0.00
Area Draining to Infiltration Trench				
Area (ha):	0.12	0.00	0.00	0.00
Total P (kg):	0.16	0.00	0.00	0.00
Infiltration Trench Treatment				
Infiltration Trench Proficiency (%):		60		
P Removed (kg):		0.10		
P Remaining (kg):		0.06		
Area Draining to Permeable Pavers				
Area (ha):	0.29	0.00	0.00	0.00
Total P (kg):	0.38	0.00	0.00	0.00
Permeable Pavers Treatment				
Permeable Pavers Proficiency (%):		45		
P Removed (kg):		0.17		
P Remaining (kg):		0.21		
Underground Storage Treatment				
P from Permeable Pavers & Infiltration Trench (kg):		0.28		
Underground Storage Proficiency (%):		25		
P Removed (kg):		0.07		
P Remaining (kg):		0.21		
Filter Strip Treatment				
P from Underground Storage (kg):		0.21		
Filter Strip Proficiency (%):		65		
P Removed (kg):		0.13		
P Remaining (kg):		0.07		
Total Post-Development P (kg) :		0.08		

Table 1. Description of Berger (2010) Land Uses in the Lake Simcoe Watershed

Berger (2010) Land Use	Included LSRCA Land Use(s)	Land Use Description
Hay / Pasture	Non-intensive Agriculture	Hay and pasture fields, including the related agricultural buildings such as barns, silos and the farm residence. Fields are dominated with herbaceous vegetation and grasses with an understory of similar material in a state of decay. Weedy hay and/or pasture covers more than 50% of the area.
Crop Land	Intensive Agriculture	Cultivated row crops, including the related agricultural buildings (e.g., barns, silos and the farm residence), producing crops in varying degrees (e.g., corn and wheat) and includes specialty agriculture (i.e., orchards, market gardens, Christmas tree plantations and nurseries).
Sod Farm / Golf Course	Sod Farm	Sod farms.
	Golf Course	Golf courses, including lane ways, but not the isolated woodlots within, unless the area of the woodlots is < 0.5 ha.
Low Intensity Development	Estate Residential	A home including the manicured area around the home and driveway, within a natural heritage feature. The natural heritage feature is not included in the Estate Residential land use classification.
	Manicured Open Space	Cleared areas with a low density of trees, including lawns and landscaping. Land use is dominated by gardens, parkland and lawns, e.g., cemeteries, urban parks, ski hills and residential/industrial open space with a minimum size of 2 ha.
	Rail	Rail lines and the associated cleared adjacent areas.
	Rural Development	Properties not directly associated with an agricultural operation and that contain residential, commercial or other buildings, as well as a manicured open space, within a natural heritage or agricultural feature (e.g., estate residential or service station). On developed portions, these properties are under intensive use. Based on canopy cover, these areas will often appear as Cultural Savannah or Cultural Woodland in aerial photographs or satellite imagery. However, the presence of buildings and manicured lands identify the properties as Rural Development.
High Intensity Development¹ (Commercial /Industrial)	Commercial	Impervious properties that contain a building and an adjacent parking lot (e.g., shopping and strip malls, power centres, scrap yards). Excludes green land areas such as parks or river valleys.
	Industrial	Impervious properties that are not commercial and include industrial operations e.g., factories, manufacturing facilities, processing facilities, bulk fuel storage. Excludes green land areas such as parks or river valleys.
	Institutional	Schools, hospitals and other institutional structures. May include large storm water management ponds. Excludes green land areas such as parks or river valleys.
High Intensity Development¹ (Residential)	Urban	Urban related land uses including continuous ribbon development. Interpreted from aerial photographs or satellite imagery by many roof tops and/or groupings of 5 or more residential properties with a combined area of ≥ 2 ha. Residential properties include single and semi-detached dwellings, apartment buildings and associated out-buildings, driveways and parking lots. Excludes green land areas such as parks or river valleys.
Quarry	Active Aggregate	Areas that are currently being excavated or have recently been excavated. Identified by pits, extraction machinery, unvegetated landscape and/or piles of extracted materials. Active aggregate areas may contain open water.
	Inactive Aggregate	Former aggregate sites that have been recently revegetated; vegetation is established and growing. Depending on their characteristics, in aerial photographs or satellite imagery, these properties may appear to be comparable to an abandoned field or forming wetland.
Road	Road	Unpaved roads, including the shoulder. Does not include driveways.

Berger (2010) Land Use	Included Ecological Land Classifications (ELC(s))	Land Use Description
Transitional	Open Alvar	Cover varies from patchy shrub and tree cover to continuous meadow. Tree cover is $\leq 25\%$; shrub cover is $\leq 25\%$. Typically restricted to bare rock and patchy, shallow substrates.
	Cultural Meadow	Tree cover is $\leq 25\%$ and shrub cover is $\leq 25\%$. The plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Cultural Thicket	Tree cover is $\leq 25\%$ and shrub cover is $> 25\%$. The plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Open Tallgrass Prairie	The ground layer of plants is dominated by prairie graminoids (grasses and grass-like plants, including sedges) such as Big and Little Bluestem, as well as Indian Grass. Tree cover is $\leq 25\%$ and shrub cover is $\leq 25\%$. Soils are well drained with prolonged summer drought and frequent disturbance by fire.
Forest ²	Cultural Plantation, Coniferous	Tree cover is $> 60\%$ of the area, with coniferous trees $> 75\%$ of the canopy area. The plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Cultural Woodland	Tree cover is between 35% and 60% of the area. There is often a large proportion of non-native plant species, and the plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Coniferous Forest	Tree cover is $> 60\%$ of the area, with coniferous trees $> 75\%$ of the canopy area.
	Cultural Plantation, Deciduous	Tree cover is greater than 60% of the area, with deciduous trees greater than 75% of the canopy area. The plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Deciduous Forest	Tree cover is $> 60\%$ of the area, with deciduous trees $> 75\%$ of the canopy area.
	Cultural Plantation	Tree cover $> 60\%$ of the area, with coniferous trees $> 25\%$ of the canopy area and deciduous trees $> 25\%$ of the canopy area. The plant community is a result of, or maintained by, anthropogenic disturbances or culture.
	Mixed Forest	Tree cover is $> 60\%$ of the area, with coniferous trees $> 25\%$ of the canopy area and deciduous trees $> 25\%$ of the canopy area.
Wetland ²	Shrub Bog	Continuous <i>Sphagnum</i> spp. moss cover. Trees > 2 m tall cover $\leq 10\%$ of the area and shrubs cover $> 25\%$ of the area. Land is rarely flooded but always saturated with water. Organic substrate > 40 cm deep consisting of <i>Sphagnum</i> peat.
	Treed Bog	Continuous <i>Sphagnum</i> spp. moss cover. Trees > 2 m tall cover 10% to 25% of the area. Land is rarely flooded but always saturated with water. Organic substrate > 40 cm deep consisting of <i>Sphagnum</i> peat.
	Open Fen	Sedges, grasses and low shrubs (< 2 m high) dominate; trees > 2 m high cover $\leq 10\%$ of the area and shrubs cover $\leq 25\%$ of the area. Land is rarely flooded but always saturated with water. Organic substrate > 40 cm deep consisting of moss or sedged peat.
	Shrub Fen	Sedges, grasses and low shrubs (< 2 m high) dominate; trees > 2 m high cover $\leq 10\%$ of the area and shrubs cover $> 25\%$ of the area. Land is rarely flooded but always saturated with water. Organic substrate > 40 cm deep consisting of moss or sedged peat.
	Treed Fen	Sedges, grasses and low shrubs (< 2 m high) dominate; trees > 2 m high cover 10% to 25% of the area. Land is rarely flooded but always saturated with water with organic substrate and > 40 cm deep moss or sedged peat.

Berger (2010) Land Use	Included Ecological Land Classifications (ELC(s))	Land Use Description
	Meadow Marsh	Dominated by emergent hydrophytic aquatic plants (grow wholly or partially in water); tree and shrub cover $\leq 25\%$. Variable flooding regimes and water depth 2m.
	Shallow Marsh	Emergent hydrophytic aquatic plant cover $\geq 25\%$, tree and shrub cover $\leq 25\%$ of the area. Water up to 2 m deep; standing or flowing water for much or all of the growing season.
Wetland³	Floating-Leaved Shallow Aquatic	Floating leaved aquatic vegetation covers $> 25\%$ of the area; no tree or shrub cover. Water up to 2 m deep; standing water is always present.
	Mixed Shallow Aquatic	A mixture of submerged and floating leaved aquatic vegetation covers $> 25\%$ of the area; no tree or shrub cover. Water up to 2 m deep; standing water is always present.
	Submerged Shallow Aquatic	Submerged aquatic vegetation covers $> 25\%$ of the area; no tree or shrub cover. Water up to 2 m deep; standing water is always present.
	Coniferous Swamp	Tree cover is $> 25\%$ of the area with trees > 5 m tall, and coniferous trees $> 75\%$ of the canopy area. Water depth is < 2 m with variable flooding regimes; standing water or spring (vernal) pooling covers $> 20\%$ of the ground.
	Deciduous Swamp	Tree cover is $> 25\%$ of the area with trees > 5 m tall, and deciduous trees $> 75\%$ of the canopy area. Water depth is < 2 m with variable flooding regimes; standing water or spring (vernal) pooling covers $> 20\%$ of the ground.
	Mixed Swamp	Tree cover is $> 25\%$ of the area with trees > 5 m tall; coniferous trees $> 25\%$ of the canopy area and deciduous trees $> 25\%$ of the canopy area. Water depth is < 2 m with variable flooding regimes; standing water or spring (vernal) pooling covers $> 20\%$ of the ground.
	Thicket Swamp	Tree or shrub cover $> 25\%$, dominated by hydrophytic shrub and tree species (grow wholly or partially in water); tree cover $\leq 25\%$, hydrophytic shrub cover $> 25\%$. Water depth is < 2 m with variable flooding regimes; standing water or spring (vernal) pooling covers $> 20\%$ of the ground.
Open Water⁴		Lakes, rivers and ponds including stormwater management ponds.

Notes: ¹High Intensity Development areas were further separated for the Tool into commercial/industrial and residential classes because the percentage of impervious area is typically much higher in commercial/industrial areas than in residential areas resulting in a greater amount of storm water runoff, ²includes CANWET classes of Coniferous Woodland, Deciduous Woodland and Mixed Woodland, ³includes CANWET classes of Emergent Wetland and Woody Wetland. ⁴Not included in the Berger (2010) land classes but added for the purposes of the Tool recognizing that some development areas may have open water areas that should be included in calculations of phosphorus export.

3.2.1.1 Derivation of Export Coefficients

Export coefficients for all land classes were derived based on total phosphorus loading estimates reported by Berger (2010) for individual subwatersheds with the exception of High Intensity Development, which was derived from measured loads in MOE's Stormwater Management Monitoring and Performance Program (SWAMP, 2005; MOE, unpublished data) and Open Water which was derived from estimates of atmospheric loads to the surface of Lake Simcoe (Scott et al., 2006; LSRCA, 2009). The following describes the derivation and rationale for the selection of export coefficients from these sources for each land use in each subwatershed as provided in Table 1.

Table 2. Land-Use Specific Phosphorus Export Coefficients (kg/ha/yr) for Lake Simcoe Subwatersheds

Subwatershed	Phosphorus Export (kg/ha/yr)											
	Cropland	Hay-Pasture	Sod Farm/Golf Course	High Intensity Development		Low Intensity Development	Quarry	Unpaved Road	Forest	Transition	Wetland	Open Water
				Commercial /Industrial	Residential							
Monitored Subwatersheds												
Beaver River	0.22	0.04	0.01	1.82	1.32	0.19	0.06	0.83	0.02	0.04	0.02	0.26
Black River	0.23	0.08	0.02	1.82	1.32	0.17	0.15	0.83	0.05	0.06	0.04	0.26
East Holland River	0.36	0.12	0.24	1.82	1.32	0.13	0.08	0.83	0.10	0.16	0.10	0.26
Hawkestone Creek	0.19	0.10	0.06	1.82	1.32	0.09	0.10	0.83	0.03	0.04	0.03	0.26
Lovers Creek	0.16	0.07	0.17	1.82	1.32	0.07	0.06	0.83	0.06	0.06	0.05	0.26
Pefferlaw/Uxbridge Brook	0.11	0.06	0.02	1.82	1.32	0.13	0.04	0.83	0.03	0.04	0.04	0.26
Whites Creek	0.23	0.10	0.42	1.82	1.32	0.15	0.08	0.83	0.10	0.11	0.09	0.26
Unmonitored Subwatersheds												
Barrie Creeks	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
GeorginaCreeks	0.36	0.12	0.24	1.82	1.32	0.13	0.08	0.83	0.10	0.16	0.10	0.26
Hewitts Creek	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
Innisfil Creeks	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
Maskinonge River	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
Oro Creeks North	0.36	0.12	0.24	1.82	1.32	0.13	0.08	0.83	0.10	0.16	0.10	0.26
Oro Creeks South	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
Ramara Creeks	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
Talbot/Upper Talbot River	0.19	0.07	0.12	1.82	1.32	0.13	0.08	0.83	0.05	0.06	0.05	0.26
West Holland River	0.36	0.12	0.24	1.82	1.32	0.13	0.08	0.83	0.10	0.16	0.10	0.26

3.2.2 Methods - Calculating Pre-development Conditions

The pre-development or “existing conditions” phosphorus load is calculated through the following steps, by the user:

1. The user will rely on the information documented and detailed in the EIS for the development that will be used to support the planning application to the Municipality.
2. The user will choose the subwatershed or geographic area of the Lake Simcoe watershed in which the development is proposed from a drop down list provided by the database. If the development area spans two or more subwatersheds, the areas within each subwatershed should be modelled separately.
3. Specific land use classifications will be delineated and their boundaries overlain on an orthographic aerial photograph that shall be included in their submission.



APPENDIX C

WATER BALANCE CALCULATIONS

**233 Dunlop Street West
Total Water Surplus Calculations**

Month	Mean Temperature (°C)	Heat Index	Potential Evapotranspiration (mm)	Daylight Correction Value	Adjusted Potential Evapotranspiration (mm)	Total Precipitation (mm)	Surplus (mm)	Defecit (mm)
January	-7.7	0.0	0.0	0.81	0.0	82.5	82.5	0.0
February	-6.6	0.0	0.0	0.81	0.0	61.8	61.8	0.0
March	-2.1	0.0	0.0	1.02	0.0	58.1	58.1	0.0
April	5.6	1.2	25.4	1.12	28.5	62.2	33.7	0.0
May	12.3	3.9	59.2	1.27	75.2	82.4	7.2	0.0
June	17.9	6.9	88.6	1.29	114.3	84.8	0.0	29.5
July	20.8	8.7	104.1	1.30	135.3	77.2	0.0	58.1
August	19.7	8.0	98.1	1.20	117.7	89.9	0.0	27.8
September	15.3	5.4	74.9	1.04	77.9	94.0	16.1	0.0
October	8.7	2.3	40.7	0.95	38.7	77.5	38.8	0.0
November	2.7	0.4	11.6	0.80	9.2	88.9	79.7	0.0
December	-3.5	0.0	0.0	0.74	0.0	73.6	73.6	0.0
TOTAL		36.8	502.5		596.7	932.9	451.5	115.4

TOTAL WATER SURPLUS 336.2 mm

Notes:

1. Mean Temperature and Total Precipitation taken from Environment Canada for the Barrie WPCC rainfall station.

2. Heat Index formula is as follows:

$$I = (T_a/5)^{1.514}$$

Where:

I is the Heat Index

T_a is the mean temperature

3. Potential Evapotranspiration formula is as follows:

$$PET = 16(L/12)(N/30)(10T_a/I)^\alpha$$

Where:

PET is the Potential Evapotranspiration

L is the average day length

N is the number of days in the month

T_a is the mean temperature

$$\alpha = (6.75 \times 10^{-7})I^3 - (7.71 \times 10^{-5})I^2 + (1.792 \times 10^{-2})I + 0.49239$$

Where:

I is the sum of all Heat Indices

**233 Dunlop Street West
Pre Development Water Balance**

Catchment Designation	Site			
	Grassed	Forest	Impervious	Total
Area	4104	806	214	5124
Pervious Area	4104	806	0	4910
Impervious Area	0	0	214	214
Infiltration Factors				
Topography Infiltration Factor	0.3	0.3	0.0	
Soil Infiltration Factor	0.3	0.3	0.0	
Land Cover Infiltration Factor	0.0	0.2	0.0	
MOE Infiltration Factor	0.6	0.8	0.0	
Actual Infiltration Factor	0.6	0.8	0.0	
Run-Off Coefficient	0.4	0.2	1.0	
Runoff from Impervious Surfaces	0.0	0.0	0.95	
Inputs (per Unit Area)				
Precipitation	932.9	932.9	932.9	932.9
Run-On	0.0	0.0	0.0	0.0
Other Inputs	0.0	0.0	0.0	0.0
Total Inputs	932.9	932.9	932.9	932.9
Outputs (per Unit Area)				
Precipitation Surplus	345.2	0.0	886.3	313.4
Net Surplus	345.2	0.0	886.3	313.4
Evapotranspiration	587.7	932.9	46.6	619.5
Infiltration	207.1	0.0	0.0	165.9
Rooftop Infiltration	0.0	0.0	0.0	0.0
Total Infiltration	207.1	0.0	0.0	165.9
Runoff Pervious Areas	138.1	0.0	0.0	110.6
Runoff Impervious Areas	0.0	0.0	886.3	36.9
Total Runoff	138.1	0.0	886.3	147.5
Total Outputs	932.9	932.9	932.9	932.9
Difference (Inputs - Outputs)	0.0	0.0	0.0	0.0
Inputs (Volumes)				
Precipitation	3829	752	199	4780
Run-On	0	0	0	0
Other Inputs	0	0	0	0
Total Inputs	3829	752	199	4780
Outputs (Volumes)				
Precipitation Surplus	1417	0	189	1606
Net Surplus	1417	0	189	1606
Evapotranspiration	2412	752	10	3174
Infiltration	850	0	0	850
Rooftop Infiltration	0	0	0	0
Total Infiltration	850	0	0	850
Runoff Pervious Areas	567	0	0	567
Runoff Impervious Areas	0	0	189	189
Total Runoff	567	0	189	756
Total Outputs	3829	752	199	4780
Difference (Inputs - Outputs)	0	0	0	0

(From MOE Table 3.1 for Flat Land)
(From MOE Table 3.1 for Medium combinations of clay and loam)

(Precipitation values from Environment Canada)

Note: Highlighted cells are input cells.

233 Dunlop Street West
Post Development Water Balance (No Infiltration)

Catchment Designation	Site			
	Grassed	Impervious	Building	Total
Area	1118	2786	1220	5124
Pervious Area	1118	0	0	1118
Impervious Area	0	2786	1220	4006
Infiltration Factors				
Topography Infiltration Factor	0.3	0.0	0.0	
Soil Infiltration Factor	0.3	0.0	0.0	
Land Cover Infiltration Factor	0.0	0.0	0.0	
MOE Infiltration Factor	0.6	0.0	0.0	
Actual Infiltration Factor	0.6	0.0	0.0	
Run-Off Coefficient	0.4	1.0	1.0	
Runoff from Impervious Surfaces	0.0	0.95	0.95	
Inputs (per Unit Area)				
Precipitation	932.9	932.9	932.9	932.9
Run-On	0.0	0.0	0.0	0.0
Other Inputs	0.0	0.0	0.0	0.0
Total Inputs	932.9	932.9	932.9	932.9
Outputs (per Unit Area)				
Precipitation Surplus	345.2	886.3	886.3	768.2
Net Surplus	345.2	886.3	886.3	768.2
Evapotranspiration	587.7	46.6	46.6	164.7
Infiltration	207.1	0.0	0.0	45.2
Rooftop Infiltration	0.0	0.0	0.0	0.0
Total Infiltration	207.1	0.0	0.0	45.2
Runoff Pervious Areas	138.1	0.0	0.0	30.1
Runoff Impervious Areas	0.0	886.3	886.3	692.9
Total Runoff	138.1	886.3	886.3	723.0
Total Outputs	932.9	932.9	932.9	932.9
Difference (Inputs - Outputs)	0.0	0.0	0.0	0.0
Inputs (Volumes)				
Precipitation	1043	2599	1138	4780
Run-On	0	0	0	0
Other Inputs	0	0	0	0
Total Inputs	1043	2599	1138	4780
Outputs (Volumes)				
Precipitation Surplus	386	2469	1081	3936
Net Surplus	386	2469	1081	3936
Evapotranspiration	657	130	57	844
Infiltration	232	0	0	232
Rooftop Infiltration	0	0	0	0
Total Infiltration	232	0	0	232
Runoff Pervious Areas	154	0	0	154
Runoff Impervious Areas	0	2469	1081	3550
Total Runoff	154	2469	1081	3705
Total Outputs	1043	2599	1138	4780
Difference (Inputs - Outputs)	0	0	0	0

(From MOE Table 3.1 for Flat Land)
(From MOE Table 3.1 for Medium combinations of clay and loam)

(Precipitation values from Environment Canada)

Note: Highlighted cells are input cells.

233 Dunlop Street West
Post Development Water Balance (With Infiltration)

Catchment Designation	Site			
	Grassed	Paved	Building (With Infiltration)	Total
Area	1118	2786	1220	5124
Pervious Area	1118	0	0	1118
Impervious Area	0	2786	1220	4006
Infiltration Factors				
Topography Infiltration Factor	0.2	0.0	0.0	
Soil Infiltration Factor	0.2	0.0	0.0	
Land Cover Infiltration Factor	0.1	0.0	0.0	
MOE Infiltration Factor	0.5	0.0	0.0	
Actual Infiltration Factor	0.5	0.0	0.0	
Run-Off Coefficient	0.5	1.0	1.0	
Runoff from Impervious Surfaces	0.0	0.95	0.95	
Inputs (per Unit Area)				
Precipitation	932.9	932.9	932.9	932.9
Run-On	0.0	0.0	0.0	0.0
Other Inputs	0.0	0.0	0.0	0.0
Total Inputs	932.9	932.9	932.9	932.9
Outputs (per Unit Area)				
Precipitation Surplus	345.2	886.3	886.3	768.2
Net Surplus	345.2	886.3	886.3	768.2
Evapotranspiration	587.7	46.6	46.6	164.7
Infiltration	172.6	0.0	0.0	37.7
Rooftop Infiltration	0.0	0.0	538.5	128.2
Total Infiltration	172.6	0.0	538.5	165.9
Runoff Pervious Areas	172.6	0.0	0.0	37.7
Runoff Impervious Areas	0.0	886.3	347.8	564.6
Total Runoff	172.6	886.3	347.8	602.3
Total Outputs	932.9	932.9	932.9	932.9
Difference (Inputs - Outputs)	0.0	0.0	0.0	0.0
Inputs (Volumes)				
Precipitation	1043	2599	1138	4780
Run-On	0	0	0	0
Other Inputs	0	0	0	0
Total Inputs	1043	2599	1138	4780
Outputs (Volumes)				
Precipitation Surplus	386	2469	1081	3936
Net Surplus	386	2469	1081	3936
Evapotranspiration	657	130	57	844
Infiltration	193	0	0	193
Rooftop Infiltration	0	0	657	657
Total Infiltration	193	0	657	850
Runoff Pervious Areas	193	0	0	193
Runoff Impervious Areas	0	2469	424	2893
Total Runoff	193	2469	424	3086
Total Outputs	1043	2599	1138	4780
Difference (Inputs - Outputs)	0	0	0	0

(From MOE Table 3.1 for Flat Land)
(From MOE Table 3.1 for Medium combinations of clay and loam)

(Precipitation values from Environment Canada)

Depth of rainfall over the rooftop required to be infiltrated to achieve water balance.

Note: Highlighted cells are input cells.

233 Dunlop Street West Water Balance Calculations

Annual Rainfall Depth Required

$$\text{Depth of Rainfall Required} = 538.5 \text{ mm} \quad (\text{From Post-Development Water Balance (With Infiltration)})$$

Find Percent of Annual Rainfall that Required Rainfall Depth represents:

$$\begin{aligned} \text{Annual Rainfall for Study Area} &= 932.9 \text{ mm} \\ \text{\% Annual Rainfall} &= \frac{538.5}{932.9} \text{ mm} \\ &= 58\% \end{aligned}$$

From MOE Figure C-2, 58% of annual rainfall occurs for storm events of 7 mm or less.

Find storage volume required for rainfall events of 7 mm to Rooftop Infiltration Gallery:

$$\begin{aligned} \text{Roof Top Area} &= 1,220 \text{ m}^2 \\ \text{Rainfall Depth} &= 7 \text{ mm} \\ \text{Storage Volume Required} &= A \times D \\ &= 1,220 \times 7 \\ &= 9 \text{ m}^3 \end{aligned}$$

Minimum Infiltration Volume as per City of Barrie Storm Drainage and Stormwater Management Policies and Design Guidelines Section 4.1.3 is as follows:

$$\begin{aligned} \text{Storage Volume Required} &= \text{Site Area} \times 5 \text{ mm} \\ &= 5,124 \times 0.005 \\ &= 26 \text{ m}^3 \end{aligned}$$

It is proposed to infiltrate the 25 mm storm event over the rooftop area, resulting in a storage volume of 31 m³ exceeding the City of Barrie Criteria. Therefore, water balance for the site is achieved.

Figure C.1 Annual Precipitation Event Distribution

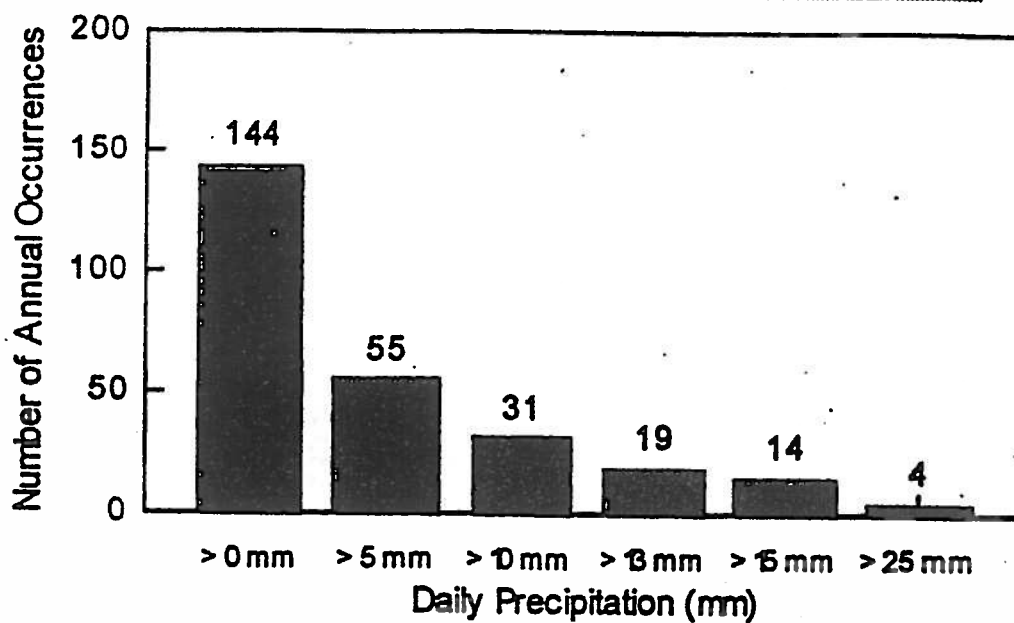


Figure C.2 Annual Capture Rate for Daily Capture Amounts

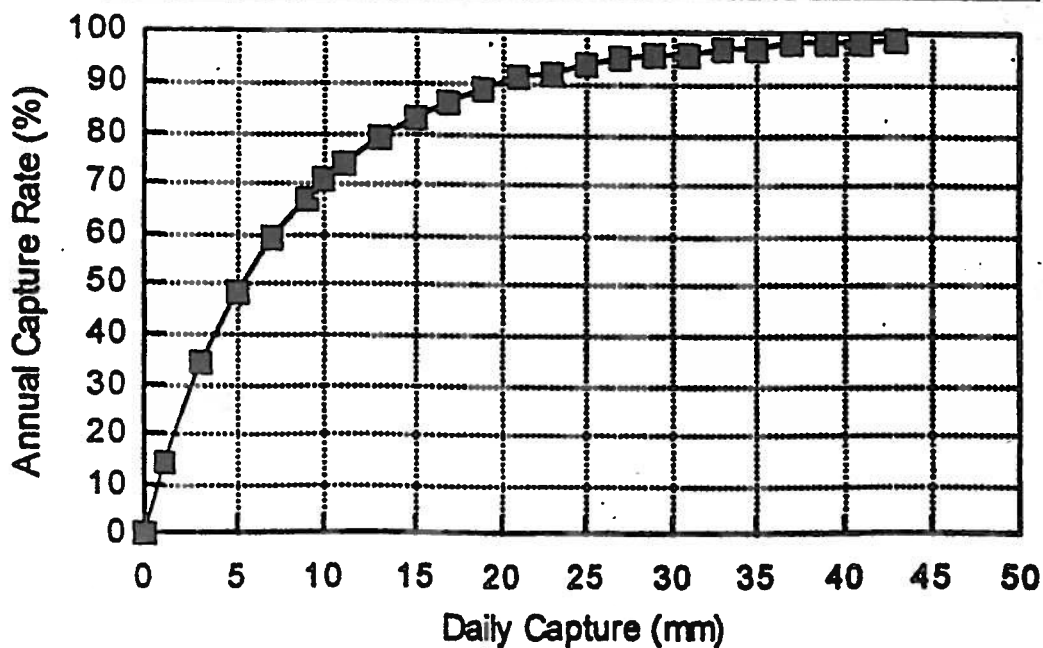


Table 3.1: Hydrologic Cycle Component Values

	Water Holding Capacity mm	Hydrologic Soil Group	Precipitation mm	Evapo- transpiration mm	Runoff mm	Infiltration* mm
Urban Lawns/Shallow Rooted Crops (spinach, beans, beets, carrots)						
Fine Sand	50	A	940	515	149	276
Fine Sandy Loam	75	B	940	525	187	228
Silt Loam	125	C	940	536	222	182
Clay Loam	100	CD	940	531	245	164
Clay	75	D	940	525	270	145
Moderately Rooted Crops (corn and cereal grains)						
Fine Sand	75	A	940	525	125	291
Fine Sandy Loam	150	B	940	539	160	241
Silt Loam	200	C	940	543	199	199
Clay Loam	200	CD	940	543	218	179
Clay	150	D	940	539	241	160
Pasture and Shrubs						
Fine Sand	100	A	940	531	102	307
Fine Sandy Loam	150	B	940	539	140	261
Silt Loam	250	C	940	546	177	217
Clay Loam	250	CD	940	546	197	197
Clay	200	D	940	543	218	179
Mature Forests						
Fine Sand	250	A	940	546	79	315
Fine Sandy Loam	300	B	940	548	118	274
Silt Loam	400	C	940	550	156	234
Clay Loam	400	CD	940	550	176	215
Clay	350	D	940	549	196	196
Notes: Hydrologic Soil Group A represents soils with low runoff potential and Soil Group D represents soils with high runoff potential. The evapotranspiration values are for mature vegetation. Streamflow is composed of baseflow and runoff.						
<i>*This is the total infiltration of which some discharges back to the stream as base flow. The infiltration factor is determined by summing a factor for topography, soils and cover.</i>						
<u>Topography</u>	Flat Land, average slope < 0.6 m/km				0.3	
	Rolling Land, average slope 2.8 m to 3.8 m/km				0.2	
	Hilly Land, average slope 28 m to 47 m/km				0.1	
<u>Soils</u>	Tight impervious clay				0.1	
	Medium combinations of clay and loam				0.2	
	Open Sandy loam				0.4	
<u>Cover</u>	Cultivated Land				0.1	
	Woodland				0.2	

Barrie Annual Rainfall Data

▼ Precipitation

1981 to 2010 Canadian Climate Normals station data

Precipitation														
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Rainfall (mm)	16.6	16.0	29.2	56.6	82.3	84.8	77.2	89.9	94.0	75.2	66.0	22.2	709.9	C
Snowfall (cm)	66	46	29	6	0	0	0	0	0	2	23	51	223	C
Precipitation (mm)	82.5	61.8	58.1	62.2	82.4	84.8	77.2	89.9	94.0	77.5	88.9	73.6	932.9	C
Average Snow Depth (cm)	16	17	8	1	0	0	0	0	0	0	2	9	4	D
Median Snow Depth (cm)	17	17	8	0	0	0	0	0	0	0	1	8	4	D
Snow Depth at Month-end (cm)	17	15	1	0	0	0	0	0	0	0	4	11	4	C
Extreme Daily Rainfall (mm)	27.0	35.0	43.0	40.0	54.4	96.0	75.0	79.0	80.0	48.8	50.0	28.6		
Date (yyyy/dd)	1998/05	1997/21	1990/11	1995/21	2004/23	1995/02	1980/20	1995/31	1986/11	1995/05	1999/02	1979/24		
Extreme Daily Snowfall (cm)	65	32	22	17	2	0	0	0	0	12	27	44		
Date (yyyy/dd)	1978/09	1984/29	1984/10	1979/04	1989/07	1978/01	1978/01	1978/01	1977/01	1997/26	2000/21	1995/10		
Extreme Daily Precipitation (mm)	65.0	35.0	43.0	40.0	54.4	96.0	75.0	79.0	80.0	48.8	52.0	44.0		
Date (yyyy/dd)	1978/09	1997/21	1990/11	1995/21	2004/23	1995/02	1980/20	1995/31	1986/11	1995/05	1999/02	1995/10		
Extreme Snow Depth (cm)	57	59	50	21	0	0	0	0	0	8	29	54		
Date (yyyy/dd)	1981/07	2001/09	2003/05	1987/01	1981/01	1981/01	1981/01	1981/01	1981/01	1997/27	1995/28	1995/11		

Government of Canada, "Canadian Climate Normals 1981-2010 Station Data For Barrie WPCC." Climate. July 9, 2014. Accessed August 6, 2014.

http://climate.weather.gc.ca/climate_normals/results_1981_2010_e.html?stnID=4408&lang=e&stationName=barrie&SearchType=Contains&stnNameSubmit=go&dCode=4&dispBack=1

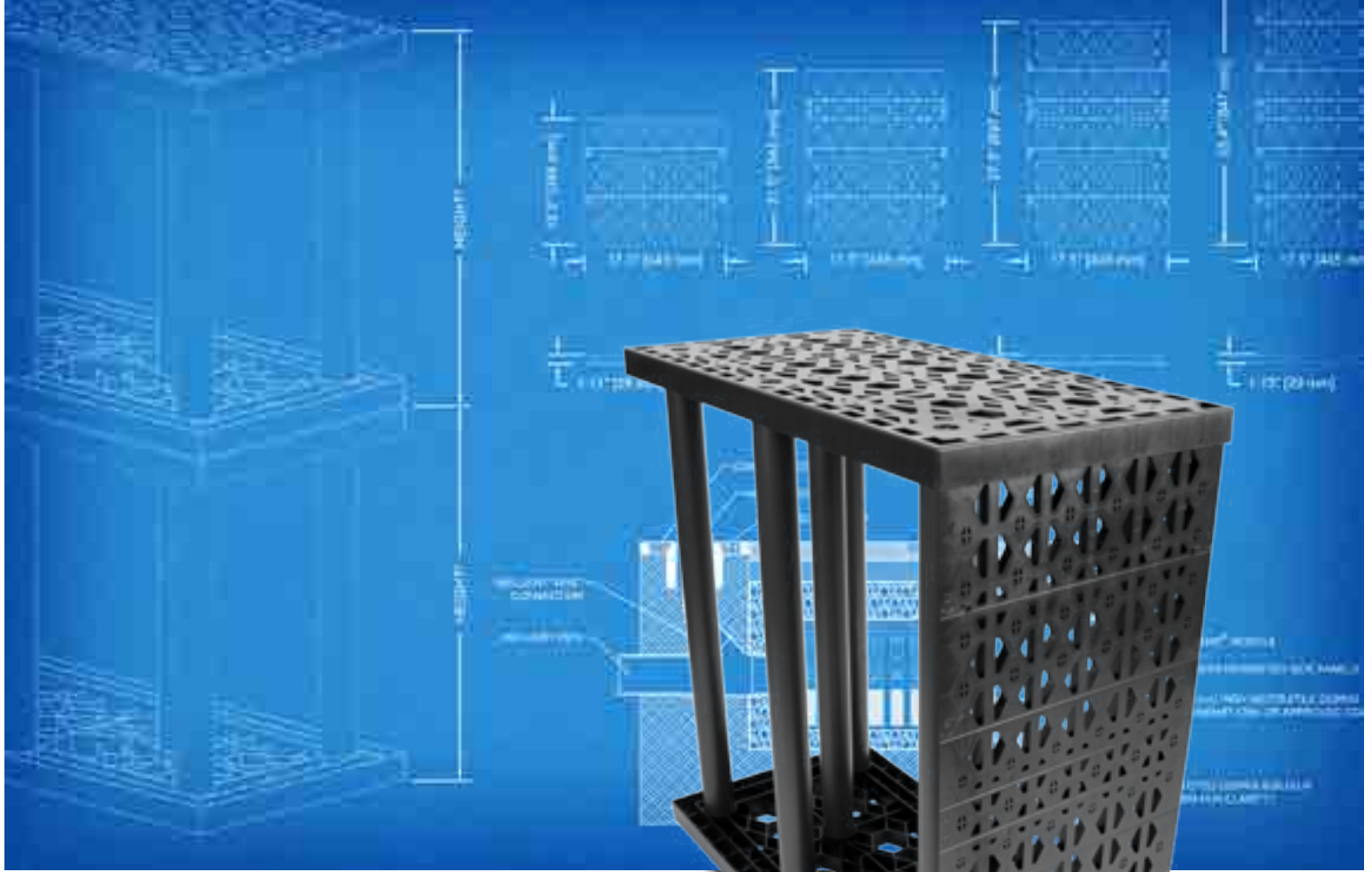


APPENDIX D

**BRENTWOOD UNDERGROUND STORAGE CHAMBER
INFORMATION**



DESIGN GUIDE



STORM TANK[®] *Module*

Contents

1.0	Introduction
2.0	Product Information
3.0	Manufacturing Standards
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8.0	Pretreatment
9.0	Additional Considerations
10.0	Inspection & Maintenance
11.0	System Sizing
12.0	Detail Drawings
13.0	Specifications
14.0	Appendix – Bearing Capacity Tables

General Notes

1. Brentwood recommends that the installing contractor contact either Brentwood or the local distributor prior to installation of the system to schedule a pre-construction meeting. This meeting will ensure that the installing contractor has a firm understanding of the installation instructions.
2. All systems must be designed and installed to meet or exceed Brentwood's minimum requirements. Although Brentwood offers support during the design, review, and construction phases of the Module system, it is the ultimate responsibility of the Engineer of Record to design the system in full compliance with all applicable engineering practices, laws, and regulations.
3. Brentwood requires a minimum cover of 24" (610 mm) and/or a maximum Module invert of 11' (3.35 m). Additionally, a minimum 6" (152 mm) leveling bed, 12" (305 mm) side backfill, and 12" (305 mm) top backfill are required on every system.
4. Brentwood recommends a minimum bearing capacity and subgrade compaction for all installations. If site conditions are found not to meet any design requirements during installation, the Engineer of Record must be contacted immediately.
5. All installations require a minimum two layers of geotextile fabric. One layer is to be installed around the Modules, and another layer is to be installed between the stone/soil interfaces.
6. Stone backfilling is to follow all requirements of the most current installation instructions.
7. The installing contractor must apply all protective measures to prevent sediment from entering the system during and after installation per local, state, and federal regulations.
8. The StormTank® Module carries a Limited Warranty, which can be accessed at www.brentwoodindustries.com.

1.0 Introduction



About Brentwood

Brentwood is a global manufacturer of custom and proprietary products and systems for the construction, consumer, medical, power, transportation, and water industries. A focus on plastics innovation, coupled with diverse production capabilities and engineering expertise, has allowed Brentwood to build a strong reputation for thermoplastic molding and solutions development.

Brentwood's product and service offerings continue to grow with an ever-increasing manufacturing presence. By emphasizing customer service and working closely with clients throughout the design, engineering, and manufacturing phases of each project, Brentwood develops forward-thinking strategies to create targeted, tailored solutions.

StormTank® Module

The StormTank Module is a strong, yet lightweight, alternative to other subsurface systems and offers the largest void space (up to 97%) of any subsurface stormwater storage unit on the market. The Modules are simple to assemble on site, limiting shipping costs, installation time, and labor. Their structural PVC columns pressure fit into the polypropylene top/bottom platens, with side panels inserted around the perimeter of the system. This open design and lack of internal walls make the Module system easy to clean compared to other subsurface box structures. When properly designed, applied, installed, and maintained, the Module system has been engineered to achieve a 50-year lifespan.

Technical Support

Brentwood's knowledgeable distributor network and in-house associates emphasize customer service and support by partnering with customers to extend the process beyond physical material supply. These trained specialists are available to assist in the review of proposed systems, conversions of alternatively designed systems, or to resolve any potential concerns before, during, and after the design process. To provide the best assistance, it is recommended that associates be provided with a site plan and cross-sections that include grading, drainage structures, dimensions, etc.

2.0 Product Information

Applications

The Module system can be utilized for detention, infiltration, capture and reuse, and specialty applications across a wide range of industries, including the commercial, residential, and recreational segments. The product’s modular design allows the system to be configured in almost any shape (even around utilities) and to be located under almost any pervious or impervious surface.

Module Selection

Brentwood manufactures the Module in five different heights (Table 1) that can be stacked uniformly up to two Modules high. This allows for numerous height configurations up to 6’ (1.83 m) tall. The Modules can be buried up to a maximum invert of 11’ (3.35 m) and require a minimum cover of 24” (610 mm) for load rating. When selecting the proper Module, it is important to consider the minimum required cover, any groundwater or limiting zone restrictions, footprint requirements, and all local, state, and federal regulations.

Table 1: Nominal StormTank® Module Specifications



	ST-18	ST-24	ST-30	ST-33	ST-36
Height	18" (457 mm)	24" (610 mm)	30" (762 mm)	33" (838 mm)	36" (914 mm)
Void Space	95.5%	96.0%	96.5%	96.9%	97.0%
Module Storage Capacity	6.54 ft³ (0.18 m³)	8.64 ft³ (0.24 m³)	10.86 ft³ (0.31 m³)	11.99 ft³ (0.34 m³)	13.10 ft³ (0.37 m³)
Min. Installed Capacity*	9.15 ft³ (0.26 m³)	11.34 ft³ (0.32 m³)	13.56 ft³ (0.38 m³)	14.69 ft³ (0.42 m³)	15.80 ft³ (0.45 m³)
Weight	22.70 lbs (10.30 kg)	26.30 lbs (11.93 kg)	29.50 lbs (13.38 kg)	31.3 lbs (14.20 kg)	33.10 lbs (15.01 kg)

*Min. Installed Capacity includes the leveling bed, Module, and top backfill storage capacity for one Module. Stone storage capacity is based on 40% void space. **Side backfill storage is not included.**

3.0 Manufacturing Standards

Brentwood selects material based on long-term performance needs. To ensure long-term performance and limit component deflection over time (creep), Brentwood selected polyvinyl chloride (PVC) for the Module's structural columns and a virgin polypropylene (PP) blend for the top/bottom and side panels. PVC provides the largest creep resistance of commonly available plastics, and therefore, provides the best performance under loading conditions. Materials like polyethylene (HDPE) and recycled PP have lower creep resistance and are not recommended for load-bearing products and applications.

Materials:

Brentwood's proprietary PVC and PP copolymer resins have been chosen specifically for utilization in the StormTank® Module. The PVC is blended in house by experts and is a 100% blend of post-manufacturing/pre-consumer recycled material. Both materials exhibit structural resilience and naturally resist the chemicals typically found in stormwater runoff.

Methods:

Injection Molding

The Module's top/bottom platens and side panels are injection molded, using proprietary molds and materials. This allows Brentwood to manufacture a product that meets structural requirements while maintaining dimensional control, molded-in traceability, and quality control.

Extrusion

Brentwood's expertise in PVC extrusion allows the structural columns to be manufactured in house. The column extrusion includes the internal structural ribs required for lateral support.

Quality Control

Brentwood maintains strict quality control in order to ensure that materials and the final product meet design requirements. This quality assurance program includes full material property testing in accordance with American Society for Testing and Materials (ASTM) standards, full-part testing, and process testing in order to quantify product performance during manufacturing. Additionally, Brentwood conducts secondary finished-part testing to verify that design requirements continue to be met post-manufacturing.

All Module parts are marked with traceability information that allows for tracking of manufacturing. Brentwood maintains equipment at all manufacturing locations, as well as at its corporate testing lab, to ensure all materials and products meet all requirements.



4.0 Structural Response

Structural Design

The Module has been designed to resist loads calculated in accordance with the American Association of State Highway and Transportation Officials' (AASHTO) Load and Resistance Factor Design (LRFD) Bridge Design manual. This fully factored load includes a multiple presence factor, dynamic load allowance, and live load factor to account for real-world situations. This loading was considered when Brentwood developed both the product and installation requirements. The developed minimum cover ensures the system maintains an adequate resistance factor for the design truck (HS-20) and HS-25 loads.

Full-Scale Product Testing

Engineers at Brentwood's in-house testing facility have completed full-scale vertical and lateral tests on the Module to evaluate product response. To date, Brentwood continues in-house testing in order to evaluate long-term creep effects.

Fully Installed System Testing

Brentwood's dedication to providing a premier product extends to fully installed testing. Through a partnership with Queen's University's GeoEngineering Centre in Kingston, Ontario, Brentwood has conducted full-scale installation tests of single- and double-stacked Module systems to analyze short- and long-term performance. Testing includes short-term ultimate limit state testing under fully factored AASHTO loads and minimum installation cover, lateral load testing, long-term performance and lifecycle testing utilizing time-temperature superposition, and load resistance development. Side backfill material tests were also performed to compare the usage of sand, compacted stone, and uncompacted stone.



5.0 Foundation

The foundation (subgrade) of the subsurface storage structure may be the most important part of the Module system installation as this is the location where the system applies the load generated at the surface. If the subgrade lacks adequate support or encounters potential settlement, the entire system could be adversely affected. Therefore, when implementing an underground storage solution, it is imperative that a geotechnical investigation be performed to ensure a strong foundation.

Considerations & Requirements:

Bearing Capacity

The bearing capacity is the ability of the soil to resist settlement. In other words, it is the amount of weight the soil can support. This is important versus the native condition because the system is replacing earth, and even though the system weighs less than the earth, the additional load displacement of the earth is not offset by the difference in weight.

Using the Loading and Resistance Factor Design (LRFD) calculation for bearing capacity, Brentwood has developed a conservative minimum bearing capacity table (see Appendix). The Engineer of Record shall reference this table to assess actual cover versus the soil bearing required for each unit system.

Limiting Zones

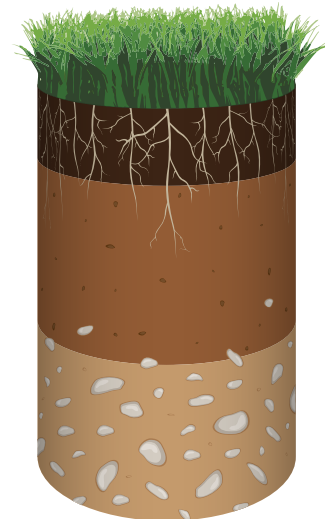
Limiting zones are conditions in the underlying soils that can affect the maximum available depth for installation and can reduce the strength and stability of the underlying subgrade. The three main forms of limiting zones are water tables, bedrock, and karst topography. It is recommended that a system be offset a minimum of 12" (305 mm) from any limiting zones.

Compaction

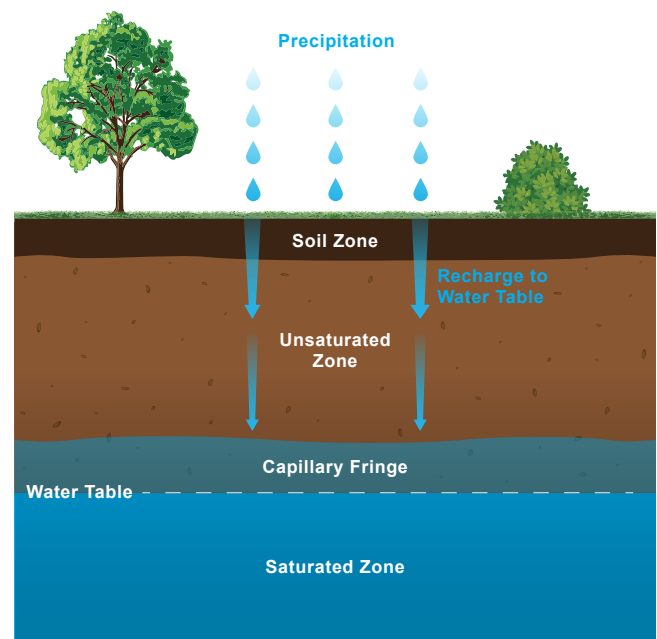
Soil compaction occurs as the soil particles are pressed together and pore space is eliminated. By compacting the soils to 95% (as recommended by Brentwood), the subgrade strength will increase, in turn limiting both the potential for the soil to move once installed and for differential settlement to occur throughout the system. If designing the specific compaction requirement, settlement should be limited to less than 1" (25 mm) through the entire subgrade and should not exceed a 1/2" (13 mm) of differential settlement between any two adjacent units within the system over time.

Mitigation

If a minimum subgrade bearing capacity cannot be achieved because of weak soil, a suitable design will need to be completed by a Geotechnical Engineer. This design may include the over-excavation of the subgrade and an engineered fill or slurry being placed. Additional material such as geogrid or other products may also be required. Please contact a Geotechnical Engineer prior to selecting products or designing the subgrade.



Soil Profile



Water Table Zones

6.0 System Materials

Geotextile Fabric

The 6-ounce geotextile fabric is recommended to be installed between the soil and stone interfaces around the Modules to prevent soil migration.

Leveling Bed

The leveling bed is constructed of 6"-thick (152 mm) angular stone (Table 2). The bed has not been designed as a structural element but is utilized to provide a level surface for the installation of the system and provide an even distribution of load to the subgrade.

Stone Backfill

The stone backfill is designed to limit the strain on the product through displacement of load and ensure the product's longevity. Therefore, a minimum of 12"-wide (305 mm) angular stone must be placed around all sides of the system. In addition, a minimum layer of 12" (305 mm) angular stone is required on top of the system. All material is to be placed evenly in 12" (305 mm) lifts around and on top of the system and aligned with a vibratory plate compactor.

Table 2: Approved Backfill Material

Material Location	Description	AASHTO M43 Designation	ASTM D2321 Class	Compaction/Density
Finished Surface	Topsoil, hardscape, stone, concrete, or asphalt per Engineer of Record	N/A	N/A	Prepare per engineered plans
Suitable Compactable Fill	Well-graded granular soil/aggregate, typically road base or earthen fill (maximum 4" particle size)	56, 57, 6, 67, 68	I & II III (Earth Only)	Place in maximum 12" lifts to a minimum 90% standard proctor density
Top Backfill	Crushed angular stone placed between Modules and road base or earthen fill	56, 57, 6, 67, 68	I & II	Plate vibrate to provide evenly distributed layers
Side Backfill	Crushed angular stone placed between earthen wall and Modules	56, 57, 6, 67, 68	I & II	Place and plate vibrate in uniform 12" lifts around the system
Leveling Bed	Crushed angular stone placed to provide level surface for installation of Modules	56, 57, 6, 67, 68	I & II	Plate vibrate to achieve level surface

Impermeable Liner

In designs that prevent runoff from infiltrating into the surrounding soil (detention or reuse applications) or groundwater from entering the system, an impermeable liner is required. When incorporating a liner as part of the system, Brentwood recommends using a manufactured product such as a PVC liner. This can be installed around the Modules themselves or installed around the excavation (to gain the benefit of the void space in the stone) and should include an underdrain system to ensure the basin fully drains. This liner is installed with a layer of geotextile fabric on both sides to prevent puncture, in accordance with manufacturer recommendations.

7.0 Connections

Stormwater runoff must be able to move readily in and out of the StormTank® Module system. Brentwood has developed numerous means of connecting to the system, including inlet/outlet ports and direct abutment to a catch basin or endwall. All methods of connection should be evaluated as each one may offer a different solution. Brentwood has developed drawings to assist with specific installation methods, and these are available at www.brentwoodindustries.com.

Inlet/Outlet and Pipe Connections

To facilitate easy connection to the system, Brentwood manufactures two inlet/outlet ports. They are 12" (305 mm) and 14" (356 mm), respectfully, and utilize a flexible coupling connection to the adjoining pipe.

Another common installation method is to directly connect the pipe to the system. In order to do this, an opening is cut into the side panels, the pipe is inserted, and then the system is wrapped in geotextile fabric. When utilizing this connection method, the pipe must be located a minimum of 3" (76 mm) from the bottom of the system. This provides adequate clearance for the bottom platen and the required strength in the remaining side panel. To maintain the required clearances or reduce pipe size, it may be necessary to connect utilizing a manifold system.

Direct Abutment

The system can also be connected by directly abutting Modules to a concrete catch basin or endwall. This allows for a seamless connection of structures in close proximity to the system and eliminates the need for numerous pipe connections. When directly abutting one of these structures, remove any side panels that fully abut the structure, and make sure it is flush with the system to prevent material migration into the structure.

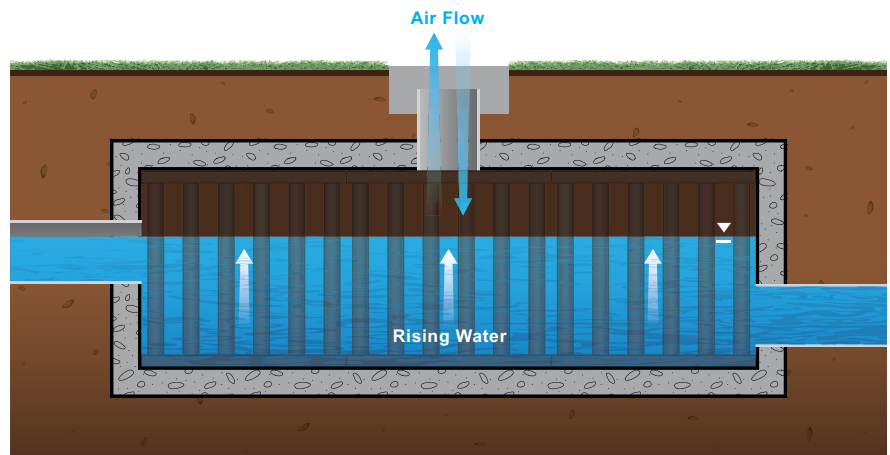
Underdrain

Underdrains are typically utilized in detention applications to ensure the system fully drains since infiltration is limited or prohibited. The incorporation of an underdrain in a detention application will require an impermeable liner between the stone-soil interface.

Cleanout Ports

Brentwood understands the necessity to inspect and clean a subsurface system and has designed the Module without any walls to allow full access. Brentwood offers three different cleanout/observation ports for utilization with the system. The ports are made from PVC, provide an easy means of connection, and are available in 6" (152 mm), 8" (203 mm) and 10" (254 mm) diameters. The 10" (254 mm) port is sized to allow access to the system by a vacuum truck suction hose for easy debris removal.

It is recommended that ports be located a maximum of 30' (9.14 m) on center to provide adequate access, ensure proper airflow, and allow the system to completely fill.



Ventilation and Air Flow

8.0 Pretreatment

Removing pollutants from stormwater runoff is an important component of any stormwater management plan. Pretreatment works to prevent water quality deterioration and also plays an integral part in allowing the system to maintain performance over time and increase longevity. Treatment products vary in complexity, design, and effectiveness, and therefore, should be selected based on specific project requirements.

Typical Stormwater System



StormTank[®] Shield

Brentwood's StormTank Shield provides a low-cost solution for stormwater pretreatment. Designed to improve sumped inlet treatment, the Shield reduces pollutant discharge through gross sediment removal and oil/water separation. For more information, please visit www.brentwoodindustries.com.

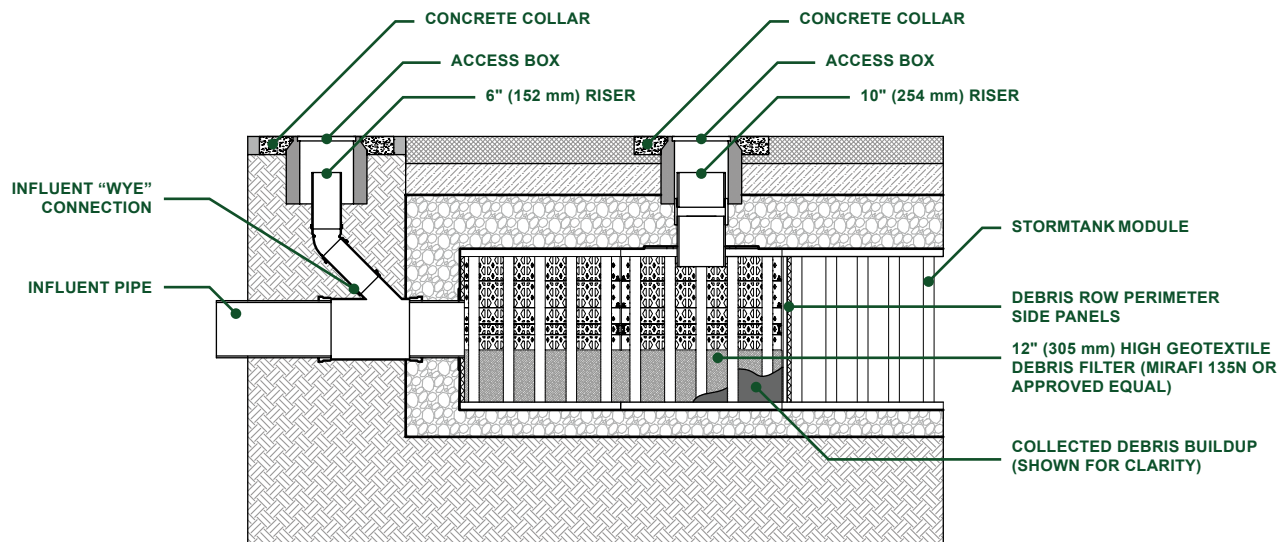
Debris Row (Easy Cleanout)

An essential step of designing, installing, and maintaining a subsurface system is preventing debris from entering the storage. This can be done by incorporating debris rows (or bays) at the inlets of the system to prevent debris from entering the rest of the system.

The debris row is built into the system utilizing side panels with a 12" (305 mm) segment of geotextile fabric. This allows for the full basin capacity to be utilized while storing any debris in an easy-to-remove location. To calculate the number of side panels required to prevent backing up, the opening area of the side panels on the area above the geotextile fabric has been calculated and compared to the inflow pipe diameter.

Debris row cleanout is made easy by including 10" (254 mm) suction ports, based on the length of the row, and a 6" (152 mm) saddle connection to the inflow pipe. If the system is directly abutting a catch basin, the saddle connection is not required, and the flush hose can be inserted through the catch basin. Debris is then flushed from the inlet toward the suction ports and removed.

Brentwood has developed drawings and specifications that are available at www.brentwoodindustries.com to illustrate the debris row configuration and layouts.



Debris Row Section Detail

9.0 Additional Considerations

Many variable factors, such as the examples below, must be taken into consideration when designing a StormTank® Module system. As these considerations require complex calculations and proper planning, please contact Brentwood or your local distributor to discuss project-specific requirements.

Adaptability

The Modules can be arranged in custom configurations to meet tight site constraints and to provide different horizontal and edge configurations. Modules can also be stacked, to a maximum 2 units tall, to meet capacity needs and can be buried to a maximum invert of 11' (3.35 m) to allow for a stacked system or deeper burial.

Adjacent Structures

The location of adjacent structures, especially the location of footings and foundations, must be taken into consideration as part of system design. The foundation of a building or retaining wall produces a load that is transmitted to a footing and then applied to the surface below. The footing is intended to distribute the line load of the wall over a larger area without increasing the larger wall's thickness. The reason this is important is because the load the footing is applying to the earth is distributed through the earth and could potentially affect a subsurface system as either a vertical load to the top of the Module or a lateral load to the side of the Module.

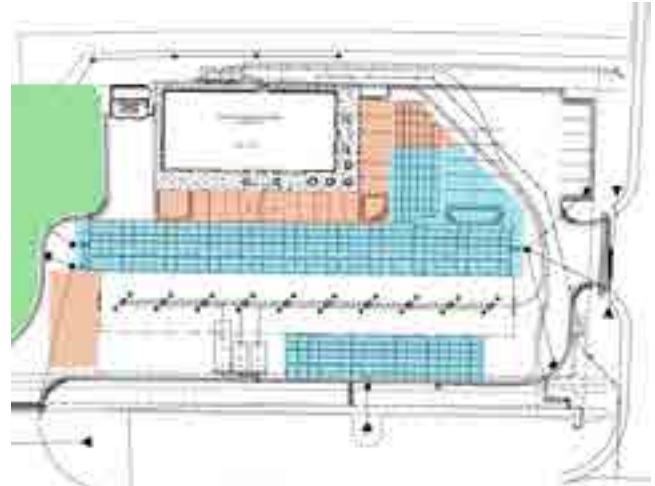
Based on this increased loading, it is recommended that the subsurface system either maintain a distance away from the foundation, footing equal to the height between the Module invert and structure invert of the system, or the foundation or footing extend at a minimum to the invert of the subsurface system. By locating the foundation away from the system or equal to the invert, the loading generated by the structure does not get transferred onto the system. It is recommended that all adjacent structures be completed prior to the installation of the Modules to prevent construction loads from being imparted on the system.

Adjacent Excavation

The subsurface system must be protected before, during, and after the installation. Once a system is installed, it is important to remember that excavation adjacent to the system could potentially cause the system to become unstable. The uniform backfilling will evenly distribute the lateral loads to the system and prohibit the system from becoming unstable and racking from unequal loads. However, it is recommended that any excavation adjacent to a system remain a minimum distance away from the system equal to the invert. This will provide a soil load that is equal to the load applied by the opposite side of the installation. If the excavation is to exceed the invert of the system, additional analysis may be necessary.

Sloped Finished Grade

Much like adjacent excavation, a finished grade with a differential cover could potentially cause a subsurface system to become disproportionately loaded. For example, if one side of the system has 10' (3.05 m) of cover and the adjacent side has 24" (610 mm) of cover, the taller side will generate a higher lateral load, and the opposite side may not have an equal amount of resistance to prevent a racking of the system. Additional evaluation may be required when working on sites where the final grade around a system exceeds 5%.



Site Plan Module Layout Adaptability
(StormTank Modules shown in blue)

10.0 Inspection & Maintenance

Description

Proper inspection and maintenance of a subsurface stormwater storage system are vital to ensuring proper product functioning and system longevity. It is recommended that during construction the contractor takes the necessary steps to prevent sediment from entering the subsurface system. This may include the installation of a bypass pipe around the system until the site is stabilized. The contractor should install and maintain all site erosion and sediment per Best Management Practices (BMP) and local, state, and federal regulations.

Once the site is stabilized, the contractor should remove and properly dispose of erosion and sediment per BMP and all local, state, and federal regulations. Care should be taken during removal to prevent collected sediment or debris from entering the stormwater system. Once the controls are removed, the system should be flushed to remove any sediment or construction debris by following the maintenance procedure outlined below.

During the first service year, a visual inspection should be completed during and after each major rainfall event, in addition to semi-annual inspections, to establish a pattern of sediment and debris buildup. Each stormwater system is unique, and multiple criteria can affect maintenance frequency. For example, whether or not a system design includes inlet protection or a pretreatment device has a substantial effect on the system's need for maintenance. Other factors include where the runoff is coming from (hardscape, gravel, soil, etc.) and seasonal changes like autumn leaves and winter salt.

During and after the second year of service, an established annual inspection frequency, based on the information collected during the first year, should be followed. At a minimum, an inspection should be performed semi-annually. Additional inspections may be required at the change of seasons for regions that experience adverse conditions (leaves, cinders, salt, sand, etc).

Maintenance Procedures

Inspection:

1. Inspect all observation ports, inflow and outflow connections, and the discharge area.
2. Identify and log any sediment and debris accumulation, system backup, or discharge rate changes.
3. If there is a sufficient need for cleanout, contact a local cleaning company for assistance.

Cleaning:

1. If a pretreatment device is installed, follow manufacturer recommendations.
2. Using a vacuum pump truck, evacuate debris from the inflow and outflow points.
3. Flush the system with clean water, forcing debris from the system.
4. Repeat steps 2 and 3 until no debris is evident.

11.0 System Sizing

System Sizing Calculation

This section provides a brief description of the process required to size the StormTank® Module system. If you need additional assistance in determining the required number of Modules or assistance with the proposed configuration, it is recommended that you contact Brentwood or your local distributor. Additionally, Brentwood's volume calculator can help you to estimate the available storage volumes with and without stone storage. This tool is available at www.brentwoodindustries.com.

1. Determine the required storage volume (Vs):

It is the sole responsibility of the Engineer of Record to calculate the storage volume in accordance with all local, state, and federal regulations.

2. Determine the required number of Modules (N):

If the storage volume does not include stone storage, take the total volume divided by the selected Module storage volume. If the stone storage is to be included, additional calculations will be required to determine the available stone storage for each configuration.

3. Determine the required volume of stone (Vstone):

The system requires a minimum 6" (152 mm) leveling bed, 12" (305 mm) backfill around the system, and 12" (305 mm) top backfill utilizing 3/4" (19 mm) angular clean stone. Therefore, take the area of the system times the leveling bed and the top backfill. Once that value is determined, add the volume based on the side backfill width times the height from the invert of the Modules to the top of the Modules.

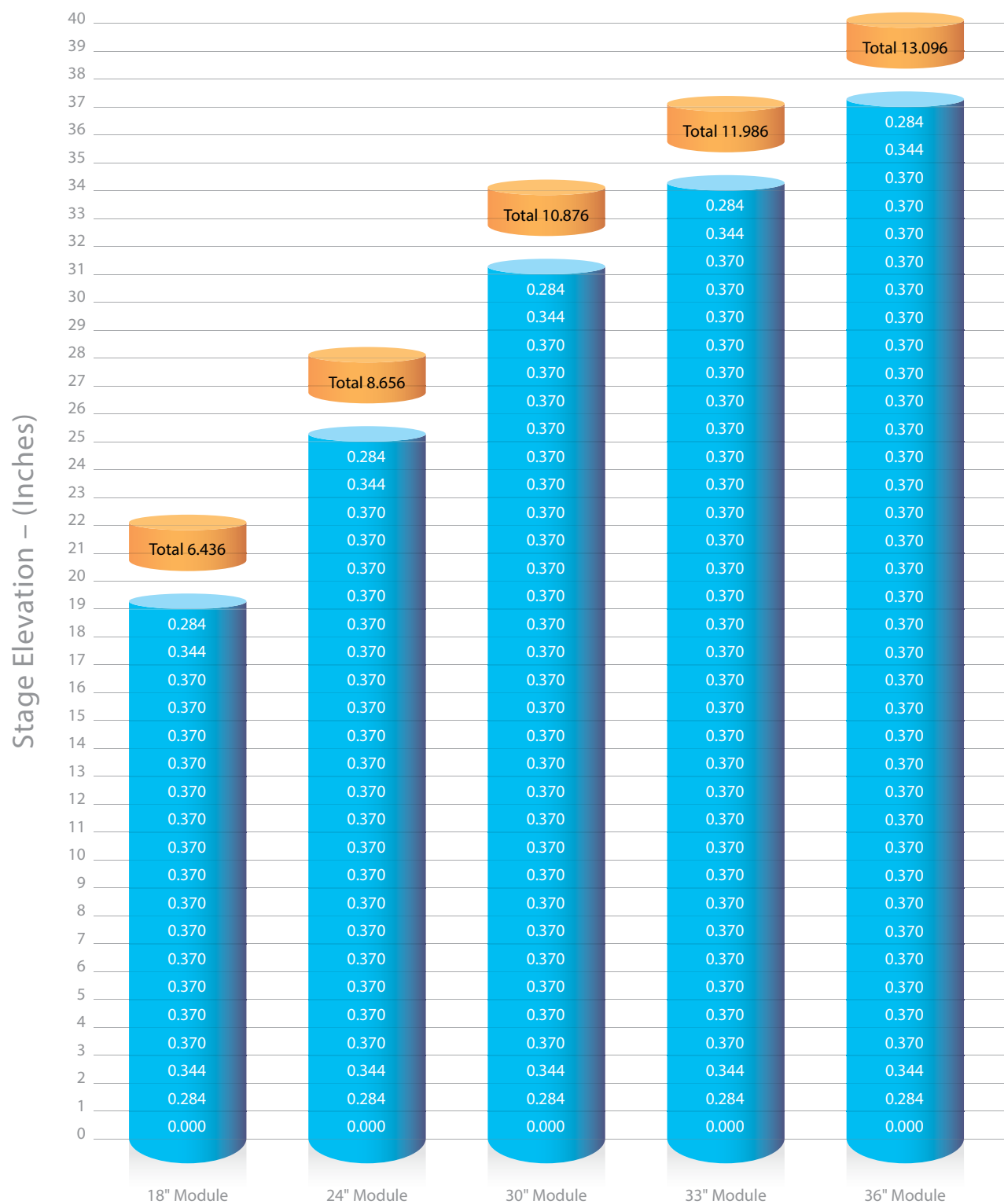
4. Determine the required excavation volume (Vexc):

Utilizing the area of the system, including the side backfill, multiply by the depth of the system including the leveling bed. It is noted that this calculation should also include any necessary side pitch or benching that is required for local, state, or federal safety standards.

5. Determine the required amount of geotextile (G):

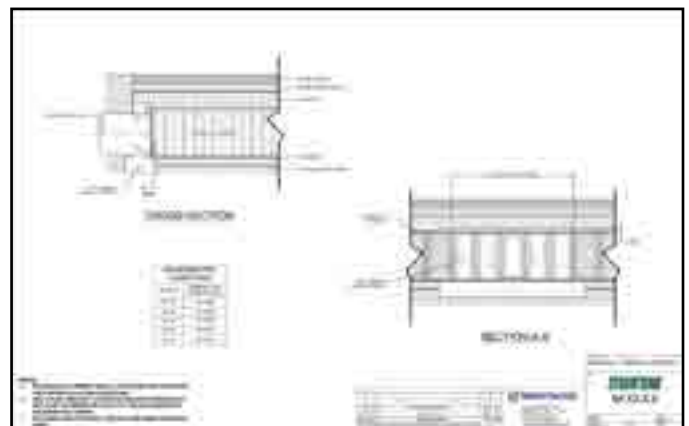
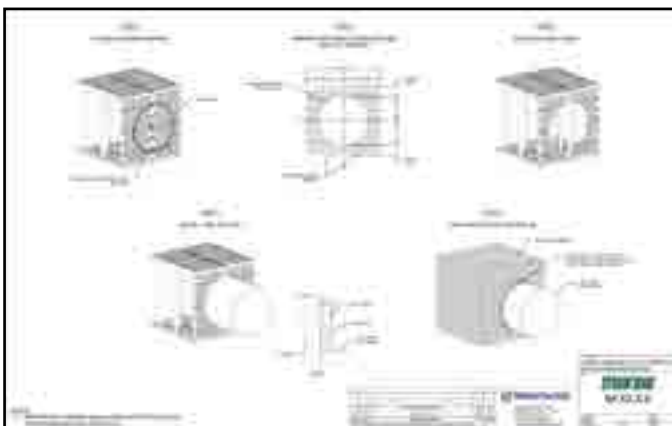
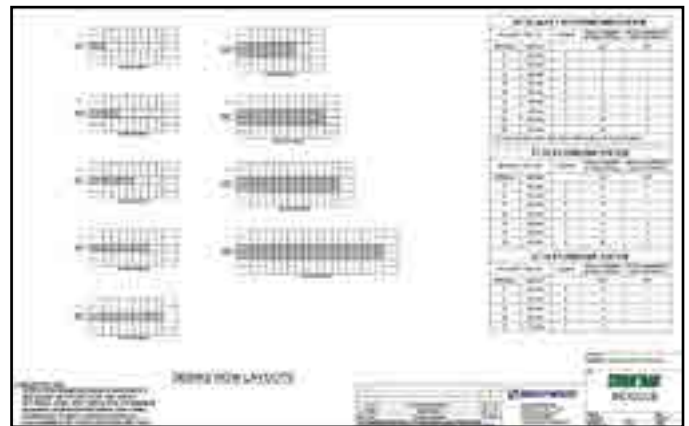
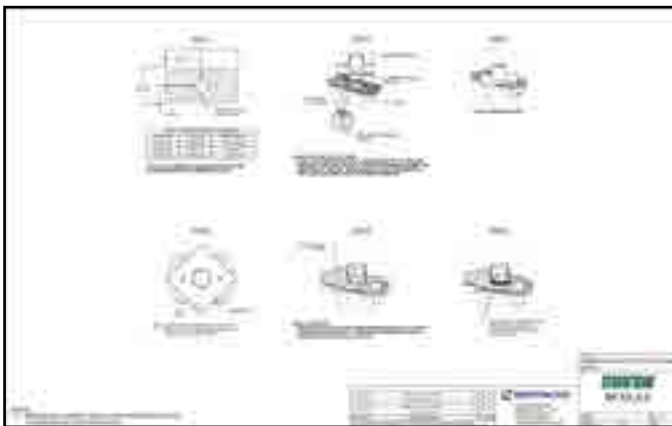
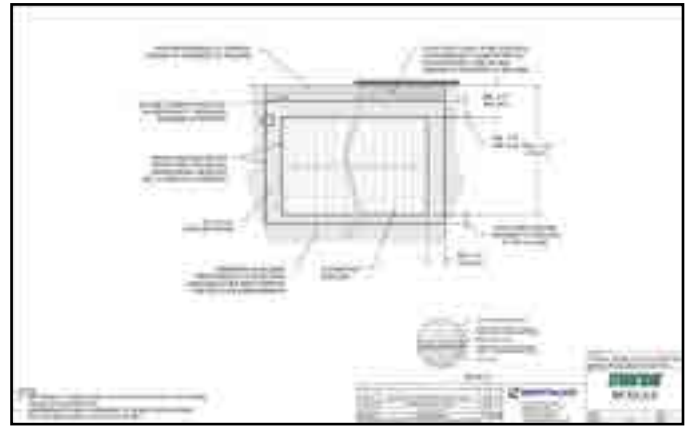
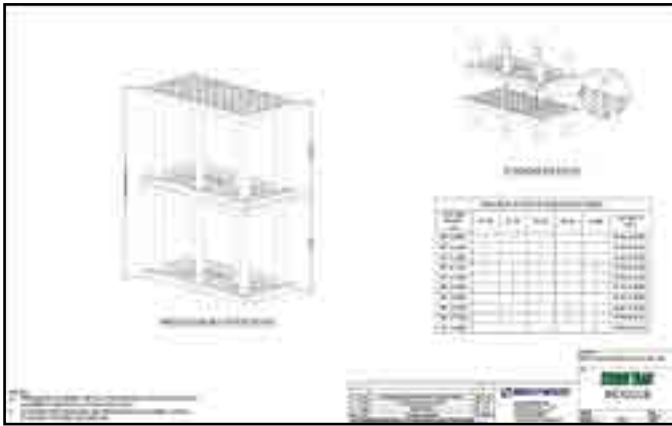
The system utilizes a multiple layer system of geotextile fabric. Therefore, two calculations are required to determine the necessary amount of geotextile. The first layer surrounds the entire system (including all backfill), and the second layer surrounds the Module system only. It is recommended that an additional 20% be included for waste and overlap.

11.1 Storage Volume



12.0 Detail Drawings

Brentwood has developed numerous drawings for utilization when specifying a StormTank® Module system. Below are some examples of drawings available at www.brentwoodindustries.com.



13.0 Specifications

1) General

- a) This specification shall govern the implementation, performance, material, and fabrication pertaining to the subsurface stormwater storage system. The subsurface stormwater storage system shall be manufactured by Brentwood Industries, Inc., 500 Spring Ridge Drive, Reading, PA 19610 (610.374.5109), and shall adhere to the following specification at the required storage capacities.
- b) All work is to be completed per the design requirements of the Engineer of Record and to meet or exceed the manufacturer's design and installation requirements.

2) Subsurface Stormwater Storage System Modules

- a) The subsurface stormwater storage system shall be constructed from virgin polypropylene and 100% recycled PVC to meet the following requirements:
 - i) High-Impact Polypropylene Copolymer Material
 - (1) Injection molded, polypropylene, top/bottom platens and side panels formed to a dimension of 36" (914 mm) long by 18" (457 mm) wide [nominal].
 - ii) 100% Recycled PVC Material
 - (1) PVC conforming to ASTM D-1784 Cell Classification 12344 b-12454 B.
 - (2) Extruded, rigid, and 100% recycled PVC columns sized for applicable loads as defined by Section 3 of the AASHTO LRFD Bridge Design Specifications and manufactured to the required length per engineer-approved drawings.
 - iii) Platens and columns are assembled on site to create Modules, which can be uniformly stacked up to two Modules high, in vertical structures of variable height (custom for each project).
 - iv) Modular stormwater storage units must have a minimum 95% void space and be continuously open in both length and width, with no internal walls or partitions.

3) Submittals

- a) Only systems that are approved by the engineer will be allowed.
- b) At least 10 days prior to bid, submit the following to the engineer to be considered for pre-qualification to bid:
 - i) A list of materials to be provided for work under this article, including the name and address of the materials producer and the location from which the materials are to be obtained.
 - ii) Three hard copies of the following:
 - (1) Shop drawings.
 - (2) Specification sheets.
 - (3) Installation instructions.
 - (4) Maintenance guidelines.
- c) Subsurface Stormwater Storage System Component Samples for review:
 - i) Subsurface stormwater storage system Modules provide a single 36" (914 mm) long by 18" (457 mm) wide, height as specified, unit of the product for review.
 - ii) Sample to be retained by owner.
- d) Manufacturers named as acceptable herein are not required to submit samples.

4) Structural Design

- a) The structural design, backfill, and installation requirements shall ensure the loads and load factors specified in the AASHTO LRFD Bridge Design Specifications, Section 3 are met.
- b) Product shall be tested under minimum installation criteria for short-duration live loads that are calculated to include a 20% increase over the AASHTO Design Truck standard with consideration for impact, multiple vehicle presences, and live load factor.
- c) Product shall be tested under maximum burial criteria for long-term dead loads.
- d) The engineer may require submission of third-party test data and results in accordance with items 4b and 4c to ensure adequate structural design and performance.

14.0 Appendix - Bearing Capacity Tables

Cover		HS-25 (Unfactored)		HS-25 (Factored)	
English (in)	Metric (mm)	English (ksf)	Metric (kPa)	English (ksf)	Metric (kPa)
24	610	1.89	90.45	4.75	227.43
25	635	1.82	86.96	4.53	216.90
26	660	1.75	83.78	4.34	207.80
27	686	1.69	80.88	4.16	199.18
28	711	1.63	78.24	3.99	191.04
29	737	1.58	75.82	3.84	183.86
30	762	1.54	73.62	3.70	177.16
31	787	1.50	71.60	3.57	170.93
32	813	1.46	69.75	3.45	165.19
33	838	1.42	68.06	3.34	159.92
34	864	1.39	66.51	3.24	155.13
35	889	1.36	65.10	3.14	150.34
36	914	1.33	63.80	3.05	146.03
37	940	1.31	62.62	2.97	142.20
38	965	1.29	61.54	2.90	138.85
39	991	1.26	60.55	2.83	135.50
40	1,016	1.25	59.65	2.76	132.15
41	1,041	1.23	58.54	2.70	129.28
42	1,067	1.21	58.09	2.67	127.84
43	1,092	1.20	57.42	2.60	124.49
44	1,118	1.19	56.81	2.55	122.09
45	1,143	1.18	56.26	2.50	119.70
46	1,168	1.16	55.77	2.46	117.79
47	1,194	1.16	55.33	2.42	115.87
48	1,219	1.15	54.94	2.39	114.43
49	1,245	1.14	54.59	2.36	113.00
50	1,270	1.13	54.29	2.33	111.56
51	1,295	1.13	54.03	2.30	110.12
52	1,321	1.12	53.80	2.27	108.69
53	1,346	1.12	53.62	2.25	107.73
54	1,372	1.12	53.46	2.23	106.77
55	1,397	1.11	53.34	2.21	105.82
56	1,422	1.11	53.24	2.19	104.86
57	1,448	1.11	53.18	2.17	103.90
58	1,473	1.11	53.14	2.16	103.42
59	1,499	1.11	53.12	2.14	102.46
60	1,524	1.11	53.13	2.13	101.98
61	1,549	1.11	53.16	2.12	101.51
62	1,575	1.11	53.21	2.11	101.03
63	1,600	1.11	53.28	2.10	100.55
64	1,626	1.11	53.37	2.09	100.07
65	1,651	1.12	53.48	2.08	99.59
66	1,676	1.12	53.61	2.08	99.59
67	1,702	1.12	53.75	2.07	99.11
68	1,727	1.13	53.91	2.07	99.11
69	1,753	1.13	54.08	2.06	98.63

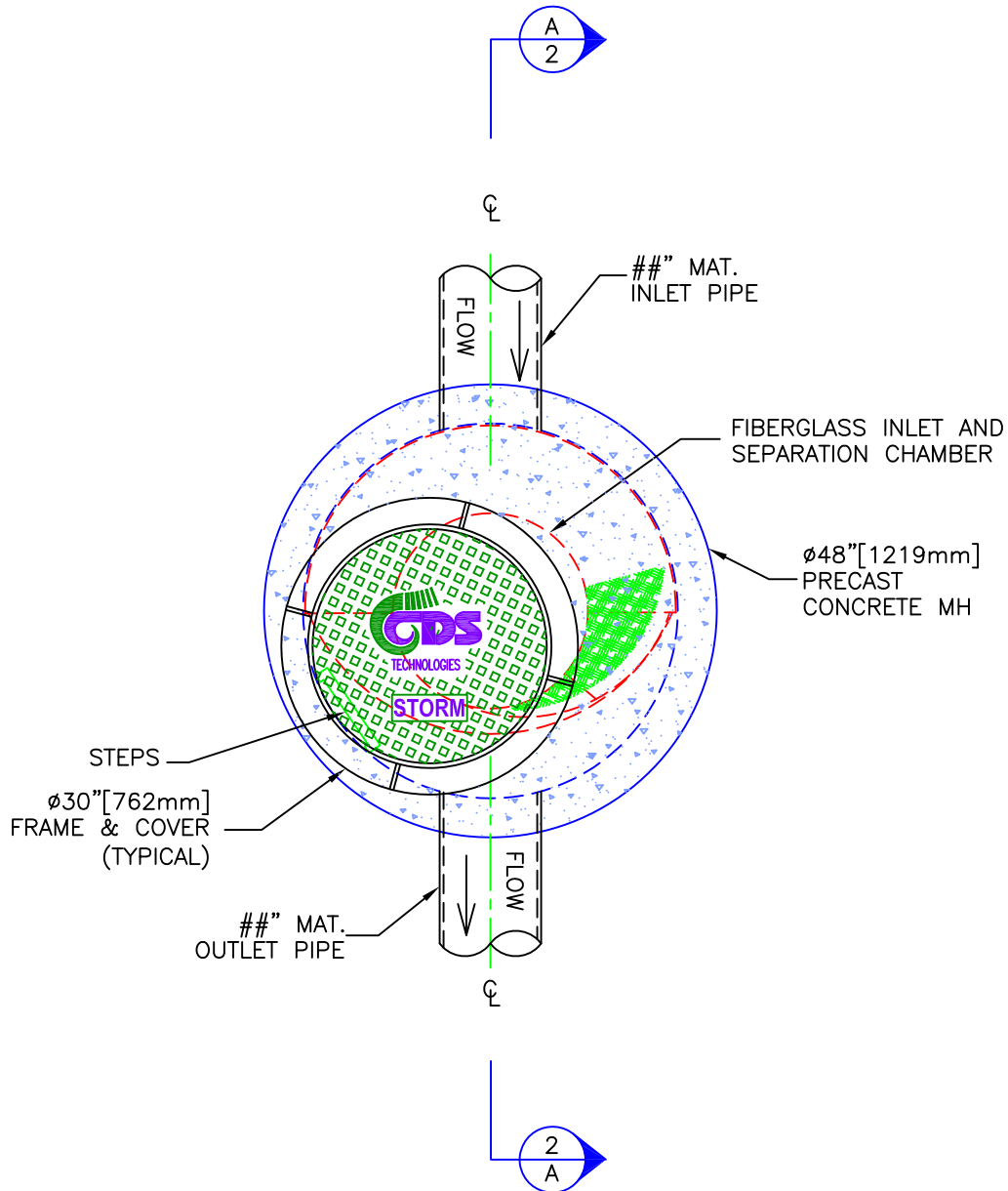
Cover		HS-25 (Unfactored)		HS-25 (Factored)	
English (in)	Metric (mm)	English (ksf)	Metric (kPa)	English (ksf)	Metric (kPa)
70	1,778	1.13	54.26	2.06	98.63
71	1,803	1.14	54.46	2.06	98.63
72	1,829	1.14	54.67	2.06	98.63
73	1,854	1.15	54.90	2.06	98.63
74	1,880	1.15	55.13	2.06	98.63
75	1,905	1.16	55.38	2.06	98.63
76	1,930	1.16	55.64	2.06	98.63
77	1,956	1.17	55.90	2.06	98.63
78	1,981	1.17	56.18	2.06	98.63
79	2,007	1.18	56.46	2.07	99.11
80	2,032	1.19	56.76	2.07	99.11
81	2,057	1.19	57.06	2.07	99.11
82	2,083	1.20	57.37	2.08	99.59
83	2,108	1.20	57.69	2.08	99.59
84	2,134	1.21	58.02	2.09	100.07
85	2,159	1.22	58.35	2.09	100.07
86	2,184	1.23	58.69	2.10	100.55
87	2,210	1.23	59.04	2.11	101.03
88	2,235	1.24	59.39	2.11	101.03
89	2,261	1.25	59.75	2.12	101.51
90	2,286	1.26	60.11	2.13	101.98
91	2,311	1.26	60.48	2.13	101.98
92	2,337	1.27	60.86	2.14	102.46
93	2,362	1.28	61.24	2.15	102.94
94	2,388	1.29	61.62	2.16	103.42
95	2,413	1.30	62.01	2.17	103.90
96	2,438	1.30	62.41	2.18	104.38
97	2,464	1.31	62.81	2.19	104.86
98	2,489	1.32	63.21	2.20	105.34
99	2,515	1.33	63.62	2.21	105.82
100	2,540	1.34	64.03	2.22	106.29
101	2,565	1.35	64.45	2.23	106.77
102	2,591	1.35	64.87	2.24	107.25
103	2,616	1.36	65.29	2.25	107.73
104	2,642	1.37	65.72	2.27	108.69
105	2,667	1.38	66.15	2.28	109.17
106	2,692	1.39	66.58	2.29	109.65
107	2,718	1.40	67.02	2.30	110.12
108	2,743	1.41	67.45	2.31	110.60
109	2,769	1.42	67.90	2.33	111.56
110	2,794	1.43	68.34	2.34	112.04
111	2,819	1.44	68.79	2.35	112.52
112	2,845	1.45	69.24	2.36	113.00
113	2,870	1.46	69.69	2.38	113.96
114	2,896	1.47	70.15	2.39	114.43



APPENDIX E

OIL/GRIT SEPARATOR DETAILS & MAINTENANCE MANUAL

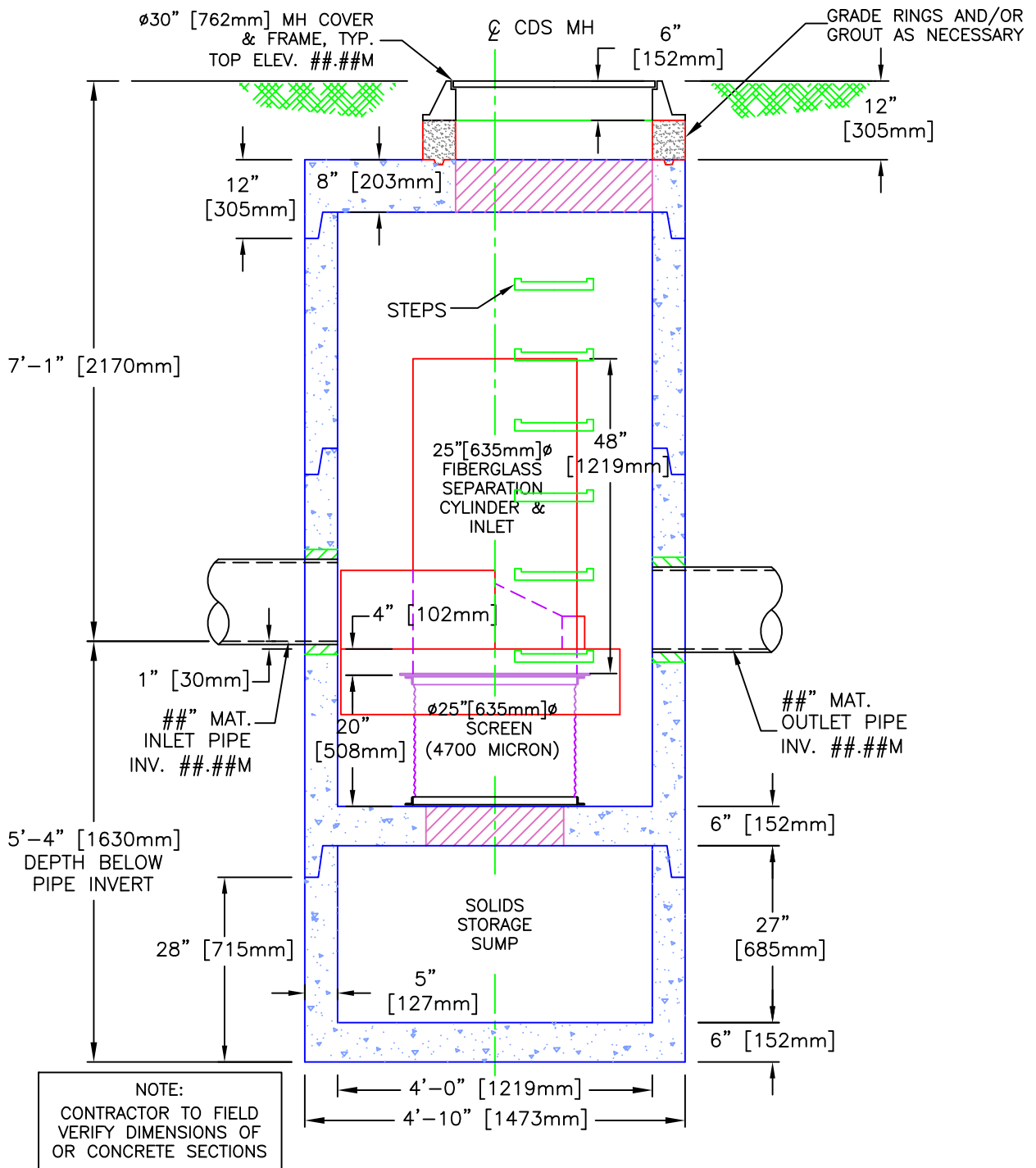
PLAN VIEW



CDS MODEL PMSU20_15_4m STORMWATER TREATMENT UNIT



SECTION A-A ELEVATION VIEW



**CDS MODEL PMSU20_15_4m
STORMWATER TREATMENT UNIT**



PROJECT NAME
CITY, STATE

JOB# XX-##-###

DATE ##/##/##

DRAWN INITIALS

APPROV.

SCALE
1" = 2'

SHEET

2

CDS Average Annual Efficiency For TSS Removal & Total Annual Volume Treated

Area = 0.43 ha C = 0.88 CDS Model: PMSU2015_4 Flowrate: 20 l/s IDF Data: Barrie PSD: FINE	Upstream Storage: Storage 165 m ³	Engineer: Pearson Engineering Contact: M. Dejean, P.Eng. Date: 15-Nov-18 Project: 233 Dunlop Street West Location: Barrie, ON OGS ID: OGS
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Return	Period	Peak Flow	TSS Percentage Captured	Treated Flow Volume	Total Flow Volume	Annual Exceedance Probability	System Flow	CDS Flow	By-Pass Flow	Volume Percentage Treated
month / yr	Yr	l/s	%	litres	litres	%	l/s	l/s	l/s	%
1-M	0.08	3.53	95.53	7919	7919	100.00	3.53	3.53	0.00	100.00
2-M	0.17	5.15	94.03	11427	11427	99.75	5.15	5.15	0.00	100.00
3-M	0.25	6.51	92.77	14380	14380	98.17	6.51	6.51	0.00	100.00
4-M	0.33	7.74	91.61	17091	17091	95.04	7.74	7.74	0.00	100.00
5-M	0.42	8.69	90.71	19212	19212	90.91	8.69	8.69	0.00	100.00
6-M	0.50	9.65	89.80	21334	21334	86.47	9.65	9.65	0.00	100.00
7-M	0.58	10.37	89.12	22948	22948	82.01	10.37	10.37	0.00	100.00
8-M	0.67	11.09	88.44	24563	24563	77.67	11.09	11.09	0.00	100.00
9-M	0.75	11.81	87.76	26177	26177	73.64	11.81	11.81	0.00	100.00
10-M	0.83	12.37	87.22	27467	27467	69.90	12.37	12.37	0.00	100.00
11-M	0.92	12.94	86.68	28757	28757	66.40	12.94	12.94	0.00	100.00
1-Yr	1	13.51	86.14	30047	30047	63.21	13.51	13.51	0.00	100.00
2-Yr	2	18.19	81.66	40956	40956	39.35	18.19	18.19	0.00	100.00
5-Yr	5	26.98	69.88	56612	62548	18.13	26.98	20.10	6.88	90.51
10-Yr	10	33.45	61.68	64503	79630	9.52	33.45	20.10	13.35	81.00
25-Yr	25	41.02	54.00	72582	101174	3.92	41.02	20.10	20.91	71.74
50-Yr	50	45.55	50.15	77032	115000	1.98	45.55	20.10	25.44	66.98
100-Yr	100	48.80	47.65	80166	125490	1.00	48.80	20.10	28.70	63.88

Average Annual TSS Removal Efficiency [%]:	89.7	Ave. Ann. T. Volume [%]:	99.4
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Notes:

- 1) CDS Efficiency based on testing conducted at the University of Central Florida
- 2) CDS design flowrate and scaling based on standard manufacturer model & product specifications





CDS[®] System

Maintenance

Procedures For General Inspection and Cleaning

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help insure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (i.e. spring and fall), however; more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Additionally, installations where excessive amounts of trash are expected should be inspected more frequently.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions to inlet and/or separation screen. The inspection should also identify evidence of vector infestation and accumulations of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If sorbent material is used for enhanced removal of hydrocarbons then the level of discoloration of the sorbent material should also be identified during inspection. It is useful and often required as part of a permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (center cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained behind the screen. For units possessing a sizable depth below grade (depth to pipe), a single manhole access point would allow both sump cleanout and access behind the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded; however, it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine if the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of the CDS systems should be done during dry weather conditions when no flow is entering the system. Cleanout of the CDS with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. Simply remove the manhole

covers and insert the vacuum hose into the sump through the center cylinder. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should be pumped out also if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants. If the screen requires cleaning, it can be washed from the surface or from the CDS inlet structure through the center cylinder.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure proper safety precautions. Confined Space Entry procedures need to be followed.

Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

SAMPLE INSPECTION & MAINTENANCE LOG

DATE/ INSPECTOR	FUNCTIONALITY/ COMPONENTS	FLOATABLES LAYER THICKNESS (IN)	DEPTH TO SEDIMENT (A) (FT)	SEDIMENT CAPACITY USED ((B-A)/D*100) %	SORBENT DISCOLORATION	MAINTENANCE PERFORMED
11/1/06/TPG	OK	.5	14	33	SLIGHT	NONE
5/1/07	OK	1	13	67	MODERATE	NONE
10/1/07	OK	2	12.5	83	HIGH	CLEANING SCHEDULED
11/1/07	OK	0	15	0	NONE	SYSTEM CLEANED

(B) DEPTH FROM GROUND SURFACE TO BOTTOM OF SUMP: 15 (FT)

(C) DEPTH FROM GROUND SURFACE TO TOP SUMP: 12 (FT)

(D) HEIGHT OF SUMP = B - C = 3 (FT)

OBSERVATIONS OF FUNCTION: _____

CDS SYSTEM INSPECTION AND MAINTENANCE LOG

[illegible]

(B) DEPTH FROM GROUND SURFACE TO BOTTOM OF SUMP: _____ (FT)

(C) DEPTH FROM GROUND SURFACE TO TOP SUMP: _____ (FT)

(D) HEIGHT OF SUMP = B - C = _____ (FT)

OBSERVATIONS OF FUNCTION: _____



CANADIAN ENVIRONMENTAL TECHNOLOGY VERIFICATION

Enhancing the Credibility of Environmental Technologies

TECHNOLOGY VERIFIED: CDS Hydrodynamic Separator®

Performance Claim

Capture test^a:

During the sediment capture test, the Contech CDS OGS device 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, removed 74, 70, 63, 53, 45, 42, 32 and 23 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, 1400 and 1893 L/min/m², respectively.

Scour test^a:

During the scour test, the Contech CDS OGS device with preloaded test sediment reaching 50% of the manufacturer's recommended maximum sediment storage depth, generated corrected effluent concentrations of 1.8, 6.5, 8.2, 11.2, and 309.3 mg/L during a test run¹ with approximately 5 minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m², respectively.

Light liquid re-entrainment test^a:

During the light liquid re-entrainment test, the Contech CDS OGS device with surrogate low-density polyethylene beads preloaded within the oil collection skirt area, representing floating liquid to a volume equal to a depth of 50.8 mm over the sedimentation area, retained 100, 99.9, 98.6, 99.5, and 99.7 percent of loaded beads by volume during a test run^b with 5 minutes duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m², respectively.

^a 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)

^b See variance #1 in "Variances from testing procedure" section

VERIFIED* PERFORMANCE:
MARCH 2017

License Number: ETV 2017-02

Issued to: CONTECH Engineered Solutions LLC

Expiration Date: March 31, 2020


John D. Wiebe, PhD
Executive Chairman



Canada

* This verification conforms to the Canadian ETV Program's General Verification Protocol and the ISO 14034:2016.
Please refer to Technology Fact Sheet for additional information on the verification of this performance claim.

CANADIAN ETV VERIFIED

CDS Hydrodynamic Separator®

Technology Fact Sheet for CONTECH Engineered Solutions LLC



Technology description and application

The CDS® is a Stormwater treatment device designed to remove pollutants, including sediment, trash and hydrocarbons from Stormwater runoff. The CDS is typically comprised of a manhole that houses flow and screening controls that use a combination of swirl concentration and continuous deflective separation.

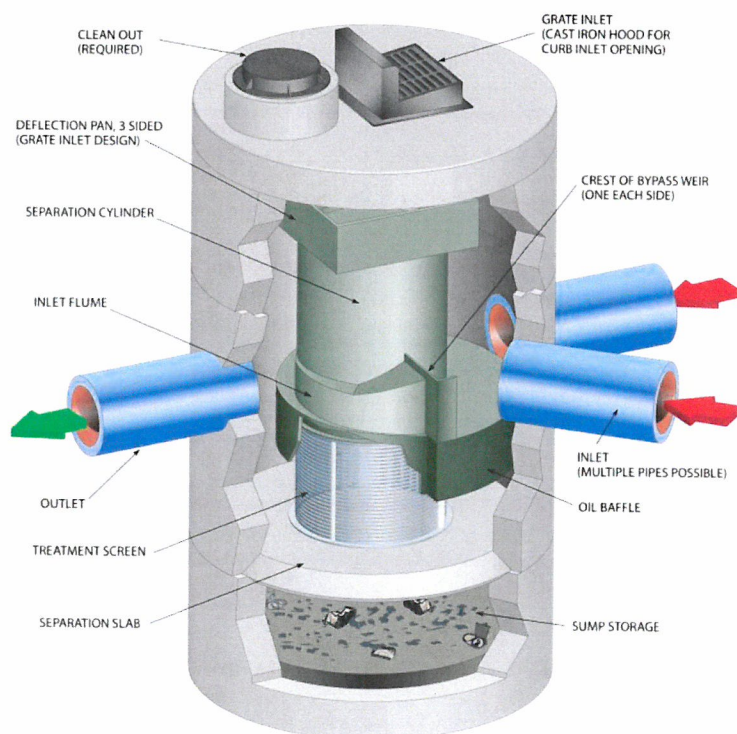


Figure 1. Graphic of typical inline CDS unit and core components.

When stormwater runoff enters the CDS unit's diversion chamber, the diversion pan guides the flow into the unit's separation chamber. The water and associated gross pollutants contained within the separation cylinder are kept in continuous circular motion by the energy generated from the incoming flow. This has the effect of a continuous deflective separation of the pollutants and their eventual deposition into the sump storage below. A perforated screen plate allows the filtered water to pass through to a volute return system and thence to the outlet pipe. The oil and other light liquids are retained within the oil baffle. Figure 1 shows a schematic representation of a typical CDS unit including critical components.

Performance conditions

The data and results published in this Technology Fact Sheet were obtained from the testing program conducted on the Contech CDS-4 OGS device, 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 Environment Canada's Environmental Technology Verification (ETV) Program requirements. A copy of the Procedure may be accessed on the Canadian ETV website at www.etvcanada.ca.

Performance claim(s)

Capture test^a:

During the sediment capture test, the Contech CDS OGS device 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, removed 74, 70, 63, 53, 45, 42, 32 and 23 percent of influent sediment by mass at surface loading rates of 40, 80, 200, 400, 600, 1000, 1400 and 1893 L/min/m², respectively.

Scour test^a:

During the scour test, the Contech CDS OGS device with preloaded test sediment reaching 50% of the manufacturer's recommended maximum sediment storage depth, generated corrected effluent concentrations of 1.8, 6.5, 8.2, 11.2, and 309.3 mg/L during a test run^b with approximately 5 minute duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m², respectively.

Light liquid re-entrainment test^a:

During the light liquid re-entrainment test, the Contech CDS OGS device with surrogate low-density polyethylene beads preloaded within the oil collection skirt area, representing floating liquid to a volume equal to a depth of 50.8 mm over the sedimentation area, retained 100, 99.9, 98.6, 99.5, and 99.7 percent of loaded beads by volume during a test run^b with 5 minutes duration surface loading rates of 200, 800, 1400, 2000, and 2600 L/min/m², 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 2 indicates that the test sediment used for the capture and scour tests met this condition.

^a 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 Testing of Oil Grit Separators (Version 3.0, June 2014)

^b See variance #1 in "Variances from testing procedure" section below.

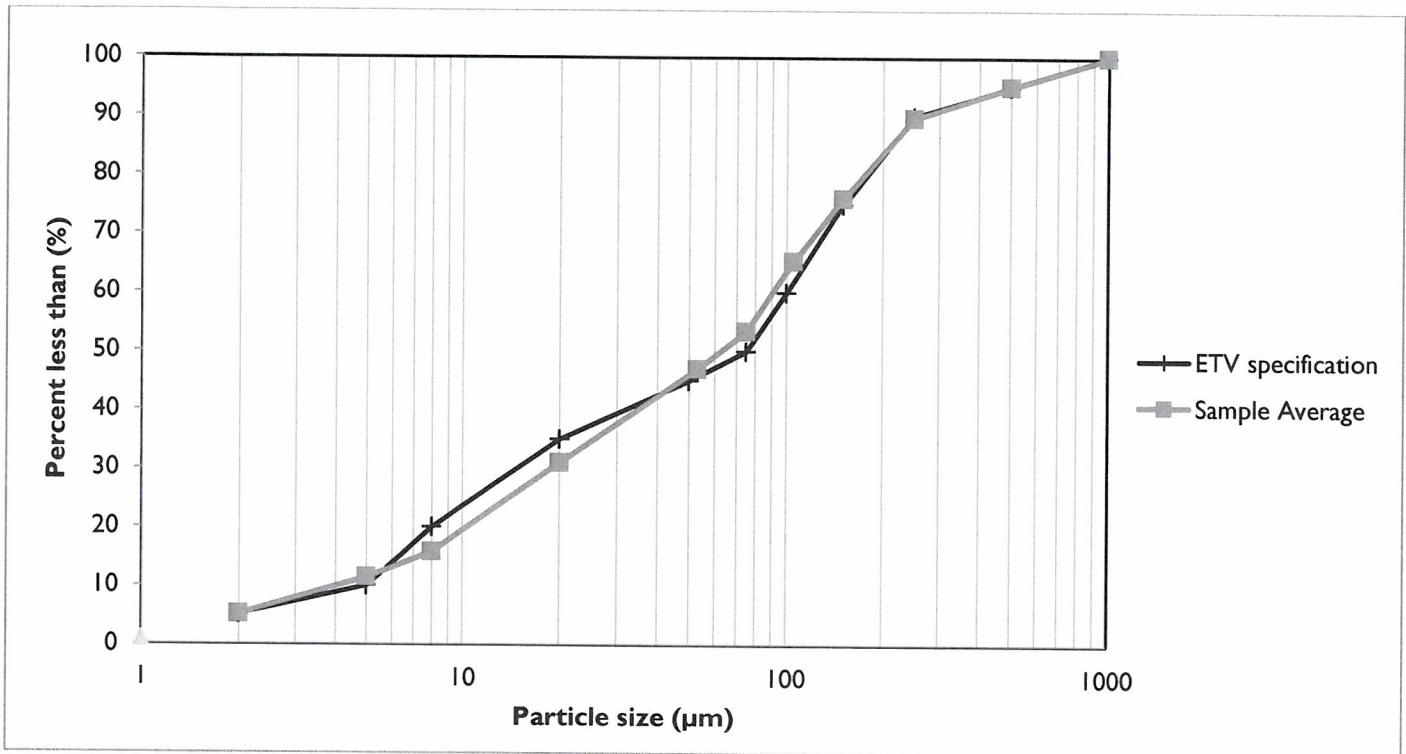


Figure 2. The three sample average particle size distribution (PSD) of the test sediment used for the capture and scour test compared to the specified PSD.

The capacity of the device to retain sediment was determined at eight 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 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 I).

In some instances, the calculated removal efficiencies were above 100% for certain particle size fractions (marked with asterisks in Table I). These discrepancies are not entirely avoidable and may be attributed to errors relating to the blending of sediment, collection of representative samples, 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” in Table I are based on measurements of the total injected and retained sediment mass, and are therefore not subject to sampling or PSD analysis errors.

Environmental Technology Verification

Table I. Removal efficiencies (%) at specified surface loading rates.

Particle size fraction (μm)	Surface loading rate (L/min/m ²)							
	40	80	200	400	600	1000	1400	1893
>500	100	100*	66	79	97	100*	84	77
250 - 500	100*	100*	85	95	100*	91	100*	75
150 - 250	99	100*	100*	97	100	75	68	37
105 - 150	100	100*	100*	74	47	45	30	27
75 - 105	90	91	100*	61	33	36	26	18
53 - 75	71	27	54	100	42	44	15	16
20 - 53	65	51	20	8	10	8	5	4
8 - 20	28	22	9	7	1	1	2	1
5 - 8	30	9	0	8	2	0	1	0
<5	11	8	16	2	6	5	2	2
All particle sizes by mass balance	73.5	70.3	63.4	52.6	45.1	41.5	32.4	23.0

* Removal efficiencies were calculated to be above 100%. Calculated values typically ranged between 101 and 175% (average 126%). Higher values were observed for the >500 μm and 150-250 μm size fractions during the 80 L/min/m² test run. 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 retained sediment at each of the tested surface loading rates. As expected, the capture efficiency for fine particles was generally found to decrease as surface loading rates increased.

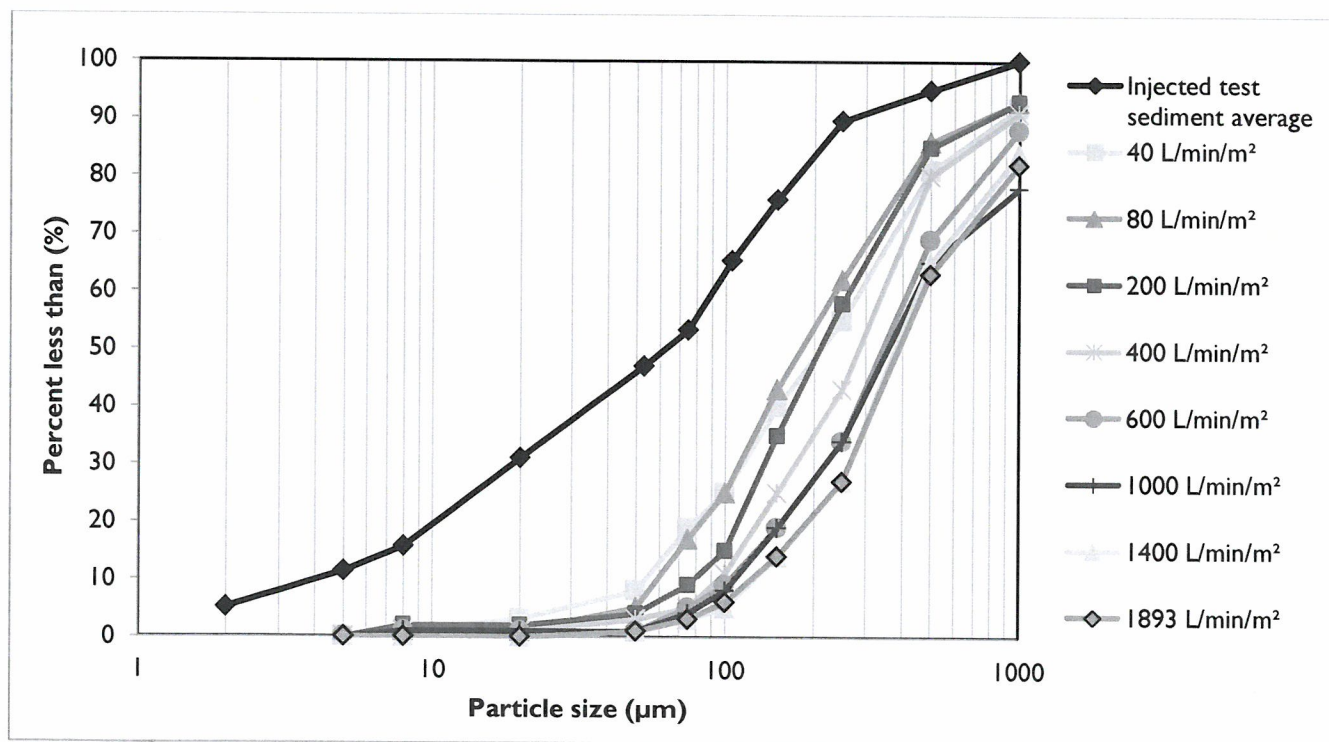


Figure 3. Particle size distribution of retained sediment in relation to the injected test sediment average.

Environmental Technology Verification

Table 2 shows the results of the sediment scour and re-suspension test. This test involved preloading 10.2 cm of fresh test sediment into the sedimentation sump of the device. The sediment was placed on a false floor to mimic a device filled to 50% of the maximum recommended sediment storage depth. Sediment was also pre-loaded to the same depth on the separation slab (see Figure 1) since sediment was observed to have been deposited in this area during the sediment capture test. Clean water was run through the device at five surface loading rates over a 36 minute period. The test was stopped and started after the second flow rate in order to change flow meters. Each flow rate was maintained for 5 minutes with a one minute transition time between flow rates. Effluent samples were collected at one minute sampling intervals and analyzed for Suspended Sediment Concentration (SSC) and PSD by recognized methods. 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, as per the method described in [Bulletin # CETV 2016-09-0001](#).

Table 2. Scour test adjusted effluent sediment concentration.

Run	Surface loading rate (L/min/m ²)	Run time (min)	Background sample concentration (mg/L)	Adjusted effluent suspended sediment concentration (mg/L) [†]	Average (mg/L)
1	200	1.03	0.5	1.0	1.8
		2.03		1.6	
		3.03		1.8	
		4.03		1.8	
		5.03		2.6	
2	800	6.23	2.0	5.0	6.5
		7.23		6.7	
		8.23		9.4	
		9.23		5.4	
		10.23		5.9	
3	1400	11.43 [‡]	2.0	3.1	8.2
		12.43		11.0	
		13.43		14.6	
		14.43		7.1	
		15.43		5.2	
4	2000	17.20	3.2	7.3	11.2
		18.20		22.8	
		19.20		6.9	
		20.20		6.8	
		21.20		12.1	
5	2600	22.40	8.5	248.5	309.3
		23.40		83.0	
		24.40		438.9	
		25.40		338.7	
		26.40		437.5	

[†] The adjusted effluent suspended sediment concentration represents the actual measured effluent concentration minus the smallest 5% of sediment particles (i.e. d₅) removed during the 40 L/min/m² capture test, minus the background concentration. For more information see [Bulletin # CETV 2016-09-0001](#).

[‡] See variance #1 in "Variances from testing procedure" section below.

Environmental Technology Verification

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 3. The test involved preloading 58.3 L (corresponding to a 5 cm depth over the collection sump area of 1.17m²) of surrogate low-density polyethylene beads within the oil collection skirt and running clean water through the device at five surface loading rates (200, 800, 1400, 2000, and 2600 L/min/m²) over a 38 minute period. As with the sediment scour test, flow was stopped and started after the second flow rate to change flow meters. Each flow rate was maintained for 5 minutes with approximately 1 minute transition time between flow rates. The effluent flow was screened to capture all re-entrained pellets throughout the test.

Table 3. Light liquid re-entrainment test results.

Target Flow (L/min/m ²)	Time Stamp	Collected Volume (L)	Collected Mass (g)	Percent re-entrained by volume	Percent retained by volume
200	10:48:42	27 pellets	0.8	0.01	99.99
800	10:55:09	0.07	41	0.12	99.88
1400	11:06:59	0.8	439	1.37	98.63
2000	11:13:00	0.31	177	0.53	99.47
2600	11:19:00	0.18	98	0.31	99.69
Interim Collection Net		0.025	14.2	0.04	99.96
Total Loaded		58.3	33398	--	--
Total Re-entrained		1.385	770	--	--
Percent Re-entrained and retained		--	--	2.38	97.62

Variances from testing Procedure

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

1. It was necessary to change flow meters during the scour and light liquid re-entrainment test, as the required flows exceeded the minimum and/or maximum range of any single meter. After the loading rate of 800 L/min/m², the flow was gradually shut down and re-initiated through the larger meter immediately after closing the valve controlling flows to the small meter. The transition time of 1-minute for each target flow was followed, resulting in an elapsed time of 3 minutes to reach the next target flow of 1400 L/min/m². 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.
2. As part of the capture test, evaluation of the 40 L/min/m² surface loading rate was split into 3 parts 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.
3. Inflow concentrations during the 40 L/min/m² surface loading rate varied from 162 mg/L to 246 mg/L, which is wider than specified ± 25 mg/L range in the Procedure.

Environmental Technology Verification

Verification

The verification was completed by Toronto and Region Conservation Authority, using the Canadian ETV Program's General Verification Protocol (March, 2000) and taking into account ISO 14034:2016. Data and information provided by Contech Engineered Solutions to support the performance claim included the following: Performance test report prepared by Alden Research Laboratory, Inc, and dated February 2015; the 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 Canadian ETV?

Canadian Environmental Technology Verification (ETV) is delivered by GLOBE Performance Solutions under a license agreement from Environment Canada. Canadian ETV is designed to support Canada's environment industry by providing credible and independent verification of technology performance claims.

For more information on the CDS Stormwater Treatment System[®] please contact:

CONTECH Engineered Solutions LLC
71 US Route 1, Suite F
Scarborough, ME
04074 USA
Tel: 207-885-9830
info@conteches.com
www.conteches.com

Canadian ETV Contact Information:

c/o GLOBE Performance Solutions
404 – 999 Canada Place
Vancouver, BC
V6C 3E2 Canada
Tel: 604-695-5018 / Toll Free: 1-855-695-5018
etv@globeperformance.com
www.etvcanada.ca

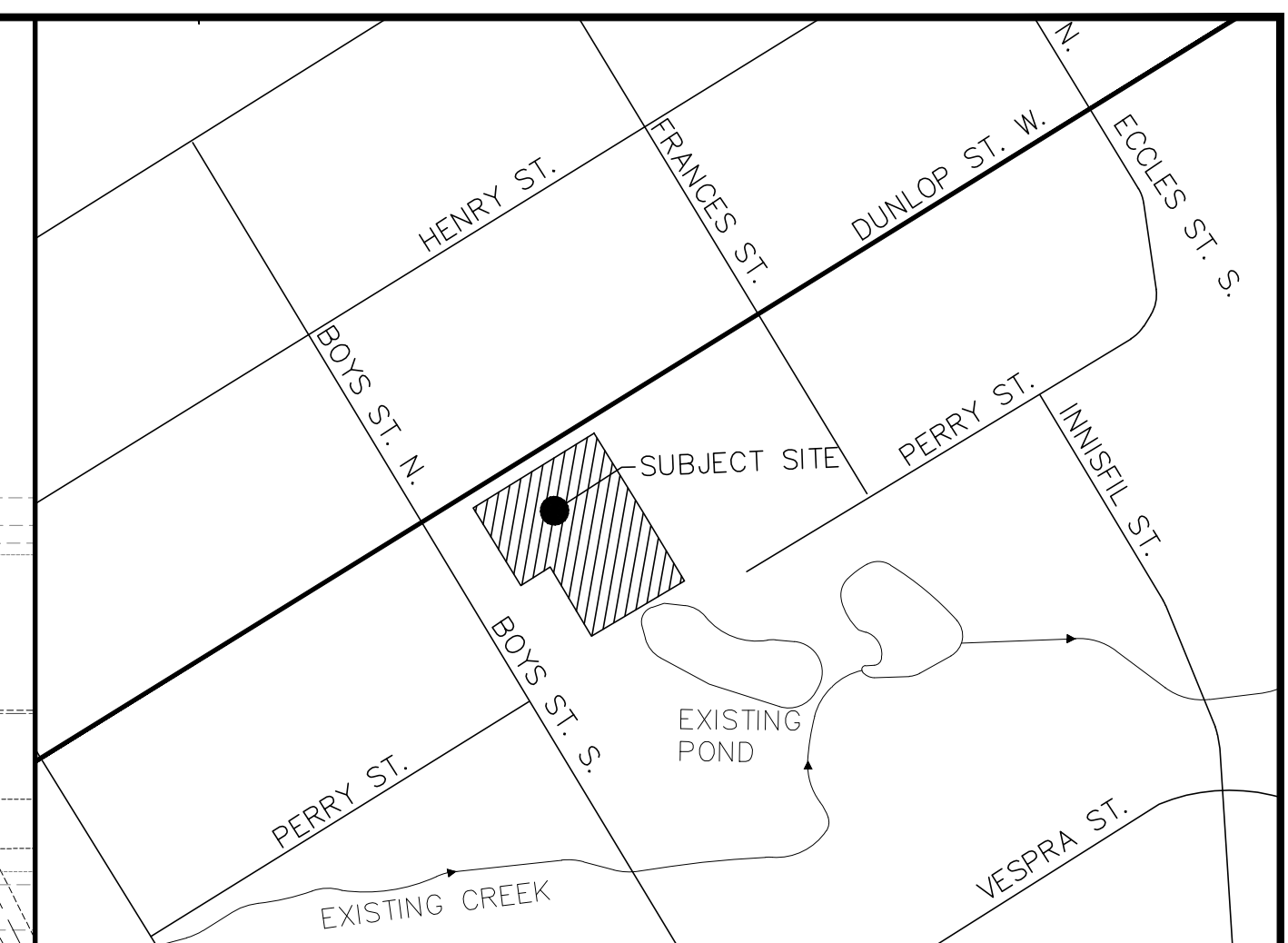
Limitation of verification

Environment Canada, Canadian ETV 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.



APPENDIX F

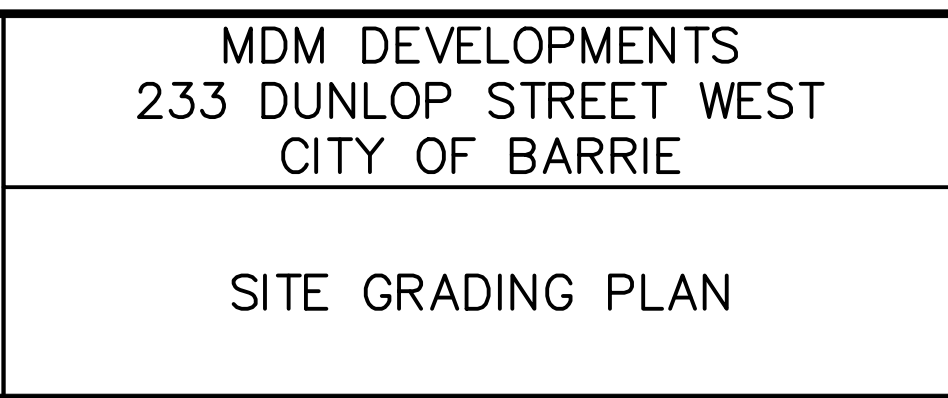
PEARSON ENGINEERING DRAWINGS



DESIGNED BY	TA/MJWP	HORIZ SCALE	1:300	PROJECT #	12081.01
DRAWN BY	MJWP	VERT SCALE		DRAWING #	SS-1
CHECKED BY	MWD	DATE	APRIL 2019	REVISION #	1

BENCHMARK:
HORIZONTAL
MTO MONUMENT 03120040023 MONUMENT CAP IS LOCATED ON THE NORTHEAST CORNER OF DUNLOP ST. W AND COLLIER ST BETWEEN THE SIDEWALK AND THE PROPERTY LINE.
MTO MONUMENT 03120020022 MONUMENT CAP IS LOCATED ON THE SE CORNER OF INNISFIL ST AND VESPERA ST APPROXIMATELY 18.5M FROM ELEVATION OF INNISFIL ST AND APPROXIMATELY 13M FROM CENTERLINE OF VESPERA ST.
MTO MONUMENT 03119310045 ELEVATION 228.735 BARRIE FUNDAMENTAL BENCH-MARK IN QUEENS PARK, 12.2 M NORTHEAST OF CURB AT NORTHEAST SIDE OF PARKSIDE DRIVE, 1.8 M NORTHEAST OF BOUNDARY BETWEEN PARK AND DRILL HALL GROUNDS, TABLET IN TOP.
MTO MONUMENT 03119840119 ELEVATION 232.035 BARRIE FEDERAL BUILDING, TABLET ON CORNER OF COLLIER AND OWEN STREETS, TABLET IN EAST SIDE OF FOUNDATION WALL, IN CENTRE OF INTERSECTION OF COLLIER AND OWEN ST. APPROXIMATELY 7.0 M NORTH OF SOUTHEAST CORNER OF BUILDING, 3.0 CM BELOW BRICK SIDING.

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DRAWN BY	MJWP	VERT SCALE		DRAWING #	SG-1
CHECKED BY	MWD	DATE	APRIL 2019	REVISION #	1



BENCHMARK:
HORIZONTAL
MTO MONUMENT 03102040023 MONUMENT CAP IS LOCATED ON THE NORTHEAST CORNER OF DUNLOP ST. W
AND EGGLES ST BETWEEN THE SIDEWALK AND THE PROPERTY LINE.
MTO MONUMENT 03102040022 MONUMENT CAP IS LOCATED ON THE SE CORNER OF INNISFILL ST AND
VESPERA ST 19.5M FROM INTERSECTION OF INNISFILL ST AND APPROXIMATELY 13M FROM
CENTERLINE OF VESPERA ST.
VERTICAL
MTO MONUMENT 03193114455 ELEVATION 228.735 BARRIE FUNDAMENTAL BENCH-MARK IN QUEENS
PARK, 12.2 M NORTHEAST OF CURB AT NORTHEAST SIDE OF PARKSIDE DRIVE, 1.8 M NORTHEAST OF
QUEENS PARK AND DRAFT HALL GROUNDS, TABLET IN TOP.
MTO MONUMENT 0319844U119 ELEVATION 232.085 BARRIE FEDERAL
BUILDING, AT CORNER OF COLLIER AND OWEN STREETS, TABLET IN EAST SIDE
SMOOTH CONCRETE FOUNDATION WALL, IN CENTRE OF NORTH SIDE OF NOTCH
IN WALL, 7.0 M NORTH OF SOUTHEAST CORNER OF BUILDING, 30 CM BELOW BRICK SIDDING.





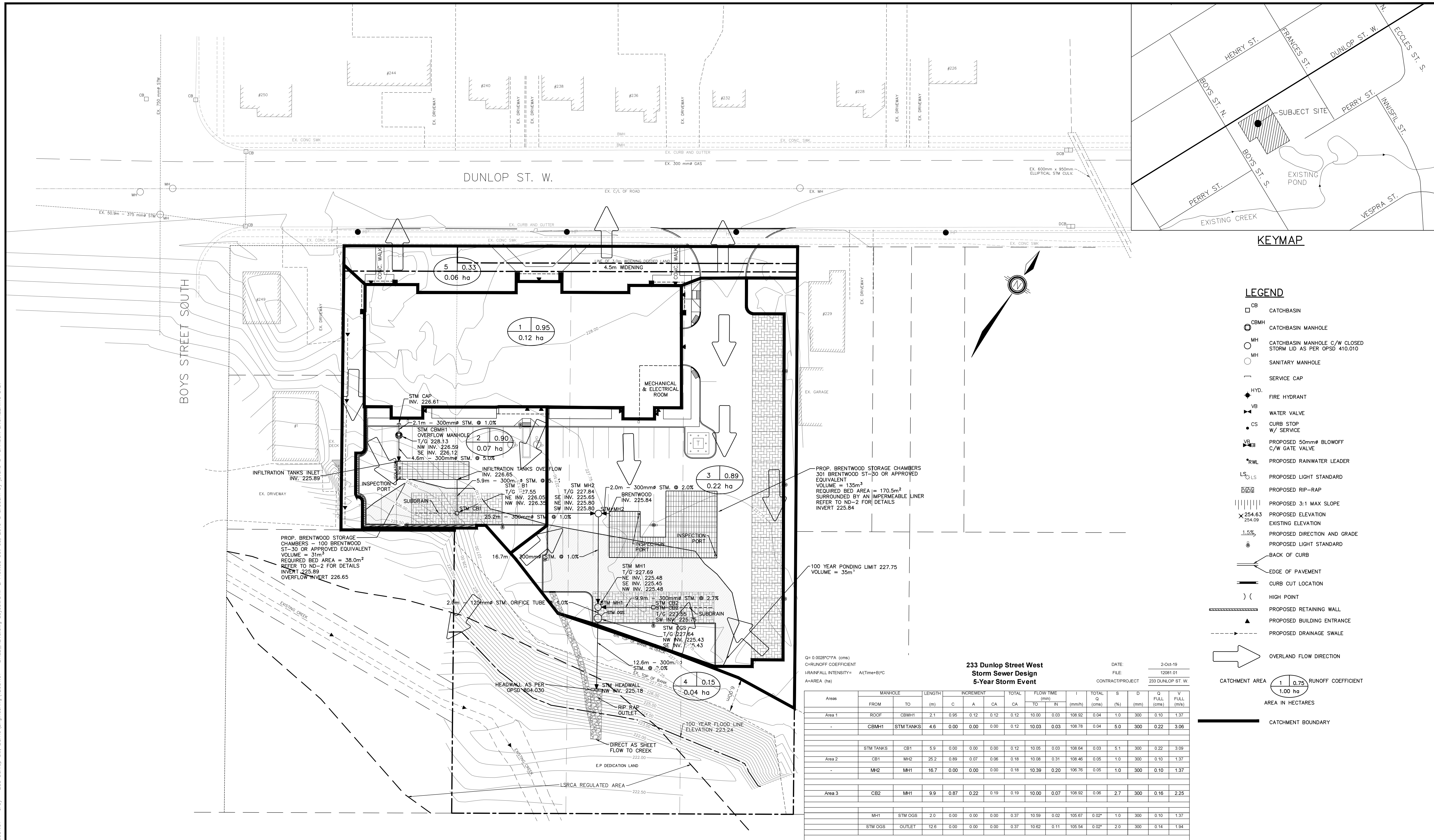
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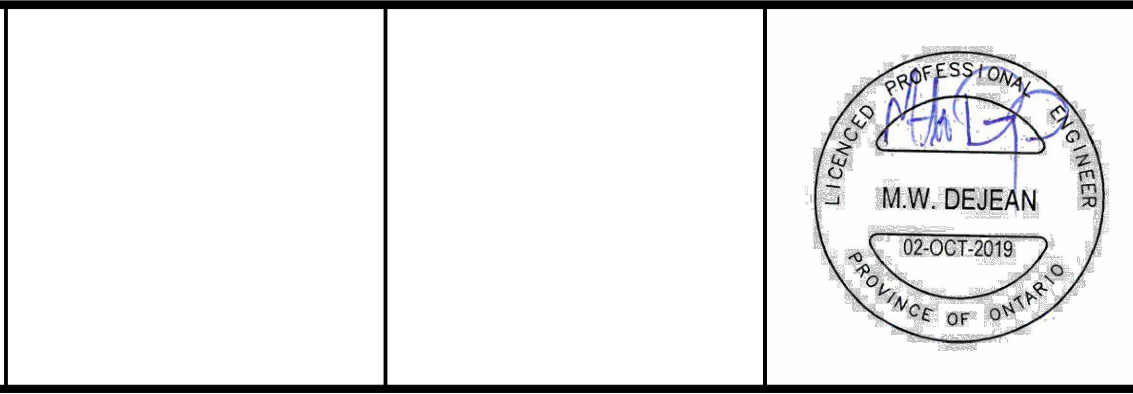
DESIGNED BY	TA/MJWP	HORIZ SCALE	1:300	PROJECT #	12081.01
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CHECKED BY	MWD	DATE	APRIL 2019	REVISION #	1

P:\Autodesk Vault\Working Folders\12081.01 - Grey - 233 Dunlop St., Barrie\Engineering\12081.01 - BASE_REV3.dwg Layout-STM-2 Pelted Oct 03, 2019 @ 8:00am by jevons @ PEARSON ENGINEERING LTD.



NO.	REVISION NOTE	DATE	BY
1.	AS PER FIRST SUBMISSION COMMENTS	10/02/19	JPE

BENCHMARK:
HORIZONTAL
MTO MONUMENT 03120040023 MONUMENT CAP IS LOCATED ON THE NORTHEAST CORNER OF DUNLOP ST. W. AND ECCLES ST. BETWEEN THE SIDEWALK AND THE PROPERTY LINE.
MTO MONUMENT 03120080022 MONUMENT CAP IS LOCATED ON THE SE CORNER OF INNES ST. AND VESPRE ST. APPROXIMATELY 18.5M FROM CENTERLINE OF INNES ST. AND APPROXIMATELY 13M FROM CENTERLINE OF VESPRE ST.
VERTICAL
MTO MONUMENT 0011931U4555 ELEVATION 228.735 BARRIE FUNDAMENTAL BENCH-MARK IN QUEENS PARK, 12.2 M NORTHEAST OF CURB AT NORTHEAST SIDE OF PARKSIDE DRIVE, 1.8 M NORTHEAST OF BOUNDARY BETWEEN PARK AND DRILL HALL GROUNDS, TABLET IN TOP.
MTO MONUMENT 0011984U119 ELEVATION 232.085 BARRIE FEDERAL BUILDING, AT CORNER OF COLLIER AND OWEN STREETS, TABLET IN EAST SIDE SMOOTH STONE FOUNDATION WALL, IN CENTRE OF FIRST STONE NORTH OF NOTCH IN WALL, 7.0 M NORTH OF SOUTHEAST CORNER OF BUILDING, 30 CM BELOW BRICK SIDING.



MDM DEVELOPMENTS
233 DUNLOP STREET WEST
CITY OF BARRIE

POST-DEVELOPMENT STORM
CATCHMENT PLAN

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CHECKED BY	MWD	DATE	APRIL 2019	REVISION #	1

1. OVERALL SITE AREA - 0.72 ha
2. EXISTING LAND USE - RESIDENTIAL & VACANT

1. ENGINEER TO BE NOTIFIED PRIOR TO INITIATION OF ANY ON SITE WORKS.
2. SILT FENCE AND CONSTRUCTION ACCESS MATS TO BE INSTALLED PRIOR TO THE COMMENCEMENT OF ANY WORKS ONSITE.
3. VEGETATION REMOVAL MAY COMMENCE AFTER SILT FENCE IS INSTALLED AND APPROVED BY THE ENGINEER.
4. COMMENCE WITH EARTH EXCAVATION AND SITE SERVICES (TO BE REMOVED FROM SITE - NO STOCKPILE).
5. EROSION CONTROL MEASURES TO BE MAINTAINED AS DIRECTED BY THE ENGINEER DURING THE CONSTRUCTION PERIOD.
6. ADDITIONAL CONTROL MEASURES MAY BE REQUIRED AT THE DISCRETION OF THE ENGINEER.
7. ALL DISTURBED GROUND LEFT INACTIVE FOR MORE THAN 30 DAYS SHALL BE STABILIZED WITH SEED, SOD, MULCH OR
8. PERMEABLE PAVERS WILL BE CONSTRUCTED ON THE SITE HAS COMPLETED FINAL GRADING WORKS.
9. PERMEABLE PAVERS AND INFILTRATION TANK AREAS NOT TO BE COMPACTED.

1. DISTURBED AREAS THAT HAVE FAILED TO HAVE STABLE GROUND COVER ESTABLISHED BY OCTOBER 30TH SHALL BE PROTECTED WITH A SILTATION CONTROL FENCE OR STRAW MULCH ETC. AND MAINTAINED BY THE CONTRACTOR UNTIL VEGETATION IS COME ESTABLISHED IN THE AREA.
2. ALL WATERING SHALL BE DISCHARGED TO A VEGETATED AREA AT LEAST 30m FROM ANY WATERCOURSE AND FILTERED. FILTERING METHODS MUST BE APPROVED BY THE SITE ADMINISTRATOR. DISCHARGE TO MUNICIPAL SERVICES MUST BE APPROVED BY THE CITY OF BARRIE PRIOR TO STARTING WORK AND ADHERE TO CITY OF BARRIE STANDARDS.
3. THE SITE ADMINISTRATOR SHALL BE ADVISED PRIOR TO ANY SODDING OR SEEDING ACTIVITIES. PRIOR TO COMMENCEMENT OF EARTH GRADING ACTIVITIES, SILT FENCE TO BE INSPECTED AND REPAIRED OR REPLACED IF DAMAGED AS DIRECTED BY THE SITE ADMINISTRATOR. SILT CONTROLS TO BE INSPECTED ON A REGULAR BASIS AND AFTER EVERY RAIN EVENT. INSTALLATION SHALL BE TO THE MANUFACTURER'S SUGGESTED SPECIFICATIONS.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR INSPECTION AND REPAIRS ACCORDING TO THE FOLLOWING: IF STOCKPILED MATERIALS OR SITE FOR NECESSARY REPAIRS AS A RESULT OF FAILED OR INADEQUATE CONTROL MEASURES. ALL SEDIMENT AND EROSION CONTROL MEASURES SHALL BE INSPECTED AT LEAST ONCE A WEEK, AND AFTER EVERY RAINFALL EVENT.
5. CONTRACTOR SHALL OBTAIN CURRENT COPY AND BECOME FAMILIAR WITH SECTION 577 CONSTRUCTION SPECIFICATIONS FOR SEDIMENT AND EROSION CONTROL MEASURES AS WELL AS APPLICABLE MUNICIPAL STANDARDS.
6. THE CONTRACTOR MAY NEED ADDITIONAL SEDIMENT AND EROSION CONTROL MEASURES. SUCH MEASURES SHOULD BE PRESENTED IN WRITING FOR APPROVAL OF THE SITE ADMINISTRATOR AND MUST BE APPROVED IN WRITING BY THE CITY OF BARRIE.
7. THE TOPS OF ALL FILTER FABRIC MUST BE A MINIMUM OF 1.0 METRES ABOVE THE GROUND LEVEL AND ATTACHED TO THE FENCE WITH A CONTINUOUS STEEL WIRE. ALTERNATIVELY, THE FILTER FABRIC MUST BE FOLDED OVER THE TOP OF THE FENCE AND ATTACHED TO THE FENCE WITH WIRE LOOPED THROUGH THE FABRIC ON BOTH SIDES OF THE FENCE. FILTER FABRIC SHALL BE SECURED TO THE GROUND WITH WIRE.
8. ALL DISTURBED GROUND LEFT INACTIVE SHALL BE STABILIZED BY SEEDING, SODDING, MULCHING, OR COVERING OR OTHER EQUIVALENT CONTROL MEASURES. THIS PERIOD OF INACTIVITY SHALL BE AT THE DISCRETION OF THE CITY OF BARRIE.
9. MANAGING OF EROSION CONTROL SHALL NOT BE USED TO DELAY THE CONSTRUCTION OF THE PROJECT. THE CONTRACTOR SHALL INSTALL AND MAINTAIN CATCHBASIN SEDIMENT BARRIERS THROUGHOUT THE SITE DURING ALL CONSTRUCTION ACTIVITIES IN ORDER TO TRAP SEDIMENT. REFER TO DETAIL.



1. TO BE USED UNDER APPROPRIATE DRAINAGE CIRCUMSTANCES, BETWEEN **APRIL** AND **DECEMBER**.
2. WOVEN GEOTEXTILE TO HAVE A MINIMUM EQUIVALENT OPENING SIZE OF 0.15mm AND A MAXIMUM EQUIVALENT OPENING SIZE OF 0.25mm OR A NON WOVEN GEOTEXTILE TO BE CONSIDERED BASED ON SOL PARAMETERS AND SITE CONDITIONS.
3. GEOTEXTILE TO BE REPLACED PERIODICALLY WHEN ACCUMULATED SEDIMENTS INTERFERES WITH DRAINAGE, OR AS DIRECTED BY THE TRANSPORTATION AND WORKS DEPARTMENT



1	SWM GUIDELINES UPDATE	06.2016	SEDIMENT CONTROL FENCE	DATE: 06.201
				SCALE: NTS
				LSRCA ESC-4
NO	REVISION	DATE		



1.	SWM GUIDELINES UPDATE	06.2016	CONSTRUCTION ACCESS MAT	DATE: 06.2016
				SCALE: NTS
				LSRCA ESC-3
NO.	REVISION	DATE		

EROSION AND SEDIMENT CONTROL PLAN NOTES

SCALE: NTS

BENCHMARK:
HORIZONTAL
MTO MONUMENT 001204040023 MONUMENT CAP IS LOCATED ON THE NORTHEAST CORNER OF DUNLOP ST. W
AND EGLES ST BETWEEN THE SIDEWALK AND PROPERTY LINE.
MTO MONUMENT 001204040022 MONUMENT CAP IS LOCATED ON THE SE CORNER OF INNISFIL ST AND
VEPSRA ST 18.5M FROM CENTRELINE OF INNISFIL ST AND APPROXIMATELY 13M FROM
CENTRELINE OF VEPSRA ST.
VERTICAL
MTO MONUMENT 001194555555 ELEVATION 228.735 BARRIE FUNDAMENTAL BENCH-MARK IN QUEENS
PARK, 12.5M NORTHEAST OF CURB AT NORTHEAST SIDE OF PARKSIDE DRIVE, 1.8M NORTHEAST OF
BOUNDARY BETWEEN PARK AND DRILL HALL GROUNDS, TABLET IN TOP
N. IN MIDDLE OF SOUTHEAST CORNER OF 235.00M BARRIE DRIVE
BUILDING, AT CORNER OF COLLIER AND OWEN STREETS, TABLET IN EAST SIDE
SMOOTH STONE FOUNDATION WALL, IN CENTRE OF FIRST STONE NORTH OF NOTCH
IN SOUTHWALL OF SOUTHEAST CORNER OF 235.00M BARRIE DRIVE, 1.8M SOUTHWEST OF
SIDEWALK.

ENVIRONMENTAL PROTECTION AND REMOVALS PLAN



DESIGNED BY	TA/MJWP	HORIZ SCALE	1:300	PROJECT #	12081.01
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CHECKED BY	MWD	DATE	APRIL 2019	REVISION #	1