UPPER CANADA CONSULTANTS
ENGINEERS / PLANNERS

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FUNCTIONAL SERVICING REPORT

Crescent Acres, Fort Erie
November 4, 2022

INTRODUCTION

This report is to address the servicing needs for the residential subdivision known as Crescent Acres. The subject lands located east of Crescent Road, south of Garrison Road, west of Kraft Road, and north of Woodside Court.

The 10.68 hectare site will be developed as residential with a mix of single detached, semi detached and street town dwellings. The site shall include asphalt roads, concrete curb, catch basins, storm sewers, sanitary sewers and water services.

The objectives of this study are as follows:

1. Identify domestic and fire protection water service needs for the site;
2. Identify sanitary servicing needs for the site; and
3. Identify stormwater management needs for the site.

WATER SERVICING

There is an existing 200mm diameter watermain located within the road allowance of Crescent Road. It is proposed to construct a 200mm diameter watermain loop within the subdivision to provide domestic water supply, with connections to the existing watermain at the proposed roadway entrances onto Crescent Road. The proposed streets outside of the 200mm diameter loop will be provided local 150mm watermains.

Proposed municipal fire hydrants will be constructed to provide fire protection within the subject lands. Future spacing and locations of the proposed hydrants will be determined as part of the detailed engineering design.

Therefore, there is expected to be adequate capacity in the existing watermain system to provide domestic water demand and fire protection for the proposed development.

SANITARY SERVICING

There is an existing 300mm diameter sanitary sewer flowing southerly on Crescent Road which increases to 350mm diameter just north of Evelyn Avenue. It is proposed to connect to the existing sanitary sewer system on Crescent Road with a new 200mm diameter sanitary sewer which will be extended within the site.

The subject lands have a total sanitary drainage area of approximately 9.28 hectares which is comprised of approximate 53% single and semi detached dwellings and 47% street townhouse dwellings. Per Town of Fort Erie municipal design standards, the population density for single and semi detached dwellings is 35 persons per hectare and 80 persons per hectare for street towns. Therefore, the overall density for the subject lands is approximately 56 persons per hectare, resulting in a total population of 520 persons.

As shown in the sanitary calculations provided in Appendix A, the total peak sanitary flow from the subject lands is approximately 10.06 L/s, which utilizes approximately 21.3% of the total capacity of the existing 300mm diameter sanitary sewer assuming a minimum slope of 0.22%.

Therefore there is expected to be adequate capacity within the existing 300mm and 350mm diameter sanitary sewers for the subject lands

STORMWATER MANAGEMENT PLAN

A separate Stormwater Management Plan has been prepared by Upper Canada Consultants for the subject lands and has been enclosed in Appendix B for reference. The following is the summarized conclusions and recommendations stated within the enclosed SWM Plan:

Based on the findings of the enclosed study, the following conclusions are offered:

- Infiltration techniques are not suitable for this site as the primary control facility due to the site size and soil conditions.
- Roof water leaders shall discharge to grade to enhance the future infiltration levels.
- A single stormwater management wet pond facility shall be constructed to provide quality and quantity control.
- Various lot level and vegetative stormwater management practices can be implemented to enhance stormwater quality.
- This report was prepared in accordance with the provincial guidelines contained in “Stormwater Management Planning and Design Manual, March 2003".

The above conclusions lead to the following recommendations:

- That the stormwater management criteria established in this report be accepted.
- That the stormwater management wet pond be constructed.
- That additional lot level controls and vegetative stormwater management practices as described previously in this report be implemented.
- That sediment and erosion controls during construction as described in this report be implemented.

CONCLUSIONS AND RECOMMENDATIONS

Therefore, based on the above comments and design calculations provided for this site, the following summarizes the servicing for this site.

1. The existing 200mm diameter watermain on Crescent Road is expected to have have sufficient capacity to provide domestic water supply and fire protection.

2. The existing 300mm diameter sanitary sewer is expected to have adequate capacity for the proposed subdivision lands.

3. Refer to the enclosed Stormwater Management Plan for detailed stormwater management calculations for the subject lands

Based on the above and the enclosed calculations and Stormwater Management Plan, there exists adequate municipal servicing for this development. We trust the above comments and enclosed calculations are satisfactory for approval. If you have any questions or require additional information, please do not hesitate to contact our office.

Prepared By:

Brendan Kapteyn, E.I.T.

Reviewed By:

LICENCED PROFESSIONAL ENGINEER
J. P. SCHOOLEY
PROVINCE OF ONTARIO

Jason Schooley, P.Eng.

APPENDICES

APPENDIX A

Sanitary Flow Calculations

UPPER CANADA CONSULTANTS
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ST.CATHARINES, ONTARIO, L2W 1A3

DESIGN FLOWS

RESIDENTIAL: 320 LITRES/PERSON/DAY (AVERAGE DAILY FLOW)
INFILTRATION RATE: 0.15 LITRES/HECTARE (M.O.E FLOW ALLOWANCE IS BETWEEN 0.10 & 0.28 LITRES/HECTARE)
POPULATION DENSITY 35.0 PERSONS/HECTARE (SINGLE/SEMI FAMILY)
80.0 PERSONS/HECTARE (TOWNHOUSES)

SEWER DESIGN

PIPE ROUGHNESS: 0.013 FOR MANNING'S EQUATION
PIPE SIZES: 1.016 IMPERIAL EQUIVALENT FACTOR
PERCENT FULL: TOTAL PEAK FLOW / CAPACITY

MUNICIPALITY: TOWN OF FORT ERIE
PROJECT : CRESCENT ACRES
PROJECT NO: 19106

SANITARY SEWER DESIGN SHEET

LOCATION			AREA		POPULATION			ACCUMULATED PEAK FLOW				DESIGN FLOW					
Description	From M.H	To M.H.	Increment (hectares)	Accumulated (hectares)	Population Density (persons/hectare)	Population Increment	Total Popln Served	Peaking Factor	Flow (L/s)	Infiltration Flow L/s	Total Peak Flow (L/s)	Pipe Diameter (mm)	Pipe Length (m)	Pipe Slope (%)	Full Flow Velocity (m/s)	Full Flow Capacity (L/s)	Check Percent Full
A1			9.28	9.28	56	520	520	4.5	8.67	1.39	10.06	300		0.22	0.65	47.3	21.3%

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APPENDIX B

Crescent Acres Stormwater Management Plan (Upper Canada Consultants, 2022)

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STORMWATER MANAGEMENT PLAN

CRESCENT ACRES

TOWN OF FORT ERIE

Prepared by:

Upper Canada Consultants
30 Hannover Drive, Unit 3
St. Catharines, Ontario
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November 2022

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REFERENCES

1. Keeping Soil on Construction Sites
   Erosion & Sediment Control Guidelines for Hamilton Harbour Watershed and Region of Hamilton-Wentworth (April 1994)

2. Stormwater Management Planning and Design Manual
   Ontario Ministry of the Environment (March 2003)

3. Stormwater Quality Best Management Practices
   Ontario Ministry of Environment and Energy (June 1991)

4. Guidelines for Development of New Subdivisions
   Town of Fort Erie (2016)

STORMWATER MANAGEMENT PLAN

CRESCENT ACRES

THE TOWN OF FORT ERIE

1.0 INTRODUCTION

1.1 Study Area

The Crescent Acres subdivision is located in the Crescent Park neighbourhood of Town of Fort Erie. As shown in Figure 1, the subject lands are located east of Crescent Road, south of Garrison Road, west of Kraft Road, and north of Woodside Court. The current land-uses surrounding the site are low density residential to the west, commercial and residential to the north, and open space to the east and south, containing a tributary to the Kraft Drain which flows southerly along the eastern limit of the site.

1.2 Objectives

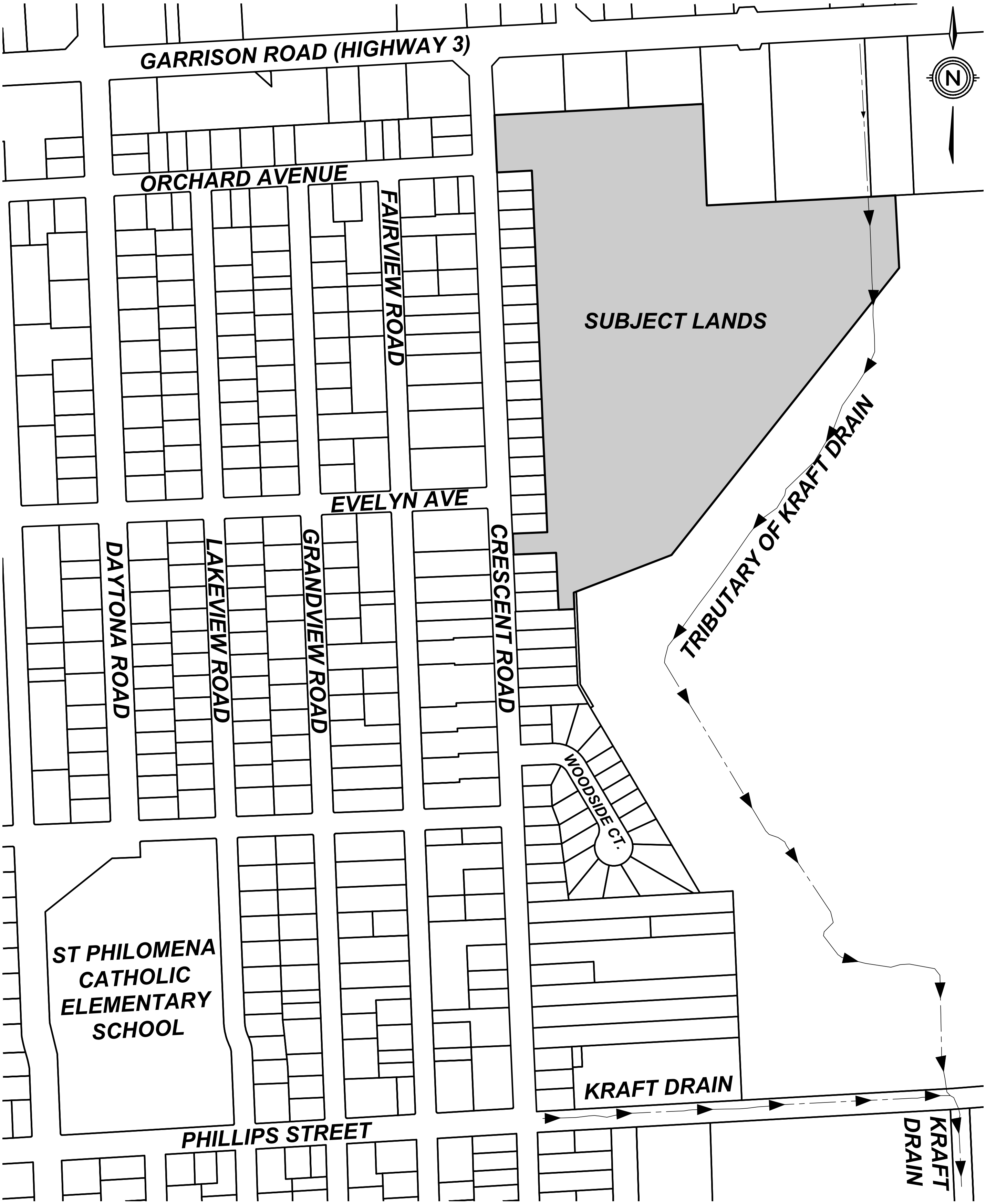
The objectives of this study are as follows:

a. Establish criteria for the management of stormwater runoff from this site.

b. Determine the impact of development on the peak flow of runoff from this site.

c. Investigate alternatives for controlling the quality of stormwater runoff from this site.

d. Establish property requirements for the stormwater management facility for the Draft Plan of Subdivision.



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CRESCENT ACRES

TOWN OF FORT ERIE

SITE LOCATION

DATE	2022-11-04
SCALE	1:5000 m
REF No.	19106
DWG No.	FIGURE 1

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1.3 Existing and Future Conditions

Existing Conditions

A Storm Drainage Area Plan was prepared by Philips Engineering for the North Crescent Park area, where the subject lands are located. An associated storm sewer design sheet for the 2 year design storm event was included to demonstrate the conveyance of stormwater flows from the North Crescent Park area to the headwall structure located at the intersection of Phillips Street and Crescent Road, discharging to the Kraft Drain. A copy of the Storm Drainage Area Plan and associated sewer design calculations have been included in Appendix A for reference.

As shown in Figure 2, the existing drainage patterns for the subject lands convey stormwater flows easterly to the adjacent tributary to the Kraft Drain. As such, stormwater flows from the subject lands were not originally allocated to the storm sewers flowing southerly on Crescent Road in the Philips Engineering sewer design. However, an analysis of the sewer design calculations show that there is available capacity in the Crescent Road storm sewers to receive peak stormwater flows from the subject lands in the 2 year design storm event, and modification to the sewer design sheet also shows that capacity is available up to the 5 year design storm event.

It was calculated that the existing Crescent Road storm sewer have an available capacity of 893.91 L/s in the 2 year design storm event and 143.9 L/s in the 5 year design storm event. Stormwater flows captured and conveyed through the Crescent Road storm sewers ultimately discharge to the Kraft Drain at a headwall structure located downstream of the subject lands, immediately east of the intersection of Crescent Road and Phillips Street. The modified storm sewer design sheets have been included in Appendix B for reference.

Future Conditions

The subject lands will consist of a mixture of single detached, semi-detached, and townhouse residential dwellings. The site will be serviced with a full urban road profile including municipal water, sanitary sewers, asphalt pavement, concrete curbs, catchbasins and storm sewers.

2.0 STORMWATER MANAGEMENT CRITERIA

New developments are required to provide stormwater management according to provincial and municipal policies including:

- Stormwater Quality Guidelines for New Development (MOEE/MNR, May 1991).
- Stormwater Management Planning and Design Manual (MOE, March 2003)

Based on policies from the Region of Niagara, the Niagara Peninsula Conservation Authority (NPCA), the Ministry of Environment, Conservation and Parks (MECP) and the Town of Fort Erie the following site specific considerations were identified:

- The ultimately outlet for the subject lands (Kraft Drain) has been classified as Marginal (Type 3) Fish Habitat by the Ministry of Natural Resources. Based on this classification, the corresponding MECP level of protection for new developments in these watersheds will be Normal (70% TSS Removal).

- The proposed stormwater management systems will be constructed to control future stormwater flows to allowable levels.

Based on the above policies and site specific considerations, the following stormwater management criteria have been established for this site.

- Stormwater **quality** controls are to be provided for the internal storm system of the subdivision to provide Normal Protection (70% TSS Removal) according to MECP guidelines.

- Stormwater **quantity** controls are to be provided to ensure future flow conditions are below the allowable 5 year capacity of the existing storm sewers on Crescent Road (143.9 L/s) for the 2 and 5 year design storms.

- Stormwater **quantity** controls are to be provided to ensure future flows from the subject lands are below existing levels in the Kraft Drain for the 100 year design storm.

3.0 STORMWATER ANALYSIS

Stormwater flows for the existing and future conditions were estimated using the MIDUSS computer modelling program. This program was selected because it is applicable to both urban and rural drainage areas like the subject lands. It is relatively easy to use and modify for the future drainage conditions and control facilities. It readily allows for design storm hyetographs for the various return periods being investigated.

3.1 Design Storms

Design storm hyetographs for the 2, 5, and 100 year events use a Chicago distribution based on the Intensity-Duration-Frequency (IDF) curves provided by the Town of Fort Erie. The 25mm design storm event IDF curve parameters were derived using a 4 hour Chicago distribution. Table 1 summarizes the rainfall data applied in the stormwater modelling.

Table 1. Rainfall Data

Design Storm (Return Period)	Chicago Distribution Parameters			Duration (minutes)
	a	b	c	
25mm	512.00	6.000	0.800	240
2 Year	628.05	6.652	0.796	240
5 Year	747.93	6.800	0.768	240
100 Year	1083.55	6.618	0.735	240

$$RainfallIntensity\ (mm/hr) = \frac{a}{(t_d + b)^c}$$

t_d = *Time of concentration/duration*

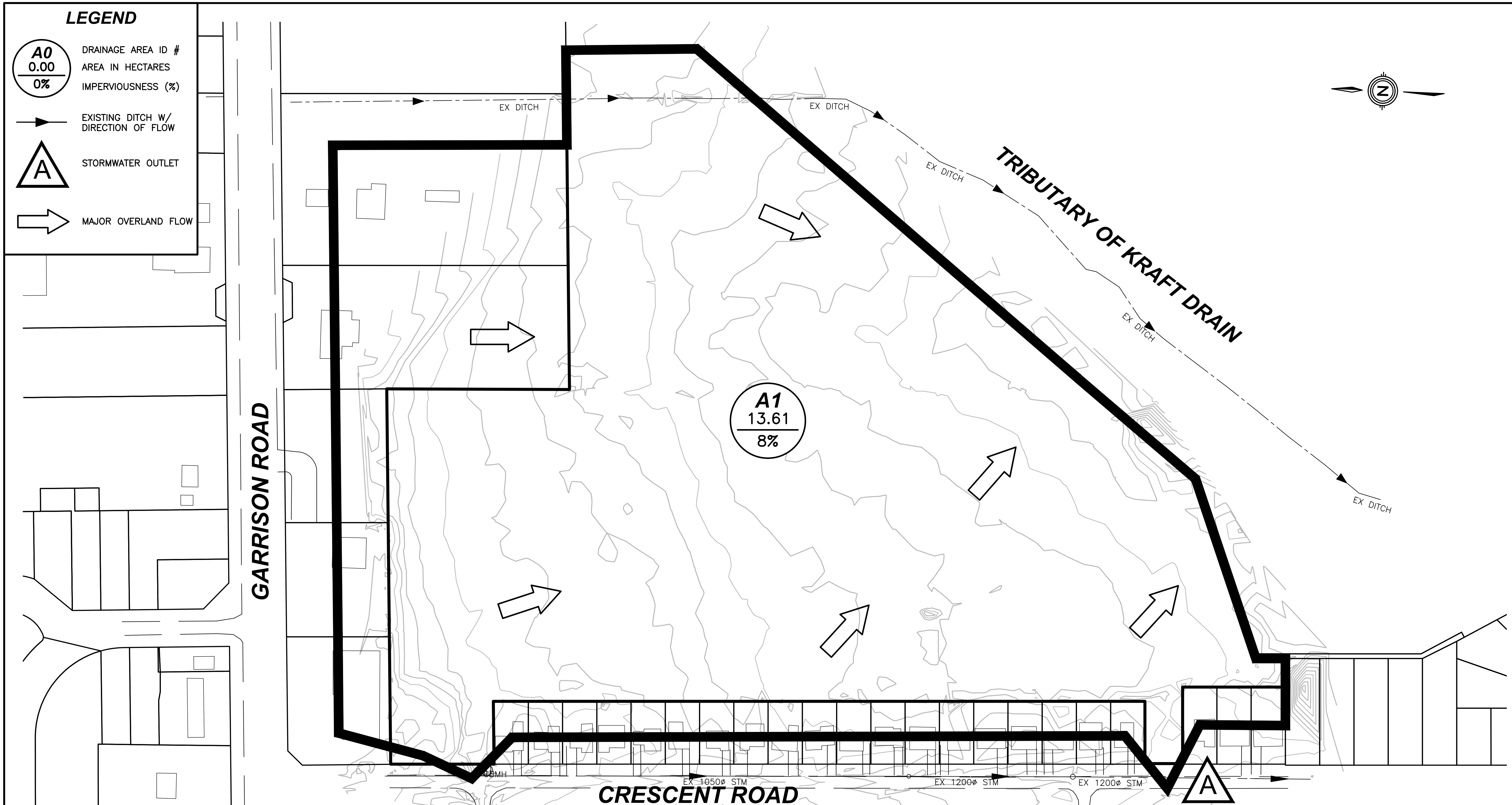
3.2 Existing Conditions

Existing stormwater flows to the Kraft Drain were determined based on existing drainage conditions shown in Figure 2 to determine the impact of the proposed development on the receiving watercourse in the 100 year design storm event. For the 2 and 5 year design storms, future peak flows are to be controlled to the allowable capacity within the existing storm sewers on Crescent Road.

The existing drainage area, as shown in Figure 2, was assessed based on the existing parameters shown in Table 2.

Table 2. Hydrologic Parameters for Existing Conditions

Area No.	Area (ha)	Length (m)	Slope (%)	Manning -"n"		Soil Types	SCS CN	Percent Impervious
				Perv	Imperv			
1	13.61	301	1.00	0.25	0.015	CD	77	8%



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TOWN OF FORT ERIE
EXISTING STORM DRAINAGE AREAS

DATE	2022-11-04
SCALE	1:2000 m
REF No.	19106
DWG No.	FIGURE 2

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3.3 Proposed Conditions

As shown in Figure 3 and summarized in Table 3 below, the future stormwater drainage areas have been delineated as follows:

- Area A10, which conveys stormwater flows to the existing storm sewers on Crescent Road; and,
- Area A11, which conveys uncontrolled flows directly to the existing tributary to the Kraft Drain to maintain base flows within the tributary.

Table 3. Hydrologic Parameters for Future Conditions

Area No.	Area (ha)	Length (m)	Slope (%)	Manning -"n"		Soil Types	SCS CN	Percent Impervious
				Perv	Imperv			
10	12.79	292	1.0%	0.25	0.015	CD	77	60%
11	0.81	73	1.0%	0.25	0.015	CD	77	15%

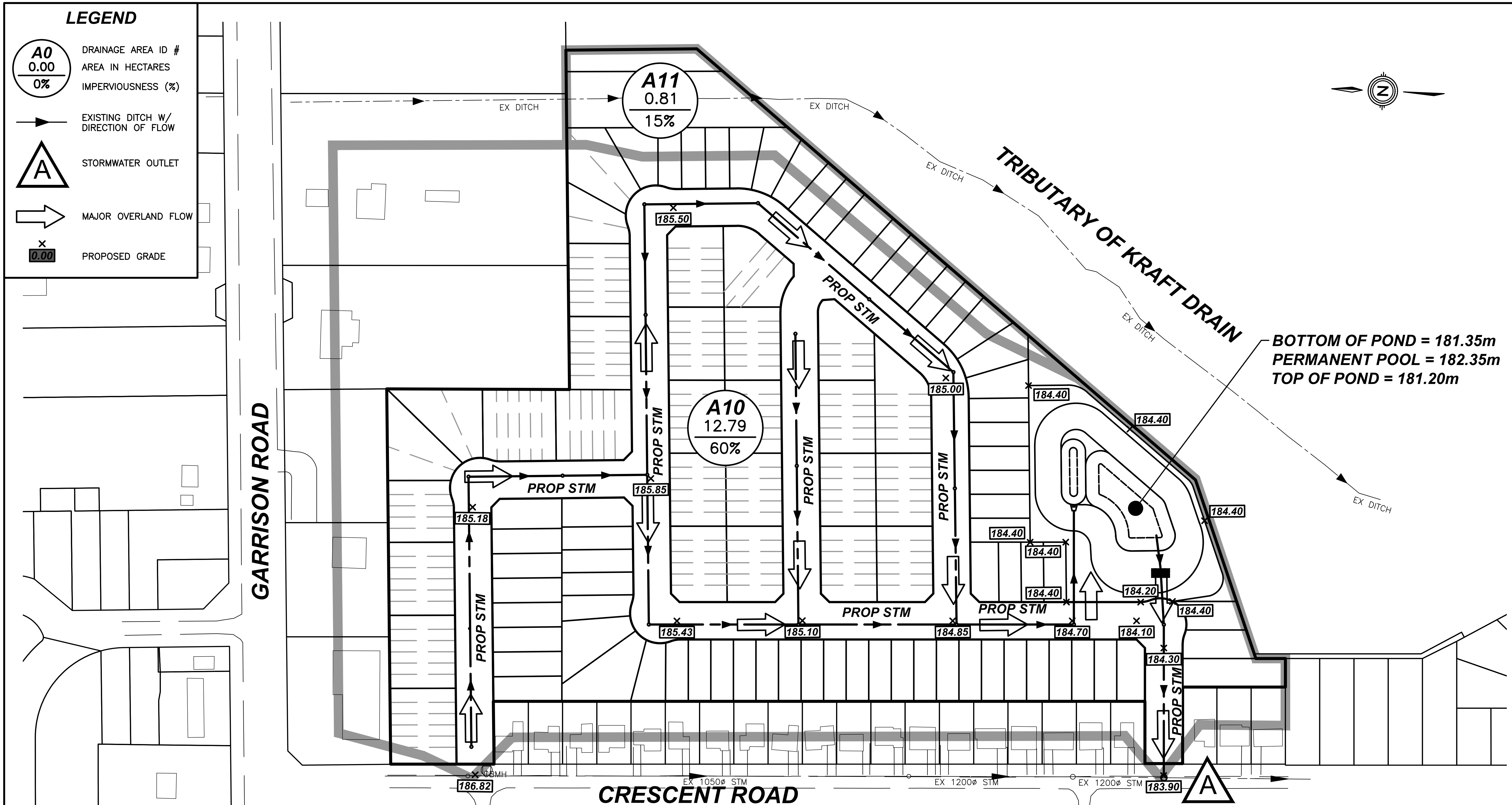
Drainage area A11 conveys clean stormwater flows from the grassed open space area within the subject lands and the rear yard areas of the proposed residential dwellings. Therefore, the uncontrolled stormwater drainage from Area A11 will have no negative impact on the overall quality of stormwater flows discharging to the existing tributary to the Kraft Drain.

Table 4. Peak Flows and Runoff Volumes

Design Storm	Peak Flows (m^3/s)			Runoff Volumes (m^3)		
	Existing/ Allowable	Future*	Change	Existing	Future*	Change
2 Year	0.144	0.887	516%	-	-	-
5 Year	0.144	1.246	765%	-	-	-
100 Year	0.477	2.140	349%	4,789	7,311	53%

*Note: * denotes peak flows without any Stormwater Management Facility in place.*

As shown in Table 4, peak stormwater flows and volumes increase above allowable/existing levels under future conditions. Therefore, stormwater management quantity controls (storage) will be required.



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TOWN OF FORT ERIE
FUTURE STORM DRAINAGE AREAS

DATE	2022-11-04
SCALE	1:2000 m
REF No.	19106
DWG No.	FIGURE 3

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4.0 STORMWATER MANAGEMENT ALTERNATIVES

4.1 Screening of Stormwater Management Alternatives

A variety of stormwater management alternatives are available to control the quantity and quality of stormwater runoff, most of which are described in the Stormwater Management Planning and Design Manual (MOE, March 2003). Alternatives for this site were considered in the following broad categories: lot level, vegetative, infiltration and surface storage controls. Individual alternatives are listed in Table 5 with comments on their effectiveness and applicability to this site.

a. Lot Level Controls

Lot level controls are not generally suitable as the primary control facility for quality control. They are generally used to enhance stormwater quality levels in conjunction with other types of control facilities. Where soils are suitable, infiltration techniques can be very effective in providing quantity and quality control.

b. Vegetative Alternatives

Vegetative stormwater management practices are generally not suitable as the primary control facility for quantity or quality controls. They are generally used to reduce the rate of runoff and to enhance stormwater quality in conjunction with other types of control facilities.

c. Infiltration Alternatives

Where soils are suitable, infiltration alternative can be very effective in providing both quality and quantity controls. However, economics generally limit the use of these techniques to relatively small sites (<1.5 ha). The soils on this site are predominantly clay with infiltration rates of less than 12 mm/hr. Infiltration alternatives may provide some quality benefits, however, due to the low infiltration rates and large development site, infiltration alternatives are not considered feasible for the primary control facilities.

d. Storage

Surface storage techniques can be very effective in providing quality and quantity control. Dry facilities are effective practices for stormwater erosion and flood control for large drainage areas (>5 ha).

Wet facilities are effective practices for stormwater erosion, quality and quantity control for large drainage areas (>5 ha).

4.2 Selection of Stormwater Management Alternatives

Stormwater management alternatives were screened based on technical effectiveness, physical suitability for this site, and their ability to meet the stormwater management criteria established for this site. The following stormwater management alternatives are recommended for implementation on this site:

a. **Lot grading** to be kept as flat as practical in order to slow down runoff and encourage infiltration.

b. **Roof water leaders** to be discharged to the ground surface in order to slow down runoff and encourage infiltration.

c. **Grassed swales** to be used to collect and convey rear lot drainage.

d. **A wet pond** will be used to provide stormwater quality control and quantity control and downstream erosion control for frequent storms.

Table 5. Evaluation of Stormwater Management Practices								
Crescent Acres	**Criteria for Implementation of Stormwater Management Practices (SWMP)**					**Technical Effectiveness (10 high)**	**Recommend Implementation Yes / No**	**Comments**
	Topography	**Soils**	**Bedrock**	**Groundwater**	**Area**			
Site Conditions	***Flat <1%***	***Clay <12mm/hr***	***At Considerable Depth***	***At Considerable Depth***	***±12.79 ha***			
Lot Level Controls								
Lot Grading	<5%	nlc	nlc	nlc	nlc	2	Yes	Quality/quantity benefits
Roof Leaders to Surface	nlc	nlc	nlc	nlc	nlc	2	Yes	Quality/quantity benefits
Roof Ldrs.to Soakaway Pits	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 0.5 ha	6	No	Quality/quantity benefits
Sump Pump Fdtn. Drains	nlc	nlc	nlc	nlc	nlc	2	Yes	Unsuitable site soil conditions
Vegetative								
Grassed Swales	< 5 %	nlc	nlc	nlc	nlc	7	Yes	Quality/quantity benefits
Filter Strips(Veg. Buffer)	< 10 %	nlc	nlc	>.5m Below Bottom	< 2 ha	5	No	Unsuitable site conditions
Infiltration								
Infiltration Basins	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 5 ha	2	No	Unsuitable site soil conditions
Infiltration Trench	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 2 ha	4	No	Unsuitable site soil conditions
Rear Yard Infiltration	< 2.0 %	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 0.5 ha	7	No	Unsuitable site soil conditions
Perforated Pipes	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	4	No	Unsuitable site soil conditions
Pervious Catch basins	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	3	No	Unsuitable site soil conditions
Sand Filters	nlc	nlc	nlc	>.5m Below Bottom	< 5 ha	5	No	High maintenance/poor aesthetics
Surface Storage								
Dry Ponds	nlc	nlc	nlc	nlc	> 5 ha	7	No	Less effective than wet facilities
Wet Ponds	nlc	nlc	nlc	nlc	> 5 ha	10	Yes	Effective quality control
Wet Lands	nlc	nlc	nlc	nlc	> 5 ha	9	No	Very effective quality control
Other								
Underground Storage	nlc	nlc	nlc	nlc	< 2.0 ha	8	No	Quantity benefits only
Oil/Grit Separator	nlc	nlc	nlc	nlc	< 2.7 ha	3	No	Quality benefits only

Reference : Stormwater Management Practices Planning and Design Manual - 1994

nlc - No Limiting Criteria

5.0 STORMWATER MANAGEMENT PLAN

A MIDUSS model was created to assess existing and future peak flows and stormwater volumes generated within the site. The proposed stormwater management facility shall provide quality and quantity controls for the subject lands.

The MIDUSS modelling output files for existing and future conditions have been provided in Appendix D for reference.

5.1 PROPOSED SWM FACILITY

5.1.1 Water Quality

The stormwater drainage outlet for the proposed wet pond is the Kraft Drain, where *Normal* protection is required. Based on Table 3.2 of SWMP & Design Manual, the Normal water quality storage requirement for wet pond facilities in a development with 60% impervious area is approximately 117 m^3/ha. The wet pond facility will provide stormwater quality controls for a drainage area of approximately 12.79 hectares as shown in the Table 6 as follows:

Table 6. Proposed SWM Facility - Stormwater Quality Volume Calculations	
Total Water Quality Volume = 12.79 ha x 117 m^3/ha = 985 m^3	Reference: Table 3.2, SWMP & Design Manual (MOE 2003)
Permanent Pool Volume = 12.79 ha x 77 m^3/ha = 985 m^3	**Extended Detention Volume** = 12.79 ha x 40 m^3/ha = 512 m^3

5.1.2 Erosion Control

Using the MIDUSS hydrological model, the stormwater volume from the 25mm - 4 hour design storm event for the 12.79 hectare study area is 1,702 m^3.

The following table shows the stormwater storage volumes required using both the water quality and erosion control guidelines.

Table 7. Proposed SWM Facility- Stormwater Quality Volume Requirements		
A.	Permanent Pool Volume	985 m^3
B.	Extended Detention Volume	512 m^3
C.	Stormwater Volume from 25mm - 4 hour rainfall event	1,702 m^3
D.	Maximum Extended Detention Volume (greater of B & C)	1,702 m^3
	Total Quality and Extended Detention Volume (A + D)	**2,687 m^3**

5.1.3 SWM Facility Configuration

It is proposed to construct a three stage outlet control structure for the facility. The first stage of control consists of an orifice to detain the extended detention volume and release it slowly over an extended period of time (minimum of 24 hours). The second stage of control is provided by a double ditch inlet catch basin and outlet control pipe which provide an outlet for flows exceeding the extended detention volume. The third stage of control is provided by an overflow spillway for major stormwater events.

The bottom elevation of the facility is 181.35 m and the permanent pool water level is 182.35 m for a water depth of 1.0 metres and provides 1,043 m^3 of permanent storage in the facility. The effective top of the facility is proposed at 184.21 m, and the facility will be constructed with 10:1 and 7:1 side slopes max in accordance with the Town of Fort Erie "Guidelines for Development of New Subdivisions" (2016).

Based on the proposed configuration of the proposed facility shown in Figure 3, it was determined that a 150mm diameter orifice at an invert of 182.35 m will provide approximately 36.8 hours of detention for the extended detention volume of storage. The proposed detention time for this facility was calculated using Equation 4.11 from section 4.6.2 of the Stormwater Management Planning & Design Manual (MOE, 2003).

The rim elevation for the double ditch inlet chamber is proposed at 183.70 m and will provide a maximum extended detention volume of 4,153 m^3, which is greater than the required 1,702 m^3. A 450mm outlet control pipe shall operate as an orifice at an invert of 182.35 m in the ditch inlet and conveys stormwater flows up to and including the 5 year design storm event to the existing storm sewers on Crescent Road.

To control stormwater flows in excess of the 5 year design storm event, a major overland flow path has been proposed to convey major overland flows from the internal subdivision roadways to the proposed SWM Facility, as shown in Figure 3. When the water surface elevation within the SWM facility exceeds 184.20 m, stormwater flows are conveyed westerly overland to the southern proposed roadway entrance onto Crescent Road without surcharging northerly within the subdivision.

The proposed roadway entrance will function as a overflow "weir" at the proposed high point of 184.30m. Major stormwater flows will discharge westerly to the road allowance of Crescent Road from the proposed curb and gutter, which will function as the weir "crest" at an elevation of 184.21m. To prevent major stormwater flows from discharging to the tributary to the Kraft Drain from the proposed SWM facility, a berm will be constructed along the eastern limit of the SWM Facility. The proposed building aprons and berm will be constructed to a minimum elevation of 184.40m.

A stage-storage-discharge relationship was prepared for the facility, which is included in Appendix C for reference purposes.

A sediment forebay was included in this stormwater management facility to minimize the transport of heavy sediment from the storm sewer outlet throughout the facility and to localize maintenance activities. Preliminary calculations for the forebay sizing follow MECP Guidelines and is shown in Table 8 for the storm sewer outlet.

Table 8. Proposed Stormwater Management Facility Forebay Sizing

a) Forebay Settling Length (MOE SWMP&D, Equation 4.5)

$$Settling\ Length = \sqrt{\frac{r * Qp}{Vs}}$$

	r =	6.5	:1	(Length:Width Ratio)
	Q_p =	0.023	m^3/s	(25mm Storm Pond Discharge)
	V_s =	0.0003	m/s	(Settling Velocity)
Settling Length =	**22.32**	**m**		

b) Dispersion Length (MOE SWMP&D, Equation 4.6)

$$Dispersion\ Length = \frac{8\ Q}{D\ V_f}$$

	Q =	1.246	m^3/s	(5 Yr Stm Sew Design Inflow)
	D =	1.50	m	(Depth of Forebay)
	V_f =	0.5	m/s	(Desired Velocity)
Dispersion Length =	**13.29**	**m**		

c) Minimum Forebay Deep Zone Bottom Width (MOE SWMP&D, Equation 4.7)

$$Width = \frac{Dispersion\ Length}{8}$$

Minimum Forebay Length from Equations 3.3 and 3.4

	22.32	m	(minimum required length)
Width =	**2.79**	**m**	(minimum required width)

d) Average Velocity of Flow

$$Average\ Velocity = \frac{Q}{A}$$

	Q =	0.679	m^3/s	(Storm Sewer Quality Design Inflow)
	A =	12.75	m^2	(Cross Sectional Area)
	D =	1.50	m	(Depth of Forebay)
	W =	4.00	m	(Proposed Bottom Width)
	S =	3	:1	(Side slopes - minimum)
Average Velocity =	**0.05**	**m/s**		
Is this Acceptable?	**Yes**			(Maximum velocity of flow = 0.15 m/s)

e) Cleanout Frequency

Is this Acceptable? **Yes**	L =	26.0	m	(Proposed Bottom Length)
	ASL =	2.0	m^3/ha	(Annual Sediment Loading)
	A =	12.79	ha	(Drainage Area)
	FRC =	70	%	(Facility Removal Efficiency)
	FV =	419.3	m^3	(Forebay Volume)
Cleanout Frequency =	**11.5**	**years**		
Is this Acceptable?	**Yes**			(10 year minimum cleanout frequency)

Tables 9 summarizes the characteristics of the proposed Wet Pond for various design storm events and indicates the peak flow to Crescent Road and ultimately the Kraft Drain. Based on the MIDUSS model, the maximum wet pond elevation is 184.00 m with an active storage volume of 5,522 m^3 for the 100 year design storm event.

Table 9. Proposed Stormwater Management Facility Characteristics

Design Storm (Return Period)	Peak Flows (m^3/s)		Maximum Elevation	Maximum Volume (m^3)
	Inflow	Outflow		
2 Year	0.887	0.030	183.01	1,846
5 Year	1.246	0.046	183.37	2,855
100 Year	2.089	0.144	184.00	5,522

Table 10. Proposed SWM Facility - MECP Quality Requirements Comparison

SWM Facility Characteristic	MECP Requirement	Provided by SWM Facility Configuration
Permanent Pool Volume (m^3)	985 (min)	784
Extended Detention Volume (m^3)	1,702 (min)	3,886
Total Quality + Detention Storage (m^3)	2,687 (min)	4,670
Forebay Length (m)	22.32 (min)	26.00
Forebay Width (m)	2.79 (min)	4.00
Average Forebay Velocity (m/s)	0.15 (max)	0.05
Cleanout Frequency (years)	10 (min)	11.5

As shown in Tables 10 and 11, the proposed stormwater management facility configuration satisfies both the quality and quantity requirements for the 12.79 hectare drainage area.

Table 11. Existing and Future Peak Flow Comparison

Design Storm (Return Period)	Peak Flows (m^3/s)		Change (%)
	Existing / Allowable Conditions	Future Conditions	
2 Year	0.144	0.023	-84.0%
5 Year	0.144	0.030	-79.2%
100 Year	0.477	0.152	-68.1%

5.3 Stormwater Management Facility Maintenance

Maintenance is a necessary and important aspect of urban stormwater quality and quantity measures such as constructed wetlands. Many pollutants (ie. nutrients, metals, bacteria, etc.) bind to sediment and therefore removal of sediment on a scheduled basis is required.

The wet pond for this development is subject to frequent wetting and deposition of sediments as a result of frequent low intensity storm events. The purpose of the wet pond is to improve future sediment and contaminant loadings by detaining the 'first flush' flow for a 24 hour period. For the initial operation period of the stormwater management facility, the required frequency of maintenance is not definitively known and many of the maintenance tasks will be performed on an 'as required' basis.

For example, during the home construction phase of the development there will be a greater potential for increased maintenance frequency, which depends on the effectiveness of sediment and erosion control techniques employed.

Inspections of the wet pond will indicate whether or not maintenance is required. Inspections should be made after every significant storm during the first two years of operation or until all development is completed to ensure the wet pond is functioning properly. This may translate into an average of six inspections per year. Once all building activity is finalized, inspections shall be performed annually. The following points should be addressed during inspections of the facility.

a) Standing water above the inlet storm sewer invert a day or more after a storm may indicate a blockage in the reverse slope pipe or orifice. The blockage may be caused by trash or sediment and a visual inspection would be required to determine the cause.

b) The vegetation around the wet pond should be inspected to ensure its function and aesthetics. Visual inspections will indicate whether replacement of plantings are required. A decline in vegetation habitat may indicate that other aspects of the constructed wet pond are operating improperly, such as the detention times may be inadequate or excessive.

c) The accumulation of sediment and debris at the wet pond inlet sediment forebay or around the high water line of the wet pond should be inspected. This will indicate the need for sediment removal or debris clean up.

d) The wet pond has been created by excavating a detention area. The integrity of the embankments should be periodically checked to ensure that it remains watertight and the side slopes have not sloughed.

Grass cutting is a maintenance activity that is done solely for aesthetic purposes. It is recommended that grass cutting be eliminated. It should be noted that municipal by-laws may require regular grass maintenance for weed control.

Trash removal is an integral part of maintenance and an annual cleanup, usually in the spring, is a minimum requirement. After this, trash removal is performed as required basis on observation of trash build-up during inspections.

To ensure long term effectiveness, the sediment that accumulates in the forebay area should be removed periodically to ensure that sediment in not deposited throughout the facility. For sediment removal operations, typical grading/excavating equipment should be used to remove sediment from the inlet forebay and detention areas. Care should be taken to ensure that limited damage occurs to existing vegetation and habitat.

Generally the sediment which is removed from the detention pond will not be contaminated to the point that it would be classified as hazardous waste. However, the sediment should be tested to determine the disposal options.

6.0 SEDIMENT AND EROSION CONTROL

Sediment and erosion controls are required during all construction phases of this development to limit the transport of sediment into downstream watercourses. Proposed sediment and erosion controls will be provided during for the final design and will include:

- Silt control fencing to minimize the transport of sediment offsite from the construction process.

- Straw bale filters in accordance with MNR/MOE guidelines.

- Re-vegetate disturbed areas as soon as possible after grading works have been completed.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study, the following conclusions are offered:

- Infiltration techniques are not suitable for this site as the primary control facility due to the site size and soil conditions.
- Roof water leaders shall discharge to grade to enhance the future infiltration levels.
- A single stormwater management wet pond facility shall be constructed to provide quality and quantity control.
- Various lot level and vegetative stormwater management practices can be implemented to enhance stormwater quality.
- This report was prepared in accordance with the provincial guidelines contained in "Stormwater Management Planning and Design Manual, March 2003".

The above conclusions lead to the following recommendations:

- That the stormwater management criteria established in this report be accepted.
- That the stormwater management wet pond be constructed.
- That additional lot level controls and vegetative stormwater management practices as described previously in this report be implemented.
- That sediment and erosion controls during construction as described in this report be implemented.

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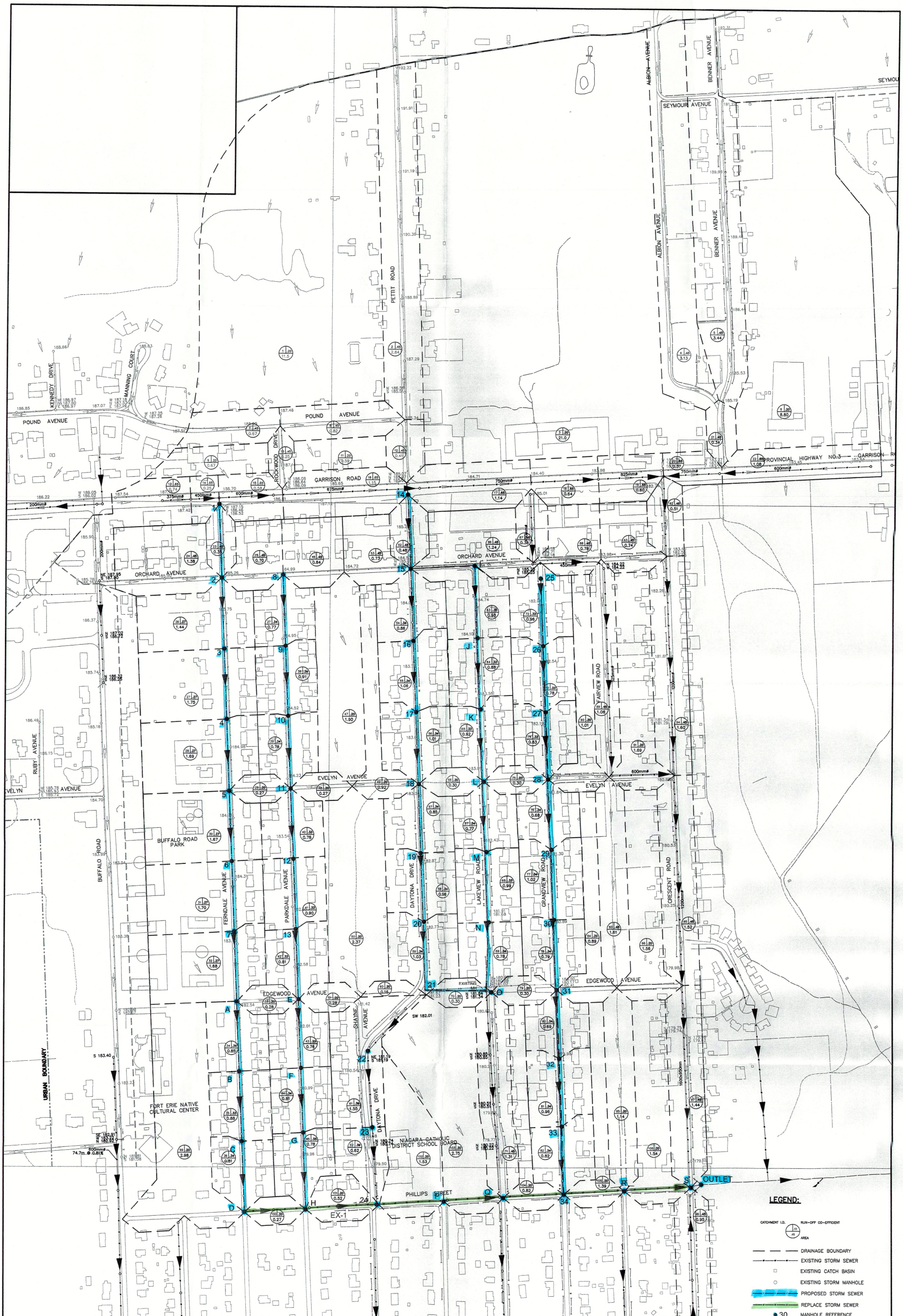
APPENDICES

APPENDIX A

North Crescent Park Storm Drainage Area Plan (Philips Engineering)
North Crescent Park Storm Sewer Design Sheet (Philips Engineering)



No.	REVISION	DATE	BY
1	ISSUED FOR MOE APPROVAL	JUN 09	MWF

LEGEND

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TOWN OF FORT ERIE
INFRASTRUCTURE SERVICES
ENGINEERING DIVISION

PLAN

NORTH CRESCENT PARK STORM DRAINAGE

DSN.	DSN. CKD.	DWN.	DWG. CKD.
S.W.H.	S.W.H.	A.K.	M.W.F.

SCALE	PROJ. No.
1: 2,500	108021

DATE	DWG. No.	REV.
MARCH 2009	1 OF 1	

FILE COPY

FILE: 108021 - STMDESIGN.xls
DATE: July 14, 2009

THE TOWN OF FORT ERIE
COMMUNITY PLANNING & DEVELOPMENT SERVICES
STORM SEWER DESIGN SHEET

Modified System
2 Year

PIPE:
n: 0.013

$Q = 2.778\ CIA$
$I = A/(B + T_c)^C$

	2 Year		100 Year
A	628.050	A	1083.550
B	6.652	B	6.618
C	0.796	C	0.735

LOCATION	STRUCTURE: FROM MH NO.	STRUCTURE: FROM MH INV.	STRUCTURE: APPROX. COVER	STRUCTURE: TO MH NO.	STRUCTURE: TO MH INV.	STRUCTURE: Sani. Invert	AREA ID	AREA (ha)	RUNOFF COEFF C	CxA (ha)	TOTAL CxA (ha)	TIME OF CONC (min)	RAINFALL INTENSITY i_5 (mm/hr)	DESIGN FLOW Q_5 (l/s)	DESIGN FLOW SLOPE (%)	PIPE DIA (mm)	PIPE VELOCITY (m/s)	LENGTH (m)	TIME OF FLOW (min)	PIPE CAPACITY (l/s)	PERCENT FULL	RAINFALL INTENSITY i_{100} (mm/hr)	DES FLOW Q_{100} (l/s)	OVERLAND FLOW (l/s)
East Drainage - Towards Kraft Drain																								
Garrison Road and North Area																								
Garrison	North Area			Crescent			1 - 22	61.01	0.30	18.1245	18.1245	10.00	66.9433	3371	0.10	**825**	0.86	675.00	13.11	474	**712**	137.3168	6914	6.4403
Ferndale Avenue - Garrison to Phillips																								
Ferndale	MH 1	184.793		MH 2	184.526	184.89	23	0.35	0.45	0.1575	0.1575	10.00	66.9433	29	0.25	**375**	0.80	107.00	2.22	91	**32**	137.3168	60	-31
Orchard	Buffalo			Ferndale			24	1.38	0.45	0.6210	0.6210	10.00	66.9433	115	0.20	OVLD		170.00				137.3168	237	237
Orchard	Parkdale			Ferndale			25	0.70	0.45	0.3150	0.3150	10.00	66.9433	59	0.20	OVLD		90.00				137.3168	120	120
Ferndale	MH 2	184.301		MH 3	184.136	184.96	26	1.44	0.27	0.3888	1.4823	12.22	60.5879	249	0.16	**600**	0.88	103.00	1.96	256	**97**	125.2119	516	259
Ferndale	MH 3	184.136		MH 4	183.899	184.53	27	1.75	0.27	0.4725	1.9548	14.18	56.0155	304	0.23	**600**	1.05	103.00	1.63	307	**99**	116.4461	632	325
Ferndale	MH 4	183.899		MH 5	183.577	184.21	28	1.69	0.27	0.4563	2.4111	15.81	52.7532	353	0.31	**600**	1.22	104.00	1.42	357	**99**	110.1602	738	381
Evelyn	Parkdale			Ferndale			29	0.27	0.20	0.0540	0.0540	10.00	66.9433	10	0.20	OVLD		100.00				137.3168	21	21
Ferndale	MH 5	183.577		MH 6	183.067	183.83	30	1.67	0.27	0.4509	2.9160	17.23	50.2434	407	0.50	**600**	1.55	102.00	1.10	453	**90**	105.3049	853	400
Ferndale	MH 6	183.067		MH 7	182.455	183.23	31	1.70	0.27	0.4590	3.3750	18.32	48.4813	455	0.60	**600**	1.70	102.00	1.00	496	**92**	101.8854	955	459
Ferndale	MH 7	182.455		MH A	181.751	182.85	32	1.68	0.27	0.4536	3.8286	19.32	46.9897	500	0.61	**600**	1.71	115.41	1.12	500	**100**	98.9837	1053	552
Edgewood	Parkdale	181.730		Ferndale			33	0.28	0.20	0.0560	0.0560	10.00	66.9433	10	0.10	OVLD		150.00				137.3168	21	21
Ferndale	MH A	181.751		MH B	181.151	181.65	34	0.85	0.34	0.2890	4.1736	20.45	45.4341	527	0.68	**600**	1.81	88.18	0.81	528	**100**	95.9503	1112	584
Ferndale	MH B	180.851		MH C	180.749	179.97	35	0.88	0.33	0.2904	4.4640	21.26	44.3787	550	0.10	**900**	0.91	102.00	1.87	597	**92**	93.8878	1164	567
Ferndale	MH C	180.749		MH D	180.647	179.60	36	0.81	0.34	0.2754	4.7394	23.13	42.1467	555	0.10	**900**	0.91	102.00	1.87	597	**93**	89.5140	1179	581
Parkdale Avenue - Orchard to Phillips																								
Parkdale	MH 8	184.360		MH 9	184.103	184.53	37	0.77	0.34	0.2618	0.2618	10.00	66.9433	49	0.25	**375**	0.80	103.00	2.14	91	**53**	137.3168	100	0.0084
Parkdale	MH 9	184.103		MH 10	183.814	184.13	38	0.91	0.34	0.3094	0.5712	12.14	60.8011	96	0.28	**375**	0.85	103.00	2.02	97	**100**	125.6194	199	0.1025
Parkdale	MH 10	183.739		MH 11	183.531	183.64	39	0.78	0.34	0.2652	0.8364	14.16	56.0507	130	0.20	**450**	0.81	104.00	2.14	133	**98**	116.5138	271	0.1377
Parkdale	MH 11	183.531		MH 12	182.511	182.88	40	0.78	0.33	0.2574	1.0938	16.30	51.8512	158	1.00	**450**	1.81	102.00	0.94	297	**53**	108.4173	329	0.0320
Parkdale	MH 12	182.511		MH 13	181.899	182.30	41	0.90	0.33	0.2970	1.3908	17.24	50.2236	194	0.60	**450**	1.40	102.00	1.21	230	**84**	105.2666	407	0.1763
Parkdale	MH 13	181.899		MH E	181.185	181.85	42	0.81	0.33	0.2673	1.6581	18.45	48.2847	222	0.70	**450**	1.52	102.00	1.12	249	**89**	101.5034	468	0.2187
Parkdale	MH E	180.960		MH F	180.838	180.71	43	0.76	0.33	0.2508	1.9089	19.57	46.6337	247	0.12	**675**	0.82	102.00	2.07	304	**81**	98.2902	521	0.2174
Parkdale	MH F	180.763		MH G	180.661	179.52	44	0.81	0.34	0.2754	2.1843	21.64	43.9007	266	0.10	**750**	0.81	102.00	2.11	367	**73**	92.9525	564	0.1968
Parkdale	MH G	180.661		MH H	180.559		45	0.78	0.35	0.2730	2.4573	23.75	41.4567	283	0.10	**750**	0.81	102.00	2.11	367	**77**	88.1586	602	0.2345
Shayne Avenue - Orchard to Daytona																								
Orchard	Parkdale			Shayne			46	0.84	0.45	0.3780	0.3780	10.00	66.9433	70	0.10	OVLD		90.00				137.3168	144	0.1442
Shayne	Orchard			Evelyn			47	1.90	0.20	0.3800	0.7580	10.00	66.9433	141	0.60	OVLD		320.00				137.3168	289	0.2892
Evelyn	Parkdale			Shayne			48	0.27	0.20	0.0540	0.0540	10.00	66.9433	10	0.10	OVLD		90.00				137.3168	21	0.0206
Evelyn	Daytona			Shayne			49	0.92	0.20	0.1840	0.1840	10.00	66.9433	34	0.10	OVLD		90.00				137.3168	70	0.0702
Shayne	Evelyn			Edgewood			50	2.37	0.20	0.4740	1.4700	10.00	66.9433	273	1.00	OVLD		320.00				137.3168	561	0.5608
Edgewood	Parkdale			Shayne			51	0.28	0.20	0.0560	0.0560	10.00	66.9433	10	0.10	OVLD		100.00				137.3168	21	0.0214

LOCATION	STRUCTURE: FROM MH NO.	FROM MH INV.	APPROX. COVER	TO MH NO.	TO MH INV.	Sani. Invert	AREA ID	AREA (ha)	RUNOFF COEFF C	CxA (ha)	TOTAL CxA (ha)	TIME OF CONC (min)	RAINFALL INTENSITY i_5 (mm/hr)	DESIGN FLOW Q_5 (l/s)	SLOPE (%)	PIPE DIA (mm)	PIPE VELOCITY (m/s)	LENGTH (m)	TIME OF FLOW (min)	PIPE CAPACITY (l/s)	PERCENT FULL	RAINFALL INTENSITY i_{100} (mm/hr)	DES FLOW Q_{100} (l/s)	OVERLAND FLOW (l/s)
Daytona Drive - Garrison to Phillips																								
Daytona	MH 14	184.170		MH 15	183.902	184.17	52	0.48	0.45	0.2160	0.2160	10.00	66.9433	40	0.25	**375**	0.80	107.00	2.22	91	**44**	137.3168	82	0.0000
Orchard	Shayne			Daytona			53	0.73	0.45	0.3285	0.3285	10.00	66.9433	61	0.10	OVLD		100.00				137.3168	125	0.1253
Daytona	MH 15	183.827		MH 16	183.197	183.45	54	0.86	0.34	0.2924	0.8369	12.22	60.5879	141	0.60	**450**	1.40	105.00	1.25	230	**61**	125.2119	291	0.0607
Daytona	MH 16	183.122		MH 17	182.860	183.14	55	1.06	0.34	0.3604	1.1973	13.47	57.5797	192	0.25	**525**	1.00	105.00	1.74	224	**85**	119.4506	397	0.1730
Daytona	MH 17	182.860		MH 18	182.492	182.85	56	1.01	0.34	0.3434	1.5407	15.21	53.8950	231	0.35	**525**	1.19	105.00	1.47	265	**87**	112.3634	481	0.2155
Daytona	MH 18	182.417		MH 19	182.237	182.47	57	0.85	0.34	0.2890	1.8297	16.69	51.1689	260	0.18	**600**	0.93	100.00	1.79	272	**96**	107.0974	544	0.2726
Daytona	MH 19	182.237		MH 20	181.987	182.17	58	0.96	0.34	0.3264	2.1561	18.48	48.2460	289	0.25	**600**	1.10	100.00	1.52	320	**90**	101.4281	608	0.2872
Daytona	MH 20	181.987		MH 21	181.736	180.93	59	1.03	0.34	0.3502	2.5063	20.00	46.0441	321	0.25	**600**	1.10	100.00	1.52	321	**100**	97.1406	676	0.3554
Edgewood	Shayne			Daytona			60	0.16	0.20	0.0320	1.5580	10.00	66.9433	290	0.10	OVLD		100.00				137.3168	594	0.5943
Daytona	MH 21	181.526		MH O	181.350			0.00	0.00	0.0000	4.0643	21.51	44.0604	497	0.20	**750**	1.14	88.00	1.29	519	**96**	93.2651	1053	0.5336
Daytona	MH 22			MH 23			60A, 61	1.55	0.39	0.6106	0.6106	10.00	66.9433	114	0.40	**525**	1.27	112.00	1.47	284	**40**	137.3168	233	0.0000
Daytona	MH 23			MH 24			62	0.62	0.39	0.2418	0.8524	11.47	62.5838	148	0.40	**525**	1.27	111.00	1.46	284	**52**	129.0229	306	0.0218
Lakeview Road - Orchard to Phillips																								
Lakeview	MH I	183.670		MH J	183.435	183.67	63	0.98	0.35	0.3430	0.3430	10.00	66.9433	64	0.25	**375**	0.80	94.00	1.95	91	**70**	137.3168	131	0.0394
Lakeview	MH J	183.435		MH K	182.857	183.08	64	0.88	0.33	0.2904	0.6334	11.95	61.2870	108	0.55	**375**	1.19	105.00	1.47	136	**79**	126.5478	223	0.0870
Lakeview	MH K	182.782		MH L	182.205	182.44	65	0.92	0.33	0.3036	0.9370	13.42	57.6854	150	0.55	**450**	1.34	105.00	1.30	221	**68**	119.6534	311	0.0909
Evelyn	Daytona			Lakeview			66	0.30	0.20	0.0600	0.0600	10.00	66.9433	11	0.20	OVLD		90.00				137.3168	23	0.0229
Lakeview	MH L	182.205		MH M	181.786	181.91	67	0.77	0.34	0.2618	1.2588	14.73	54.8701	192	0.41	**450**	1.16	102.00	1.46	191	**101**	114.2422	399	0.2088
Lakeview	MH M	181.636		MH N	181.493	180.98	68	0.99	0.33	0.3267	1.5855	16.19	52.0526	229	0.14	**600**	0.82	102.00	2.07	240	**96**	108.8066	479	0.2396
Lakeview	MH N	181.493		MH O	181.350	180.28	69	0.78	0.34	0.2652	1.8507	22.80	42.5199	219	0.14	**600**	0.82	102.00	2.07	240	**91**	90.2466	464	0.2243
Edgewood	Daytona			Lakeview			70	0.30	0.20	0.0600	0.0600	10.00	66.9433	11	0.10	OVLD		90.00				137.3168	23	0.0229
Lakeview	Edgewood	181.350		Phillips	179.860		71	1.31	0.45	0.5895	6.5645	24.87	40.2818	735	0.50	**750**	1.80	310.00	2.87	821	**89**	85.8464	1566	0.7443
Grandview - Orchard to Phillips																								
Grandview	MH 25	182.259	4.34	MH 26	182.063	182.31	72	0.96	0.33	0.3168	0.3168	10.00	66.9433	59	0.20	**450**	0.81	98.00	2.02	133	**44**	137.3168	121	0.0000
Grandview	MH 26	182.063	4.54	MH 27	181.671	181.88	73	0.78	0.33	0.2574	0.5742	12.02	61.1226	97	0.40	**450**	1.15	98.00	1.43	188	**52**	126.2337	201	0.0132
Grandview	MH 27	181.671	4.93	MH 28	181.279	181.48	74	0.83	0.33	0.2739	0.8481	13.44	57.6453	136	0.40	**450**	1.15	98.00	1.43	188	**72**	119.5764	282	0.0936
Evelyn	Lakeview			Grandview			75	0.30	0.20	0.0600	0.0600	10.00	66.9433	11	0.30	OVLD		90.00				137.3168	23	0.0229
Grandview	MH 28	181.279	3.02	MH 29	180.565	180.99	76	0.68	0.34	0.2312	1.1393	14.87	54.5846	173	0.70	**450**	1.52	102.00	1.12	249	**69**	113.6925	360	0.1110
Grandview	MH 29	180.265	3.73	MH 30	180.163	180.19	77	1.02	0.34	0.3468	1.4861	15.99	52.4212	216	0.10	**750**	0.81	102.00	2.11	367	**59**	109.5189	452	0.0849
Grandview	MH 30	180.163	3.84	MH 31	180.061	179.67	78	0.79	0.34	0.2686	1.7547	18.10	48.8305	238	0.10	**750**	0.81	102.00	2.11	367	**65**	102.5637	500	0.1327
Edgewood	Lakeview			Grandview			79	0.30	0.20	0.0600	0.0600	10.00	66.9433	11	0.10	OVLD		90.00				137.3168	23	0.0229
Grandview	MH 31	180.061	2.04	MH 32	179.961	179.22	80	0.69	0.34	0.2346	2.0493	20.21	45.7508	260	0.10	**750**	0.81	100.00	2.07	367	**71**	96.5684	550	0.1825
Grandview	MH 32	179.961	2.14	MH 33	179.861	178.82	81	0.96	0.34	0.3264	2.3757	22.28	43.1262	285	0.10	**750**	0.81	100.00	2.07	367	**77**	91.4356	603	0.2362
Grandview	MH 33	179.861	2.24	MH 34	179.761		82	0.82	0.34	0.2788	2.6545	24.35	40.8186	301	0.10	**750**	0.81	100.00	2.07	367	**82**	86.9035	641	0.2736
Fairview - Evelyn to Phillips																								
Fairview	Evelyn			Edgewood			83	1.61	0.45	0.7245	0.7245	10.00	66.9433	135	0.50	OVLD		300.00				137.3168	276	0.2764
Edgewood	Grandview			Fairview			84	0.89	0.20	0.1780	0.1780	10.00	66.9433	33	0.10	OVLD		90.00				137.3168	68	0.0679
Fairview	Edgewood			Phillips			85	1.14	0.20	0.2280	1.1305	10.00	66.9433	210	0.50	OVLD		310.00				137.3168	431	0.4312

LOCATION	STRUCTURE: FROM MH NO.	FROM MH INV.	APPROX. COVER	TO MH NO.	TO MH INV.	Sani. Invert	AREA ID	AREA (ha)	RUNOFF COEFF C	CxA (ha)	TOTAL CxA (ha)	TIME OF CONC (min)	RAINFALL INTENSITY i_5 (mm/hr)	DESIGN FLOW Q_5 (l/s)	SLOPE (%)	PIPE DIA (mm)	PIPE VELOCITY (m/s)	LENGTH (m)	TIME OF FLOW (min)	PIPE CAPACITY (l/s)	PERCENT FULL	RAINFALL INTENSITY i_{100} (mm/hr)	DES FLOW Q_{100} (l/s)	OVERLAND FLOW (l/s)
Crescent - Garrison to Phillips																								
Orchard	Daytona			Grandview			86	1.24	0.45	0.5580	0.5580	10.00	66.9433	104	0.20	OVLD		100.00				137.3168	213	0.2129
Grandview	Garrison			Orchard			87	0.38	0.45	0.1710	0.1710	10.00	66.9433	32	1.50	450	2.22	90.00	0.68	364	9	137.3168	65	0.0000
Orchard	Grandview			Fairview			88	0.78	0.45	0.3510	1.0800	10.68	64.8560	195	0.50	450	1.28	180.00	2.34	210	93	133.3508	400	0.1898
Fairview	Orchard			Evelyn			89	1.06	0.45	0.4770	1.5570	13.02	58.6313	254	0.70	525	1.68	320.00	3.17	375	68	121.4669	525	0.1500
Evelyn	Grandview			Fairview			90	1.01	0.20	0.2020	0.2020	10.00	66.9433	38	0.70	OVLD		90.00				137.3168	77	0.0771
Evelyn	Fairview			Crescent			91	1.69	0.20	0.3380	2.0970	16.19	52.0476	303	0.50	600	1.55	90.00	0.97	453	67	108.7970	634	0.1808
Crescent	Garrison			Orchard			92	0.51	0.45	0.2295	18.3540	23.11	42.1668	2150	0.90	1050	3.02	120.00	0.66	2703	80	89.5535	4566	1.8635
Orchard	Fairview			Crescent			93	0.74	0.45	0.3330	0.3330	10.00	66.9433	62	0.50	OVLD		95.00				137.3168	127	0.1270
Crescent	Orchard			Evelyn			94	1.60	0.45	0.7200	19.4070	23.77	41.4354	2234	0.80	1050	2.85	320.00	1.87	2548	88	88.1166	4751	2.2026
Crescent	Evelyn			Edgewood			95	1.52	0.45	0.6840	22.1880	25.64	39.5130	2436	0.67	1200	2.85	310.00	1.81	3329	73	84.3309	5198	1.8688
Edgewood	Fairview			Crescent			96	1.56	0.20	0.3120	0.3120	10.00	66.9433	58	0.20	OVLD		90.00				137.3168	119	0.1190
Crescent	Edgewood			Phillips			97	1.44	0.45	0.6480	23.1480	27.45	37.8329	2433	0.50	1500	2.86	300.00	1.75	5215	47	81.0111	5209	0.0000
Crescent	Hollywood			Phillips			98	0.95	0.45	0.4275	0.4275	10.00	66.9433	80	0.30	450	0.99	200.00	3.36	163	49	137.3168	163	0.0002
Old Phillips -Lakeview to Crescent																								
Phillips	Parkdale	180.579		MH EX-1	180.520			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	0.14	675	0.89	40.00	0.75	328	0	270.1561	0	
Phillips	MH EX-1	180.520		Daytona	180.433			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	0.14	675	0.89	56.00	1.05	328	0	270.1561	0	
Phillips	Daytona	180.403		MH 24	180.383			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	1.00	450	1.81	2.00	0.02	297	0	270.1561	0	
Phillips	Daytona	180.283		Lakeside	180.176			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	0.12	825	0.94	106.00	1.88	519	0	270.1561	0	
Phillips	Lakeside	180.176		Lakeview	180.056			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	0.12	825	0.94	71.00	1.26	519	0	270.1561	0	
Phillips	Lakeview	180.026		MH Q	179.986			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	1.00	450	1.81	4.00	0.04	297	0	270.1561	0	
Phillips	Lakeview	179.831		Grandview	179.745			0.00	0.00	0.0000	0.0000	0.00	138.9710	0	0.10	1050	1.01	85.00	1.41	901	0	270.1561	0	
Phillips	Grandview	179.745		Fairview	179.658		105	1.39	0.20	0.2780	2.9325	26.42	38.7720	316	0.10	1050	1.01	87.00	1.44	901	35	82.8681	675	0.0000
Phillips	Fairview	179.658		Crescent	179.556		106	1.54	0.20	0.3080	4.3710	27.86	37.4798	455	0.12	1050	1.10	83.00	1.25	987	46	80.3121	975	0.0000
Phillips	Crescent	179.556		MH S	179.553			0.00	0.00	0.0000	4.3710	34.02	32.8833	399	0.12	750	0.88	3.00	0.06	402	99	71.1648	864	0.4618
New Phillips -Buffalo to Crescent																								
Phillips	Buffalo			Ferndale			99	2.98	0.20	0.5960	0.5960	10.00	66.9433	111	0.20	OVLD		90.00				137.3168	227	227
Phillips	MH D	180.587		MH H	180.499		100	0.27	0.20	0.0540	5.3894	25.00	40.1529	601	0.10	975	0.96	88.00	1.53	739	81	85.5925	1281	0.5421
Phillips	MH H	180.424		MH 24	180.320		101	0.52	0.20	0.1040	7.9507	25.86	39.2997	868	0.10	1050	1.01	104.00	1.72	901	96	83.9102	1853	0.9525
Phillips	MH 24	180.170		MH P	180.073		102	1.53	0.20	0.3060	9.1091	27.58	37.7200	955	0.10	1200	1.10	97.00	1.47	1286	74	80.7876	2044	0.7581
Phillips	MH P	180.073		MH Q	179.992		103	2.75	0.20	0.5500	9.6591	29.05	36.4806	979	0.10	1200	1.10	81.00	1.23	1286	76	78.3311	2102	0.8157
Phillips	MH Q	179.842		MH 34	179.761		104	0.82	0.20	0.1640	16.3876	30.27	35.5137	1617	0.10	1350	1.19	93.00	1.30	1761	92	76.4103	3479	1.7177
Phillips	MH 34	179.761		MH R	179.668			0.00	0.20	0.0000	16.3876	31.57	34.5484	1573	0.10	1350	1.19	88.00	1.23	1761	89	74.4889	3391	1.6303
Phillips	MH R	179.668		MH S	179.553			0.00	0.20	0.0000	16.3876	32.81	33.6879	1534	0.10	1350	1.19	87.00	1.22	1761	87	72.7726	3313	1.5521
Phillips	MH S	179.553		Outlet	179.535			0.00	0.20	0.0000	20.7586	34.02	32.8833	1896	0.12	1350	1.31	15.00	0.19	1929	98	71.1648	4104	2.1750

LICENSED PROFESSIONAL ENGINEER
M. W. FISHER
100088817
2009/07/14
PROVINCE OF ONTARIO

APPENDIX B

Modified Storm Sewer Design Sheet Calculations

UPPER CANADA CONSULTANTS
30 HANNOVER DRIVE, UNIT 3
ST. CATHARINES, ONTARIO, L2W 1A3

RAINFALL PARAMETERS:	A =	628.05	mm/hr	**SEWER DESIGN:**	PIPE ROUGHNESS:	0.013 FOR MANNING'S EQUATION
2 YEAR DESIGN STORM EVENT	B =	6.65	minutes		PIPE SIZES:	1.016 ACTUAL DIAMETER SIZE FACTOR
TOWN OF FORT ERIE IDF	C =	0.796			PERCENT FULL:	TOTAL PEAK FLOW / CAPACITY

MUNICIPALITY: TOWN OF FORT ERIE
PROJECT NAME: CRESCENT ACRES
PROJECT NO.: 19106

S T O R M S E W E R D E S I G N S H E E T

LOCATION			STORMWATER ANALYSIS								STORM SEWER DESIGN					
DESCRIPTION	From M.H.	To M.H.	A Area (hectares)	R Runoff Coeff.	A*R	Accumulated A*R	Time of Concentration (min)	Flow Time (min.)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Length (m)	Nominal Diameter (mm.)	Slope (%)	Full Flow Capacity (L/s)	Full Flow Velocity (m/s)	Percent Full
Existing stormwater drainage areas and concentration times from Philips Engineering North Crescent Park Storm Drainage (July 2009) unless stated otherwise.																
A1 to A22 - GARRISON ROAD			61.01	0.30	18.125	18.125	10.00	13.11	66.9	3370.3						
A92 - CRESCENT ROAD			0.51	0.45	0.230	18.354	23.11	0.66	42.2	2149.8	120.0	1050	0.90	2702.6	3.02	79.5%
A93 - ORCHARD AVENUE			0.74	0.45	0.333	0.333	10.00		66.9	61.9						
A94 - DAYTONA DRIVE			1.60	0.45	0.720	19.407	23.77	1.87	41.4	2233.7	320.0	1050	0.80	2548.0	2.85	87.7%
A86 to A91 - EVELYN AVENUE			6.16	0.34	2.097	2.097	16.19	0.97	52.1	303.2	90.0	600	0.50	452.9	1.55	66.9%
A95 - EVELYN AVENUE			1.52	0.45	0.684	22.188	25.64	1.81	39.5	2435.3	310.0	1200	0.67	3329.2	2.85	73.1%
AVAILABLE CAPACITY IN CRESCENT ROAD STORM SEWERS =										**893.9 L/s**						
A96 - EDGEWOOD AVENUE			1.56	0.20	0.312	0.312	10.00		66.9	58.0						
A97 - CRESCENT DRIVE			1.44	0.45	0.648	23.148	27.45	1.75	37.8	2432.7	300.0	1500	0.50	5214.6	2.86	46.7%

UPPER CANADA CONSULTANTS
30 HANNOVER DRIVE, UNIT 3
ST. CATHARINES, ONTARIO, L2W 1A3

RAINFALL PARAMETERS:	A =	747.93	mm/hr	**SEWER DESIGN:**	PIPE ROUGHNESS: 0.013 FOR MANNING'S EQUATION
5 YEAR DESIGN STORM EVENT	B =	6.80	minutes		PIPE SIZES: 1.016 ACTUAL DIAMETER SIZE FACTOR
TOWN OF FORT ERIE IDF	C =	0.768			PERCENT FULL: TOTAL PEAK FLOW / CAPACITY

MUNICIPALITY: TOWN OF FORT ERIE
PROJECT NAME: CRESCENT ACRES
PROJECT NO.: 19106

S T O R M S E W E R D E S I G N S H E E T

LOCATION			STORMWATER ANALYSIS								STORM SEWER DESIGN					
DESCRIPTION	From M.H.	To M.H.	A Area (hectares)	R Runoff Coeff.	A*R	Accumulated A*R	Time of Concentration (min)	Flow Time (min.)	Rainfall Intensity (mm/hr)	Peak Flow (L/s)	Length (m)	Nominal Diameter (mm.)	Slope (%)	Full Flow Capacity (L/s)	Full Flow Velocity (m/s)	Percent Full
Existing stormwater drainage areas and concentration times from Philips Engineering North Crescent Park Storm Drainage (July 2009) unless stated otherwise.																
A1 to A22 - GARRISON ROAD			61.01	0.30	18.125	18.125	10.00	13.11	85.7	4313.1						
A92 - CRESCENT ROAD			0.51	0.45	0.230	18.354	23.11	0.66	55.0	2804.6	120.0	1050	0.90	2702.6	3.02	103.8%
A93 - ORCHARD AVENUE			0.74	0.45	0.333	0.333	10.00		85.7	79.2						
A94 - DAYTONA DRIVE			1.60	0.45	0.720	19.407	23.77	1.87	54.1	2916.1	320.0	1050	0.80	2548.0	2.85	114.4%
A86 to A91 - EVELYN AVENUE			6.16	0.34	2.097	2.097	16.19	0.97	67.3	392.2	90.0	600	0.50	452.9	1.55	86.6%
A95 - EVELYN AVENUE			1.52	0.45	0.684	22.188	25.64	1.81	51.7	3185.3	310.0	1200	0.67	3329.2	2.85	95.7%
AVAILABLE CAPACITY IN CRESCENT ROAD STORM SEWERS = 143.9 L/s																
A96 - EDGEWOOD AVENUE			1.56	0.20	0.312	0.312	10.00		85.7	74.2						
A97 - CRESCENT DRIVE			1.44	0.45	0.648	23.148	27.45	1.75	49.6	3187.3	300.0	1500	0.50	5214.6	2.86	61.1%

APPENDIX C

Stormwater Management Facility Calculations

Upper Canada Consultants
3-30 Hannover Drive
St. Catharines, ON, L2W 1A3
PROJECT NAME: **CRESCENT ACRES**
PROJECT NO.: **19106**

WET POND CALCULATIONS

Quality Requirements			**Quality Orifice**	**Outlet Weir**	**Outflow Pipe Orifice**	**Overflow Spillway**
Drainage Area (ha) =	12.79		Diameter (m) = 0.150	Perimeter Length (m) = 1.20	Diameter (m) = 0.450	Slopes (X:1) = 50.00
Normal (m^3/ha) =	117	(@ 60% IMP)	Cd = 0.62	Grate Slope (X:1) = 7	Cd = 0.63	Invert (m) = 184.21
Perm Pool (m^3/ha) =	77		Invert (m) = 182.35	Inlet Elevation (m) = 183.70	Invert (m) = 182.35	
Perm Pool Vol (m^3) =	985				Obvert (m) = 182.80	
Extended Vol (m^3) =	512					
Required Vol (m^3) =	1,496					
25mm MOE Volume =	1,702		MOE Equation 4.11 Drawdown Coefficient 'C2' = 1,559			
Water Level Elev. =	182.35	m	MOE Equation 4.11 Drawdown Coefficient 'C3' = 2,076			
			MOE Equation 4.11 Drawdown Time (h) = **36.8**			

Elevation	**Increment Depth (m)**	**Active Depth (m)**	**Surface Area (m^2)**	**Average Surface Area (m^2)**	**Increment Volume (m^3)**	**Permanent Volume (m^3)**	**Active Volume (m^3)**	**Quality Orifice (m^3/s)**	**Ditch Inlet (m^3/s)**	**Max Pipe Orifice (m^3/s)**	**Receiving Sewer Capacity (m^3/s)**	**Overflow Spillway (m^3/s)**	**Total Outflow (m^3/s)**	**Average Discharge (m^3/s)**
181.35		-1.00	576			0								
	0.50			800	400									
181.85		-0.50	1,024			400								
	0.50			1,286	643									
182.35		0.00	1,548			1,043								
182.35		0.00	2,120				0	0.000	0.000	0.000	0.144	0.000	0.000	
	1.00			2,793	2,793									0.023
183.35		1.00	3,466				2,793	0.046	0.000	0.371	0.144	0.000	0.046	
	0.35			3,886	1,360									0.050
183.70		**1.35**	**4,306**				**4,153**	**0.054**	**0.000**	**0.455**	0.144	**0.000**	**0.054**	
	0.30			4,587	1,376									0.099
184.00		1.65	4,868				5,529	0.060	0.336	0.516	0.144	0.000	0.144	
	0.21			5,073	1,065									0.162
184.21		1.86	5,278				6,594	0.064	0.745	0.554	0.180	0.000	0.180	
	0.09			5,367	483									0.397
184.30		1.95	5,457				7,077	0.066	0.951	0.570	0.216	0.399	0.615	

Notes

1. Quality Orifice flow is the orifice controlling for the 24 hour detention period and uses an orifice formula.
2. Pipe Orifice flow is calcuated using an orifice formula on the pipe from the ditch inlet to the outlet and uses the total head on the orifice.
3. Overflow Weir flow is calculated using a trapezondial weir to convey outflow for less frequent storms through the embankment with an emergency spillway.
4. Receiving Sewer Capacity is calculated as the identified 5 year capacity available in Crescent Road storm sewers (144 L/s) where Quality Orifice plus Ditch Inlet is less that 144 L/s, and up to a maximum of 216 L/s (144 L/s + 15%) to account for pressure effects in Crescent Road storm sewer system.
5. Total Outflow is calculated by adding the Overflow Spillway with the lowest of Quality Orifice plus Ditch Inlet, Max Pipe Orifice, or capacity of receiving storm sewer.

APPENDIX D

MIDUSS Existing and Future Drainage Analysis Output Files

Existing Conditions

```
         Output File (4.7) EX.OUT       opened 2022-11-02  17:06
         Units used are defined by G =    9.810
             24   144    10.000        are MAXDT MAXHYD & DTMIN values
         Licensee: UPPER CANADA CONSULTANTS
 35      COMMENT
        3     line(s) of comment
         CRESCENT ACRES, FORT ERIE
         STORMWATER MANAGEMENT PLAN
         EXISTING CONDITIONS
 35      COMMENT
        3     line(s) of comment
         ********************
         100 YEAR DESIGN STORM
         ********************
  2      STORM
             1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      1083.550     Coefficient  a
         6.618     Constant  b    (min)
          .735     Exponent  c
          .400     Fraction to peak  r
       240.000     Duration ó  240 min
                  75.641 mm     Total depth
  3      IMPERVIOUS
             1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
          .015     Manning "n"
        98.000     SCS Curve No or C
          .100     Ia/S Coefficient
          .518     Initial Abstraction
  4      CATCHMENT
         1.000     ID No.ó 99999
        13.610     Area in hectares
       301.000     Length (PERV) metres
         1.000     Gradient (%)
         8.000     Per cent Impervious
       301.000     Length (IMPERV)
          .000     %Imp. with Zero Dpth
             1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
          .250     Manning "n"
        77.000     SCS Curve No or C
          .100     Ia/S Coefficient
         7.587     Initial Abstraction
             1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
                .477       .000       .000       .000 c.m/s
                .425       .925       .465     C perv/imperv/total
 15      ADD RUNOFF
                .477       .477       .000       .000 c.m/s
 27      HYDROGRAPH DISPLAY
        5     is # of Hyeto/Hydrograph chosen
         Volume  =  .4788025E+04 c.m
 14      START
        1     1=Zero; 2=Define
```

Proposed Conditions without SWM

```
        Output File (4.7) FUT.OUT      opened 2022-11-04  11:55
        Units used are defined by G =     9.810
            24   144    10.000        are MAXDT MAXHYD & DTMIN values
        Licensee: UPPER CANADA CONSULTANTS
  35    COMMENT
       3     line(s) of comment
        CRESCENT ACRES, FORT ERIE
        STORMWATER MANAGEMENT PLAN
        FUTURE CONDITIONS WITHOUT SWM
  35    COMMENT
       3     line(s) of comment
        *********************
        2 YEAR DESIGN STORM
        *********************
   2    STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      628.050     Coefficient  a
        6.652     Constant  b    (min)
         .796     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
               31.329 mm     Total depth
   3    IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
  35    COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
   4    CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .887       .000       .000       .000 c.m/s
              .181       .831       .571     C perv/imperv/total
  15    ADD RUNOFF
              .887       .887       .000       .000 c.m/s
  27    HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .2284462E+04 c.m
  14    START
       1     1=Zero; 2=Define
  35    COMMENT
       3     line(s) of comment
        *********************
        5 YEAR DESIGN STORM
        *********************
   2    STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      747.930     Coefficient  a
        6.800     Constant  b    (min)
         .768     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
               43.510 mm     Total depth
   3    IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
  35    COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
   4    CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
             1.246       .000       .000       .000 c.m/s
              .265       .877       .632     C perv/imperv/total
  15    ADD RUNOFF
             1.246      1.246       .000       .000 c.m/s
  27    HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .3518997E+04 c.m
  14    START
       1     1=Zero; 2=Define
  35    COMMENT
       3     line(s) of comment
        *********************
        100 YEAR DESIGN STORM
        *********************
   2    STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
     1083.550     Coefficient  a
        6.618     Constant  b    (min)
         .735     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
               75.641 mm     Total depth
   3    IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
  35    COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
   4    CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
             2.089       .000       .000       .000 c.m/s
              .425       .923       .724     C perv/imperv/total
  15    ADD RUNOFF
             2.089      2.089       .000       .000 c.m/s
   4    CATCHMENT
       10.000     ID No.ó 99999
         .810     Area in hectares
       73.000     Length (PERV) metres
        1.000     Gradient (%)
       15.000     Per cent Impervious
       73.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .056      2.089       .000       .000 c.m/s
              .425       .915       .498     C perv/imperv/total
  15    ADD RUNOFF
              .056      2.140       .000       .000 c.m/s
  27    HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .7310660E+04 c.m
  14    START
       1     1=Zero; 2=Define
```

Proposed Conditions with SWM

```
        Output File (4.7) SWM.OUT      opened 2022-11-02  17:06
        Units used are defined by G =     9.810
            24   144    10.000        are MAXDT MAXHYD & DTMIN values
        Licensee: UPPER CANADA CONSULTANTS
 35     COMMENT
       3     line(s) of comment
        CRESCENT ACRES, FORT ERIE
        STORMWATER MANAGEMENT PLAN
        FUTURE CONDITIONS WITH SWM
 35     COMMENT
       3     line(s) of comment
        *********************
        25mm DESIGN STORM
        *********************
  2     STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      512.000     Coefficient  a
        6.000     Constant  b    (min)
         .800     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
                25.036 mm     Total depth
  3     IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
 35     COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
  4     CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
               .679       .000       .000       .000 c.m/s
               .130       .801       .533     C perv/imperv/total
 15     ADD RUNOFF
               .679       .679       .000       .000 c.m/s
 27     HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .1702490E+04 c.m
 10     POND
       6 Depth - Discharge - Volume sets
        182.350        .000          .0
        183.350       .0460      2793.0
        183.700       .0540      4153.0
        184.000        .144      5529.0
        184.210        .180      6594.0
        184.300        .615      7077.0
        Peak Outflow    =      .023 c.m/s
        Maximum Depth   =   182.841 metres
        Maximum Storage =     1372. c.m
               .679       .679       .023       .000 c.m/s
 14     START
       1     1=Zero; 2=Define
 35     COMMENT
       3     line(s) of comment
        *********************
        2 YEAR DESIGN STORM
        *********************
  2     STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      628.050     Coefficient  a
        6.652     Constant  b    (min)
         .796     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
                31.329 mm     Total depth
  3     IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
 35     COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
  4     CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
               .887       .000       .023       .000 c.m/s
               .181       .831       .571     C perv/imperv/total
 15     ADD RUNOFF
               .887       .887       .023       .000 c.m/s
 27     HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .2286383E+04 c.m
 10     POND
       6 Depth - Discharge - Volume sets
        182.350        .000          .0
        183.350       .0460      2793.0
        183.700       .0540      4153.0
        184.000        .144      5529.0
        184.210        .180      6594.0
        184.300        .615      7077.0
        Peak Outflow    =      .030 c.m/s
        Maximum Depth   =   183.011 metres
        Maximum Storage =     1846. c.m
               .887       .887       .030       .000 c.m/s
 14     START
       1     1=Zero; 2=Define
 35     COMMENT
       3     line(s) of comment
        *********************
        5 YEAR DESIGN STORM
        *********************
  2     STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
      747.930     Coefficient  a
        6.800     Constant  b    (min)
         .768     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
                43.510 mm     Total depth
  3     IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
 35     COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
  4     CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              1.246       .000       .030       .000 c.m/s
               .265       .877       .632     C perv/imperv/total
 15     ADD RUNOFF
              1.246      1.246       .030       .000 c.m/s
 27     HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .3519148E+04 c.m
 10     POND
       6 Depth - Discharge - Volume sets
        182.350        .000          .0
        183.350       .0460      2793.0
        183.700       .0540      4153.0
        184.000        .144      5529.0
        184.210        .180      6594.0
        184.300        .615      7077.0
        Peak Outflow    =      .046 c.m/s
        Maximum Depth   =   183.366 metres
        Maximum Storage =     2855. c.m
              1.246      1.246       .046       .000 c.m/s
 14     START
       1     1=Zero; 2=Define
 35     COMMENT
       3     line(s) of comment
        *********************
        100 YEAR DESIGN STORM
        *********************
  2     STORM
            1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
     1083.550     Coefficient  a
        6.618     Constant  b    (min)
         .735     Exponent  c
         .400     Fraction to peak  r
      240.000     Duration ó  240 min
                75.641 mm     Total depth
  3     IMPERVIOUS
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .015     Manning "n"
       98.000     SCS Curve No or C
         .100     Ia/S Coefficient
         .518     Initial Abstraction
 35     COMMENT
       3     line(s) of comment
        **********************
             TO SWM POND
        **********************
  4     CATCHMENT
       10.000     ID No.ó 99999
       12.790     Area in hectares
      292.000     Length (PERV) metres
        1.000     Gradient (%)
       60.000     Per cent Impervious
      292.000     Length (IMPERV)
         .000     %Imp. with Zero Dpth
            1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
         .250     Manning "n"
       77.000     SCS Curve No or C
         .100     Ia/S Coefficient
        7.587     Initial Abstraction
            1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              2.089       .000       .046       .000 c.m/s
               .425       .923       .724     C perv/imperv/total
 15     ADD RUNOFF
              2.089      2.089       .046       .000 c.m/s
 27     HYDROGRAPH DISPLAY
       5     is # of Hyeto/Hydrograph chosen
        Volume  =  .7005564E+04 c.m
```

```
10     POND
      6 Depth - Discharge - Volume sets
       182.350        .000          .0
       183.350       .0460      2793.0
       183.700       .0540      4153.0
       184.000        .144      5529.0
       184.210        .180      6594.0
       184.300        .615      7077.0
       Peak Outflow    =      .144 c.m/s
       Maximum Depth   =   183.999 metres
       Maximum Storage =     5522. c.m
             2.089      2.089       .144       .000 c.m/s
16     NEXT LINK
             2.089       .144       .144       .000 c.m/s
 4     CATCHMENT
      10.000     ID No.ó 99999
        .810     Area in hectares
      73.000     Length (PERV) metres
       1.000     Gradient (%)
      15.000     Per cent Impervious
      73.000     Length (IMPERV)
        .000     %Imp. with Zero Dpth
           1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
        .250     Manning "n"
      77.000     SCS Curve No or C
        .100     Ia/S Coefficient
       7.587     Initial Abstraction
           1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .056       .144       .144       .000 c.m/s
              .425       .915       .498     C perv/imperv/total
15     ADD RUNOFF
              .056       .152       .144       .000 c.m/s
14     START
      1     1=Zero; 2=Define
```