EMPIRE (GRAND NIAGARA) PROJECT GP INC.

Report Number: 211-08936-00

DRAFT PLAN OF GRAND NIAGARA MIXED USE SUBDIVISION

STORMWATER MANAGEMENT REPORT

February 03, 2023

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EMPIRE (GRAND NIAGARA) PROJECT GP INC.

Project No.: 211-08936-00
Date: February 03, 2023

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REVISION 2			
FINAL			

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APPENDICES

1 INTRODUCTION

WSP Canada Inc. (WSP) has been retained by Empire (Grand Niagara) Project GP Inc. to prepare a stormwater management (SWM) report in support of the Draft Plan of proposed mixed-use subdivision of Grand Niagara in the City of Niagara Falls (the City), Ontario.

The proposed development consists of mixed residential development with townhouses and single-family homes, school blocks, employment developments, SWM blocks, and open spaces.

This report provides the conceptual framework for stormwater drainage and management for the subdivision prior to detailed design being undertaken. The report outlines the existing drainage conditions, SWM design criteria, the proposed SWM strategies for the post-development conditions, and the corresponding supporting documents.

This report has been prepared to accompany the submission for Draft Plan approval of a subdivision, known as the Grand Niagara. All required approvals from Niagara Peninsula Conservation Authority (NPCA), the Ministry of Environment, Conservation and Parks (MECP) and all other governing bodies shall be obtained as part of the registration of the subdivision.

1.1 Site Location

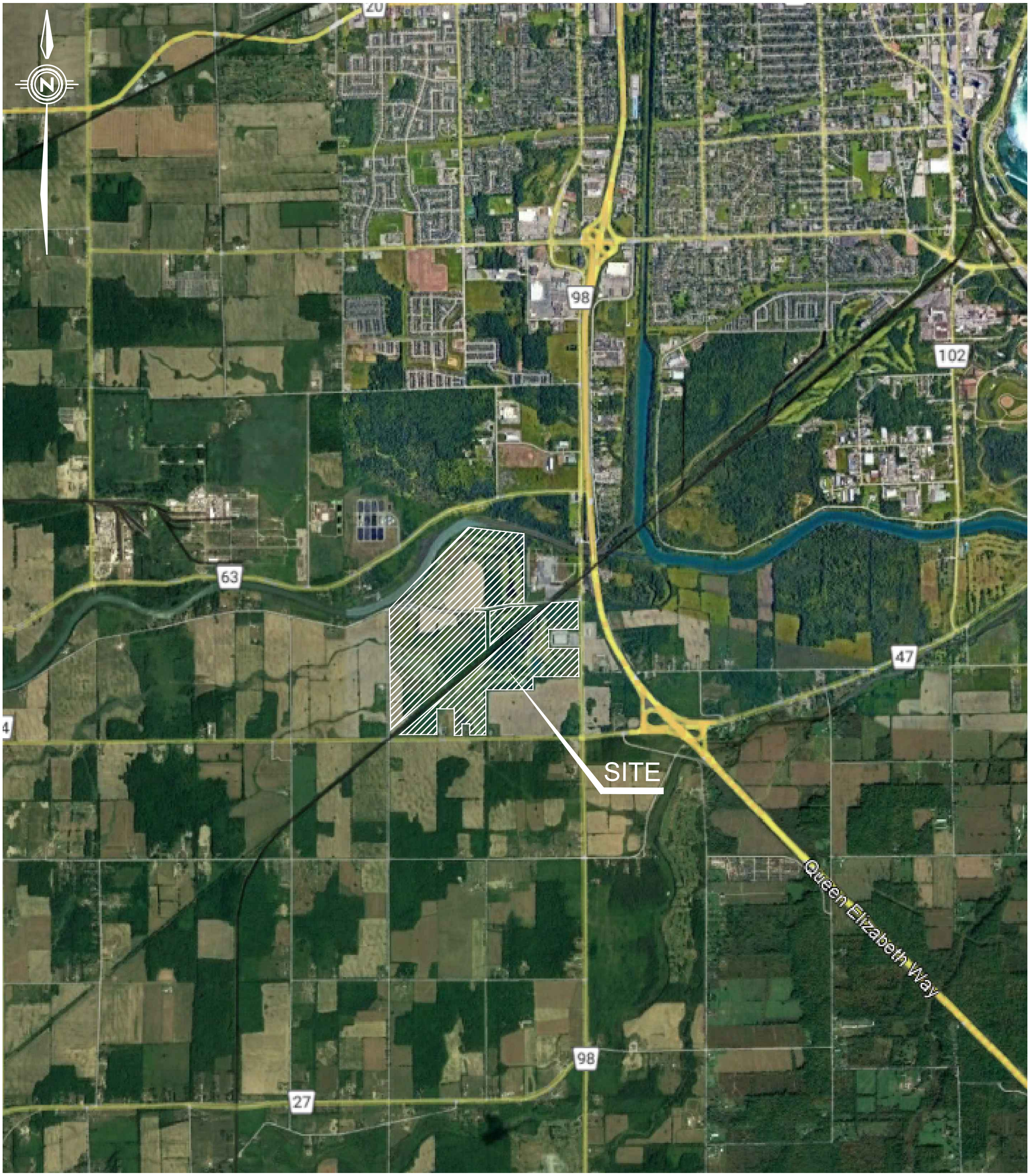
The subject property occupies an area of 184.47 hectares in the city of Niagara Falls. The subject site is bounded by Crowland Avenue to the west, the Welland River to the north, Montrose Road to the east and Biggar Road to the south.

Figure 1 presents the location of the subdivision.

1.2 Development Proposal

Draft Plan of Subdivision for Grand Niagara (Drawing DPP at back) has a total area of 184.47 ha, which is comprised of mixed-density residential developments, schools, hospital employment, parks, SWM blocks, and open space, including:

- Residential Developments (back-to-back, townhouses, semi-detached, detached, medium density, mixed use) – 5,351 units max. (60.30 ha);
- School Blocks (5.78 ha);
- Parks (5.23 ha)



CLIENT	EMPIRE (GRAND NIAGARA) PROJECT GP INC.
TITLE	GRAND NIAGARA MIXED-USE SUBDIVISION
	LOCATION PLAN

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Checked	ADR	Drawn	10/12 Cad
Date	FEB 2023	Proj. No.	211-08936
Scale	NTS	Figure No.	1

- Hospital Employment (0.85 ha);
- SWM Blocks (8.78 ha);
- Open Space and Buffers (79.94 ha);
- Drainage Swale (0.09 ha);
- Rights-of-Way (ROW) and Road Widenings (23.49 ha).

1.3 Background Documents

In preparing this report, we have consulted with the requirements of City of Niagara Falls, Niagara Peninsula Conservation Authority (NPCA), the Ontario Ministry of Environment, Conservation and Parks (MECP).

The following documents have been reviewed in preparing this SWM report:

- Stormwater Management Planning and Design (SWMPD) Manual, Ontario Ministry of Environment, Conservation and Parks (MECP), March 2003;
- Stormwater Management Guidelines, Niagara Peninsula Conservation Authority (NPCA), March 2010;
- Engineering Design Guidelines Manual, City of Niagara Falls, April 2016;
- Environmental Impact Study for Grand Niagara Secondary Plan, Savanta Inc., February 2017;
- Stormwater Management Plan for Grand Niagara Secondary Plan, WSP, November 2016;
- Preliminary Geotechnical Investigation Report for Proposed Grand Niagara Residential Subdivision, GeoTerre Limited, March 2021;
- Preliminary Hydrogeologic Assessment and Water Balance Study for Proposed Grand Niagara Residential Subdivision, Terra-Dynamics Consulting Inc., October 2022;
- Low Impact Development Stormwater Management Planning and Design Guide, Version 1.0, Credit Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA), 2010;

2 PREDEVELOPMENT CONDITIONS

2.1 General

The subject site is located within the City of Niagara Falls and bounded by Welland River to the north, Crowland Avenue to the west, Biggar Road to the south, and the Montrose Road to the east, as shown in Figure1. The subject property occupies an area of 184.47 ha and currently occupied by the Grand Niagara golf course. A railway runs southwest – northeast direction and bisects the property into two parcels.

Three watercourses – Welland River, Grassy Brook and Lyons Creek Tributary 1 drain the Grand Niagara property from west to east. These watercourses are located within the jurisdiction of Niagara Peninsula Conservation Authority.

The existing condition for the site is illustrated in Drawing EDP at back.

2.2 Soil Conditions

The site is situated within the Physiographic Region known as the Haldimand Clay Plain as per Chapman and Putnam (1984). The Haldimand Clay Plain is characterized by heavy clay soils with poor drainage, resulting in a high level of runoff and minimal groundwater recharge.

As per the Preliminary Geotechnical Investigation Report (GeoTerre Ltd., March 2021), the typical overburden soils consist of a variable thickness surface layer of lacustrine silty clay associated with glacial Lake Warren overlying glacial till materials.

The boreholes generally revealed topsoil overlying silty clay and silty clay till. A surficial layer of topsoil was encountered at the surface of all borehole locations, extending to depths varying from 0.15 m to 0.20 m below ground surface. A discontinuous layer of surface fill materials, which are presumably associated with the development of the existing golf course, were encountered in a number of boreholes with total thicknesses below the surface topsoil/organics of between 0.8 m and 2.8 m. Below the surface layer of topsoil/organics/fill, a cohesive deposit of silty clay was encountered, extending to depths in the order of 10 m to 12 m below ground surface. Deep buried layer of silty clay till extends to a depth of 21.5 m. Bedrock of the Salina Formation might be present below the silty clay till materials.

2.3 Surface Drainage

The subject property contributes flows to three watercourses: Lower Welland River, Grassy Brook, and Lyons Creek Tributary 1, which are within the jurisdiction of Niagara Peninsula Conservation Authority.

2.3.1 Lower Welland River

Lower Welland River runs west-east direction along the north property limit and continues east, joining the Niagara River upstream of Niagara Falls. Grand Niagara development within the Lower Welland River watershed is 59.2 hectares, which is approximately 2.9% of the total drainage area (20.7 km^2).

2.3.2 Grassy Brook

Grassy Brook originates 5.5 km to the west of the subject lands, extends through the central of the property, and continues in an easterly direction, eventually flowing into the Lower Welland River east of the Queen Elizabeth Way (QEW). Grand Niagara development within the Grassy Brook watershed is 84.0 hectares, which is approximately 6.6% of the total drainage area (12.8 km^2).

2.3.3 Lyons Creek Tributary 1

Lyons Creek Tributary 1 enters the subject lands at the western boundary, and continues across the site generally parallel to, and south of, Grassy Brook. It continues in an easterly direction to its confluence with Lyons Creek, east of the QEW immediately south of Lyons Creek Road. This tributary is an intermittent watercourse. Grand Niagara development within the Lyons Creek Tributary 1 is 94.4 hectares, which is approximately 31.3% of the total drainage area (3.02 km^2).

2.4 Topography

The topography of the site is generally flat and with steep slopes at the valley lands of all three watercourses.

2.5 Groundwater

Groundwater levels are generally quite shallow - typically 2.0 to 3.0 m below ground surface, as per the Preliminary Geotechnical Investigation Report by GeoTerra Limited

(2021) and Preliminary Hydrogeologic Assessment and Water Balance Study by Terra-Dynamics Consulting Inc. (2022).

2.6 Natural Heritage

Development and site alteration shall not be permitted in significant natural heritage features such as provincially significant wetlands (PSW), significant woodlands, significant valley lands, significant wildlife habitat or significant areas of natural and scientific interest (ANSIs), unless it is demonstrated that there will be no negative impacts on the natural features or their ecological functions. A number of these elements appear to occur within and/or immediately adjacent to the subject lands: PSWs (Portion of the Low Grassy Brook PSW complex and Welland River East PSW complex), fish habitat (all three watercourses), significant valley lands (Welland River).

2.7 Development Constraints

The existing conditions of the site provide constraints which have been considered in the development of the Draft Plan and SWM strategies discussed herein. The items considered in identifying the development limits include buffer on provisionally significant wetlands (PSWs), non-PSWs and retained woodlands; buffers on valley lands of Welland River, Grassy Brook, and Lyons Creek; Regulatory Floodplain, and Limit of Meander Belt. Refer to the Environmental Impact Study (EIS) for more details. While the Grand Niagara area is in some 184 ha, the developable areas is approximately 100 ha.

The clayey soils with low permeability, shallow groundwater table and bedrock layer limit the potential to implement low impact development (LID) measures.

3 PROPOSED DEVELOPMENT AND STORMWATER MANAGEMENT

3.1 Proposed Development Layout

The proposed development consists of mixed residential development with townhouses, semi-detached and detached units, schools, hospital employment, parks, SWM blocks, and open space. Refer to Drawing PP at back of the report for the proposed development layout.

3.2 Stormwater Management Design Criteria

The management of water resources within the subject development shall be undertaken in accordance with the directions of MECP's Stormwater Management Planning and Design Manual (2003), NPCA's Stormwater Management Guidelines (2010), City of Niagara Falls Engineering Design Guidelines Manual (2016), and the design criteria established in the Stormwater Management Plan for Grand Niagara Secondary Plan (2016).

Table 7.6.1 of NPCA's SWM Guidelines contains a summary of the stormwater management policies and technical guidelines in SWM controls regarding to Flood/Quantity Control, Quality Control, Water Balance, Erosion/Geomorphologic Consideration, etc. Refer to excerpt included in Appendix A.

NPVA states that:

> "*Sufficient SWM controls are required by the NPCA to ensure that flooding, pollution, surface erosion and conservation of land impacts due to development do not occur*."

The SWM requirements applicable to the proposed development is summarized as below.

3.2.1 Water Balance

The proposed development would change some of the land cover from pervious surface to impervious pavement and rooftops, and result in increased runoff and peak flows and reduced infiltration and evapotranspiration.

In the absence of a sub-watershed plan and where suitable soils exist, the NPCA requires that best efforts be made to match pre- and post-development infiltration volumes in order to maintain groundwater recharge.

3.2.2 Water Quality

The NPCA typically requires that a Normal Level of stormwater quality control be implemented as the minimum acceptable standard regardless of the condition of the receiving watercourse. The NPCA also indicates that additional measures would be required for fishery sensitive watercourses to control TSS and TP in order to achieve a more stringent standard (i.e., Enhanced Level of protection).

An Enhanced Level Protection or a long-term removal of 80% total suspended solids (TSS) is required for all development areas draining to all three receiving watercourses (i.e., Welland Rover, Grassy Brook, and Lyons Creek Tributary #1), which contain Type 1 – critical fish habitats.

Properly sized oil/grit separator (OGS) units might be considered for commercial, industrial, or infill developments.

3.2.3 Erosion Control

In the absence of a subwatershed study outlining specific requirements, erosion control criteria for the subject development follows the MECP's Simplified Design Approach. The runoff from a 25 mm rainfall storm shall be detained in SWM wet ponds/wetlands and released over a minimum 24-hour period.

3.2.4 Water Quantity

The NPCA requires that all proposed development does not increase flood risk to existing developments. Typically, the NPCA requires that post-development runoff flows from a site are controlled to a level that matches or is below the pre-development flows for the 2, 5, 25, and 100-year design storm events.

The NPCA also indicates that consideration may be given to not requiring peak flow controls if the assessment of receiving system capacity demonstrates little or no benefit to such controls.

The subject development is located at the downstream of the receiving watercourses and covers relatively small portion of the entire subwatersheds. The SWM Plan for Grand Niagara Secondary Plan (2016) has demonstrated that providing quantity control storage on the subject site shall result in the coincidence of the controlled peak flows and upstream peaks, and thus increase downstream peak flow rates within Grassy Brook and Lyons Creek Tributary #1. Meanwhile, the Welland River is considered a major river system. Therefore, quantity control is not recommended for the Grand Niagara subdivision.

Major overland flow routes are to be designed to have sufficient capacity for the Regulatory event (100-year storm). Different design storm distributions and durations (3-hour Chicago, 12-hour AES, and 24-hour SCS distribution) shall be assessed to estimate the peak flow rates to be used for conveyance capacity check.

3.3 Stormwater Management Alternatives

MECP recommends that stormwater management practices (SWMPs) be implemented, on a hierarchical basis, to provide an integrated "treatment train approach" to water management, with preference for source control at the lot level, followed by conveyance system control, with less reliance on end-of-pipe control.

Table 1.3 of MECP's Manual and Table 7.3.1 of NPCA's Guidelines include a comprehensive list of current available SWMPs associated with each of these levels.

Not all SWMPs are feasible in all areas. The long list of available SWMPs has been evaluated in the following sub-sections through various screening factors with respect to physical constraints, municipal standards and maintenance concerns, concerns for groundwater contamination and site planning requirements.

This section describes the possible controls and indicate their feasibility and applicability to the proposed development. Through an evaluation of each management opportunity, various opportunities have been identified for further consideration in developing a preferred SWM strategy for the Grand Niagara subdivision.

The evaluation of alternative SWMPs has made use of relevant guidelines in the Stormwater Management Planning and Design Manual (MECP, 2003), and the Low Impact Development Stormwater Management Planning and Design Guide (CVC and TRCA, 2010).

Section 3.4 integrates this evaluation into a stormwater concept proposed for the subject development.

3.3.1 Infiltration Potential

Both lot level and conveyance controls are primarily based on infiltration techniques which are dependent on the soil type and strata found on the site. The soil conditions found on the site have been described previously in Section 2.2. the site topography has been described in Section 2.3.

Generally, the site underlain soils are silty clay and silty clay till with low percolation rate (< 15 mm/hr) and do not meet the minimum requirements for infiltration based SWMPs. Meanwhile, the subsurface infiltration measures, such as soakaway pits, infiltration trenches, etc., are excluded due to the shallow groundwater table.

3.3.2 Lot Level Controls

Lot level SWMPs include reducing lot grades, discharging clean roof runoff to pervious surfaces, infiltration swales, or soakaway pits, rain gardens, pervious pavements, green roofs and reduced lot gradings. These SWMPs encourage infiltration to groundwater, help to reduce the volume of water travelling to the major and minor systems and help to preserve the pre-development hydrologic regime. Infiltration is also effective for reducing runoff temperature increases and removing sediment, heavy metals and nutrients from runoff. Generally, infiltration techniques are recommended in areas where the minimum infiltration rate is equal to or greater than 15 mm/hr. Where practical, this is a preferable SWMP. As described in above section, the site soils are generally not suitable for infiltration practices.

Reduced lot grading involves the grading of individual lots at less than the 2% normally required by municipal standards. At grades approaching 0.5%, which are optimum for this type of control, it is generally recognized that consistent grading is not possible and that some short term, localized ponding and wet areas will occur on the lots; However, this localized ponding should not create any significant inconvenience for the landowners.

It is encouraged to discharge roof leaders to surface ponding areas created in the rear yard. However, roof leaders and sump pumps discharge to soakaway pits are typically not supported due to low permeability of the soil and maintenance and impacts on use of rear yards.

Rain barrels or cisterns can be used to temporarily store the rainwater for later use in the garden or on the lawn. This is particularly useful in areas where impermeable soils, while infiltration is low and ponding areas may remain wet for an extended period of time.

According to a document entitled, “Stormwater Planning: A Guidebook for British Columbia, updated September 6, 2005”, it suggests that runoff from landscaped areas can be virtually eliminated by providing a 300 mm layer of landscaping absorbent soil, even under very wet conditions where the hydraulic conductivity of the underlying soil is low.

In general, porous pavements have a poor performance history and require frequent maintenance in order to be effective. The MECP's Stormwater Management Planning and Design Manual does not recommend the use of this type of practise. Further, within the context of this development, the use of porous pavements is not appropriate because it is in areas of predominantly clayey soils with limited infiltration capacity. The use of porous pavement systems is therefore not recommended.

3.3.3 Conveyance Controls

Conveyance SWMPs include pervious catchbasins, infiltration facility and drainage swales. Each type of control has been evaluated on physical feasibility, pre-treatment requirements, and utility. Since conveyance controls infiltrate road runoff, the potential of chloride contamination of the underlying aquifer must also be considered in decisions to implement these types of controls.

Drainage swales rely on various forms of vegetation to enhance pollutant removal, habitat value and aesthetics of a development. They work best in areas where the soils allow infiltration of runoff; however, they also provide water quality treatment through filtration and may be used in areas with poor soils if an underdrain system is incorporated into the design. To be effective in filtration, swale drainage systems require a broad cross-section (3.25 m minimum), adequate length between driveway culverts (5 m minimum) and a gentle slope (< 1%). Drainage swales are excluded from the recommended SWM plan due to the limited infiltration potential of the site soil and lack of semi-urban road of the proposed development.

Both perforated pipe systems and pervious catchbasins should receive pre-treatment to prevent premature clogging of the infiltration components. The use of perforated pipes is therefore not recommended.

3.3.4 End-of-Pipe Controls

End-of-pipe SWMPs, such as extended detention wet ponds / wetlands can remove moderate to high levels of sediment from stormwater runoff. Extended detention wet ponds / wetlands are also efficient in removing nutrients from stormwater during the summer months. These facilities can be effective for a wide variety of land areas.

Infiltration facilities, filter strips, and sand filters are normally recommended for use only when there is a relatively small contributing area (< 2 hectare for the first two and < 5 hectare for the sand filter systems). Distributed use of these devices is not practical on the site because of problems with providing pre-treatment due to the nature of the soils with limited infiltration characteristics.

As a result, the preferred types of end-of-pipe controls for the site are either wet ponds or wetlands. Total four SWM wet facilities are identified in the Draft Plan of subdivision as main component of the SWMPs for the subject property. The specific location and type of SWM wet facility have been identified based on block-specific conditions and analysis.

As per NPCA's SWM Guidelines, properly sized oil/grit separator (OGS) units may be considered for commercial or industrial developments, or those areas either too small to warrant a SWM wet facility or cannot be directed to the proposed SWM wet facilities due to grading constraints.

3.4 Recommended Stormwater Management Approach

The objective of the SWM plan is to provide satisfactory storm drainage from the site and ensure the long-term sustainability of the receiving watercourses. The primary factor from a water quality perspective is to remove sediment and associated pollutants from stormwater runoff, thus preventing them from entering the receiving waterbodies.

The recommended SWM concept for the subdivision consists of four SWM wet ponds, a grassed swale, and OGS units for the hospital employment developments, residential development blocks, and mixed-use blocks.

A description of the proposed SWM facilities is presented in **Table 3.1** and discussed in Section 3.4.1 ~ 3.4.3. Refer to Drawing PDP at back of the report for the proposed Drainage Plan.

Table 3.1 Proposed SWM Strategies

Catchment ID	Primary Land Use	Area (ha)	IMP (%)	SWM Facility	Stormwater Management
1001 ~ 1003	Mixed Residential	33.17	50.2	SWM Wet Pond #1	Water Quality and Erosion Control
1004	Mixed Residential	23.05	60.4	SWM Wet Pond #2	Water Quality and Erosion Control
2001	Mixed Residential	17.75	58.4	SWM Wet Pond #3	Water Quality and Erosion Control
2002, 2010	Mixed Residential	26.69	30.5	SWM Wet Pond #4	Water Quality and Erosion Control
2003	Mixed Residential	3.22	50.6	Grassed Swale	Water Quality
Others				OGS Units	Water Quality

3.4.1 SWM Wet Ponds

A total of four (4) SWM wet ponds (Pond #1 ~ #4) are proposed to provide water quality (Enhanced Level of Protection) and Erosion Control (Extended Detention of runoff from 25 mm rainfall event for minimum 24-hours). Quantity control is not required for the subject development.

Minor flow shall be conveyed to the proposed SWM wet ponds via on-site storm sewer system. Major flow shall be conveyed through proposed road networks and directly discharge into receiving watercourses via overland flow channels.

Storage requirements, preliminary layouts and outlet control structure designs for SWM Wet Pond #1 ~ #4 are presented in Section 6.2 ~ 6.5 of this report. Detailed calculations are included in Section 5 ~ 8 in Appendix A.

3.4.2 Grassed Swale

A grassed swale is proposed to provide water quality treatment for runoff generated from Catchment 2003. Refer to Section 6.6 of this report and Section 9 of Appendix A for more details.

3.4.3 Oil/Grit Separator (OGS) Units

For development blocks which can not be directed to the proposed SWM wet ponds for water quality treatment, such as hospital employment development (catchment 3003), mixed use block (Catchment 2005, 3001 and 3002), and medium density residential development (catchment 2004), Oil/Grit Separator (OGS) units shall be proposed to address water quality prior to discharging into the watercourses.

For the preliminary design purposes, a computer program developed by PCSWMM model for Stormceptor was used to size the required OGS units to provide minimum 60% TSS removal and 90% annual runoff treatment for the proposed development area. **Table 3.2** summarizes the drainage, OGS units and TSS removal efficiency. Detailed OGS sizing reports are included in Appendix C.

Table 3.2 Proposed OGS Units

Area ID	Land Use	Area (ha)	TIMP (%)	OGS Model	No. of Units	Area Per Unit (ha)	TSS Removal (%)	Runoff Treated (%)
2004	Medium Density	1.07	50.0	EFO8	1	1.07	63%	>90%
2005	Mixed Use	2.14	78.6	EFO10	1	2.14	60%	>90%
3001-1	Mixed Use	2.88	78.6	EFO12	1	2.88	61%	>90%
3001-2	Mixed Use	4.84	78.6	2 X EFO10	2	2.42	60%	>90%
3001-3	Road ROW	0.90	57.1	EFO6	1	0.90	61%	>90%
3002	Mixed Use	2.20	78.6	EFO10	1	2.20	60%	>90%
3003	Hospital Employ.	2.30	76.7	EFO10	1	2.30	62%	>90%

It is generally accepted that OGS units, operating alone, are capable of achieving a TSS removal efficiency of 50%. Therefore, treatment train approach with combination of OGS units and LID measures is proposed to achieve an 80% TSS removal. The LID measures may include Goss Traps in the catch basins, bioswales, settling basins, and vegetated wetland features at storm outfalls, etc.

3.4.4 Low Impact Development (LID) Practices

A long list of potential SWM LID practices has been evaluated in Section 3.3. Most have been screened out due to the low infiltration potential of the site subsurface soils, and shallow groundwater table.

The following LID measures might be implemented in the subject development to address water quality and water balance:

- Reduced lot grading;
- Downspout disconnection and direct roof leader to pervious areas;
- Rain barrels;
- Absorbent soils;
- Grassed Swale (Refer to Section 6.6);
- Bioswales, settling basins, and vegetated wetland features at storm outfalls.

4 HYDROLOGIC ANALYSIS AND MODELLING APPROACH

4.1 Hydrologic Analysis

The Visual OTTHYMO (VO) hydrologic model has been used to simulate the pre-development and post-development flow rates from the subject site, and to size and confirm the performance of the proposed SWM facility.

The 25 mm rainfall event is modelled to estimate the required erosion control storage and to size the low flow control device to achieve preferred extended detention time.

Quantity control is not required for the subject development. However, the regional event, along with 100-year storm are used to check the conveyance capacity and size the emergency spillway.

4.2 Meteorological Data

The design storm approach was used to generate runoff from the site. Intensity Duration Frequency (IDF) curves derived for the City of Niagara Falls from historical rainfall data shall be used to synthesize the 3-hour Chicago, 12-hour AES, and 24-hour SCS design storms.

Both the IDF curves from Niagara Peninsula Conservation Authority (NPCA) and Environment Canada were evaluated. Data from the latter are considered appropriate and shall be used in the hydrologic analysis.

4.2.1 IDF Curves from NPCA

Table 7.2.2 in the NPCA's Stormwater Management Guidelines (2010) gives standard IDF coefficient (a, b, c) for City of Niagara Falls where the rainfall intensity can be calculated using the following equation:

$$I = \frac{a}{(t_c + b)^c}$$

Where, I = Rainfall Intensity in mm/hr;

T_c = time of Concentration in minutes;

a, b, c = Coefficient

Table 4.1 presents IDF coefficients, 10 minutes rainfall intensity, and rainfall depths of various durations for the City of Niagara Falls, as per NPCA SWM Manual.

Table 4.1 IDF Data for City of Niagara Falls (as per NPCA SWM Manual)

Return Period (Years)	a	b	c	10 minutes Rainfall Intensity (mm/hr.)	Rainfall Depth (mm)		
					3-hour	12-hour	24-hour
2	521.97	5.28	0.759	65.94	29.8	42.3	50.1
5	719.50	6.34	0.769	84.02	38.8	54.6	64.3
10	577.93	2.48	0.669	106.77	53.2	84.8	106.8
25	1020.69	7.29	0.779	110.83	52.0	72.2	84.5
100	1264.57	7.72	0.781	133.78	63.5	88.1	102.9

As shown in **Table 4.1**, the IDF coefficients for 50-year design storm are missing. Furthermore, the rainfall volumes for the 25-year event are less than those for the 10-year event.

4.2.2 IDF Curves from Environment Canada

IDF curves were generated by Environment Canada for City of Niagara using the data from nearby rainfall gauge. **Table 4.2** presents IDF coefficients, 10 minutes rainfall intensity, and rainfall depths of various durations for the City of Niagara Falls, as per Environment Canada. The rainfall intensity can be calculated using the following equation:

$$I = AT^B$$

Where, I = Rainfall Intensity in mm/hr;

T = Rainfall Duration in hours;

A, B = Constant Coefficient

The IDF data generated by Environment Canada for City of Niagara Falls shall have 10 minutes rainfall intensity comparable to that obtained from NPCA. Furthermore, the former also gives the IDF coefficient for 50-year design storm and the 4-hour rainfall depth shall increase with the increase of the return periods of the design storm.

Therefore, the IDF data from Environment Canada shall be used in the hydrologic analysis for the subject site.

Table 4.2 IDF Data for City of Niagara Falls (as per Environment Canada)

Return Period (Years)	A	B	10 minutes Rainfall Intensity (mm/hr.)	Rainfall Depth (mm)		
				3-hour	12-hour	24-hour
2	19.50	-0.668	64.54	27.9	44.3	55.7
5	25.30	-0.673	84.49	36.2	57.0	71.5
10	29.20	-0.676	98.04	41.5	65.1	81.5
25	34.00	-0.678	114.57	48.4	75.7	94.6
50	37.60	-0.680	127.15	53.4	83.3	104.0
100	41.20	-0.681	139.58	58.5	91.0	113.5

4.3 Pre-Development Conditions

The subject property occupies an area of 184.47 ha and currently occupied by the Grand Niagara golf course . The subject lands are delineated into sub-catchments based on the available topographic information. Note that the rail corridor and external residential and agricultural lands north of Biggar Road are also included in the drainage delineation, resulting in a total drainage area of 238.58 ha.

Refer to Drawing EDP at back of this report for the existing drainage plan. **Table 4.3** presents the drainage parameters under pre-development conditions. The imperviousness area is estimated using Google Map. A weighted SCS Curve Number (CN) is calculated with a typical CN value of 80 for pervious area and a value of 96 for impervious area. A typical initial abstraction (IA) of 10 mm is assumed for the pre-development conditions. Airport method is used to estimate the Time of Concentration (Tc) and then converted to Time to Peak (Tp).

Note that quantity control is not required for the subject development, and thus the hydrologic simulation of the existing drainage conditions. Therefore, Drawing EFP and **Table 4.3** are used for the illustration purpose only.

Table 4.3 Pre-Development Drainage Catchment Parameters

Watershed	Catchment ID	Area (ha)	TIMP (%)	CN	IA (mm)	Tp (hrs)	Command
Welland River	101	25.91	4.9%	81	10.0	0.72	NASHYD
	102	33.27	13.8%	82	10.0	0.98	NASHYD
	Subtotal	59.17					
Grassy Brook	201	20.10	13.5%	82	10.0	0.48	NASHYD
	202	33.90	0.7%	80	10.0	1.02	NASHYD
	203	6.46	1.1%	80	10.0	0.24	NASHYD
	204	18.28	6.3%	81	10.0	1.06	NASHYD
	205	5.30	0.0%	80	10.0	0.32	NASHYD
	Subtotal	84.04					
Lyons Creek	301	14.49	0.0%	80	10.0	0.43	NASHYD
	302	23.98	7.9%	81	10.0	0.69	NASHYD
	303	31.49	0.4%	80	10.0	0.83	NASHYD
	304	12.74	9.2%	81	10.0	0.32	NASHYD
	305	11.66	1.9%	80	10.0	0.89	NASHYD
	Subtotal	94.36					
Total		238.58					

4.4 Post-Development Conditions

Draft Plan of Grand Niagara Subdivision (Drawing DPP at back) has a total area of 184.47 ha, which is comprised of mixed-density residential developments, schools, hospital employment, parks, SWM blocks, and open spaces.

4.4.1 Post-Development Drainage Boundary

A preliminary grading plan for the proposed development is prepared to ensure integration with neighbouring lands, and protection of retained natural areas through interim development phases and under the ultimate development condition. The proposed development is delineated into sub-catchments based on the preliminary grading, as shown in Drawing PDP at back of this report.

Note that the rail corridor and external residential and agricultural lands north of Biggar Road are also included in the drainage delineation, resulting in a total drainage area of 238.47 ha.

4.4.2 Conveyance of Minor System Flows

The subject property will be serviced by a conventional storm sewer system designed in accordance with the City's standards (2016). The storm sewers will be sized using a 5-year return period frequency and the current City's IDF curves. The site storm sewer system shall convey the minor system flows to a SWM wet pond or storm outfall.

4.4.3 Conveyance of Major System Flows

Major system flows in excess of the minor system shall be contained within either the roadway right-of-way (ROW) or by other lands such as flow easements under the City's control. The major system flow shall be directed to the receiving watercourses via properly designed overland flow channels.

4.4.4 Post-Development Parameters

As shown in Drawing PDP, the proposed development is delineated into sub-catchments to reflect the post-development drainage conditions.

Catchment 1001 ~ 1005 represents areas contributing flows to Welland River; Catchment 2001 ~ 2011 represents areas contributing flows to Grassy Brook; while catchment 3001 ~ 3007 represents areas contributing flows to Lyons Creek Tributary #1.

Flows from the sub-catchments with imperviousness greater than 20% were modelled using the STANDHYD command in Visual OTTHYMO, while sub-catchments with imperviousness less than 20% were modelled using the NASHYD command.

For sub-catchments with mixed land uses, the drainage catchment was broken down based on the proposed Draft Plan and a weighted runoff coefficient / imperviousness was calculated. **Table 4.4** shows the typical runoff coefficient for various types of land use in the analysis as per Section 5.2.4 of the City's Engineering Design Guidelines Manual (2016).

Table 4.4 Runoff Coefficient for Various Land Uses

Land Uses	Runoff Coefficient
High Density (Townhouses, Apartments)	0.75
Low to Medium Density (Semi-Detached or Single)	0.55
Mixed Use	0.75
Schools	0.75
Employment / Commercial	0.90
Road ROWs	0.65
SWM Block	0.50
Park and Open Space	0.20

A CN value of 80 and IA value of 5.0 mm are assigned to the pervious areas within development catchments.

The hydrological parameters for undeveloped catchments, i.e., the values of CN and IA and the Time to Peak (Tp) are obtained following the methodology used to determine the catchment parameters for pre-development conditions. The IA values of 10 mm for the open spaces remain the same.

The post-development catchment parameters are summarized in **Table 4.5**. The detailed calculations are included in Appendix A.

Table 4.5 Post-Development Drainage Catchment Parameters

Watershed	Catchment ID	Area (ha)	TIMP (%)	CN	IA (mm)	Tp (hrs)	Command
Welland river	1001	10.47	66.9	80	5.0	---	STANDHYD
	1002	15.10	57.5	80	5.0	---	STANDHYD
	1003	7.60	12.5	80	5.0	1.01	NASHYD
	1004	22.80	60.4	80	5.0	---	STANDHYD
	1005	13.17	0.0	80	5.0	0.68	NASHYD
	Subtotal	69.39					
Grassy Brook	2001	17.75	58.4	80	5.0	---	STANDHYD
	2002	14.51	56.1	80	5.0	---	STANDHYD
	2003	3.22	50.6	80	5.0	---	STANDHYD
	2004	1.07	50.0	80	5.0	---	STANDHYD
	2005	2.14	78.6	80	5.0	---	STANDHYD
	2006	2.88	0.0	80	10.0	0.35	NASHYD
	2007	5.93	5.0	81	10.0	0.21	NASHYD
	2008	16.71	0.0	80	10.0	1.02	NASHYD
	2009	4.65	0.0	80	10.0	0.33	NASHYD
	2010	12.18	0.0	80	10.0	1.11	NASHYD
	2011	5.30	5.1	81	10.0	0.30	NASHYD
	Subtotal	86.36					
Lyons Creek	3001	9.03	75.9	80	5.0	---	STANDHYD
	3002	2.20	78.6	80	5.0	---	STANDHYD
	3003	2.30	76.7	80	5.0	---	STANDHYD
	3004	10.53	7.6	81	10.0	0.41	NASHYD
	3005	11.85	4.9	81	10.0	0.71	NASHYD
	3006	44.22	0.0	80	10.0	0.83	NASHYD
	3007	1.71	0.0	80	10.0	0.22	NASHYD
	Subtotal	81.84					
Total		238.58					

4.4.5 Hydrologic Modelling Results

Table 4.6 presents the required extended detention volume in the proposed SWM wet ponds for erosion control, which is estimated by simulating the post-development hydrologic model for the 25 mm rainfall event.

Table 4.6 Runoff Volume from 25 mm Rainfall Event

SWM Facility	Catchment ID	Area (ha)	IMP (%)	Runoff Depth (mm)	Runoff Volume (m^3)
Wet Pond #1	1001 ~ 1003	33.17	50.2	13.87	4,602
Wet Pond #2	1004	23.05	60.4	16.39	3,779
Wet Pond #3	2001	17.75	58.4	16.01	2,841
Wet Pond #4	2002, 2010	26.69	30.5	9.77	2,608

Hydrologic modelling is also used in sizing the outlet control structures and confirm the operation performance of the proposed SWM wet ponds. Refer to **Section 6.2 ~ 6.5** for more details.

5 WATER BALANCE

The proposed development would increase the site imperviousness by converting pervious surface to impervious surface, resulting in less infiltration, less evaporation, and more runoff from the site. The subject development shall demonstrate that the pre-development water balance conditions are maintained and there are no negative impacts to the natural heritage systems.

A detailed water balance assessment has been prepared by Terra-Dynamics Consulting (TDC) Inc. (in separate cover). It is recommended to

- Implement rear yard and roof drainage towards wetlands for lots adjacent to wetlands.
- Implement buffers to the wetland, woodlands, etc.
- Direct additional clean runoff to identified wetlands.
- Continue the groundwater level monitoring program in selected monitoring wells.

For more details, please refer to Preliminary Hydrogeologic Assessment and Water Balance Study by Terra-Dynamics Consulting Inc. (October 2022).

6 PRELIMINARY DESIGN OF SWM FACILITIES

6.1 General

The post-development hydrologic model was developed to support the design and to evaluate the operation performance of four (4) SWM wet ponds and gassed swale

The types and locations of the SWM facilities have been sited based on the nature of the developments and the principle of maintaining the existing drainage patterns and flow regimes in the receiving watercourse.

Section 3.4 discusses the SWM facilities proposed for the subject development. The drainage areas for the proposed SWM facilities are provided in **Table 3.1**.

This section of the report documents the outline design work completed for the proposed SWM facilities, which includes preliminary grading proposal, design of outlet control structures, and hydrologic modelling to verify compliance with the target discharge rates. Preliminary calculations have been undertaken to confirm that the allowances of the blocks of these proposed SWM facilities are adequate. All proposed facilities will be designed to provide stormwater quality and erosion control in accordance with the design criteria identified in **Section 3.2**.

6.2 SWM Wet Pond #1

6.2.1 Drainage and Design Criteria

Catchment 1001 ~ 1003 have a total drainage area of 33.17 ha and consists of mixed residential development, park, open space, and SWM block with a lumped imperviousness of 50.2%. SWM Wet Pond #1 is proposed to provide an Enhanced Level water quality treatment (or 80% TSS removal) and erosion control in terms of extended detention of runoff from 25 mm rainfall event for minimum 24 hours.

Quantity control is not required for SWM Wet Pond #1.

6.2.2 Volume Requirements

The proposed SWM Wet Pond #1 shall provide an enhanced level protection for runoff from a drainage area of 33.17 ha at an imperviousness of 50.2%. Based on Table 3.2 of the MECP's SWMPD Manual and a lumped imperviousness of 50.2%, a wet pond will require 178.0 m^3/ha of storage volume to provide an "Enhanced Level of Protection" or 80% TSS removal, of which 40 m^3/ha will be extended detention storage and 138.0 m^3/ha will be permanent pool storage.

Based on a total drainage area of 33.17 ha, these objectives translate to a volume of 5,903 m^3, of which 4,576 m^3 is the permanent pool volume and 1,327 m^3 is extended detention storage for quality control.

The extended detention volume for erosion control has been estimated in Section 4.4.5. From the hydrologic analysis results, 13.87 mm of the 25 mm rainfall event is expected to contribute to excess runoff from the area contributing flows to the SWM Wet Pond #1. This translates to a storage volume of 4,602 m^3.

Note that the extended detention volume for water quality control is smaller than that for the erosion control and shall be combined with the larger volume to be released over a minimum 24 hours.

Minimum 0.30 m freeboard shall be provided above the required active storage to incorporate emergency spillway in case of blockage of low flow control devices.

6.2.3 Preliminary Grading and Layout

The preliminary layout of SWM Wet Pond #1 is shown in Drawing PDP. The wet pond is designed to provide the required permanent pool and active storage volumes, and to conform to the grading of the site.

The SWM Wet Pond #1 provides 8,754 m^3 of total permanent pool storage at the elevation 192.00 m. The permanent pool storage is provided with a depth of 1.0 m at both the sediment forebay and the main cell.

An extended detention volume of 5,174 m^3 is provided at the elevation 172.45 m, with a maximum depth of 0.45 m above the permanent pool elevation. Total 35,350 m^3 active storage is provided at the elevation of 174.50 m. A 2.05 m freeboard is available above the design high water level.

SWM Wet Pond #1 has a 6:1 slope for 3 m on either side of the permanent pool elevation and 4:1 slope at elsewhere.

A summary of required storage volumes and provided storage for water quality and erosion control and is provided in **Table 6.1**.

Table 6.1 Storage Summary for SWM Wet Pond #1

Components		Required Storage (m^3)	Storage Provided (m^3)	Elevation (m)
Permanent Pool Storage	Water Quality	4,576	**8,754**	**172.00**
Active Storage	Water Quality *	1,327	5,174	**172.45**
	Erosion Control	4,602		
Total Storage **		**9,178**	**44,104**	**174.50**

* *Extended detention storage for water quality and erosion control will be combined.*

** *A 2.05 m freeboard is provided above the extended detention water level.*

6.2.4 Storm Inlet and Sediment Forebay

Two storm inlets are proposed at the north end of the SWM pond block to convey the minor system flow from catchment 1001 and 1002 to SWM Wet Pond #1.

A sediment forebay is required at each storm inlet to settle out most of the sediment load within an area that can be conveniently accessed for maintenance. The sediment forebays are sized according to the guidelines given in the Stormwater Management

Planning and Design Manual (SWMPDM, MOE, 2003). The forebay length is determined based on calculations of the dispersion and settling lengths, as shown in the Appendix A.

6.2.5 Overland Flow Route

Major flow from catchment 1001 and 1002 shall be conveyed via the road networks to a low point where an overland flow channel with sufficient capacity is proposed to convey surface flow away from the SWM Wet Pond #1 and directly discharge into Welland River.

6.2.6 Outlet Control Structure

The outlet structure for SWM Wet Pond #1 is located at the north end of the pond. The outlet structure consists of a reverse slope pipe configured with an orifice plate for erosion control, and ditch inlet catch basins (DICBs) followed with storm pipe

A 200 mm diameter orifice plate (invert = 192.00 m) is proposed to achieve a maximum discharge rate of 0.052 m^3/s with an extended detention storage of 5,174 m^3 (EL= 192.45 m).

Due to the grading constraints, it is not feasible to incorporate an emergency spillway. Therefore, two DICBs (1200 X 600 mm, Invert = 172.80 m) followed with two 450 mm storm pipes (Invert = 172.10 m) are proposed to capture and convey the peak flows to the control MH, while a 1200 mm outlet pipe is proposed to convey the flow north to the Welland River.

6.2.7 Operation Performance

Table 6.2 present the stage – storage – discharge (SSD) relationship for the SWM Wet Pond #1 with the outlet control configurations described above. Refer to Appendix A for detailed calculations.

The SSD table for SWM Wet Pond #1 was then incorporated into the VO model and simulated for the 25 mm, 5-year and 100-year design storms and regional storm to verify the SWM pond functions properly.

Table 6.3 summarizes simulated outflow and utilized active storage volumes in the SWM Wet Pond #1.

Table 6.2 SSD Relationship for SWM Wet Pond #1

Description	Elevation (m)	Discharge (m^3/s)	Storage (m^3)
Permanent Pool	172.00	0.000	0
	172.10	0.014	1,150
	172.20	0.028	2,299
	172.30	0.039	3,449
	172.40	0.048	4,599
Extended Detention	172.45	0.052	5,174
	172.50	0.055	5,749
	172.60	0.062	7,077
	172.70	0.068	8,405
	172.80	0.073	9,733
	172.90	0.141	11,062
	173.00	0.722	12,390
	173.25	1.178	15,959
	173.50	1.326	19,529
	173.75	1.458	23,353
	174.00	1.580	27,178
	174.25	1.692	31,264
Top of Pond	174.50	1.798	35,350

Table 6.3 Operation Performance of SWM Wet Pond #1

Design Storm	Inflow Rate (m^3/s)	Outflow Rate (m^3/s)	Used Storage (m^3)	Water Elevation (m)
25 mm	1.824	0.044	4,061	172.35
5-yr 3-hr Chicago	3.283	0.059	6,597	172.56
100-yr 3-hr Chicago	3.303	0.125	10,749	172.88
100-yr 12-hr AES	1.250	0.841	13,322	173.07
100-yr 24-hr SCS	3.454	0.872	13,579	173.08
Regional Storm (48-hr Hurricane Hazel)	3.814	1.720	32,360	174.40

6.3 SWM Wet Pond #2

6.3.1 Drainage and Design Criteria

Catchment 1004 has a total drainage area of 23.05 ha and consists of mixed residential development, school block, park, open space, and SWM block with a lumped imperviousness of 60.4%. SWM Wet Pond #2 is proposed to provide an Enhanced Level water quality treatment (or 80% TSS removal) and erosion control in terms of extended detention of runoff from 25 mm rainfall event for minimum 24 hours.

Quantity control is not required for SWM Wet Pond #2.

6.3.2 Volume Requirements

The proposed SWM Wet Pond #2 shall provide an enhanced level protection for runoff from a drainage area of 23.05 ha at an imperviousness of 60.4%. Based on Table 3.2 of the MECP's SWMPD Manual and a lumped imperviousness of 60.4%, a wet pond will require 202.6 m^3/ha of storage volume to provide an “Enhanced Level of Protection” or 80% TSS removal, of which 40 m^3/ha will be extended detention storage and 162.6 m^3/ha will be permanent pool storage.

Based on a total drainage area of 23.05 ha, these objectives translate to a volume of 4,670 m^3, of which 3,748 m^3 is the permanent pool volume and 922 m^3 is extended detention storage for quality control.

The extended detention volume for erosion control has been estimated in Section 4.4.5. From the hydrologic analysis results, 16.39 mm of the 25 mm rainfall event is expected to contribute to excess runoff from the area contributing flows to the SWM Wet Pond #2. This translates to a storage volume of 3,779 m^3.

Note that the extended detention volume for water quality control is smaller than that for the erosion control and shall be combined with the larger volume to be released over a minimum 24 hours.

Minimum 0.30 freeboard shall be provided above the required active storage to incorporate emergency spillway in case of blockage of low flow control devices.

6.3.3 Preliminary Grading and Layout

The preliminary layout of SWM Wet Pond #2 is shown in Drawing PDP. The wet pond is designed to provide the required permanent pool and active storage volumes, and to conform to the grading of the site.

The SWM Wet Pond #2 provides 7,702 m^3 of total permanent pool storage at the elevation 191.95 m. The permanent pool storage is provided with a depth of 1.0 m at both the sediment forebay and the main cell.

An extended detention volume of 4,058 m^3 is provided at the elevation 172.35 m, with a maximum depth of 0.40 m above the permanent pool elevation. Total 10,892 m^3 active storage is provided at the elevation of 172.95 m. A 0.60 m freeboard is available above the design high water level.

SWM Wet Pond #1 has a 6:1 slope for 3 m on either side of the permanent pool elevation and 4:1 slope at elsewhere.

A summary of required storage volumes and provided storage for water quality and erosion control and is provided in **Table 6.4**.

Table 6.4 Storage Summary for SWM Wet Pond #2

Components		Required Storage (m^3)	Storage Provided (m^3)	Elevation (m)
Permanent Pool Storage	Water Quality	**3,748**	**7,702**	**171.95**
Active Storage	Water Quality *	922	4,058	**172.35**
	Erosion Control	**3,779**		
Total Storage **		**7,527**	**18,594**	**172.95**

* *Extended detention storage for water quality and erosion control will be combined.*

** *A 0.60 m freeboard is provided above the extended detention water level.*

6.3.4 Storm Inlet and Sediment Forebay

A storm inlet is proposed at the east end of the SWM pond block to convey the minor system flow from catchment 1004 to SWM Wet Pond #2.

A sediment forebay is required for the storm inlet to settle out most of the sediment load within an area that can be conveniently accessed for maintenance. The forebay is sized according to the guidelines given in the Stormwater Management Planning and Design

Manual (SWMPDM, MOE, 2003). The forebay length is determined based on calculations of the dispersion and settling lengths, as shown in the Appendix A.

6.3.5 Overland Flow Route

Major flow from catchment 1004 shall be conveyed via the road networks to a low point where an overland flow channel with sufficient capacity is proposed to convey surface flow away from the SWM Wet Pond #2 and directly discharge into Welland River.

6.3.6 Outlet Control Structure

The outlet structure for SWM Wet Pond #2 is located at the north berm of the pond. The outlet structure consists of a reverse slope pipe configured with an orifice plate for erosion control.

A 180 mm diameter orifice plate (invert = 191.95 m) is proposed to achieve a maximum discharge rate of 0.040 m^3/s with an extended detention storage of 4,058 m^3 (EL= 192.35 m).

In case of blockage to the outlet control structure, an emergency spillway with 10 m bottom width (invert = 172.35 m) is proposed to safely convey the inflow rate from the minor system.

6.3.7 Operation Performance

Table 6.5 present the stage – storage – discharge (SSD) relationship for the SWM Wet Pond #2 with the outlet control configurations described above. Refer to Appendix A for detailed calculations.

The SSD table for SWM Wet Pond #2 was then incorporated into the VO model and simulated for the 25 mm, 5-year and 100-year design storms and regional storm to verify the SWM pond functions properly.

Table 6.6 summarizes simulated outflow and utilized active storage volumes in the SWM Wet Pond #2.

Table 6.5 SSD Relationship for SWM Wet Pond #2

Description	Elevation (m)	Discharge (m^3/s)	Storage (m^3)
Permanent Pool	171.95	0.000	0
	172.05	0.007	1,014
	172.15	0.024	2,029
	172.25	0.033	3,043
Extended Detention	172.35	0.040	4,058
	172.45	0.583	5,072
	172.55	1.571	6,236
	172.65	2.849	7,400
	172.75	4.361	8,564
	172.85	6.074	9,728
Top of Pond	172.95	7.969	10,892

Table 6.6 Operation Performance of SWM Wet Pond #2

Design Storm	Inflow Rate (m^3/s)	Outflow Rate (m^3/s)	Used Storage (m^3)	Water Elevation (m)
25 mm	1.334	0.036	3,414	172.29
5-yr 3-hr Chicago	2.767	0.272	4,491	172.39
100-yr 3-hr Chicago	2.767	0.817	5,349	172.47
100-yr 12-hr AES	0.974	0.918	5,469	172.48
100-yr 24-hr SCS	2.767	2.279	6,937	172.61
Regional Storm (48-hr Hurricane Hazel)	2.767	2.729	7,295	172.64

6.4 SWM Wet Pond #3

6.4.1 Drainage and Design Criteria

Catchment 2001 has a total drainage area of 17.75 ha and consists of mixed residential development, school block, and SWM block with a lumped imperviousness of 58.4%. SWM Wet Pond #3 is proposed to provide an Enhanced Level water quality treatment (or 80% TSS removal) and erosion control in terms of extended detention of runoff from 25 mm rainfall event for minimum 24 hours.

Quantity control is not required for SWM Wet Pond #3.

6.4.2 Volume Requirements

The proposed SWM Wet Pond #3 shall provide an Enhanced Level Protection for runoff from a drainage area of 17.75 ha at an imperviousness of 58.4%. Based on Table 3.2 of the MECP's SWMPD Manual and a lumped imperviousness of 58.4%, a wet pond will require 198.0 m^3/ha of storage volume to provide an "Enhanced Level of Protection" or 80% TSS removal, of which 40 m^3/ha will be extended detention storage and 158.0 m^3/ha will be permanent pool storage.

Based on a total drainage area of 17.75 ha, these objectives translate to a volume of 3,514 m^3, of which 2,804 m^3 is the permanent pool volume and 710 m^3 is extended detention storage for quality control.

The extended detention volume for erosion control has been estimated in Section 4.4.5. From the hydrologic analysis results, 16.01 mm of the 25 mm rainfall event is expected to contribute to excess runoff from the area contributing flows to the SWM Wet Pond #3. This translates to a storage volume of 2,841 m^3.

Note that the extended detention volume for water quality control is smaller than that for the erosion control and shall be combined with the larger volume to be released over a minimum 24 hours.

Minimum 0.30 m freeboard shall be provided above the required active storage to incorporate emergency spillway in case of blockage of low flow control devices.

6.4.3 Preliminary Grading and Layout

The preliminary layout of SWM Wet Pond #3 is shown in Drawing PDP. The wet pond is designed to provide the required permanent pool and active storage volumes, and to conform to the grading of the site.

The SWM Wet Pond #3 provides 8,176 m^3 of total permanent pool storage at the elevation 193.85 m. The permanent pool storage is provided with a depth of 1.0 m at both the sediment forebay and the main cell.

An extended detention volume of 3,412 m^3 is provided at the elevation 174.15 m, with a maximum depth of 0.30 m above the permanent pool elevation. Total 11,552 m^3 active storage is provided at the elevation of 174.85 m. A 0.70 m freeboard is available above the design high water level.

SWM Wet Pond #3 has a 6:1 slope for 3 m on either side of the permanent pool elevation and 4:1 slope at elsewhere.

A summary of required storage volumes and provided storage for water quality and erosion control and is provided in **Table 6.7**.

Table 6.7 Storage Summary for SWM Wet Pond #3

Components		Required Storage (m^3)	Storage Provided (m^3)	Elevation (m)
Permanent Pool Storage	Water Quality	**2,804**	**8,176**	**173.85**
Active Storage	Water Quality *	710	3,412	**174.15**
	Erosion Control	**2,841**		
Total Storage **		**5,645**	**19,254**	**174.85**

* *Extended detention storage for water quality and erosion control will be combined.*

** *A 0.70 m freeboard is provided above the design high water level.*

6.4.4 Storm Inlet and Sediment Forebay

A storm inlet is proposed at the west end of the SWM pond block to convey the minor system flow from catchment 2001 to SWM Wet Pond #3.

A sediment forebay is required for the storm inlet to settle out most of the sediment load within an area that can be conveniently accessed for maintenance. The forebay is sized according to the guidelines given in the Stormwater Management Planning and Design

Manual (SWMPDM, MOE, 2003). The forebay length is determined based on calculations of the dispersion and settling lengths, as shown in the Appendix A.

6.4.5 Overland Flow Route

Major flow from catchment 2001 shall be conveyed via the road networks to a low point where an overland flow channel with sufficient capacity is proposed to convey surface flow away from the SWM Wet Pond #3 and directly discharge into Grassy Brook.

6.4.6 Outlet Control Structure

The outlet structure for SWM Wet Pond #3 is located at the east berm of the pond. The outlet structure consists of a reverse slope pipe configured with an orifice plate for erosion control.

A 170 mm diameter orifice plate (invert = 173.85 m) is proposed to achieve a maximum discharge rate of 0.029 m^3/s with an extended detention storage of 3,412 m^3 (EL= 194.15 m).

In case of blockage to the outlet control structure, an emergency spillway with 10 m bottom width (invert = 174.25 m) is proposed to safely convey the inflow rate from the minor system.

6.4.7 Operation Performance

Table 6.8 present the stage – storage – discharge (SSD) relationship for the SWM Wet Pond #3 with the outlet control configurations described above. Refer to Appendix A for detailed calculations.

The SSD table for SWM Wet Pond #3 was then incorporated into the VO model and simulated for the 25 mm, 5-year and 100-year design storms and Regional storm to verify the SWM pond functions properly.

Table 6.9 summarizes simulated outflow and utilized active storage volumes in the SWM Wet Pond #3.

Table 6.8 SSD Relationship for SWM Wet Pond #3

Description	Elevation (m)	Discharge (m^3/s)	Storage (m^3)
Permanent Pool	173.85	0.000	0
	173.95	0.008	1,137
	174.05	0.021	2,275
Extended Detention	174.15	0.029	3,412
Emergency Spillway	174.25	0.036	4,549
	174.35	0.578	5,686
	174.45	1.566	6,860
	174.55	2.843	8,033
	174.65	4.354	9,206
	174.75	6.068	10,379
Top of Pond	174.85	7.961	11,552

Table 6.9 Operation Performance of SWM Wet Pond #3

Design Storm	Inflow Rate (m^3/s)	Outflow Rate (m^3/s)	Used Storage (m^3)	Water Elevation (m)
25 mm	1.166	0.023	2,601	174.08
5-yr 3-hr Chicago	2.114	0.033	4,120	174.21
100-yr 3-hr Chicago	2.114	0.350	5,210	174.31
100-yr 12-hr AES	0.743	0.595	5,710	174.35
100-yr 24-hr SCS	2.114	1.373	6,643	174.43
Regional Storm (48-hr Hurricane Hazel)	2.114	2.083	7,334	174.49

6.5 SWM Wet Pond #4

6.5.1 Drainage and Design Criteria

Catchment 2002 and 2010 has a total drainage area of 26.69 ha and consists of mixed residential development, park and open space, and SWM block with a lumped imperviousness of 30.5%. SWM Wet Pond #4 is proposed to provide an Enhanced Level water quality treatment (or 80% TSS removal) and erosion control in terms of extended detention of runoff from 25 mm rainfall event for minimum 24 hours.

Quantity control is not required for SWM Wet Pond #4.

6.5.2 Volume Requirements

The proposed SWM Wet Pond #4 shall provide an enhanced level protection for runoff from a drainage area of 26.69 ha at an imperviousness of 30.5%. Based on Table 3.2 of the MECP's SWMPD Manual and a lumped imperviousness of 30.5%, a wet pond will require 132.9 m^3/ha of storage volume to provide an "Enhanced Level of Protection" or 80% TSS removal, of which 40 m^3/ha will be extended detention storage and 92.9 m^3/ha will be permanent pool storage.

Based on a total drainage area of 26.69 ha, these objectives translate to a volume of 3,546 m^3, of which 2,479 m^3 is the permanent pool volume and 1,068 m^3 is extended detention storage for quality control.

The extended detention volume for erosion control has been estimated in Section 4.4.5. From the hydrologic analysis results, 9.77 mm of the 25 mm rainfall event is expected to contribute to excess runoff from the area contributing flows to the SWM Wet Pond #4. This translates to a storage volume of 2,608 m^3.

Note that the extended detention volume for water quality control is smaller than that for the erosion control and shall be combined with the larger volume to be released over a minimum 24 hours.

Minimum 0.30 freeboard shall be provided above the required active storage to incorporate emergency spillway in case of blockage of low flow control devices.

6.5.3 Preliminary Grading and Layout

The preliminary layout of SWM Wet Pond #4 is shown in Drawing PDP. The wet pond is designed to provide the required permanent pool and active storage volumes, and to conform to the grading of the site.

The proposed SWM Wet Pond #4 shall use the existing pond as the main cell and a sediment forebay be proposed to receive the minor flow from catchment 2002. The total flow from catchment 2010 and major flow from catchment 2002 shall be directed to the main cell of SWM Wet Pond #4.

The SWM Wet Pond #4 provides 18,970 m^3 of total permanent pool storage at the elevation 174.00 m. The permanent pool storage is provided with a depth of 1.0 m at the sediment forebay and 2.0 m at the main cell.

An extended detention volume of 2,701 m^3 is provided at the elevation 174.20 m, with a maximum depth of 0.20 m above the permanent pool elevation. Total 30,155 m^3 active storage is available at the elevation of 176.00 m.

SWM Wet Pond #4 has a 6:1 slope for 3 m on either side of the permanent pool elevation and 3:1 slope at elsewhere.

A summary of required storage volumes and provided storage for water quality and erosion control and is provided in **Table 6.10**.

Table 6.10 Storage Summary for SWM Wet Pond #4

Components		Required Storage (m^3)	Storage Provided (m^3)	Elevation (m)
Permanent Pool Storage	Water Quality	**2,479**	**18,970**	**174.00**
Active Storage	Water Quality *	1,068	2,701	**174.20**
	Erosion Control	**2,608**		
Total Storage **		**5,087**	**49,125**	**176.00**

* *Extended detention storage for water quality and erosion control will be combined.*

** *A 0.60 m freeboard is provided above the design high water level.*

6.5.4 Storm Inlet and Sediment Forebay

A storm inlet is proposed at the southwest corner of the SWM pond block to convey the minor system flow from catchment 2002 to SWM Wet Pond #4.

A sediment forebay is required for the storm inlet to settle out most of the sediment load within an area that can be conveniently accessed for maintenance. The forebay is sized according to the guidelines given in the Stormwater Management Planning and Design Manual (SWMPDM, MOE, 2003). The forebay length is determined based on calculations of the dispersion and settling lengths, as shown in the Appendix A.

6.5.5 Overland Flow Route

Major flow from catchment 2002 shall be conveyed via the road networks to a low point where an overland flow channel with sufficient capacity is proposed to convey surface flow the main cell of SWM Wet Pond #4. Runoff from catchment 2010 shall drain to the main cell of the SWM Pond #4 as is.

6.5.6 Outlet Control Structure

The outlet structure for SWM Wet Pond #4 is located at the north berm of the pond. The outlet structure consists of a concrete wall with an orifice tube for erosion control and an overflow weir.

A 150 mm diameter orifice tube (invert = 174.00 m) is proposed to achieve a maximum discharge rate of 0.022 m^3/s with an extended detention storage of 2,701 m^3 (EL= 194.20 m).

In case of blockage to the outlet control structure, an emergency overflow weir with 2.50 m bottom width (invert = 174.30 m) is proposed to safely convey the inflow rate. An open channel is proposed to convey the outflow from SWM Wet Pond #4 to Grassy Brook.

6.5.7 Operation Performance

Table 6.11 present the stage – storage – discharge (SSD) relationship for the SWM Wet Pond #4 with the outlet control configurations described above. Refer to Appendix A for detailed calculations.

The SSD table for SWM Wet Pond #2 was then incorporated into the VO model and simulated for the 25 mm, 5-year and 100-year design storms and Regional storm to verify the SWM pond functions properly.

Table 6.12 summarizes simulated outflow and utilized active storage volumes in the SWM Wet Pond #4.

Table 6.11 SSD Relationship for SWM Wet Pond #4

Description	Elevation (m)	Discharge (m^3/s)	Storage (m^3)
Permanent Pool	174.00	0.000	0
	174.10	0.011	1,350
Extended Detention	174.20	0.022	2,701
	174.30	0.030	4,051
	174.40	0.181	5,402
	174.50	0.452	6,752
	174.60	0.801	8,226
	174.70	1.213	9,701
	174.80	1.680	11,175
	174.90	2.195	12,649
	175.00	2.754	14,123
	175.50	6.122	21,920
Top of Pond	176.00	10.283	30,155

Table 6.12 Operation Performance of SWM Wet Pond #4

Design Storm	Inflow Rate (m^3/s)	Outflow Rate (m^3/s)	Used Storage (m^3)	Water Elevation (m)
25 mm	0.936	0.019	2,330	174.17
5-yr 3-hr Chicago	1.693	0.030	4,013	174.30
100-yr 3-hr Chicago	3.116	0.343	6,211	174.46
100-yr 12-hr AES	0.804	0.659	7,629	174.56
100-yr 24-hr SCS	3.886	0.896	8,571	174.62
Regional Storm (48-hr Hurricane Hazel)	2.851	2.492	13,447	174.95

6.6 Grassed Swale

A grassed swale is proposed to provide an Enhanced Level of Protection of 80% TSS removal on an annual loading basis for runoff generated from Catchment 2003.

The Section 4.5.9 of the MECP Stormwater Management Planning and Design Manual (2003) provides guidance on the design of Grassed Swale.

1) As a general guideline, grassed swales designed for water quality enhancement should be designed to convey the peak flow from a 25 mm Chicago storm with a velocity ≤ 0.5 m/s.

   This guideline results in a requirement for wide, flat swales for larger drainage areas.

2) The grass swales must be evaluated under major system and minor system events to ensure that the swale can convey these storms effectively.

Furthermore, an article produced by Gary R. Minton, (Stormwater, March/April 2005) suggests a procedure to determine swale dimensions likely to produce 80% TSS removal. The procedure (copy of article attached to Appendix D) suggests that a swale with no appreciable infiltration must detain stormwater for a minimum of 8 minutes to achieve 80% TSS removal.

A trapezoid swale with bottom width of 6.0 m, side slopes of 3:1, a minimum depth of 0.60 m and a longitudinal slope of 0.30% satisfies all above design criteria.

Wooden check dams with height of 0.10 m and 30 m distance can be proposed to promote the performance of the grassed swale.

Refer to Section 9 of Appendix A for more details.

7 DEVELOPMENT PHASING

Due to the large scale of the proposed development, the development will proceed in phases. Phases shall be proposed in a manner such that all units within each phase are fully serviced on the basis of road networks, stormwater management facilities, water servicing and sanitary servicing prior to build-out.

The major consideration for the construction phasing is stormwater management. Phases shall be completed in such a manner that no stage will be developed prior to the construction of the SWM facilities that service the stage.

Development Phasing may be refined during the detailed design stage.

8 EROSION AND SEDIMENT CONTROL DURING CONSTRUCTION PERIOD

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

The proposed sediment and erosion control plan during construction will follow the overall environmentally sound development approach and achieve the highest level of control possible. The proposed sediment and erosion control plan during construction will include the following:

1. Sediment and erosion control works for each phase will be in place prior to the commencement of construction for that phase.

2. Construction will be scheduled to minimize the extent and period to which disturbed soils are exposed to weathering. As such, all disturbed areas will be stabilized within forty-five (45) days of commencing work at that location. Stabilization of disturbed areas may be accomplished by seeding, mulching, hydroseeding and planting. Temporary measures may employ the use of geotextile mats and nets.

3. Access to the site during construction will be limited to a maximum of two locations at any one time. The entrances of the access roads will be paved to promote the loosening and dislodging of soil attached to construction vehicles prior to them leaving the site.

4. Perimeter silt fencing will be placed and maintained around disturbed areas and around natural features which are to be preserved.

5. Silt traps or temporary sedimentation basins will be constructed for all overland flow routes. Basin sizing will be based on TRCA's Erosion and Sediment Control Guidelines for Urban Construction, with a total 250 m^3 per hectare of contributing area, of which 125 m^3/ha is permanent pool storage and 125 m^3/ha is active storage. Perforated riser pipes will be used in the temporary sedimentation basins to detain the stormwater flows for 24 ~ 48 hours before being discharged to drainage ways.

6. Rock flow check dams will be placed at all sedimentation basin and temporary swale outlets. These flow check dams are intended as fail-safe controls to trap any sediment which circumvents the other sediment control measures. Erosion protection measures will also be provided at all outfall locations.

9 CONCLUSIONS

A comprehensive stormwater management (SWM) plan has been developed in support of the Draft Plan Approval Application for Grand Niagara mixed-use subdivision in the City of Niagara Falls, ON, to address the potential impacts on the water balance, quality, erosion and quantity.

The key components of the proposed SWM plan are summarized as below:

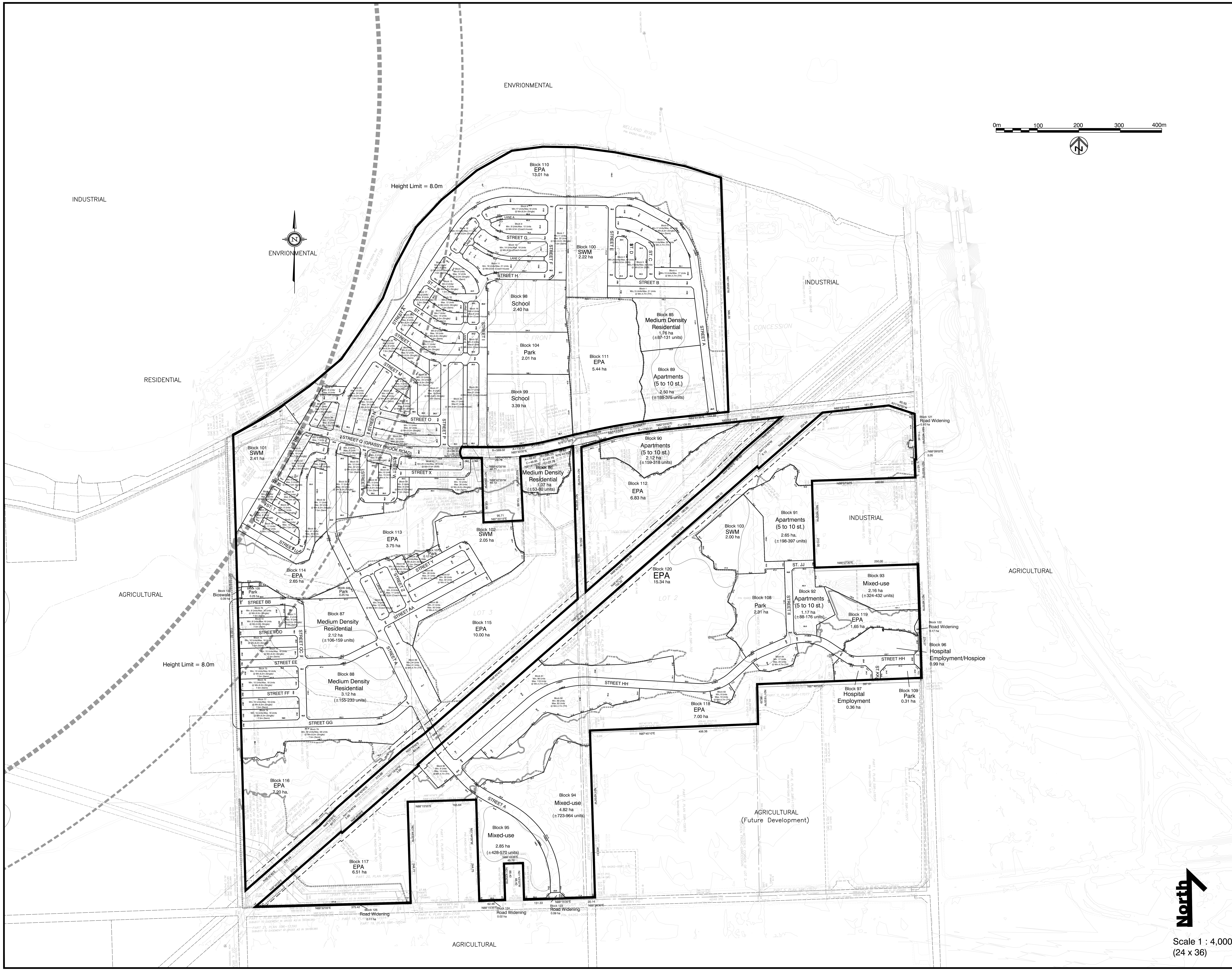
1) Stormwater quantity control is not required for the subject development;
2) Low Impact Development (LID) measures are proposed to match pre- and post-development infiltration volumes in order to maintain groundwater recharge.
3) Total four (4) SWM wet ponds are proposed to provide water quality and erosion control for runoff from major development areas within the subdivision;
4) A grassed swale is proposed to provide water quality and conveyance for runoff from a 3.22 ha development area;
5) Treatment train approach with combination of Oil/Grit Separator (OGS) units and other LID measures are proposed to provide water quality for other development blocks cannot be serviced by the SWM wet ponds;

The SWM strategies described in this report address all stormwater related impacts from the proposed development and satisfies the intent of the Design Criteria and SWM guidelines from the City, NPCA, and MECP.

Respectively Submitted

WSP

Exhibits

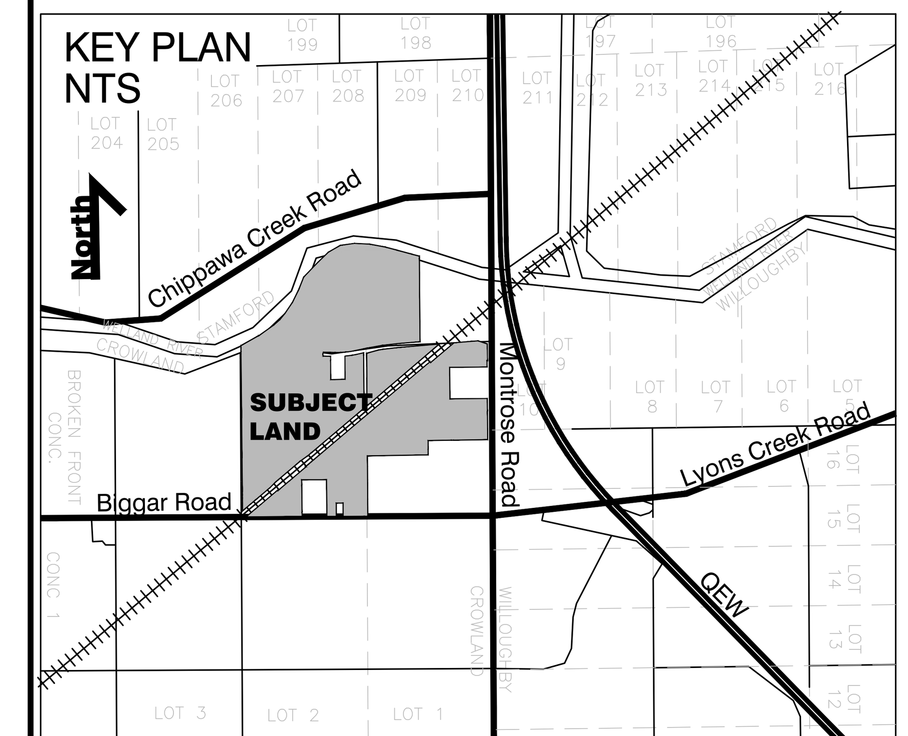


DRAFT PLAN OF SUBDIVISION

FOR PART OF LOTS 1 & 2
BROKEN FRONT CONCESSION
(GEOGRAPHIC TOWNSHIP OF CROWLAND)
REGIONAL MUNICIPALITY OF NIAGARA

January 26, 2023

KEY PLAN
NTS



LAND USE	Block Number	Units	Area (ha)	Area (ac)
Residential Back-to-back, 6.5m x 14.75m	2, 3, 61	57 to 74	0.99	2.5
Residential Townhouse, 4.7m x 28.0m	1, 4, 5, 58, 66, 67 68, 69, 80-84	374 to 455	10.13	25.0
Residential, Detached with coach house, 9.5m x 28.0m	11, 19, 20, 29, 65	50 to 66	1.87	4.6
Residential, Detached with coach house, 9.5m x 36.0m	9, 10, 28, 64	48 to 62	2.21	5.5
Residential Detached, Semi-det. 28.0m	3, 6, 7,13-18, 21-27 30-36, 52-57, 59, 60, 62, 63, 70-79	348 to 678	15.39	38.0
Residential Detached, 28.0m	8, 12	27 to 29	0.62	1.5
Residential Small-lot Detached, 7.0m x 20.0m	37-51	142 to 184	2.81	6.9
Residential Medium Density	85-88	403 to 605*	8.07	19.9
Residential Apartments	89-92	633 to 1,266*	8.44	20.9
Residential Mixed Use	93-95	1476 to 1,968*	9.84	24.3
Subtotal		3,558 to 5,387	60.36	149.2

LAND USE	Block Number	Units	Area (ha)	Area (ac)
Hospital Employment/Hospice	96, 97	-	1.35	3.34
Schools	98, 99	-	5.78	14.3
SWM	100-103	-	8.78	21.7
Parks	104-109	-	5.23	12.9
EPA (Envrionmental Protection Area)	110-120	-	79.38	196.1
Road Widenings	121-125	-	0.49	1.2
Bioswale	126	-	0.09	0.2
Roads	Streets A-NN	-	23.00	56.8
Subtotal		-	124.10	306.7
Subtotal		3,558 to 5,387	60.36	149.2
Total		3,558 to 5,387	184.46	455.8

Development Limit
2.0km to Cytec property
200m buffer to Cytec 2.0km line
15.0m setback from rail line

* DENSITY RANGE BASED ON 50/75 UPHA FOR MEDIUM, 75/150 UPHA FOR APARTMENT AND 150/200 UPHA FOR MIXED

ADDITIONAL INFORMATION REQUIRED UNDER SECTION 51 (17) OF THE PLANNING ACT, R.S.O., 1990

(a) AS SHOWN ON DRAFT AND KEY PLANS
(b) AS SHOWN ON DRAFT PLAN AS SHOWN ON DRAFT AND KEY PLANS
(c) AS SHOWN ON DRAFT PLAN AS SHOWN ON DRAFT AND KEY PLANS
(d) THE LAND IS TO BE USED ACCORDING TO THE SCHEDULE OF LAND USE
(e) AS SHOWN ON DRAFT AND KEY PLANS
(f) AS SHOWN ON DRAFT PLAN
(g) AS SHOWN ON DRAFT AND KEY PLANS
(h) MUNICIPAL WATER SUPPLY TO BE MADE AVAILABLE
(i) SOIL IS SILTY CLAY
(j) AS SHOWN ON DRAFT PLAN
(k) FULL MUNICIPAL SERVICES TO BE MADE AVAILABLE
(l) SUBJECT TO EASEMENTS AS SHOWN ON THE DRAFT PLAN

Note:
All dimensions on curves are chord lengths unless otherwise indicated.

OWNER'S AUTHORIZATION

I AUTHORIZE WSP CANADA GROUP LTD. TO PREPARE AND SUBMIT THIS DRAFT PLAN OF SUBDIVISION TO THE CITY OF NIAGARA FALLS FOR APPROVAL.

Daniel Guizzetti, President
Empire (Grand Niagara) Project GP Inc.
DATE

SURVEYOR'S CERTIFICATE

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED AS SHOWN ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

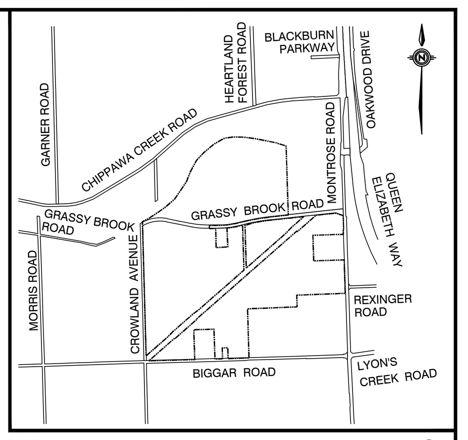
Yuriy Bogdanov, Ontario Land Surveyor, OLIP
Geoverra
JAN. 26, 2023
DATE

PLAN PREPARED BY

Nathan Hanas, CPT
WSP CANADA GROUP LTD.
JAN. 26, 2023
DATE

WSP

211-08936-00-PL2



KEY PLAN NTS

LEGEND

- LIMIT OF PROPERTY
- LIMIT OF SUBDIVISION
- EX. DRAINAGE BOUNDARY
- 205 — CATCHMENT ID No.
- 5.72 — EX. AREA (HA)

No.	REVISIONS TO DRAWING	BY	DATE	APPR.
1	FIRST DPA SUBMISSION	ZB/VL	2023/02/03	ADR

ALL PREVIOUS ISSUES OF THIS DRAWING ARE SUPERSEDED

CLIENT
EMPIRE (GRAND NIAGARA) PROJECT GP INC.

MUNICIPALITY
CITY OF NIAGARA FALLS

PROJECT TITLE
GRAND NIAGARA MIXED-USE SUBDIVISION

SHEET TITLE
EXISTING DRAINAGE PLAN

CONSULTANT
wsp
100 Commerce Valley Dr. West, Thornhill, ON Canada L3T 0A1
t: 905.882.1100 f: 905.882.0055 www.wsp.com

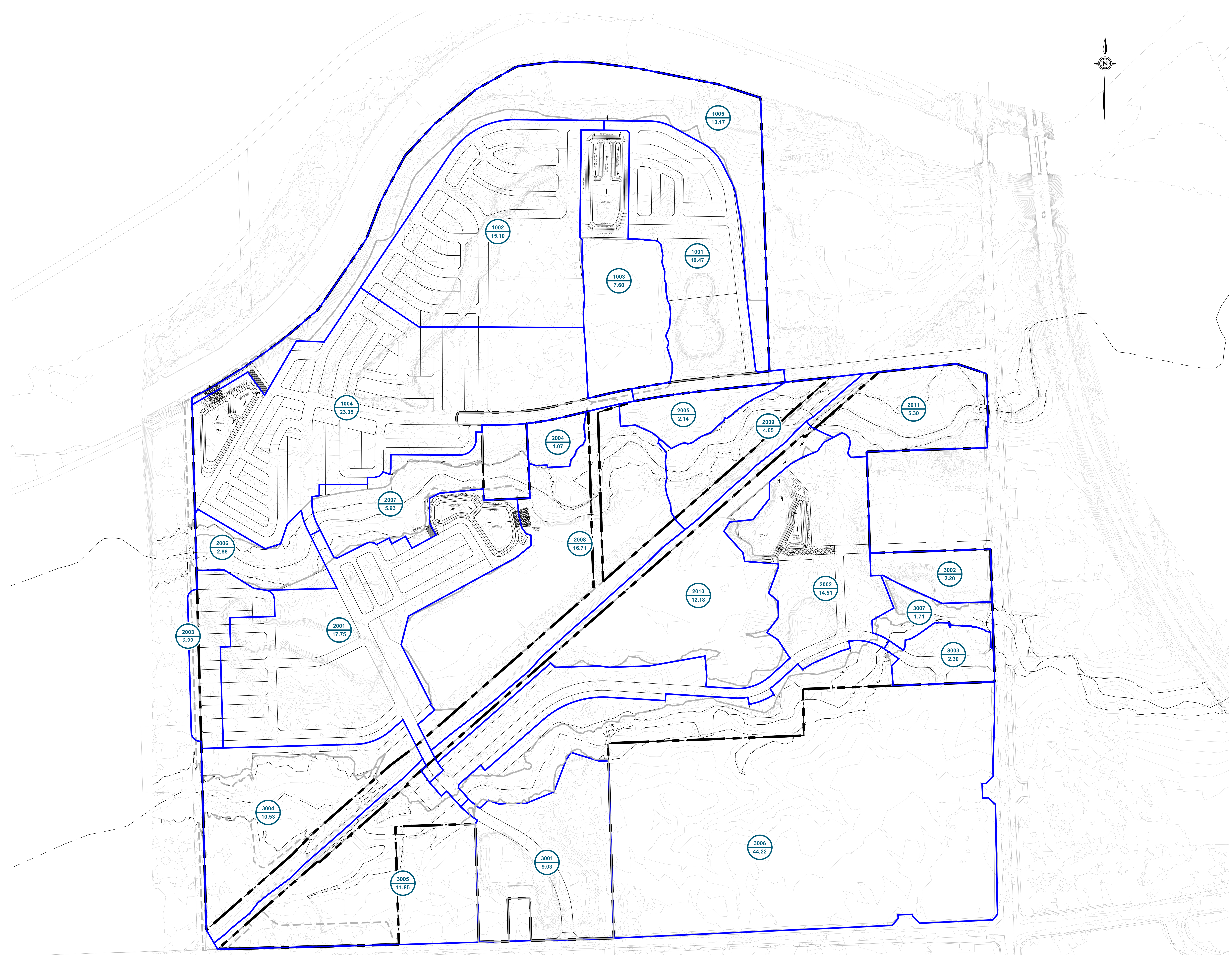
STAMP

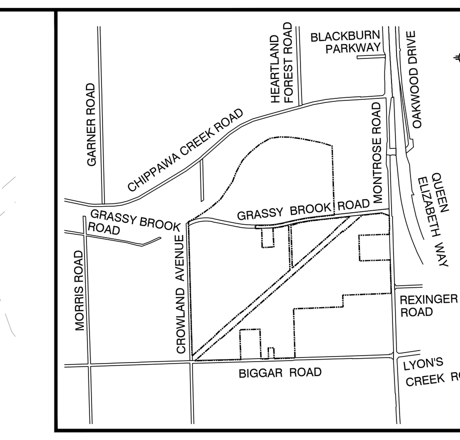
APPROVAL

DESIGNED	DRAWN	CHECKED
ZB/VL	ZB/VL	ADR

SCALE	DATE
1:2500	JANUARY 2023

PROJECT NUMBER	DWG. NUMBER
211-08936	EDP





KEY PLAN NTS

LEGEND

- LIMIT OF PROPERTY
- LIMIT OF SUBDIVISION
- APPROXIMATE CREEK CENTERLINE
- PROP. DRAINAGE BOUNDARY
- 2005 / 5.72 — CATCHMENT ID No. / EX. AREA (HA)

No.	REVISIONS TO DRAWING	BY	DATE	APPR.
1	FIRST DPA SUBMISSION	ZB/VL	2023/02/03	ADR

ALL PREVIOUS ISSUES OF THIS DRAWING ARE SUPERSEDED

CLIENT
EMPIRE (GRAND NIAGARA) PROJECT GP INC.

MUNICIPALITY
CITY OF NIAGARA FALLS

PROJECT TITLE
GRAND NIAGARA MIXED-USE SUBDIVISION

SHEET TITLE
PROPOSED DRAINAGE PLAN

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STAMP
APPROVAL

DESIGNED	DRAWN	CHECKED
ZB/VL	ZB/VL	ADR

SCALE	DATE
1:2500	JANUARY 2023

PROJECT NUMBER	DWG. NUMBER
211-08936	PDP

APPENDIX

A

STORMWATER MANAGEMENT CALCULATIONS

1.1 Background Information

The following documents are reviewed to determine the SWM Design Criteria for the subject development:

1) MECP Stormwater Management Planning and Design Manual (March 2003);
2) Niagara Peninsula Conservation Authority (NPCA) Stormwater Management Policies and Guidelines (March 2010);
3) Stormwater Management Plan for Grand Niagara Secondary Plan (WSP, November 2016);

1.2 Stormwater Management Design Criteria

1.2.1 Water Balance

Water balance impacts should be evaluated and all efforts should be made to match pre- and post-development infiltration volumes in order to maintain groundwater recharge.

1.2.2 Water Quality

An Enhanced Level of water quality treatment (80% TSS Reduction) will be required for the subject development.

Properly sized OGS units might be considered for commercial, industrial, or infill developments.

1.2.3 Erosion Control

Runoff from the 25mm, 4-hour Chicago design storm shall be detained in the SWM facilities and released over a minimum 24-hour period.

1.2.4 Quantity Control

SWM study (2016) indicated that water quantity control is not required for the Grand Niagara Secondary Plan Area.

2 Hydrologic Modelling and Design Rainfall Events

2.1 Hydrologic Modelling

Hydrologic Modelling is carried out using Visual OTTHYMO (VO) model, version 6.2.

2.2 Design Rainfall Event

Design Storm
- 3 Hour Chicago Storm
- 12-hour AES Storm
- 24 hour SCS Type II Design Storm
- 25 mm Rainfall Event
- Regional Storm

2.3 Intensity Duration - Frequency (IDF) Curves

Rainfall Data (IDF Curves) from NPCA and Environment Canada were evaluated. The latter shall be used in the hydrologic modelling.

2.3.1 Source: Niagara Peninsula Conservation Authority (NPCA)

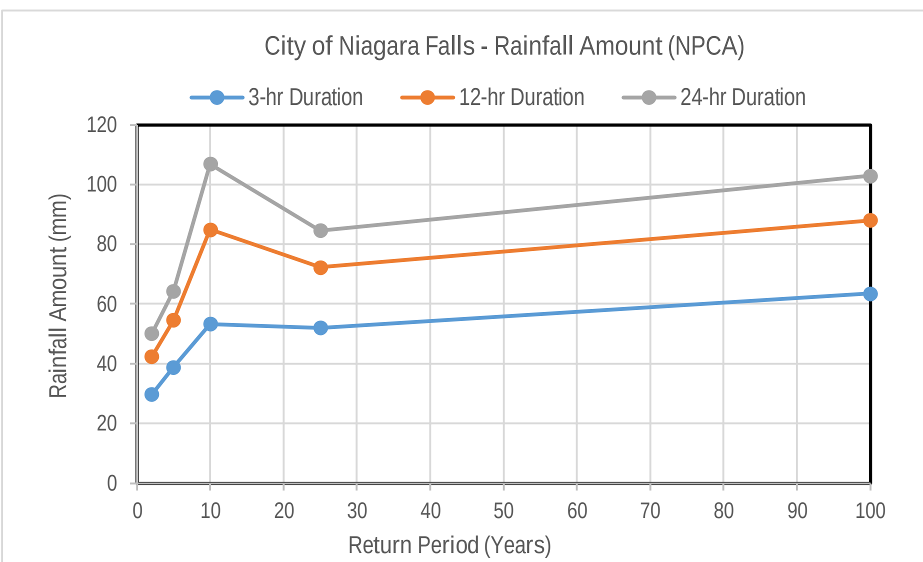
City of Niagara Falls Rainfall Intensity-Duration-Frequency (IDF) Equations from NPCA's SWM Policies and Guidelines

$$I = \frac{A}{(T_d + B)^C}$$

Refer to Table 7.2.2 of NPCA's SWM Policies and Guidelines

Where,
I = Rainfall Intensity (mm/hr)
T_d = Rainfall Duration (minutes)
A, B, C = Constant Parameters for Given Return Period.

Return Period (Years)	A	B	C	Rainfall Volume (mm)		
				3-hour	12-hour	24-hour
2	521.97	5.280	0.7588	29.8	42.3	50.1
5	719.50	6.340	0.7687	38.8	54.6	64.3
10	577.93	2.483	0.6690	53.2	84.8	106.8
25	1020.69	7.290	0.7790	52.0	72.2	84.5
100	1264.57	7.720	0.7814	63.5	88.1	102.9



1.2.2 Source: Atmospheric Environment Canada _ Niagara Falls, ON (6135638)

City of Niagara Falls Intensity-Duration-Frequency (IDF) Equations (from AES Rain Gauge)

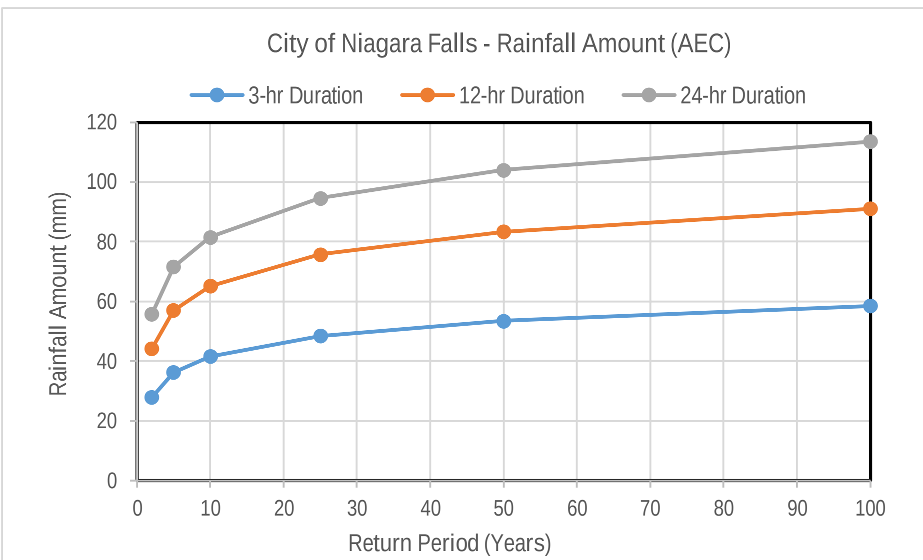
$$I = AT^B$$

Where, I = Rainfall Intensity in mm/hr

T = Time of Concentration in minutes, use 10 min

A, B = Rainfall Parameters.

Return Period (years)	A	B	10 Minutes Intensity (mm/hr)	Rainfall Volume (mm)		
				3-hour	12-hour	24-hour
2	19.40	-0.668	64.21	27.9	44.3	55.7
5	25.30	-0.673	84.49	36.2	57.0	71.5
10	29.10	-0.676	97.71	41.5	65.1	81.5
25	34.00	-0.678	114.57	48.4	75.7	94.6
50	37.60	-0.680	127.15	53.4	83.3	104.0
100	41.20	-0.681	139.58	58.5	91.0	113.5



The above two-parameter IDF curve is converted to three-parameter IDF curve and shall be used to generate 3-hour Chicago design storm in VO Model.

Return Period (years)	A	B	C	10 Minutes Intensity (mm/hr)	Rainfall Volume (mm)		
					3-hour	12-hour	24-hour
2	298.96	0.00	0.668	64.21	27.9	44.3	55.7
5	397.94	0.00	0.673	84.49	36.2	57.0	71.5
10	463.37	0.00	0.676	97.71	41.5	65.1	81.5
25	545.84	0.00	0.678	114.57	48.4	75.7	94.6
50	608.60	0.00	0.680	127.15	53.4	83.3	104.0
100	669.60	0.00	0.681	139.58	58.5	91.0	113.5

3. Pre-Development Drainage Plan

The subject property occupies an area of 184.47 ha and currently comprised by the Grand Niagara golf course.

Given that quantity control is not required for the subject development, hydrologic analysis for the pre-development conditions are not carried out. Pre-development drainage plan was prepared for illustration purpose only.

3.1 Pre-Development Catchment Delineation

With external drainage area, the total study area shall be 238.5 ha and are represented by twelve (12) subcatchments.

Watershed	Catchment ID	Area (ha)	TIMP (%)	CN	IA (mm)	Tp (hrs)	Commend
Welland River	101	25.91	4.9%	81	10.0	0.72	NASHYD
	102	33.27	13.8%	82	10.0	0.98	NASHYD
	Subtotal	59.17					
Grassy Brook	201	20.10	13.5%	82	10.0	0.48	NASHYD
	202	33.90	0.7%	80	10.0	1.02	NASHYD
	203	6.46	1.1%	80	10.0	0.24	NASHYD
	204	18.28	6.3%	81	10.0	1.06	NASHYD
	205	5.30	0.0%	80	10.0	0.32	NASHYD
	Subtotal	84.04					
Lyon Creek	301	14.49	0.0%	80	10.0	0.43	NASHYD
	302	23.98	7.9%	81	10.0	0.69	NASHYD
	303	31.49	0.4%	80	10.0	0.83	NASHYD
	304	12.74	9.2%	81	10.0	0.32	NASHYD
	305	11.66	1.9%	80	10.0	0.89	NASHYD
	Subtotal	94.36					
Total		237.58					

3.1.1 Imperviousness

Impervious level is calculated with various type of land use measured from the topographic data.

The existing site is golf course. The only impervious area will be the Grassy Brook Road, Grand Niagara Golf Club (Building and Parking), Ponds within Golf Course, and scattered residential units.

Catchment	Club Building & Parking	Grassy Brook Road*	Pond in Golf Course	Existing Residential & Others	Total Impervious Area (ha)
	75%	100%	100%	10%	
101		0.15	1.12		1.27
102	1.06	0.37	3.44		4.60
201	0.38	0.03	2.40		2.72
202		0.25			0.25
203		0.07			0.07
204			1.16		1.16
205					0.00
301					0.00
302			1.46	4.41	1.90
303				1.30	0.13
304			1.18		1.18
305		0.22			0.22

* Grassy Brook Road has a 7.0 m wide pavement.

3.1.2 SCS Curve Number

The site soil is mainly silty clay with a hydrologic soil group (HSG) of "C".

A weighted CN number is calculated with a typical CN of 80 for pervious area and 96 for impervious area.

3.1.3 Initial Abstraction for Pervious Area

A typical initial abstraction (IA) of 10 mm is assumed for the pre-development conditions.

3.1.4 Time of Concentration (T_C) and Time to Peak (T_P)

The Airport Formula is used to obtain the Time of Concentration.

$$T_C = \frac{3.26\,(1.1 - C)L^{0.5}}{S_W^{0.33}} \quad \text{and} \quad T_P = \frac{2}{3}T_C$$

Where,
T_C = Time of Concentration (minutes)
C = Runoff Coefficient, dimensionless
L = Watershed Length (m)
SW = Watershed Slope % (m/m)
T_P = Time to Peak (hours)

Catchment	Land Use	RC	L (m)	EL_1 (m)	EL_2 (m)	S_W (%)	T_C (min)	T_P (hr)
101	Open	0.23	657	180.00	171.00	1.37	65.2	0.72
102	Open	0.30	942	179.50	172.50	0.74	88.6	0.98
201	Open	0.29	398	180.50	173.50	1.76	43.5	0.48
202	Open	0.21	570	179.00	176.50	0.44	91.4	1.02
203	Open	0.21	135	177.00	172.00	3.70	21.9	0.24
204	Open	0.24	950	180.50	173.50	0.74	95.1	1.06
205	Open	0.20	196	177.50	171.50	3.06	28.4	0.32
301	Open	0.20	202	179.00	176.50	1.24	38.9	0.43
302	Open	0.26	462	179.50	175.50	0.87	62.1	0.69
303	Open	0.20	606	180.50	175.00	0.91	74.3	0.83
304	Open	0.26	203	180.00	175.00	2.46	28.8	0.32
305	Open	0.21	645	180.00	175.00	0.78	79.8	0.89

4. Proposed Development Drainage Plan

The proposed development consists of mixed-density residential, community parkland, stormwater management facilities, open space, and natural heritage areas.

4.1 Proposed Development Catchment Parameters

Watershed	Catchment	Area (ha)	RC	TIMP (%)	CN (II)	IA (mm)	Tp (hrs)	Command
Welland River	1001	10.47	0.67	66.9	80	5.0	---	StandHyd
	1002	15.10	0.60	57.5	80	5.0	---	StandHyd
	1003	7.60	0.29	12.5	80	5.0	1.01	NasHyd
	1004	23.05	0.62	60.4	80	5.0	---	StandHyd
	1005	13.17	0.20	0.0	80	10.0	0.68	NasHyd
	Subtotal	69.39						
Grassy Brook	2001	17.75	0.61	58.4	80	5.0	---	StandHyd
	2002	14.51	0.59	56.1	80	5.0	---	StandHyd
	2003	3.22	0.55	50.6	80	5.0	---	StandHyd
	2004	1.07	0.55	50.0	80	5.0	---	StandHyd
	2005	2.14	0.75	78.6	80	5.0	---	StandHyd
	2006	2.88	0.20	0.0	80	10.0	0.35	NasHyd
	2007	5.93	0.23	5.0	81	10.0	0.21	NasHyd
	2008	16.71	0.20	0.0	80	10.0	1.02	NasHyd
	2009	4.65	0.20	0.0	80	10.0	0.33	NasHyd
	2010	12.18	0.20	0.0	80	10.0	1.11	NasHyd
	2011	5.30	0.24	5.1	81	10.0	0.30	NasHyd
	Subtotal	86.36						
Lyon Creek	3001	9.03	0.73	75.9	80	5.0	---	StandHyd
	3002	2.20	0.75	78.6	80	5.0	---	StandHyd
	3003	2.30	0.74	76.7	80	5.0	---	StandHyd
	3004	10.53	0.25	7.6	81	10.0	0.41	NasHyd
	3005	11.85	0.23	4.9	81	10.0	0.71	NasHyd
	3006	44.22	0.20	0.0	80	10.0	0.83	NasHyd
	3007	1.71	0.20	0.0	80	10.0	0.22	NasHyd
	Subtotal	81.84						
Total		237.58						

* The imperviousness is calculated by converting the runoff coefficient using equation IMP=(RC-0.20)/0.70.

4.1.1 SCS Curve Number

A weighted CN number is calculated, as shown in above table.

The site soil is mainly silty clay with a hydrologic soil group (HSG) of "C".

4.1.2 Initial Abstraction for Pervious Area

A weighted initial abstraction (IA) is calculated, as shown in above table.

4.1.3 Imperviousness

Impervious level is calculated with various type of land use measured from the topographic data.

Catchment	Land Uses / Runoff Coefficient								Total Area (ha)	Runoff Coefficient (RC)
	High Density	Low to Medium Density	Mixed Use	School	Employment/ Commercial	Road ROW	SWM Block	Park/ Open Space		
	0.75	0.55	0.75	0.75	0.90	0.65	0.50	0.20		
1001	4.45	2.51				3.52			10.47	0.67
1002	2.87	3.18		2.40		4.59		2.05	15.10	0.60
1003							2.22	5.38	7.60	0.29
1004	1.79	8.31		3.39		7.46	2.09		23.05	0.62
1005								13.17	13.17	0.20
2001	3.33	7.68				4.77	1.97		17.75	0.61
2002	6.91					2.89	2.00	2.71	14.51	0.59
2003		1.55				1.34		0.34	3.22	0.55
2004		1.07							1.07	0.55
2005	2.14								2.14	0.75
2006								2.88	2.88	0.20
2007		0.59						5.34	5.93	0.23
2008								16.71	16.71	0.20
2009								4.65	4.65	0.20
2010								12.18	12.18	0.20
2011						0.42		4.88	5.30	0.24
3001		0.40	7.726			0.90			9.03	0.73
3002			2.20						2.20	0.75
3003					1.35	0.64		0.31	2.30	0.74
3004	1.03							9.50	10.53	0.25
3005		4.05						7.80	11.85	0.23
3006								44.22	44.22	0.20
3007								1.71	1.710	0.20

Existing Residential with a runoff coefficient of 0.30.

4.1.4 Time of Concentration (T_C) and Time to Peak (T_P)

The Airport Formula is used to obtain the Time of Concentration, and then converted to Time to Peak.

Catchment	Land Use	C	L (m)	EL_1 (m)	EL_2 (m)	S_W (%)	T_C (min)	T_P (hr)
1003	Open	0.29	337	176.50	176.00	0.15	91.2	1.01
1005	Open	0.20	442	177.00	172.50	1.02	61.3	0.68
2006	Open	0.20	207	178.86	174.00	2.35	31.9	0.35
2007	Open	0.23	102	176.50	173.00	3.45	18.9	0.21
2008	Open	0.20	570	179.00	176.50	0.44	91.9	1.02
2009	Open	0.20	202	177.50	172.00	2.72	30.0	0.33
2010	Open	0.20	950	180.50	173.50	0.74	100.0	1.11
2011	Open	0.24	196	177.50	171.50	3.06	27.3	0.30
3004	Open	0.25	202	179.00	176.50	1.24	36.6	0.41
3005	Open	0.23	462	179.50	175.50	0.87	63.6	0.71
3006	Open	0.20	606	180.50	175.00	0.91	74.6	0.83
3007	Open	0.20	120	180.50	175.00	4.58	19.4	0.22

4.3 Stormwater Management Strategy

4.3.1 SWM Wet Ponds

Total four (4) SWM wet ponds are proposed to provide water quality and erosion control.

Catchment	Land Use	Area (ha)	Imp (%)	SWM Facilities	Stormwater Management	Section
1001 ~ 1003	Mixed Use	33.17	50.2	Pond #1	Quality and Erosion Control	Section 5
1004	Mixed Use	23.05	60.4	Pond #2	Quality and Erosion Control	Section 6
2001	Mixed Use	17.75	58.4	Pond #3	Quality and Erosion Control	Section 7
2002, 2010	Mixed Use	26.69	30.5	Pond #4	Quality and Erosion Control	Section 8

4.3.2 Grassed Swale

A grassed swale is proposed to provide water quality for runoff from catchment 2003.

Refer to Section 9 of this Appendix for more details.

4.3.3 SWM Wet OGS Units

Total seven (7) OGS units are proposed to provide water quality treatment for runoff from development blocks which can be serviced by the proposed SWM wet ponds.

Catchment	Land Use	Area (ha)	Imp (%)	OGS	No. of Units	Area per Unit (ha)	TSS (≥60%)	Runoff (>90%)
2004	Medium	1.07	50.0	EFO8	1	1.07	63%	> 90%
2005	Mixed Use	2.14	78.6	EFO10	1	2.14	60%	> 90%
3001-1	Mixed Use	2.89	78.6	EFO12	1	2.89	61%	> 90%
3001-2	Mixed Use	4.84	78.6	2 X EFO10	2	2.42	60%	> 90%
3001-3	Road ROW	0.90	57.1	EFO6	1	0.90	61%	> 90%
3002	Mixed Use	2.20	78.6	EFO10	1	2.20	60%	> 90%
3003	Hospital	2.30	76.7	EFO10	1	2.30	62%	> 90%

5 Preliminary Design of SWM Pond #1

5.1 Design Criteria

1. Provide an Enhanced Level (80% TSS Removal) of Stormwater Quality Control per MECP guidelines.
2. Provide extended detention for runoff from a 25 mm rainfall event and release over a 24-hour to 48-hour period.
3. Quantity Control is not required.

5.2 Drainage to SWM Pond #1

Catchment	Area(ha)	TIMP(%)
1001	10.47	66.9
1002	15.10	57.5
1003	7.60	12.5
Total	33.17	50.2

5.3 Storage Requirements

5.3.1 Water Quality Control

SWM Wet Pond #1 must provide water quality control at Enhanced Level Protection

Refer to Table 3.2 in "Stormwater Management Planning and Design Manual" (MECP, 2003)

Protection Level	SWM Type	Storage Volume (m^3/ha)			
		35%	55%	70%	85%
Enhanced Level	Wet Pond	140	190	225	250

Total Drainage Area	33.17	ha			
Imperviousness	50.2	%			
SWMP Type	Wet Pond				
Enhanced Level Protection:	80	% TSS Removal			
Total Storage Volume	178.0	m^3/ha	or	5,903	m^3
Extended Detention Volume	40.0	m^3/ha	or	1,327	m^3
Permanent Pool Storage	138.0	m^3/ha	or	4,576	m^3

5.3.2 Erosion Control

Runoff Volume for 25 mm event	13.87	mm	(Refer to VO output)
Extended Detention (Erosion Control)	4,602	m^3	
Max. Release Rate over 48-hour Period	0.053	m^3/s	

5.3.3 Quantity Control

Quantity control is not required.

5.4 Preliminary Grading of SWM Pond #1

5.4.1 Permanent Pool Depth

Permanent Pool Depth at Sediment Forebays (~ 1.0 m) and Main cells (1.0 m)

5.4.2 STM Inlet & Sediment Forebay

Two storm inlets are proposed to convey the minor system flows into the SWM wet pond.

A sediment forebay is required at each storm inlet to the wet pond to settle out most of the sediment load within an area that can be conveniently accessed for maintenance.

5.4.3 Overland Flow Channel

An overland flow channel is proposed to convey the major system flow away from the SWM wet pond #1 and directly discharge into Welland River.

5.4.4 Active Storage Depth

Total active storage depth shall be 2.5 m.

5.4.5 Freeboard and Emergency Spill

Emergency spillway shall be incorporated above the design high water level to capture runoff during the 100-year and Regional storm or in case of blockage of low flow orifice plate.

5.4.6 Side Slope

6:1 for 3 m on either side of the Permanent Pool and 3:1 at elsewhere.

5.4.7 Maintenance Access Road

A 5.0 m wide maintenance access road is proposed along the north and west limit of the SWM wet pond to facilitate the maintenance of the sediment forebay and the outlet control structures.

5.4.8 Storage Volume Provided

Description	Elevation (m)	Area (m^2)	Total Storage (m^3)	Active Storage (m^3)
Bottom of Pond	171.00	7433	0	
	171.50	8571	4001	
Permanent Pool (PP)	172.00	10567	8754	0
	172.50	12790	14503	5,749
	173.00	13774	21144	12,390
	173.50	14782	28283	19,529
	174.00	15815	35932	27,178
Top of Pond	174.50	16874	44104	35,350

5.5 Outlet Control Structure

The outlet structure consists of a reverse slope pipe configured with orifice plate for erosion control and Ditch Inlet Catch Basin (DICB) followed with storm pipes (orifice tube) for Quantity Control and Conveyance up too 100-year storm events.
Due to the constraints of the grading, there is no positive emergency spillway.

5.5.1 Orifice Plate for Erosion Control

A 200 mm orifice plate is proposed for erosion control.

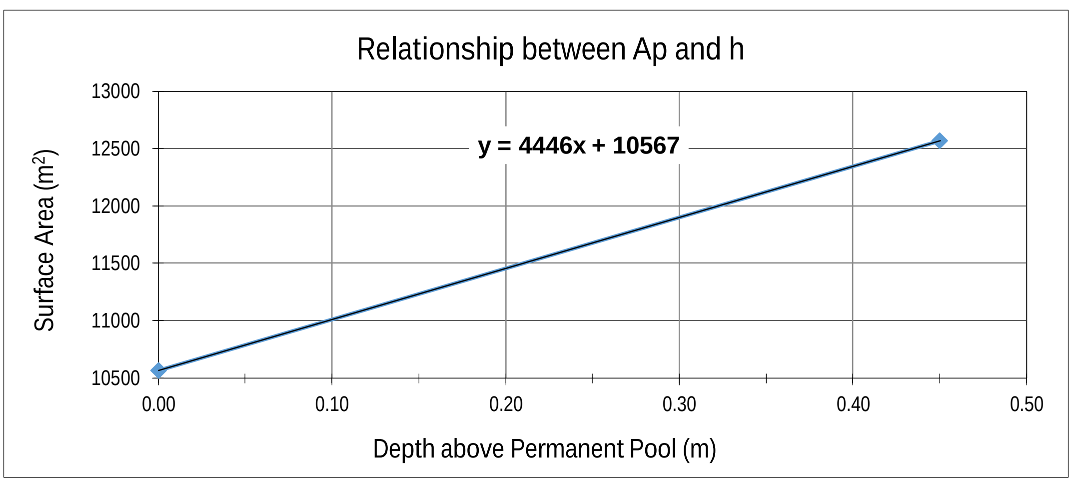
The detention time is approximated by the drawdown time which is estimated using the Falling Head Orifice Equation.

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_0}$$

Where,

C_2 =	Slope coefficient from the area-depth linear regression		4446	
C_3 =	Intercept from the area-depth linear regression		10567	
h =	Maximum water elevation above the orifice (m)		0.45	m
d =	Diameter of orifice plate (mm)		200	mm
A_0 =	Cross-section area of the orifice plate (m^2)		0.0314	m^2
t =	Drawdown time in seconds		174352	s, or
		or	48.4	hrs

Elevation (m)	Depth to PP (m)	Surface Area (m^2)	Active Volume (m^3)
172.00	0.00	10567	0
172.45	0.45	12568	5174



Orifice Discharge Equation is used to calculate the release rate from the 200 mm orifice plate:

$$Q = CA\sqrt{2gh}$$

Where,

Q = Orifice Plate Flow Rate (m^3/s)	0.052	m^3/s
C = Flow Coefficient for Orifice Plate	0.63	
d = Diameter of Orifice Plate (mm)	200	mm
A = Cross-section Area of Orifice Plate (m^2)	0.0314	m^2
g = Gravity Acceleration (m/s^2)	9.81	m/s^2
h = Water Head above Centerline of Orifice Plate (m)	0.35	m
The invert of the Orifice Plate is set at	172.00	m
Water Level for Extended Detention	172.45	m

5.5.2 Ditch Inlet Catch Basin (DICB) and Orifice Tube ffor larger events

Two 1200 x 600 mm precast concrete ditch inlets (OPSD 705.040) with 2400 X 600 mm grate (OPSD 403.010) & a 4:1 slope is proposed to convey the flow to the DICBs.

The invert of the grate is set at elevation: 172.80 m

Two 450 mm orifice tubes are proposed as overflow outlet.
The invert of the orifice tubes are set at elevation: 172.10 m

5.5.2.1 Ditch Inlet Catch Basin (DICB)

The flow rate through the grate can be estimated using either weir flow equation or orifice discharge equation, depending on the water head. Note that a 50% blockage is assumed in the flow capacity calculations.

When water head is low and the grate is not submerged, the flow rate can be estimated using Sharp-Crested Weir Equation

$$Q = 50\%\ CLH^{1.5}$$

Where,

Q = Sharp-Crested Weir Flow Rate (m^3/s)		
C = Flow Coefficient for Sharp-Crested Weir	1.84	
L' = Length of the Ditch Inlet Catch Basin (m)	2.40	m
α = Effective Length Ratio	0.90	
L = Effective Weir Length (m)	2.16	m
H = Water Depth (m) = Water surface Elevation - 172.8 m.	(Note: H < = 0.6/4= 0.15 m)	

When water head is high and the grate is submerged, the flow can be estimated using Orifice Discharge Equation

$$Q = 50\%\ CA\sqrt{2gh}$$

Where,

Q = Orifice Plate Flow Rate (m^3/s)		
C = Flow Coefficient for Orifice Plate	0.63	
A = Cross-section Area of Orifice Plate (m^2)		
= Length X Width X 0.9 (Opening Ratio)	1.296	m^2
g = Gravity Acceleration (m/s^2)	9.81	m/s^2
h = Water Head above centerline of the grate (m) = Water Surface Elevation - 172.80 - 0.15/2		

5.5.2.2 Orifice Tubes for overflow up to 100-year Event

Orifice Discharge Equation is used to calculate the release rate from the 450 mm orifice tubes:

$$Q = CA\sqrt{2gh}$$

Where,

Q = Flow Rate of Orifice Tubes (m^3/s)	1.662	m^3/s
C = Flow Coefficient for Orifice Tubes	0.80	
d = Diameter of Orifice Tubes (mm)	450	mm
Number of Orifice Tubes	2	
A = Cross-section Area of Orifice Tubes (m^2)	0.3181	m^2
g = Gravity Acceleration (m/s^2)	9.81	m/s^2
h = Water Head above Centerline of Orifice Tubes (m)	2.17	m
The inverts of the Orifice Tubes are set at	172.10	m
Top of Pond	174.50	m

5.6 Stage - Storage - Discharge Relationship

Elevation (m)	Flow Control for Extended Detention		Flow Capture and Quantity Control up to 100-year Storm Events					Total Discharge (m^3/s)	Active Storage (m^3)
	Orifice Plate #1 C = 0.63 Dia. = 200 Inv. = 172.00		Grating of DICB C = 0.63 2 X1200 x 600 Lid. = 172.80		Orifice Tube #2, #3 C = 0.80 Dia. = 450 X 2 Inv. = 172.10		Orifice Tube #2 Controlled Flow (m^3/s)		
	Depth (m)	Flow (m^3/s)	Depth (m)	Flow (m^3/s)	Depth (m)	Flow (m^3/s)			
172.00	0.00	0.000						0.000	0
172.10	0.10	0.014			0.00	0.000		0.014	1,150
172.20	0.20	0.028			0.10	0.103		0.028	2,299
172.30	0.30	0.039			0.20	0.206		0.039	3,449
172.40	0.40	0.048			0.30	0.309		0.048	4,599
172.45	0.45	0.052			0.35	0.399		0.052	5,174
172.50	0.50	0.055			0.40	0.472		0.055	5,749
172.60	0.60	0.062			0.50	0.591		0.062	7,077
172.70	0.70	0.068			0.60	0.690		0.068	8,405
172.80	0.80	0.073	0.00	0.000	0.70	0.777	0.000	0.073	9,733
172.90	0.90	0.078	0.10	0.063	0.80	0.855	0.063	0.141	11,062
173.00	1.00	0.083	0.12	0.639	0.90	0.926	0.639	0.722	12,390
173.25	1.25	0.094	0.37	1.107	1.15	1.084	1.084	1.178	15,959
173.50	1.50	0.104	0.62	1.430	1.40	1.222	1.222	1.326	19,529
173.75	1.75	0.113	0.87	1.691	1.65	1.346	1.346	1.458	23,353
174.00	2.00	0.121	1.12	1.918	1.90	1.459	1.459	1.580	27,178
174.25	2.25	0.129	1.37	2.120	2.15	1.564	1.564	1.692	31,264
174.50	2.50	0.136	1.62	2.305	2.40	1.662	1.662	1.798	35,350

5.7 Quantity Control Performance

Storm Event	Q_{in} (m^3/s)	Q_{out} (m^3/s)	V_{ACTIVE} (m^3)	WSE (m)	VO Sc.
25 mm	1.824	0.044	4,061	172.35	Run 01
5-yr 3-hr Chicago	3.283	0.059	6,597	172.56	Run 02
100-yr 3-hr Chicago	3.303	0.125	10,749	172.88	Run 03
100-yr 12-hr AES	1.250	0.841	13,322	173.07	Run 04
100-yr 24-hr SCS	3.454	0.872	13,579	173.08	Run 05
Regional (48-hr Hurricane Hazel)	3.814	1.720	32,360	174.40	Run 06

5.8. Outlet Pipe

An outlet pipe is proposed underneath the proposed Street "A" to convey the peak flow from the control MH to the Welland River.

Dia (mm)	θ	A (m^2)	P (m)	R (m)	n	S (%)	Q_C (m^3/s)	Q_P (m^3/s)
1200	6.28	1.131	3.770	0.300	0.012	0.30	2.313	1.720

5.9 Sediment Forebay #1 Configuration

The sediment forebay design guidelines are presented in section 4.6.2 of the <Stormwater Management Practice Planning and Design Manual> (MECP, 2003) on page 4.55 to 4.57.

5.9.1 Settling Calculation

$$D_{ist} = \sqrt{rQ_p / V_s}$$

Equation 4.5 of MOE Manual

Where,	D_{ist} =	Forebay length (m)	24.2	m
	r =	Length -to-Width ratio of forebay	4.0	
	Q_p =	Peak flow rate from the pond during design quality storm (25 mm)		
		Refer to Table in Page 26 or VO Output	0.044	m^3/s
	V_s =	Setting velocity	0.0003	m/s

5.9.2 Dispersion Length

The dispersion length refers to the length of fluid required to slow a jet discharge. It is recommended that the forebay length is such that a fluid jet will disperse to a velocity of ≤ 0.50 m/s at the forebay berm.

$$D_{ist} = 8Q / dV_f$$

Equation 4.6 of MOE Manual

Where,	D_{ist} =	Dispersion Length	23.7	m
	Q =	Inlet flow rate from design storm (5-year) (Refer to VO output)	1.48	m^3/s
	d =	Depth of permanent pool in the forebay	1.00	m
	V_f =	Desired velocity in the forebay	0.50	m/s

5.9.3 Minimum Forebay Bottom Width

$$W_{idth} = D_{ist} / 8$$

Equation 4.7 of MOE Manual

Where,	W_{idth} =	Minimum Forebay Deep Zone Bottom Width	3.0	m
	D_{ist} =	Larger of Settling Length and Dispersion Length	24.2	m

5.9.4 Forebay Configuration

Description	Required	Provided
Depth (m)	1.0	1.0
Settling Length (m)	24.2	76.0
Dispersion Length (m)	23.7	
Minimum Bottom Width of Forebay Deep Zone (m)	3.0	10.0

5.9.5 Average Flow Velocity in the forebay

A check should be made using the entire forebay cross-sectional area to ensure that the average velocity in the forebay is less than, or equal to , 0.15 m/s which is empirically recognized as the maximum permissible velocity before which erosion will occur in a channel.

$$V_{avg} = Q/A$$

Where,	V_{avg} =	Average velocity in the forebay	0.11	m/s
	Q =	Inlet flow rate from design storm (5-year)	1.48	m^3/s
	A =	Entire forebay cross-sectional area	13.75	m^2
	d =	Depth of permanent pool in the forebay	1.00	m
	W_b =	Forebay Deep Zone Bottom Width	10.00	m
	W_t =	Forebay Deep Zone Top Width at Permanent Pool Elevation	17.50	m

5.10 Sediment Forebay #2 Configuration

The sediment forebay design guidelines are presented in section 4.6.2 of the <Stormwater Management Practice Planning and Design Manual> (MECP, 2003) on page 4.55 to 4.57.

5.10.1 Settling Calculation

$$D_{ist} = \sqrt{{rQ_p}/{V_s}}$$

Equation 4.5 of MOE Manual

Where,	D_{ist} =	Forebay length (m)	24.2	m
	r =	Length -to-Width ratio of forebay	4.0	
	Q_p =	Peak flow rate from the pond during design quality storm (25 mm)		
		Refer to Table in Page 26 or VO Output	0.044	m^3/s
	V_s =	Setting velocity	0.0003	m/s

5.10.2 Dispersion Length

The dispersion length refers to the length of fluid required to slow a jet discharge. It is recommended that the forebay length is such that a fluid jet will disperse to a velocity of ≤ 0.50 m/s at the forebay berm.

$$D_{ist} = {8Q}/{dV_f}$$

Equation 4.6 of MOE Manual

Where,	D_{ist} =	Dispersion Length	28.7	m
	Q =	Inlet flow rate from design storm (5-year) (Refer to VO output)	1.80	m^3/s
	d =	Depth of permanent pool in the forebay	1.00	m
	V_f =	Desired velocity in the forebay	0.50	m/s

5.10.3 Minimum Forebay Bottom Width

$$W_{idth} = {D_{ist}}/{8}$$

Equation 4.7 of MOE Manual

Where,	W_{idth} =	Minimum Forebay Deep Zone Bottom Width	3.6	m
	D_{ist} =	Larger of Settling Length and Dispersion Length	28.7	m

5.10.4 Forebay Configuration

Description	Required	Provided
Depth (m)	1.0	1.0
Settling Length (m)	24.2	76.0
Dispersion Length (m)	28.7	
Minimum Bottom Width of Forebay Deep Zone (m)	3.6	10.0

5.10.5 Average Flow Velocity in the forebay

A check should be made using the entire forebay cross-sectional area to ensure that the average velocity in the forebay is less than, or equal to , 0.15 m/s which is empirically recognized as the maximum permissible velocity before which erosion will occur in a channel.

$$V_{avg} = Q/A$$

Where,	V_{avg} =	Average velocity in the forebay	0.13	m/s
	Q =	Inlet flow rate from design storm (5-year)	1.80	m^3/s
	A =	Entire forebay cross-sectional area	13.75	m^2
	d =	Depth of permanent pool in the forebay	1.00	m
	W_b =	Forebay Deep Zone Bottom Width	10.00	m
	W_t =	Forebay Deep Zone Top Width at Permanent Pool Elevation	17.50	m

6 Preliminary Design of SWM Pond #2

6.1 Design Criteria

1. Provide an Enhanced Level (80% TSS Removal) of Stormwater Quality Control per MECP guidelines.
2. Provide extended detention for runoff from a 25 mm rainfall event and release over a 24-hour to 48-hour period.
3. Quantity Control is not required.

6.2 Drainage to SWM Pond #2

Catchment	Area(ha)	TIMP(%)
1004	23.05	60.4

6.3 Storage Requirements

6.3.1 Water Quality Control

SWM Wet Pond #2 must provide water quality control at Enhanced Level Protection

Refer to Table 3.2 in "Stormwater Management Planning and Design Manual" (MECP, 2003)

Protection Level	SWM Type	Storage Volume (m^3/ha)			
		35%	55%	70%	85%
Enhanced Level	Wet Pond	140	190	225	250

Total Drainage Area	23.05	ha			
Imperviousness	60.4	%			
SWMP Type	Wet Pond				
Enhanced Level Protection:	80	% TSS Removal			
Total Storage Volume	202.6	m^3/ha	or	4,670	m^3
Extended Detention Volume	40.0	m^3/ha	or	922	m^3
Permanent Pool Storage	162.6	m^3/ha	or	3,748	m^3

6.3.2 Erosion Control

Runoff Volume for 25 mm event	16.39	mm	(Refer to VO output)
Extended Detention (Erosion Control)	3,779	m^3	
Max. Release Rate over 48-hour Period	0.044	m^3/s	

6.3.3 Quantity Control

Quantity control is not required.

6.4 Preliminary Grading of SWM Pond #2

6.4.1 Permanent Pool Depth

Permanent Pool Depth at Sediment Forebay (1.0 m) and Main cell (1.0 m)

6.4.2 STM Inlets & Sediment Forebays

A storm inlet is proposed to convey the minor system flows into the wet pond.

A sediment forebay is required at the storm inlet to the wet pond to settle out most of the sediment load within an area that can be conveniently accessed for maintenance.

6.4.3 Overland Flow Channel

An overland flow channel is proposed to convey the major system flow away from the SWM wet pond #2 and directly discharge into Welland River.

6.4.4 Active Storage Depth

Total active storage depth shall be 1.0 m.

6.4.5 Freeboard and Emergency Spill

Emergency spillway shall be incorporated above the design high water level to capture runoff during the 100-year and Regional storm or in case of blockage of low flow orifice plate.

6.4.6 Side Slope

6:1 for 3 m on either side of the Permanent Pool and 4:1 at elsewhere.

6.4.7 Maintenance Access Road

A 5.0 m wide maintenance access road is proposed along the north and east limit of the SWM wet pond to facilitate the maintenance of the sediment forebay and the outlet control structures.

6.4.8 Storage Volume Provided

Description	Elevation (m)	Area (m^2)	Total Storage (m^3)	Active Storage (m^3)
Bottom of Pond	170.95	6489	0	
	171.45	7588	3519	
Permanent Pool (PP)	171.95	9333	7702	0
	172.45	11069	12774	5,073
Top of Pond	172.95	12208	18594	10,892

6.5 Outlet Control Structure

The outlet structure consists of a reverse slope pipe configured with orifice plate for erosion control.

Emergency spillway shall be incorporated in the north embankment to convey the peak flow rate during the 100-year or regional event, whichever is larger.

6.5.1 Orifice Plate for Erosion Control

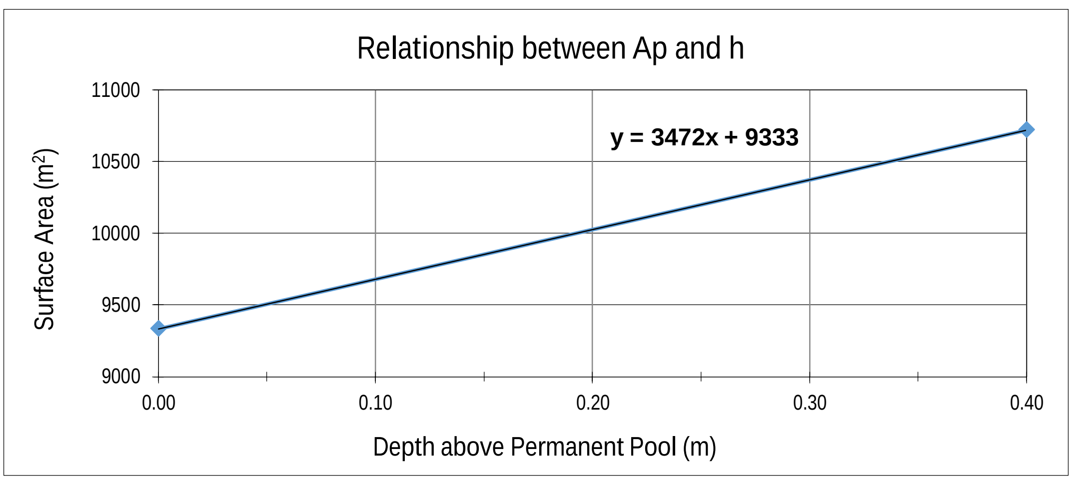
A 180 mm orifice plate is proposed for erosion control.

The detention time is approximated by the drawdown time which is estimated using the Falling Head Orifice Equation.

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_0}$$

Where,				
	C_2 =	Slope coefficient from the area-depth linear regression	3472	
	C_3 =	Intercept from the area-depth linear regression	9333	
	h =	Maximum water elevation above the orifice (m)	0.40	m
	d =	Diameter of orifice plate (mm)	180	mm
	A_0 =	Cross-section area of the orifice plate (m^2)	0.0254	m^2
	t =	Drawdown time in seconds	176984	s, or
		or	49.2	hrs

Elevation (m)	Depth to PP (m)	Surface Area (m^2)	Active Volume (m^3)
171.95	0.00	9333	0
172.35	0.40	10722	4058



Orifice Discharge Equation is used to calculate the release rate from the 180 mm orifice plate:

$$Q = CA\sqrt{2gh}$$

Where,			
	Q = Orifice Plate Flow Rate (m^3/s)	0.040	m^3/s
	C = Flow Coefficient for Orifice Plate	0.63	
	d = Diameter of Orifice Plate (mm)	180	mm
	A = Cross-section Area of Orifice Plate (m^2)	0.0254	m^2
	g = Gravity Acceleration (m/s^2)	9.81	m/s^2
	h = Water Head above Centerline of Orifice Plate (m)	0.31	m
	The invert of the Orifice Plate is set at	171.95	m
	Water Level for Extended Detention	172.35	m

6.5.3 Emergency Spillway

Emergency spillway which functions as a broad-crested weir, is proposed to safely convey the full inflow to the SWM wet pond

Inflow Rate (minor system flow, 5-year 3-hour Chicago storm) 2.740 m^3/s

The lid elevation of the weir is set at 172.35 m

The flow rate for broad-crested weir is calculated using the following equation

$$Q = CLH^{1.5}$$

Where,
- Q = Broad-Crested Weir Flow Rate (m^3/s) 2.79 m^3/s
- C = Flow Coefficient for Broad-Crested Weir 1.70
- L = Weir Length (m) 10.00 m
- H = Water Depth (m) 0.30 m

6.6 Stage - Storage - Discharge Relationship

Elevation (m)	Orifice Plate		Emergency Spill		Total Discharge (m^3/s)	Active Storage (m^3)
	Depth (m)	Flow (m^3/s)	Depth (m)	Flow (m^3/s)		
171.95	0.00	0.000			0.000	0
172.05	0.10	0.007			0.007	1,014
172.15	0.20	0.024			0.024	2,029
172.25	0.30	0.033			0.033	3,043
172.35	0.40	0.040	0.00	0.00	0.040	4,058
172.45	0.50	0.045	0.10	0.54	0.583	5,072
172.55	0.60	0.051	0.20	1.52	1.571	6,236
172.65	0.70	0.055	0.30	2.79	2.849	7,400
172.75	0.80	0.060	0.40	4.30	4.361	8,564
172.85	0.90	0.064	0.50	6.01	6.074	9,728
172.95	1.00	0.068	0.60	7.90	7.969	10,892

6.7 Quantity Control Performance

Storm Event	Q_{in} (m^3/s)	Q_{out} (m^3/s)	V_{ACTIVE} (m^3)	WSE (m)	VO Sc.
25 mm	1.334	0.036	3,414	172.29	Run 01
5-yr 3-hr Chicago	2.767	0.272	4,491	172.39	Run 02
100-yr 3-hr Chicago	2.767	0.817	5,349	172.47	Run 03
100-yr 12-hr AES	0.974	0.918	5,469	172.48	Run 04
100-yr 24-hr SCS	2.767	2.279	6,937	172.61	Run 05
Regional (48-hr Hurricane Hazel)	2.767	2.729	7,295	172.64	Run 06

6.8 Sediment Forebay Configuration

The sediment forebay design guidelines are presented in section 4.6.2 of the <Stormwater Management Practice Planning and Design Manual> (MECP, 2003) on page 4.55 to 4.57.

6.8.1 Settling Calculation

$$D_{ist} = \sqrt{rQ_p / V_s}$$

Equation 4.5 of MOE Manual

Where,	D_{ist} =	Forebay length (m)	15.5	m
	r =	Length -to-Width ratio of forebay	2.0	
	Q_p =	Peak flow rate from the pond during design quality storm (25 mm) Refer to Table in Page 26 or VO Output	0.036	m^3/s
	V_s =	Setting velocity	0.0003	m/s

6.8.2 Dispersion Length

The dispersion length refers to the length of fluid required to slow a jet discharge. It is recommended that the forebay length is such that a fluid jet will disperse to a velocity of ≤ 0.50 m/s at the forebay berm.

$$D_{ist} = 8Q / dV_f$$

Equation 4.6 of MOE Manual

Where,	D_{ist} =	Dispersion Length	44.3	m
	Q =	Inlet flow rate from design storm (5-year) (Refer to VO output)	2.77	m^3/s
	d =	Depth of permanent pool in the forebay	1.00	m
	V_f =	Desired velocity in the forebay	0.50	m/s

6.8.3 Minimum Forebay Bottom Width

$$W_{idth} = D_{ist} / 8$$

Equation 4.7 of MOE Manual

Where,	W_{idth} =	Minimum Forebay Deep Zone Bottom Width	5.5	m
	D_{ist} =	Larger of Settling Length and Dispersion Length	44.3	m

6.8.4 Forebay Configuration

Description	Required	Provided
Depth (m)	1.0	1.0
Settling Length (m)	15.5	60.0
Dispersion Length (m)	44.3	
Minimum Bottom Width of Forebay Deep Zone (m)	5.5	23.0

6.8.5 Average Flow Velocity in the forebay

A check should be made using the entire forebay cross-sectional area to ensure that the average velocity in the forebay is less than, or equal to , 0.15 m/s which is empirically recognized as the maximum permissible velocity before which erosion will occur in a channel.

$$V_{avg} = Q/A$$

Where,	V_{avg} =	Average velocity in the forebay	0.10	m/s
	Q =	Inlet flow rate from design storm (5-year)	2.77	m^3/s
	A =	Entire forebay cross-sectional area	27.50	m^2
	d =	Depth of permanent pool in the forebay	1.00	m
	W_b =	Forebay Deep Zone Bottom Width	23.00	m
	W_t =	Forebay Deep Zone Top Width at Permanent Pool Elevation	32.00	m

7 Preliminary Design of SWM Pond #3

7.1 Design Criteria

1. Provide an Enhanced Level (80% TSS Removal) of Stormwater Quality Control per MECP guidelines.
2. Provide extended detention for runoff from a 25 mm rainfall event and release over a 24-hour to 48-hour period.
3. Quantity Control is not required.

7.2 Drainage to SWM Pond #3

Catchment	Area(ha)	TIMP(%)
2001	17.75	58.4

7.3 Storage Requirements

7.3.1 Water Quality Control

SWM Wet Pond #3 must provide water quality control at Enhanced Level Protection

Refer to Table 3.2 in "Stormwater Management Planning and Design Manual" (MECP, 2003)

Protection Level	SWM Type	Storage Volume (m^3/ha)			
		35%	55%	70%	85%
Enhanced Level	Wet Pond	140	190	225	250

Total Drainage Area	17.75	ha			
Imperviousness	58.4	%			
SWMP Type	Wet Pond				
Enhanced Level Protection:	80	% TSS Removal			
Total Storage Volume	198.0	m^3/ha	or	3,514	m^3
Extended Detention Volume	40.0	m^3/ha	or	710	m^3
Permanent Pool Storage	158.0	m^3/ha	or	2,804	m^3

7.3.2 Erosion Control

Runoff Volume for 25 mm event	16.01	mm	(Refer to VO output)
Extended Detention (Erosion Control)	2,841	m^3	
Max. Release Rate over 48-hour Period	0.033	m^3/s	

7.3.3 Quantity Control

Quantity control is not required.

7.4 Preliminary Grading of SWM Pond #3

7.4.1 Permanent Pool Depth

Permanent Pool Depth at Sediment Forebay (1.0 m) and Main cell (1.0 m)

7.4.2 STM Inlets & Sediment Forebays

A storm inlet is proposed to convey the minor system flows into the wet pond.

A sediment forebay is required at the storm inlet to the wet pond to settle out most of the sediment load within an area that can be conveniently accessed for maintenance.

7.4.3 Overland Flow Channel

An overland flow channel is proposed to convey the major system flow away from the SWM wet pond #3 and directly discharge into Grassy Brook..

7.4.4 Active Storage Depth

Total active storage depth shall be 1.0 m.

7.4.5 Freeboard and Emergency Spill

Emergency spillway shall be incorporated above the design high water level to capture runoff during the 100-year and Regional storm or in case of blockage of low flow orifice plate.

7.4.6 Side Slope

6:1 for 3 m on either side of the Permanent Pool and 4:1 at elsewhere.

7.4.7 Maintenance Access Road

A 5.0 m wide maintenance access road is proposed along the south and east limit of the south cell of the SWM wet pond to facilitate the maintenance of the sediment forebay #3 and the outlet control structures.

7.4.8 Storage Volume Provided

Description	Elevation (m)	Area (m^2)	Total Storage (m^3)	Active Storage (m^3)
Bottom of Pond	172.85	7047	0	
	173.35	8041	3772	
Permanent Pool (PP)	173.85	9669	8176	0
	174.35	11179	13388	5,687
Top of Pond	174.85	12284	19254	11,552

7.5 Outlet Control Structure

The outlet structure consists of a reverse slope pipe configured with orifice plate for erosion control.

Emergency spillway shall be incorporated in the east embankment to convey the peak flow rate during the 100-year or regional event, whichever is larger.

7.5.1 Orifice Plate for Erosion Control

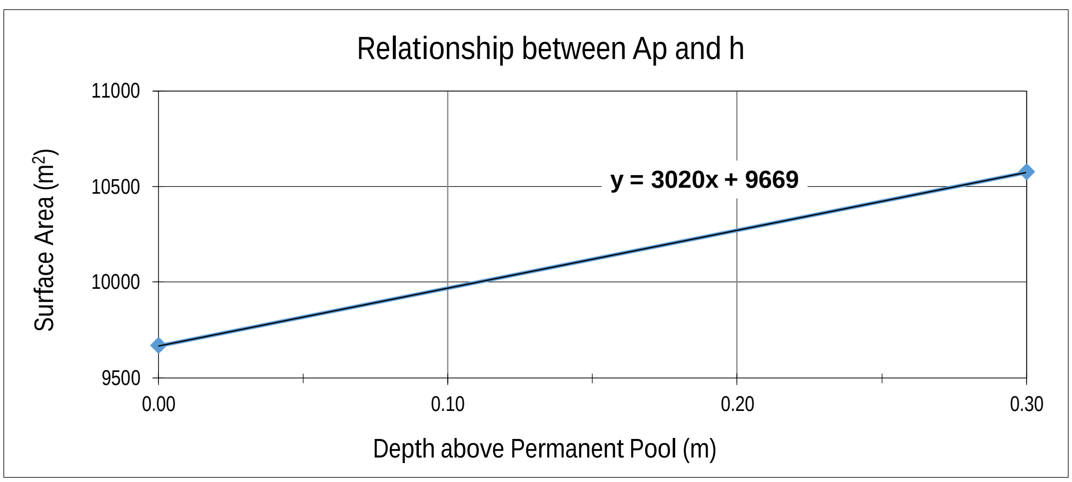
A 170 mm orifice plate is proposed for erosion control.

The detention time is approximated by the drawdown time which is estimated using the Falling Head Orifice Equation.

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_0}$$

Where,	C_2 =	Slope coefficient from the area-depth linear regression		3020	
	C_3 =	Intercept from the area-depth linear regression		9669	
	h =	Maximum water elevation above the orifice (m)		0.30	m
	d =	Diameter of orifice plate (mm)		170	mm
	A_0 =	Cross-section area of the orifice plate (m^2)		0.0227	m^2
	t =	Drawdown time in seconds		174935	s, or
			or	48.6	hrs

Elevation (m)	Depth to PP (m)	Surface Area (m^2)	Active Volume (m^3)
173.85	0.00	9669	0
174.15	0.30	10575	3412



Orifice Discharge Equation is used to calculate the release rate from the 170 mm orifice plate:

$$Q = CA\sqrt{2gh}$$

Where,	Q = Orifice Plate Flow Rate (m^3/s)	0.029	m^3/s
	C = Flow Coefficient for Orifice Plate	0.63	
	d = Diameter of Orifice Plate (mm)	170	mm
	A = Cross-section Area of Orifice Plate (m^2)	0.0227	m^2
	g = Gravity Acceleration (m/s^2)	9.81	m/s^2
	h = Water Head above Centerline of Orifice Plate (m)	0.22	m
	The invert of the Orifice Plate is set at	173.85	m
	Water Level for Extended Detention	174.15	m

7.5.3 Emergency Spillway

Emergency spillway which functions as a broad-crested weir, is proposed to safely convey the full inflow to the SWM wet pond

Inflow Rate (minor system flow, 5-year 3-hour Chicago storm) 2.114 m^3/s

The lid elevation of the weir is set at 174.25 m

The flow rate for broad-crested weir is calculated using the following equation

$$Q = CLH^{1.5}$$

Where,

Q = Broad-Crested Weir Flow Rate (m^3/s)	2.79	m^3/s
C = Flow Coefficient for Broad-Crested Weir	1.70	
L = Weir Length (m)	10.00	m
H = Water Depth (m)	0.30	m

7.6 Stage - Storage - Discharge Relationship

Elevation (m)	Orifice Plate		Emergency Spill		Total Discharge (m^3/s)	Active Storage (m^3)
	Depth (m)	Flow (m^3/s)	Depth (m)	Flow (m^3/s)		
173.85	0.00	0.000			0.000	0
173.95	0.10	0.008			0.008	1,137
174.05	0.20	0.021			0.021	2,275
174.15	0.30	0.029			0.029	3,412
174.25	0.40	0.036	0.00	0.00	0.036	4,549
174.35	0.50	0.041	0.10	0.54	0.578	5,686
174.45	0.60	0.045	0.20	1.52	1.566	6,860
174.55	0.70	0.050	0.30	2.79	2.843	8,033
174.65	0.80	0.054	0.40	4.30	4.354	9,206
174.75	0.90	0.057	0.50	6.01	6.068	10,379
174.85	1.00	0.061	0.60	7.90	7.961	11,552

7.7 Quantity Control Performance

Storm Event	Q_{in} (m^3/s)	Q_{out} (m^3/s)	V_{ACTIVE} (m^3)	WSE (m)	VO Sc.
25 mm	1.166	0.023	2,601	174.08	Run 01
5-yr 3-hr Chicago	2.114	0.033	4,120	174.21	Run 02
100-yr 3-hr Chicago	2.114	0.350	5,210	174.31	Run 03
100-yr 12-hr AES	0.743	0.595	5,710	174.35	Run 04
100-yr 24-hr SCS	2.114	1.373	6,643	174.43	Run 05
Regional (48-hr Hurricane Hazel)	2.114	2.083	7,334	174.49	Run 06

7.8 Sediment Forebay Configuration

The sediment forebay design guidelines are presented in section 4.6.2 of the <Stormwater Management Practice Planning and Design Manual> (MECP, 2003) on page 4.55 to 4.57.

7.8.1 Settling Calculation

$$D_{ist} = \sqrt{rQ_p / V_s}$$

Equation 4.5 of MOE Manual

Where,	D_{ist} =	Forebay length (m)	17.5	m
	r =	Length -to-Width ratio of forebay	4.0	
	Q_p =	Peak flow rate from the pond during design quality storm (25 mm)		
		Refer to Table in Page 26 or VO Output	0.023	m^3/s
	V_s =	Setting velocity	0.0003	m/s

7.8.2 Dispersion Length

The dispersion length refers to the length of fluid required to slow a jet discharge. It is recommended that the forebay length is such that a fluid jet will disperse to a velocity of ≤ 0.50 m/s at the forebay berm.

$$D_{ist} = 8Q / dV_f$$

Equation 4.6 of MOE Manual

Where,	D_{ist} =	Dispersion Length	33.8	m
	Q =	Inlet flow rate from design storm (5-year) (Refer to VO output)	2.11	m^3/s
	d =	Depth of permanent pool in the forebay	1.00	m
	V_f =	Desired velocity in the forebay	0.50	m/s

7.8.3 Minimum Forebay Bottom Width

$$W_{idth} = D_{ist} / 8$$

Equation 4.7 of MOE Manual

Where,	W_{idth} =	Minimum Forebay Deep Zone Bottom Width	4.2	m
	D_{ist} =	Larger of Settling Length and Dispersion Length	33.8	m

7.8.4 Forebay Configuration

Description	Required	Provided
Depth (m)	1.0	1.0
Settling Length (m)	17.5	95.0
Dispersion Length (m)	33.8	
Minimum Bottom Width of Forebay Deep Zone (m)	4.2	22.8

7.8.5 Average Flow Velocity in the forebay

A check should be made using the entire forebay cross-sectional area to ensure that the average velocity in the forebay is less than, or equal to , 0.15 m/s which is empirically recognized as the maximum permissible velocity before which erosion will occur in a channel.

$$V_{avg} = Q / A$$

Where,	V_{avg} =	Average velocity in the forebay	0.08	m/s
	Q =	Inlet flow rate from design storm (5-year)	2.11	m^3/s
	A =	Entire forebay cross-sectional area	27.80	m^2
	d =	Depth of permanent pool in the forebay	1.00	m
	W_b =	Forebay Deep Zone Bottom Width	22.80	m
	W_t =	Forebay Deep Zone Top Width at Permanent Pool Elevation	32.80	m

8 Preliminary Design of SWM Pond #4

8.1 Design Criteria

1. Provide an Enhanced Level (80% TSS Removal) of Stormwater Quality Control per MECP guidelines.
2. Provide extended detention for runoff from a 25 mm rainfall event and release over a 24-hour to 48-hour period.
3. Quantity Control is not required.

8.2 Drainage to SWM Pond #4

Catchment	Area(ha)	TIMP(%)
2002	14.51	56.1
2010	12.18	0.0
Total	26.69	30.5

8.3 Storage Requirements

8.3.1 Water Quality Control

SWM Wet Pond #4 must provide water quality control at Enhanced Level Protection

Refer to Table 3.2 in "Stormwater Management Planning and Design Manual" (MECP, 2003)

Protection Level	SWM Type	Storage Volume (m^3/ha)			
		35%	55%	70%	85%
Enhanced Level	Wet Pond	140	190	225	250

Total Drainage Area	26.69	ha			
Imperviousness	30.5	%			
SWMP Type	Wet Pond				
Enhanced Level Protection:	80	% TSS Removal			
Total Storage Volume	132.9	m^3/ha	or	3,546	m^3
Extended Detention Volume	40.0	m^3/ha	or	1,068	m^3
Permanent Pool Storage	92.9	m^3/ha	or	2,479	m^3

8.3.2 Erosion Control

Runoff Volume for 25 mm event	9.77	mm	(Refer to VO output)
Extended Detention (Erosion Control)	2,608	m^3	
Max. Release Rate over 24-hour Period	0.060	m^3/s	

8.3.3 Quantity Control

SWM Wet Pond shall provide extended detention for 25 mm rainfall event and control 2- to 100-year peak flow rates to the pre-development levels as per Hagersville MSP.

8.4 Preliminary Grading of SWM Pond #4

The proposed SWM Wet Pond #4 shall use the existing pond as the main cell and a sediment forebay be proposed to receive the minor flow from catchment 2002.

8.4.1 Permanent Pool Depth

Permanent Pool Depth at Sediment Forebay (1.0 m) and Main cell (~ 2.0 m)

8.4.2 STM Inlets & Sediment Forebays

A storm inlet is proposed to convey the minor system flows into the wet pond.

A sediment forebay is required at the storm inlet to the wet pond to settle out most of the sediment load within an area that can be conveniently accessed for maintenance.

8.4.3 Overland Flow Channel

An overland flow channel is proposed to convey the major system flow from catchment 2002 to the mail cell of SWM wet pond #4.

8.4.4 Active Storage Depth

Total active storage depth shall be ~ 2.0 m.

8.4.5 Freeboard and Emergency Spill

Emergency spillway shall be incorporated above the design high water level to capture runoff during the 100-year and Regional storm or in case of blockage of low flow orifice plate.

8.4.6 Side Slope

6:1 for 3 m on either side of the Permanent Pool and 3:1 at elsewhere.

8.4.7 Maintenance Access Road

A 5.0 m wide maintenance access road is proposed along the east limit of the SWM wet pond to facilitate the maintenance of the sediment forebay and the outlet control structures.

8.4.8 Storage Volume Provided

Description	Elevation (m)	Area (m^2)	Total Storage (m^3)	Active Storage (m^3)
Bottom of Pond	172.00	7,703	0	
	172.50	8,407	3,029	
	173.00	10,453	7,413	
	173.50	11,500	12,901	
Permanent Pool (PP)	174.00	12,866	18,970	0
	174.50	14,323	25,722	6,752
	175.00	15,160	33,093	14,123
	175.50	16,028	40,890	21,920
Top of Pond	176.00	16,914	49,125	30,156

8.5 Outlet Control Structure

The outlet structure consists of an orifice for tube erosion control.

Emergency spill weir shall be incorporated in north end of the pond to convey the peak flow rate from 100-year or regional event, whichever is larger.

8.5.1 Orifice Plate for Erosion Control

A 150 mm orifice tube is proposed for erosion control.

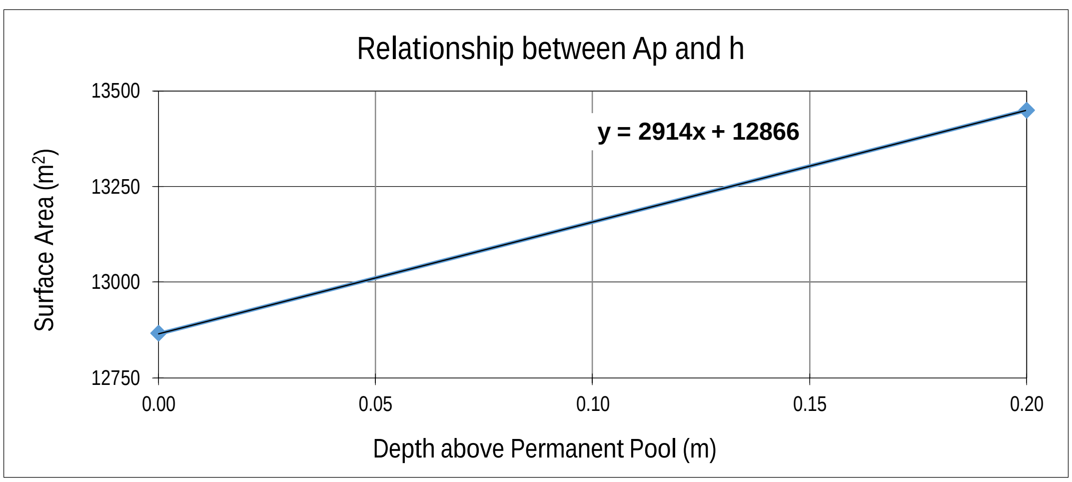
The detention time is approximated by the drawdown time which is estimated using the Falling Head Orifice Equation.

$$t = \frac{0.66C_2h^{1.5} + 2C_3h^{0.5}}{2.75A_0}$$

Where,

C_2	=	Slope coefficient from the area-depth linear regression	2914	
C_3	=	Intercept from the area-depth linear regression	12866	
h	=	Maximum water elevation above the orifice (m)	0.20	m
d	=	Diameter of orifice tube (mm)	150	mm
A_0	=	Cross-section area of the orifice plate (m^2)	0.0177	m^2
t	=	Drawdown time in seconds	189268	s, or
		or	52.6	hrs

Elevation (m)	Depth to PP (m)	Surface Area (m^2)	Active Volume (m^3)
174.00	0.00	12866	0
174.20	0.20	13449	2701



Orifice Discharge Equation is used to calculate the release rate from the 150 mm orifice tube:

$$Q = CA\sqrt{2gh}$$

Where,

Q = Orifice Plate Flow Rate (m^3/s)	0.022	m^3/s
C = Flow Coefficient for Orifice Tube	0.80	
d = Diameter of Orifice Tube (mm)	150	mm
A = Cross-section Area of Orifice Tube (m^2)	0.0177	m^2
g = Gravity Acceleration (m/s^2)	9.81	m/s^2
h = Water Head above Centerline of Orifice Tube (m)	0.12	m
The invert of the Orifice Tube is set at	174.00	m
Water Level for Extended Detention	174.20	m

8.5.3 Emergency Spillway

A sharp-crest emergency overflow weir is proposed to safely convey the full inflow to the SWM wet pond

Inflow Rate (100-year 24-hour SCS storm) 3.886 m^3/s

The lid elevation of the weir is set at 174.30 m

The flow rate for sharp-crested weir is calculated using the following equation

$$Q = CLH^{1.5}$$

Where,

Q = Broad-Crested Weir Flow Rate (m^3/s)	4.600	m^3/s
C = Flow Coefficient for Broad-Crested Weir	1.84	
L = Weir Length (m)	2.50	m
H = Water Depth (m)	1.00	m

8.6 Stage - Storage - Discharge Relationship

Elevation (m)	Orifice Plate		Emergency Spill Weir		Total Discharge (m^3/s)	Active Storage (m^3)
	Depth (m)	Flow (m^3/s)	Depth (m)	Flow (m^3/s)		
174.00	0.00	0.000			0.000	0
174.10	0.10	0.011			0.011	1,350
174.20	0.20	0.022			0.022	2,701
174.30	0.30	0.030	0.00	0.00	0.030	4,051
174.40	0.40	0.036	0.10	0.15	0.181	5,402
174.50	0.50	0.041	0.20	0.41	0.452	6,752
174.60	0.60	0.045	0.30	0.76	0.801	8,226
174.70	0.70	0.050	0.40	1.16	1.213	9,701
174.80	0.80	0.053	0.50	1.63	1.680	11,175
174.90	0.90	0.057	0.60	2.14	2.195	12,649
175.00	1.00	0.060	0.70	2.69	2.754	14,123
175.50	1.50	0.075	1.20	6.05	6.122	21,920
176.00	2.00	0.087	1.70	10.20	10.283	30,155

8.7 Quantity Control Performance

Storm Event	Q_{in} (m^3/s)	Q_{out} (m^3/s)	V_{ACTIVE} (m^3)	WSE (m)	VO Sc.
25 mm	0.936	0.019	2,330	174.17	Run 01
5-yr 3-hr Chicago	1.693	0.030	4,013	174.30	Run 02
100-yr 3-hr Chicago	3.116	0.343	6,211	174.46	Run 03
100-yr 12-hr AES	0.804	0.659	7,629	174.56	Run 04
100-yr 24-hr SCS	3.886	0.896	8,571	174.62	Run 05
Regional (48-hr Hurricane Hazel)	2.851	2.492	13,447	174.95	Run 06

8.8 Sediment Forebay Configuration

The sediment forebay design guidelines are presented in section 4.6.2 of the <Stormwater Management Practice Planning and Design Manual> (MECP, 2003) on page 4.55 to 4.57.

8.8.1 Settling Calculation

$$D_{ist} = \sqrt{rQ_p / V_s}$$

Equation 4.5 of MOE Manual

Where,	D_{ist} =	Forebay length (m)	13.8	m
	r =	Length -to-Width ratio of forebay	3.0	
	Q_p =	Peak flow rate from the pond during design quality storm (25 mm)		
		Refer to Table in Page 26 or VO Output	0.019	m^3/s
	V_s =	Setting velocity	0.0003	m/s

8.8.2 Dispersion Length

The dispersion length refers to the length of fluid required to slow a jet discharge. It is recommended that the forebay length is such that a fluid jet will disperse to a velocity of ≤ 0.50 m/s at the forebay berm.

$$D_{ist} = 8Q / dV_f$$

Equation 4.6 of MOE Manual

Where,	D_{ist} =	Dispersion Length	27.1	m
	Q =	Inlet flow rate from design storm (5-year) (Refer to VO output)	1.69	m^3/s
	d =	Depth of permanent pool in the forebay	1.00	m
	V_f =	Desired velocity in the forebay	0.50	m/s

8.8.3 Minimum Forebay Bottom Width

$$W_{idth} = D_{ist} / 8$$

Equation 4.7 of MOE Manual

Where,	W_{idth} =	Minimum Forebay Deep Zone Bottom Width	3.4	m
	D_{ist} =	Larger of Settling Length and Dispersion Length	27.1	m

8.8.4 Forebay Configuration

Description	Required	Provided
Depth (m)	1.0	1.0
Settling Length (m)	13.8	69.0
Dispersion Length (m)	27.1	
Minimum Bottom Width of Forebay Deep Zone (m)	3.4	12.5

8.8.5 Average Flow Velocity in the forebay

A check should be made using the entire forebay cross-sectional area to ensure that the average velocity in the forebay is less than, or equal to , 0.15 m/s which is empirically recognized as the maximum permissible velocity before which erosion will occur in a channel.

$$V_{avg} = Q/A$$

Where,	V_{avg} =	Average velocity in the forebay	0.10	m/s
	Q =	Inlet flow rate from design storm (5-year)	1.69	m^3/s
	A =	Entire forebay cross-sectional area	16.25	m^2
	d =	Depth of permanent pool in the forebay	1.00	m
	W_b =	Forebay Deep Zone Bottom Width	12.50	m
	W_t =	Forebay Deep Zone Top Width at Permanent Pool Elevation	20.00	m

9 Preliminary Design of Grassed Swale

9.1 Design Criteria

1. Provide an Enhanced Level (80% TSS Removal) of Stormwater Quality Control per MECP guidelines.
2. Provide sufficient conveyance for the 100-year peak flow rates from the contributing areas.

9.2 Design Guidance

The Section 4.5.9 of the MECP Stormwater Management Planning and Design Manual (2003) provides guidance on the design of Grassed Swales.

1. As a general guideline, grassed swales designed for water quality enhancement should be designed to convey the peak flow from a 4 hour 25 mm Chicago storm with a velocity ≤ 0.5 m/s.
   This guideline results in a requirement for wide, flat swales for larger drainage areas.
2. The grass swales must be evaluated under major system and minor system events to ensure that the swale can convey these storms effectively.

An article produced by Gary R. Minton, (Stormwater, March/April 2005) suggests a procedure to determine swale dimensions likely to produce 80% TSS removal. The procedure (copy of article attached to appendix A) suggests that a swale with no appreciable infiltration must detain stormwater below the maximum flow depth of about 100mm for a minimum of 8 minutes to achieve 80% TSS removal.

9.3 Grassed Swale #1

9.3.1 Drainage to Grassed Swale

Catchment	Area(ha)	TIMP(%)
2003	3.22	50.6

9.3.2 Design Peak flow Rates

Storm Events	Peak Flow (m^3/s)
25 mm	0.212
100-year	0.821

9.3.3 Geometry of Grassed Swale

U/S Invert (m)	D/S Invert (m)	Length (m)	Slope (%)	Bottom Width (m)	Z	Depth (m)
175.00	174.75	90	0.30	6.0	3:1	0.60

9.3.4 Flow Depth and Velocity

Manning's Equation is used to determine the flow depth and flow velocity within the grassed swale.

$$v = \frac{1}{n} \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

Where,

v = flow velocity (m/s)
n = Manning's Coefficient
R = Hydraulic Radius (=A/R) (m)
S = Bed Slope of Grassed Swale

Storm Event	D (m)	A (m^2)	P (m)	R (m)	n	v (m/s)	Q (m3/s)
25 mm	0.166	1.08	7.05	0.15	0.080	0.20	0.212
100-yr	0.263	1.78	7.66	0.23	0.045	0.46	0.821

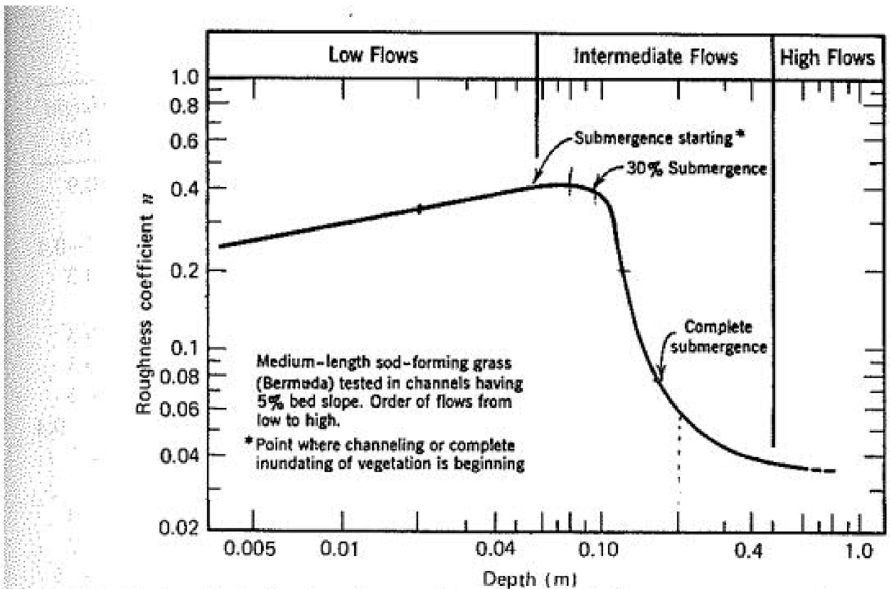


Fig. 7.3 Hydraulic behavior of a medium-length sod-forming grass. (Adapted from Ree, 1949.)

9.3.5 Residual Time

A residual time is calculated for the 25 mm rainfall event using the following equation.

$$D_t = \frac{L}{60v}$$

Where,	Dt =	Residual time (minutes)	7.7	minutes
	L =	Length of Swale (m)	90.0	m
	v =	Flow velocity (m/s)	0.20	m/s

9.3.6 Conclusion

Thus, a trapezoidal grassed swale with a bottom width (Bw) of 6.0 m, side slops (Z:1) of 3, total depth of 0.60 m, and bed slope (S) of 0.30%

1. can convey the peak flow from a 25 mm rainfall event with a velocity ≤ 0.5 m/s.
2. can convey the flow from a 25 mm rainfall event with a period greater than 8 minutes.
3. can convey the 100-year peak flow rates at a flow depth of 0.26 m, with a freeboard of 0.34 m.

It is concluded that the proposed grassed swale could provide an enhanced level of treatment or 80% TSS removal for the runoff from a 3.22 ha drainage area at an imperviousness level of 50.6%.

APPENDIX

B

VISUAL OTTHYMO MODEL OUTPUT

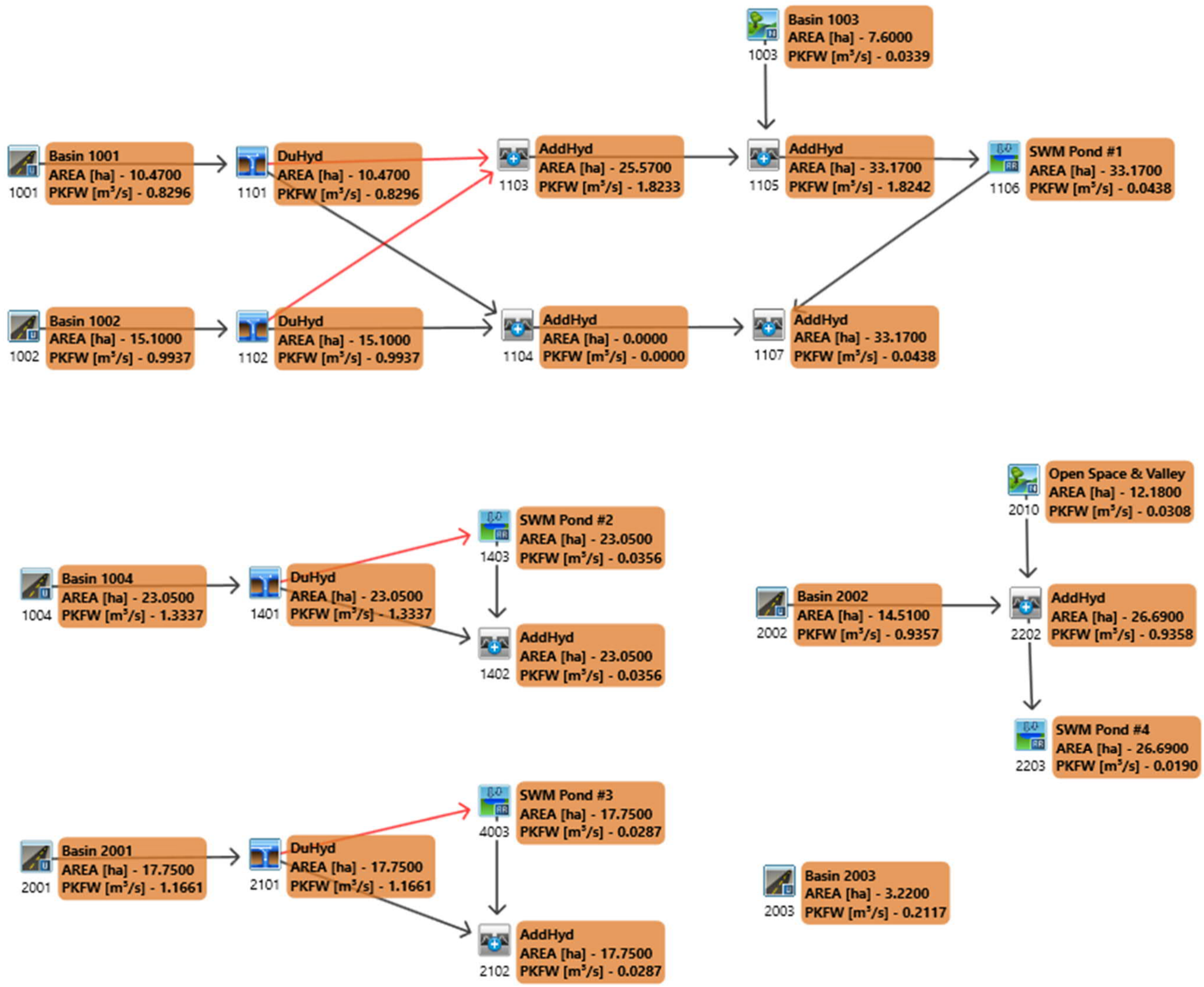


Figure B1 – Visual OTTHYMO Model Schematic

Proposed SWM Wet Ponds & Grassed Swale

```
===================================================================================
========================

       V    V   I    SSSSS  U   U    A    L              (v 6.2.2001)
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

Developed and Distributed by Smart City Water Inc

***** D E T A I L E D   O U T P U T *****

Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

Output filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\849588
54-3c23-49cd-a589-d30b8c4deb44\scenar

Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\849588
54-3c23-49cd-a589-d30b8c4deb44\scenar

DATE: 01-12-2023   TIME: 11:32:41

USER:

COMMENTS: ____

```
-----------------------------------------------------------------------------------
------------------------
  ************************************************
  ** SIMULATION : Run 01                        **
  ************************************************
```



```
--------------------
|    READ STORM    |    Filename: C:\Users\zhouj\AppD
|                  |              ata\Local\Temp\
|                  |              d2870494-74fa-435e-8860-3b342214a80d\6d097a9e
| Ptotal= 25.00 mm |    Comments: 25 mm _ Water Quality & Erosion
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.17	2.07	1.17	5.70	2.17	5.19	3.17	2.80
0.33	2.27	1.33	10.78	2.33	4.47	3.33	2.62
0.50	2.52	1.50	50.21	2.50	3.95	3.50	2.48
0.67	2.88	1.67	13.37	2.67	3.56	3.67	2.35
0.83	3.38	1.83	8.29	2.83	3.25	3.83	2.23
1.00	4.18	2.00	6.30	3.00	3.01	4.00	2.14

```
--------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD (  1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      13.92         9.13
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     392.00        40.00
     Mannings n           =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.07	1.083	5.70	2.083	5.19	3.08	2.80
0.167	2.07	1.167	5.70	2.167	5.19	3.17	2.80
0.250	2.27	1.250	10.78	2.250	4.47	3.25	2.62
0.333	2.27	1.333	10.78	2.333	4.47	3.33	2.62
0.417	2.52	1.417	50.21	2.417	3.95	3.42	2.48
0.500	2.52	1.500	50.21	2.500	3.95	3.50	2.48
0.583	2.88	1.583	13.37	2.583	3.56	3.58	2.35
0.667	2.88	1.667	13.37	2.667	3.56	3.67	2.35
0.750	3.38	1.750	8.29	2.750	3.25	3.75	2.23
0.833	3.38	1.833	8.29	2.833	3.25	3.83	2.23
0.917	4.18	1.917	6.30	2.917	3.01	3.92	2.14
1.000	4.18	2.000	6.30	3.000	3.01	4.00	2.14


```
     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)       10.00        35.00
     Storage Coeff.  (min)=       7.64 (ii)   32.03 (ii)
     Unit Hyd. Tpeak (min)=      10.00        35.00
     Unit Hyd. peak  (cms)=       0.13         0.03
                                                           *TOTALS*
     PEAK FLOW       (cms)=       1.32         0.06          1.334 (iii)
     TIME TO PEAK    (hrs)=       1.58         2.17           1.58
     RUNOFF VOLUME    (mm)=      24.00         4.79          16.39
     TOTAL RAINFALL   (mm)=      25.00        25.00          25.00
     RUNOFF COEFFICIENT   =       0.96         0.19           0.66

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      1.33      1.58   16.39
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  23.05      1.33      1.58   16.39

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |
--------------------
```

OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
0.0000	0.0000	1.5710	0.6240
0.0070	0.1010	2.8490	0.7400
0.0240	0.2030	4.3610	0.8560
0.0330	0.3040	6.0740	0.9730
0.0400	0.4060	7.9690	1.0890
0.5830	0.5070	0.0000	0.0000


```
                            AREA     QPEAK     TPEAK       R.V.
                            (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1401)     23.050      1.334      1.58      16.39
   OUTFLOW: ID= 1 (  1403)     23.050      0.036      4.33      16.21

                 PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.67
                 TIME SHIFT OF PEAK FLOW         (min)=165.00
                 MAXIMUM  STORAGE   USED       (ha.m.)=  0.3414

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1402)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1401 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1402 = HYDROGRAPH 1403
        ID1= 1 (  1401):     0.00   0.000     0.00     0.00
      + ID2= 2 (  1403):    23.05   0.036     4.33    16.21
        =====================================================
        ID = 3 (  1402):    23.05   0.036     4.33    16.21

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.07	1.083	5.70	2.083	5.19	3.08	2.80
0.167	2.07	1.167	5.70	2.167	5.19	3.17	2.80
0.250	2.27	1.250	10.78	2.250	4.47	3.25	2.62
0.333	2.27	1.333	10.78	2.333	4.47	3.33	2.62
0.417	2.52	1.417	50.21	2.417	3.95	3.42	2.48
0.500	2.52	1.500	50.21	2.500	3.95	3.50	2.48
0.583	2.88	1.583	13.37	2.583	3.56	3.58	2.35
0.667	2.88	1.667	13.37	2.667	3.56	3.67	2.35
0.750	3.38	1.750	8.29	2.750	3.25	3.75	2.23
0.833	3.38	1.833	8.29	2.833	3.25	3.83	2.23
0.917	4.18	1.917	6.30	2.917	3.01	3.92	2.14

```
             1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Unit Hyd Qpeak  (cms)=   0.419

     PEAK FLOW       (cms)=   0.031 (i)
     TIME TO PEAK    (hrs)=   3.833
     RUNOFF VOLUME    (mm)=   2.866
     TOTAL RAINFALL   (mm)=  25.000
     RUNOFF COEFFICIENT   =   0.115

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.14         6.37
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     311.02        40.00
     Mannings n           =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
              TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
               hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
             0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
             0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
             0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
             0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
             0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
             0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
             0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
             0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
             0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
             0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
             0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
             1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)        5.00        35.00
     Storage Coeff.  (min)=       6.65 (ii)   31.04 (ii)
```



```
     Unit Hyd. Tpeak (min)=       5.00        35.00
     Unit Hyd. peak  (cms)=       0.18         0.03
                                                        *TOTALS*
     PEAK FLOW       (cms)=       0.93         0.04          0.936 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.17           1.50
     RUNOFF VOLUME    (mm)=      24.00         4.79          15.57
     TOTAL RAINFALL   (mm)=      25.00        25.00          25.00
     RUNOFF COEFFICIENT   =       0.96         0.19           0.62

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  2002):    14.51   0.936     1.50    15.57
     + ID2= 2 (  2010):    12.18   0.031     3.83     2.87
       ====================================================
       ID = 3 (  2202):    26.69   0.936     1.50     9.77

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.2130      0.9700
                          0.0110     0.1350   |   1.6800      1.1170
                          0.0220     0.2700   |   2.1950      1.2650
                          0.0300     0.4050   |   2.7540      1.4120
                          0.1810     0.5400   |   6.1220      2.1920
                          0.4520     0.6750   |  10.2830      3.0160
                          0.8010     0.8230   |   0.0000      0.0000

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690      0.936      1.50       9.77
   OUTFLOW: ID= 1 (  2203)     26.690      0.019      5.33       9.65
```



```
               PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.03
               TIME SHIFT OF PEAK FLOW         (min)=230.00
               MAXIMUM  STORAGE   USED       (ha.m.)=  0.2330

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  2001)|   Area    (ha)=  17.75
|ID= 1 DT= 5.0 min |   Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n           =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
              TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
               hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
             0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
             0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
             0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
             0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
             0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
             0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
             0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
             0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
             0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
             0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
             0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
             1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)        5.00        35.00
     Storage Coeff.  (min)=       7.06 (ii)   31.45 (ii)
     Unit Hyd. Tpeak (min)=       5.00        35.00
     Unit Hyd. peak  (cms)=       0.17         0.03
                                                        *TOTALS*
     PEAK FLOW       (cms)=       1.16         0.05          1.166 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.17           1.50
     RUNOFF VOLUME    (mm)=      24.00         4.79          16.01
     TOTAL RAINFALL   (mm)=      25.00        25.00          25.00
     RUNOFF COEFFICIENT   =       0.96         0.19           0.64
```



```
       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      1.17      1.50   16.01
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  17.75      1.17      1.50   16.01

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     17.750      1.166      1.50      16.01
   OUTFLOW: ID= 1 (  4003)     17.750      0.029      4.25      15.80

               PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.46
               TIME SHIFT OF PEAK FLOW         (min)=165.00
               MAXIMUM  STORAGE   USED       (ha.m.)=  0.2555

--------------------------------------------------------------------------------

--------------------
```

```
| ADD HYD  (  2102)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   2101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   2102 = HYDROGRAPH 4003
        ID1= 1 (  2101):     0.00   0.000     0.00     0.00
      + ID2= 2 (  4003):    17.75   0.029     4.25    15.80
        ===================================================
        ID = 3 (  2102):    17.75   0.029     4.25    15.80

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
                0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
                0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
                0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
                0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
                0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
                0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
                0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
                0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
                0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
                0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
                1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)        5.00        30.00
     Storage Coeff.  (min)=       4.23 (ii)   28.62 (ii)
     Unit Hyd. Tpeak (min)=       5.00        30.00
```



```
     Unit Hyd. peak  (cms)=       0.24         0.04
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.21         0.01         0.212 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.08          1.50
     RUNOFF VOLUME    (mm)=      24.00         4.79         14.50
     TOTAL RAINFALL   (mm)=      25.00        25.00         25.00
     RUNOFF COEFFICIENT   =       0.96         0.19          0.58

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  1003)|   Area    (ha)=   7.60   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.01

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
                0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
                0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
                0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
                0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
                0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
                0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
                0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
                0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
                0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
                0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
                1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Unit Hyd Qpeak  (cms)=   0.287

     PEAK FLOW       (cms)=   0.034 (i)
     TIME TO PEAK    (hrs)=   3.083
     RUNOFF VOLUME    (mm)=   4.790
```



```
     TOTAL RAINFALL   (mm)=  25.000
     RUNOFF COEFFICIENT   =   0.192

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1001)|   Area    (ha)=  10.47
|ID= 1 DT= 5.0 min |   Total Imp(%)=  66.90   Dir. Conn.(%)=  66.90
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       7.00         3.47
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     264.20        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
                0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
                0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
                0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
                0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
                0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
                0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
                0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
                0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
                0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
                0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
                1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)        5.00        35.00
     Storage Coeff.  (min)=       6.03 (ii)   30.42 (ii)
     Unit Hyd. Tpeak (min)=       5.00        35.00
     Unit Hyd. peak  (cms)=       0.19         0.04
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.83         0.02         0.830 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.17          1.50
     RUNOFF VOLUME    (mm)=      24.00         4.79         17.64
     TOTAL RAINFALL   (mm)=      25.00        25.00         25.00
```



```
     RUNOFF COEFFICIENT   =       0.96         0.19          0.71


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1101)|
| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      0.83      1.50   17.64
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  10.47      0.83      1.50   17.64

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.68         6.42
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     317.28        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    2.07 | 1.083    5.70 | 2.083    5.19 |  3.08    2.80
                0.167    2.07 | 1.167    5.70 | 2.167    5.19 |  3.17    2.80
                0.250    2.27 | 1.250   10.78 | 2.250    4.47 |  3.25    2.62
                0.333    2.27 | 1.333   10.78 | 2.333    4.47 |  3.33    2.62
                0.417    2.52 | 1.417   50.21 | 2.417    3.95 |  3.42    2.48
```

```
                0.500    2.52 | 1.500   50.21 | 2.500    3.95 |  3.50    2.48
                0.583    2.88 | 1.583   13.37 | 2.583    3.56 |  3.58    2.35
                0.667    2.88 | 1.667   13.37 | 2.667    3.56 |  3.67    2.35
                0.750    3.38 | 1.750    8.29 | 2.750    3.25 |  3.75    2.23
                0.833    3.38 | 1.833    8.29 | 2.833    3.25 |  3.83    2.23
                0.917    4.18 | 1.917    6.30 | 2.917    3.01 |  3.92    2.14
                1.000    4.18 | 2.000    6.30 | 3.000    3.01 |  4.00    2.14

     Max.Eff.Inten.(mm/hr)=      50.21         4.50
                over (min)        5.00        35.00
     Storage Coeff.  (min)=       6.73 (ii)   31.12 (ii)
     Unit Hyd. Tpeak (min)=       5.00        35.00
     Unit Hyd. peak  (cms)=       0.18         0.03
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.99         0.04          0.994 (iii)
     TIME TO PEAK    (hrs)=       1.50         2.17           1.50
     RUNOFF VOLUME    (mm)=      24.00         4.79          15.83
     TOTAL RAINFALL   (mm)=      25.00        25.00          25.00
     RUNOFF COEFFICIENT   =       0.96         0.19           0.63


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      0.99      1.50   15.83
     ====================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  15.10      0.99      1.50   15.83

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
```



```
        ID1= 1 (  1101):    10.47   0.830     1.50    17.64
      + ID2= 2 (  1102):    15.10   0.994     1.50    15.83
        ====================================================
        ID = 3 (  1103):    25.57   1.823     1.50    16.57

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1003):     7.60   0.034     3.08     4.79
      + ID2= 2 (  1103):    25.57   1.823     1.50    16.57
        ====================================================
        ID = 3 (  1105):    33.17   1.824     1.50    13.87

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730      0.9730
                          0.0140     0.1150   |   0.1410      1.1060
                          0.0280     0.2300   |   0.7220      1.2390
                          0.0390     0.3450   |   1.1780      1.5960
                          0.0480     0.4600   |   1.3260      1.9530
                          0.0520     0.5170   |   1.4580      2.3350
                          0.0550     0.5750   |   1.5800      2.7180
                          0.0620     0.7080   |   1.6920      3.1260
                          0.0680     0.8410   |   1.7980      3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     33.170      1.824      1.50      13.87
   OUTFLOW: ID= 1 (  1106)     33.170      0.044      4.50      13.81

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.40
                   TIME SHIFT OF PEAK FLOW         (min)=180.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.4061

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
```



```
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1102 <ID= 2> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1104 <ID= 3> IS ALSO DRY
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1104 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1107 = HYDROGRAPH 1106
        ID1= 1 (  1104):     0.00   0.000     0.00     0.00
      + ID2= 2 (  1106):    33.17   0.044     4.50    13.81
        ====================================================
        ID = 3 (  1107):    33.17   0.044     4.50    13.81

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

```
===================================================================================
========================

       V    V   I    SSSSS  U   U    A    L             (v 6.2.2001)
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
Developed and Distributed by Smart City Water Inc
```



```
                   *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

  Output  filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\9e733e
c0-b6cd-4034-91cd-a0e085037bd6\scenar
  Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\9e733e
c0-b6cd-4034-91cd-a0e085037bd6\scenar


DATE: 01-12-2023                           TIME: 11:32:42

USER:


COMMENTS: ____________________________________________________________


-----------------------------------------------------------------------------------
------------------------
  ************************************************
  ** SIMULATION : Run 02                        **
  ************************************************

--------------------
```



```
| CHICAGO STORM    |    IDF curve parameters: A= 397.940
| Ptotal= 36.21 mm |                          B=   0.000
--------------------                          C=   0.673
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  3.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =  0.33

                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.17    4.57 |  1.00   84.49 |  1.83    6.98 |  2.67    4.42
                 0.33    5.35 |  1.17   19.68 |  2.00    6.19 |  2.83    4.15
                 0.50    6.58 |  1.33   12.63 |  2.17    5.59 |  3.00    3.92
                 0.67    8.89 |  1.50    9.73 |  2.33    5.12 |
                 0.83   16.15 |  1.67    8.07 |  2.50    4.74 |


--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      13.92         9.13
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     392.00        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                              ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92
```



```
     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        25.00
     Storage Coeff.  (min)=       6.20 (ii)   22.01 (ii)
     Unit Hyd. Tpeak (min)=       5.00        25.00
     Unit Hyd. peak  (cms)=       0.19         0.05
                                                          *TOTALS*
     PEAK FLOW       (cms)=       2.73         0.18          2.767 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.33           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          25.34
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
     RUNOFF COEFFICIENT   =       0.97         0.28           0.70


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      2.77      1.00   25.34
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  23.05      2.77      1.00   25.34

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
```



```
                              (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1401)     23.050      2.767      1.00      25.34
   OUTFLOW: ID= 1 (  1403)     23.050      0.272      2.50      25.14

                PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.81
                TIME SHIFT OF PEAK FLOW         (min)= 90.00
                MAXIMUM  STORAGE   USED       (ha.m.)=  0.4491

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1402)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1401 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1402 = HYDROGRAPH 1403
        ID1= 1 (  1401):     0.00   0.000     0.00     0.00
      + ID2= 2 (  1403):    23.05   0.272     2.50    25.14
        ==================================================
        ID = 3 (  1402):    23.05   0.272     2.50    25.14

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                              ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Unit Hyd Qpeak  (cms)=   0.419
```

```
     PEAK FLOW       (cms)=   0.092 (i)
     TIME TO PEAK    (hrs)=   2.917
     RUNOFF VOLUME    (mm)=   7.658
     TOTAL RAINFALL   (mm)=  36.211
     RUNOFF COEFFICIENT   =   0.211

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.14         6.37
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     311.02        40.00
     Mannings n           =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        25.00
     Storage Coeff.  (min)=       5.40 (ii)   21.21 (ii)
     Unit Hyd. Tpeak (min)=       5.00        25.00
     Unit Hyd. peak  (cms)=       0.21         0.05
                                                              *TOTALS*
     PEAK FLOW       (cms)=       1.66         0.13          1.691 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.33           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          24.27
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
```



```
     RUNOFF COEFFICIENT   =       0.97         0.28           0.67


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  2002):    14.51   1.691     1.00    24.27
      + ID2= 2 (  2010):    12.18   0.092     2.92     7.66
        ==================================================
        ID = 3 (  2202):    26.69   1.693     1.00    16.69

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
------------------------------------------------------------------------------
--------------------
| RESERVOIR(  2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.2130     0.9700
                          0.0110     0.1350   |   1.6800     1.1170
                          0.0220     0.2700   |   2.1950     1.2650
                          0.0300     0.4050   |   2.7540     1.4120
                          0.1810     0.5400   |   6.1220     2.1920
                          0.4520     0.6750   |  10.2830     3.0160
                          0.8010     0.8230   |   0.0000     0.0000

                                AREA     QPEAK      TPEAK       R.V.
                                (ha)     (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690     1.693      1.00      16.69
   OUTFLOW: ID= 1 (  2203)     26.690     0.030      4.83      16.55

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.76
                   TIME SHIFT OF PEAK FLOW        (min)=230.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.4013

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| CALIB            |
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```
| STANDHYD (  2001)|   Area    (ha)=  17.75
|ID= 1 DT= 5.0 min |   Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n           =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        25.00
     Storage Coeff.  (min)=       5.74 (ii)   21.55 (ii)
     Unit Hyd. Tpeak (min)=       5.00        25.00
     Unit Hyd. peak  (cms)=       0.20         0.05
                                                              *TOTALS*
     PEAK FLOW       (cms)=       2.08         0.15          2.114 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.33           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          24.84
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
     RUNOFF COEFFICIENT   =       0.97         0.28           0.69


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      2.11      1.00   24.84
     ====================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  17.75      2.11      1.00   24.84

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710     0.6240
                          0.0070     0.1010   |   2.8490     0.7400
                          0.0240     0.2030   |   4.3610     0.8560
                          0.0330     0.3040   |   6.0740     0.9730
                          0.0400     0.4060   |   7.9690     1.0890
                          0.5830     0.5070   |   0.0000     0.0000

                                AREA     QPEAK      TPEAK       R.V.
                                (ha)     (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     17.750     2.114      1.00      24.84
   OUTFLOW: ID= 1 (  4003)     17.750     0.043      3.33      24.59

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  2.02
                   TIME SHIFT OF PEAK FLOW        (min)=140.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.4066

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--------------------
| ADD HYD  (  2102)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   2101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   2102 = HYDROGRAPH 4003
        ID1= 1 (  2101):     0.00   0.000     0.00     0.00
      + ID2= 2 (  4003):    17.75   0.043     3.33    24.59
        ==================================================
        ID = 3 (  2102):    17.75   0.043     3.33    24.59
```

```
     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        20.00
     Storage Coeff.  (min)=       3.44 (ii)   19.25 (ii)
     Unit Hyd. Tpeak (min)=       5.00        20.00
     Unit Hyd. peak  (cms)=       0.26         0.06
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.37         0.03          0.375 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.25           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          22.89
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
     RUNOFF COEFFICIENT   =       0.97         0.28           0.63

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
```



```
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  1003)|   Area    (ha)=   7.60   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.01

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Unit Hyd Qpeak  (cms)=   0.287

     PEAK FLOW       (cms)=   0.081 (i)
     TIME TO PEAK    (hrs)=   2.500
     RUNOFF VOLUME    (mm)=  10.285
     TOTAL RAINFALL   (mm)=  36.211
     RUNOFF COEFFICIENT   =   0.284

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1001)|   Area    (ha)=  10.47
|ID= 1 DT= 5.0 min |   Total Imp(%)=  66.90   Dir. Conn.(%)=  66.90
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       7.00         3.47
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     264.20        40.00
```



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     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        25.00
     Storage Coeff.  (min)=       4.90 (ii)   20.71 (ii)
     Unit Hyd. Tpeak (min)=       5.00        25.00
     Unit Hyd. peak  (cms)=       0.22         0.05
                                                            *TOTALS*
     PEAK FLOW       (cms)=       1.47         0.07          1.484 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.33           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          26.96
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
     RUNOFF COEFFICIENT   =       0.97         0.28           0.74

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1101)|
| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      1.48      1.00   26.96
     =====================================================
```



```
     MAJOR SYS.(ID= 2):   0.00      0.00      1.00   26.96
     MINOR SYS.(ID= 3):  10.47      1.48      1.00   26.96

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.68         6.42
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     317.28        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    4.57 | 0.833   16.15 | 1.583    8.07 |  2.33    5.12
                0.167    4.57 | 0.917   84.49 | 1.667    8.07 |  2.42    4.74
                0.250    5.35 | 1.000   84.49 | 1.750    6.98 |  2.50    4.74
                0.333    5.35 | 1.083   19.68 | 1.833    6.98 |  2.58    4.42
                0.417    6.58 | 1.167   19.68 | 1.917    6.19 |  2.67    4.42
                0.500    6.58 | 1.250   12.63 | 2.000    6.19 |  2.75    4.15
                0.583    8.89 | 1.333   12.63 | 2.083    5.59 |  2.83    4.15
                0.667    8.89 | 1.417    9.73 | 2.167    5.59 |  2.92    3.92
                0.750   16.15 | 1.500    9.73 | 2.250    5.12 |  3.00    3.92

     Max.Eff.Inten.(mm/hr)=      84.49        13.31
                over (min)        5.00        25.00
     Storage Coeff.  (min)=       5.46 (ii)   21.28 (ii)
     Unit Hyd. Tpeak (min)=       5.00        25.00
     Unit Hyd. peak  (cms)=       0.20         0.05
                                                            *TOTALS*
     PEAK FLOW       (cms)=       1.77         0.13          1.796 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.33           1.00
     RUNOFF VOLUME    (mm)=      35.21        10.29          24.62
     TOTAL RAINFALL   (mm)=      36.21        36.21          36.21
     RUNOFF COEFFICIENT   =       0.97         0.28           0.68
```

```
       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      1.80      1.00   24.62
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      1.00   24.62
     MINOR SYS.(ID= 3):  15.10      1.80      1.00   24.62

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):    10.47   1.484     1.00    26.96
      + ID2= 2 (  1102):    15.10   1.796     1.00    24.62
        ====================================================
        ID = 3 (  1103):    25.57   3.280     1.00    25.58

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1003):     7.60   0.081     2.50    10.28
      + ID2= 2 (  1103):    25.57   3.280     1.00    25.58
        ====================================================
        ID = 3 (  1105):    33.17   3.283     1.00    22.07

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
```



```
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730     0.9730
                          0.0140     0.1150   |   0.1410     1.1060
                          0.0280     0.2300   |   0.7220     1.2390
                          0.0390     0.3450   |   1.1780     1.5960
                          0.0480     0.4600   |   1.3260     1.9530
                          0.0520     0.5170   |   1.4580     2.3350
                          0.0550     0.5750   |   1.5800     2.7180
                          0.0620     0.7080   |   1.6920     3.1260
                          0.0680     0.8410   |   1.7980     3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     33.170      3.283      1.00      22.07
   OUTFLOW: ID= 1 (  1106)     33.170      0.059      3.83      22.01

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=  1.81
                  TIME SHIFT OF PEAK FLOW         (min)=170.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.6597

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     0.00   0.000     1.00    26.96
      + ID2= 2 (  1102):     0.00   0.000     1.00    24.62
        ====================================================
        ID = 3 (  1104):     0.00   0.000     1.00    26.61

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1104):     0.00   0.000     1.00    26.61
      + ID2= 2 (  1106):    33.17   0.059     3.83    22.01
        ====================================================
        ID = 3 (  1107):    33.17   0.059     3.83    22.01

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

```
===================================================================================
========================

       V    V   I    SSSSS  U   U    A    L              (v 6.2.2001)
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
Developed and Distributed by Smart City Water Inc
```



```
                  *****  D E T A I L E D   O U T P U T *****

  Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

  Output  filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\1009e7
b8-7636-4594-97e4-3fd2fc62ec2a\scenar
  Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\1009e7
b8-7636-4594-97e4-3fd2fc62ec2a\scenar


DATE: 01-12-2023                           TIME: 11:32:40

USER:


COMMENTS: ____________________________________________________________


-----------------------------------------------------------------------------------
------------------------
  **************************************************
  ** SIMULATION : Run 03                          **
  **************************************************

--------------------
```



```
| CHICAGO STORM    |    IDF curve parameters: A= 669.600
| Ptotal= 58.45 mm |                          B=   0.000
--------------------                          C=   0.681
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  3.00 hrs
                        Storm time step    = 10.00 min
                        Time to peak ratio =  0.33

                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.17    7.22 |  1.00  139.58 |  1.83   11.06 |  2.67    6.97
                 0.33    8.46 |  1.17   31.59 |  2.00    9.80 |  2.83    6.54
                 0.50   10.42 |  1.33   20.17 |  2.17    8.85 |  3.00    6.17
                 0.67   14.14 |  1.50   15.49 |  2.33    8.09 |
                 0.83   25.87 |  1.67   12.82 |  2.50    7.48 |


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
    Surface Area     (ha)=      13.92         9.13
    Dep. Storage     (mm)=       1.00         5.00
    Average Slope     (%)=       1.00         2.00
    Length            (m)=     392.00        40.00
    Mannings n          =      0.013        0.250

        NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                           ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
                0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
                0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
                0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
                0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
                0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
                0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
                0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
                0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17
```



```
     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       5.07 (ii)   14.22 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.21         0.08
                                                           *TOTALS*
     PEAK FLOW       (cms)=       4.78         0.65          5.086 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.17           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          44.37
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.76


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      5.09      1.00   44.37
     ==================================================
     MAJOR SYS.(ID= 2):   2.51      2.32      1.00   44.37
     MINOR SYS.(ID= 3):  20.54      2.77      0.92   44.37

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW     STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)      (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
```



```
                               (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1401)     20.544      2.767      0.92      44.37
   OUTFLOW: ID= 1 (  1403)     20.544      0.817      1.67      44.15

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 29.54
                  TIME SHIFT OF PEAK FLOW         (min)= 45.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.5349

-------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1402)|
|  1 +  2 =  3     |        AREA    QPEAK    TPEAK     R.V.
--------------------        (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1401):     2.51   2.319     1.00    44.37
      + ID2= 2 (  1403):    20.54   0.817     1.67    44.15
        ==================================================
        ID = 3 (  1402):    23.05   2.347     1.00    44.18

    NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11

        NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                           ---- TRANSFORMED HYETOGRAPH ----
                 TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                  hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
                0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
                0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
                0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
                0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
                0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
                0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
                0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
                0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

    Unit Hyd Qpeak  (cms)=   0.419

    PEAK FLOW       (cms)=   0.254 (i)
    TIME TO PEAK    (hrs)=   2.583
```

```
     RUNOFF VOLUME    (mm)=  20.969
     TOTAL RAINFALL   (mm)=  58.452
     RUNOFF COEFFICIENT   =   0.359

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.14         6.37
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     311.02        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.

                               ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.42 (ii)   13.56 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.23         0.08
                                                           *TOTALS*
     PEAK FLOW       (cms)=       2.89         0.47          3.109 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.17           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          42.95
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.73
```



```
***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  2002):    14.51   3.109     1.00    42.95
     + ID2= 2 (  2010):    12.18   0.254     2.58    20.97
       ==================================================
       ID = 3 (  2202):    26.69   3.116     1.00    32.92

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.2130      0.9700
                          0.0110     0.1350   |   1.6800      1.1170
                          0.0220     0.2700   |   2.1950      1.2650
                          0.0300     0.4050   |   2.7540      1.4120
                          0.1810     0.5400   |   6.1220      2.1920
                          0.4520     0.6750   |  10.2830      3.0160
                          0.8010     0.8230   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690      3.116      1.00      32.92
   OUTFLOW: ID= 1 (  2203)     26.690      0.343      3.08      32.77

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 11.02
                  TIME SHIFT OF PEAK FLOW         (min)=125.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.6211

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2001)|   Area    (ha)=  17.75
```



```
|ID= 1 DT= 5.0 min |   Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.

                               ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.69 (ii)   13.84 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.22         0.08
                                                           *TOTALS*
     PEAK FLOW       (cms)=       3.63         0.54          3.881 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.17           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          43.71
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.75

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
```



```
| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      3.88      1.00   43.71
     ==================================================
     MAJOR SYS.(ID= 2):   0.94      1.14      1.00   43.71
     MINOR SYS.(ID= 3):  16.81      2.74      0.92   43.71

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     16.814      2.740      0.92      43.71
   OUTFLOW: ID= 1 (  4003)     16.814      0.487      1.92      43.44

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 17.79
                  TIME SHIFT OF PEAK FLOW         (min)= 60.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.4893

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  2102)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  2101):     0.94   1.141     1.00    43.71
     + ID2= 2 (  4003):    16.81   0.487     1.92    43.44
       ==================================================
       ID = 3 (  2102):    17.75   1.166     1.00    43.46

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

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--------------------
| CALIB             |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                         ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.81 (ii)   11.96 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.28         0.09
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.62         0.12          0.677 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.17           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          41.14
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.70

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
```



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--------------------------------------------------------------------------------
--------------------
| CALIB             |
| NASHYD   (  1003)|   Area    (ha)=   7.60   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.01

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                         ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Unit Hyd Qpeak  (cms)=   0.287

     PEAK FLOW       (cms)=   0.199 (i)
     TIME TO PEAK    (hrs)=   2.333
     RUNOFF VOLUME    (mm)=  24.430
     TOTAL RAINFALL   (mm)=  58.452
     RUNOFF COEFFICIENT   =   0.418

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  1001)|   Area    (ha)=  10.47
|ID= 1 DT= 5.0 min |   Total Imp(%)=  66.90   Dir. Conn.(%)=  66.90
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       7.00         3.47
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     264.20        40.00
     Mannings n          =      0.013        0.250
```



```
         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                         ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       4.00 (ii)    8.67 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.24         0.12
                                                          *TOTALS*
     PEAK FLOW       (cms)=       2.53         0.34          2.792 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.08           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          46.52
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.80

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1101)|
| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      2.79      1.00   46.52
     ===========================================================
     MAJOR SYS.(ID= 2):   1.29      1.31      1.00   46.52
     MINOR SYS.(ID= 3):   9.18      1.48      0.92   46.52
```



```
     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.68         6.42
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     317.28        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                         ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    7.22 | 0.833   25.87 | 1.583   12.82 |  2.33    8.09
               0.167    7.22 | 0.917  139.58 | 1.667   12.82 |  2.42    7.48
               0.250    8.46 | 1.000  139.58 | 1.750   11.06 |  2.50    7.48
               0.333    8.46 | 1.083   31.60 | 1.833   11.06 |  2.58    6.97
               0.417   10.42 | 1.167   31.59 | 1.917    9.80 |  2.67    6.97
               0.500   10.42 | 1.250   20.17 | 2.000    9.80 |  2.75    6.54
               0.583   14.14 | 1.333   20.17 | 2.083    8.85 |  2.83    6.54
               0.667   14.14 | 1.417   15.49 | 2.167    8.85 |  2.92    6.17
               0.750   25.87 | 1.500   15.49 | 2.250    8.09 |  3.00    6.17

     Max.Eff.Inten.(mm/hr)=     139.58        52.32
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.47 (ii)   13.61 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.23         0.08
                                                          *TOTALS*
     PEAK FLOW       (cms)=       3.07         0.47          3.294 (iii)
     TIME TO PEAK    (hrs)=       1.00         1.17           1.00
     RUNOFF VOLUME    (mm)=      57.45        24.43          43.42
     TOTAL RAINFALL   (mm)=      58.45        58.45          58.45
     RUNOFF COEFFICIENT   =       0.98         0.42           0.74

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
```

```
          CN*  =  80.0    Ia = Dep. Storage  (Above)
    (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
         THAN THE STORAGE COEFFICIENT.
   (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      3.29      1.00   43.42
     ==================================================
     MAJOR SYS.(ID= 2):   1.62      1.50      1.00   43.42
     MINOR SYS.(ID= 3):  13.48      1.80      0.92   43.42

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     9.18   1.484     0.92    46.52
      + ID2= 2 (  1102):    13.48   1.796     0.92    43.42
        ====================================================
        ID = 3 (  1103):    22.66   3.280     0.92    44.67

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1003):     7.60   0.199     2.33    24.43
      + ID2= 2 (  1103):    22.66   3.280     0.92    44.67
        ====================================================
        ID = 3 (  1105):    30.26   3.303     1.08    39.59

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
```



```
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730     0.9730
                          0.0140     0.1150   |   0.1410     1.1060
                          0.0280     0.2300   |   0.7220     1.2390
                          0.0390     0.3450   |   1.1780     1.5960
                          0.0480     0.4600   |   1.3260     1.9530
                          0.0520     0.5170   |   1.4580     2.3350
                          0.0550     0.5750   |   1.5800     2.7180
                          0.0620     0.7080   |   1.6920     3.1260
                          0.0680     0.8410   |   1.7980     3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     30.258      3.303      1.08      39.59
   OUTFLOW: ID= 1 (  1106)     30.258      0.125      3.75      39.52

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  3.79
                   TIME SHIFT OF PEAK FLOW         (min)=160.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  1.0749

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     1.29   1.308     1.00    46.52
      + ID2= 2 (  1102):     1.62   1.498     1.00    43.42
        ====================================================
        ID = 3 (  1104):     2.91   2.806     1.00    44.79

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1104):     2.91   2.806     1.00    44.79
      + ID2= 2 (  1106):    30.26   0.125     3.75    39.52
        ====================================================
        ID = 3 (  1107):    33.17   2.839     1.00    39.98

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

```
=====================================================================================
========================

       V    V   I    SSSSS  U   U    A    L             (v 6.2.2001)
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
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                    *****  D E T A I L E D   O U T P U T *****


  Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

  Output  filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\9549fa
7c-cbd4-4dd4-81c9-5052cc84a165\scenar
  Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\9549fa
7c-cbd4-4dd4-81c9-5052cc84a165\scenar


DATE: 01-12-2023                           TIME: 11:32:41

USER:



COMMENTS: ____________________________________________________________

-------------------------------------------------------------------------------------
------------------------
  ************************************************
  ** SIMULATION : Run 04                         **
  ************************************************
```



```
--------------------
|   READ STORM    |    Filename: C:\Users\zhouj\AppD
|                 |              ata\Local\Temp\
|                 |              d2870494-74fa-435e-8860-3b342214a80d\2f834a84
| Ptotal= 91.00 mm |   Comments: 100-yr 12-hr AES_NiagaraFalls
--------------------
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                1.00   16.38 |  4.00   13.65 |  7.00    2.73 | 10.00    0.00
                2.00   19.11 |  5.00   12.74 |  8.00    0.91 | 11.00    0.00
                3.00   18.20 |  6.00    7.28 |  9.00    0.00 | 12.00    0.00

--------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD (  1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      13.92         9.13
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     392.00        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083   16.38 | 3.083   13.65 | 6.083    2.73 |  9.08    0.00
               0.167   16.38 | 3.167   13.65 | 6.167    2.73 |  9.17    0.00
               0.250   16.38 | 3.250   13.65 | 6.250    2.73 |  9.25    0.00
               0.333   16.38 | 3.333   13.65 | 6.333    2.73 |  9.33    0.00
               0.417   16.38 | 3.417   13.65 | 6.417    2.73 |  9.42    0.00
               0.500   16.38 | 3.500   13.65 | 6.500    2.73 |  9.50    0.00
               0.583   16.38 | 3.583   13.65 | 6.583    2.73 |  9.58    0.00
               0.667   16.38 | 3.667   13.65 | 6.667    2.73 |  9.67    0.00
               0.750   16.38 | 3.750   13.65 | 6.750    2.73 |  9.75    0.00
               0.833   16.38 | 3.833   13.65 | 6.833    2.73 |  9.83    0.00
               0.917   16.38 | 3.917   13.65 | 6.917    2.73 |  9.92    0.00
               1.000   16.38 | 4.000   13.65 | 7.000    2.73 | 10.00    0.00
               1.083   19.11 | 4.083   12.74 | 7.083    0.91 | 10.08    0.00
               1.167   19.11 | 4.167   12.74 | 7.167    0.91 | 10.17    0.00
               1.250   19.11 | 4.250   12.74 | 7.250    0.91 | 10.25    0.00
```



```
               1.333   19.11 | 4.333   12.74 | 7.333    0.91 | 10.33    0.00
               1.417   19.11 | 4.417   12.74 | 7.417    0.91 | 10.42    0.00
               1.500   19.11 | 4.500   12.74 | 7.500    0.91 | 10.50    0.00
               1.583   19.11 | 4.583   12.74 | 7.583    0.91 | 10.58    0.00
               1.667   19.11 | 4.667   12.74 | 7.667    0.91 | 10.67    0.00
               1.750   19.11 | 4.750   12.74 | 7.750    0.91 | 10.75    0.00
               1.833   19.11 | 4.833   12.74 | 7.833    0.91 | 10.83    0.00
               1.917   19.11 | 4.917   12.74 | 7.917    0.91 | 10.92    0.00
               2.000   19.11 | 5.000   12.74 | 8.000    0.91 | 11.00    0.00
               2.083   18.20 | 5.083    7.28 | 8.083    0.00 | 11.08    0.00
               2.167   18.20 | 5.167    7.28 | 8.167    0.00 | 11.17    0.00
               2.250   18.20 | 5.250    7.28 | 8.250    0.00 | 11.25    0.00
               2.333   18.20 | 5.333    7.28 | 8.333    0.00 | 11.33    0.00
               2.417   18.20 | 5.417    7.28 | 8.417    0.00 | 11.42    0.00
               2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
               2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
               2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
               2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
               2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
               2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
               3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00

     Max.Eff.Inten.(mm/hr)=      19.11        12.04
                over (min)       10.00        30.00
     Storage Coeff.  (min)=      11.24 (ii)   27.70 (ii)
     Unit Hyd. Tpeak (min)=      10.00        30.00
     Unit Hyd. peak  (cms)=       0.10         0.04
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.74         0.28          0.974 (iii)
     TIME TO PEAK    (hrs)=       2.00         3.25           3.00
     RUNOFF VOLUME    (mm)=      90.00        49.47          73.95
     TOTAL RAINFALL   (mm)=      91.00        91.00          91.00
     RUNOFF COEFFICIENT   =       0.99         0.54           0.81


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|      AREA     QPEAK     TPEAK    R.V.
```



```
--------------------       (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      0.97      3.00   73.95
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  23.05      0.97      3.00   73.95

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710     0.6240
                          0.0070     0.1010   |   2.8490     0.7400
                          0.0240     0.2030   |   4.3610     0.8560
                          0.0330     0.3040   |   6.0740     0.9730
                          0.0400     0.4060   |   7.9690     1.0890
                          0.5830     0.5070   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1401)     23.050     0.974      3.00      73.95
   OUTFLOW: ID= 1 (  1403)     23.050     0.918      3.17      73.73

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 94.28
                   TIME SHIFT OF PEAK FLOW         (min)= 10.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.5469

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--------------------
| ADD HYD  (  1402)|
|  1 +  2 =  3     |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1401 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1402 = HYDROGRAPH 1403
          ID1= 1 (  1401):     0.00   0.000     0.00     0.00
        + ID2= 2 (  1403):    23.05   0.918     3.17    73.73
          ===============================================
          ID = 3 (  1402):    23.05   0.918     3.17    73.73

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
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| CALIB            |
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| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                           ---- TRANSFORMED HYETOGRAPH ----
                  TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.083   16.38 | 3.083   13.65 | 6.083    2.73 |  9.08    0.00
                 0.167   16.38 | 3.167   13.65 | 6.167    2.73 |  9.17    0.00
                 0.250   16.38 | 3.250   13.65 | 6.250    2.73 |  9.25    0.00
                 0.333   16.38 | 3.333   13.65 | 6.333    2.73 |  9.33    0.00
                 0.417   16.38 | 3.417   13.65 | 6.417    2.73 |  9.42    0.00
                 0.500   16.38 | 3.500   13.65 | 6.500    2.73 |  9.50    0.00
                 0.583   16.38 | 3.583   13.65 | 6.583    2.73 |  9.58    0.00
                 0.667   16.38 | 3.667   13.65 | 6.667    2.73 |  9.67    0.00
                 0.750   16.38 | 3.750   13.65 | 6.750    2.73 |  9.75    0.00
                 0.833   16.38 | 3.833   13.65 | 6.833    2.73 |  9.83    0.00
                 0.917   16.38 | 3.917   13.65 | 6.917    2.73 |  9.92    0.00
                 1.000   16.38 | 4.000   13.65 | 7.000    2.73 | 10.00    0.00
                 1.083   19.11 | 4.083   12.74 | 7.083    0.91 | 10.08    0.00
                 1.167   19.11 | 4.167   12.74 | 7.167    0.91 | 10.17    0.00
                 1.250   19.11 | 4.250   12.74 | 7.250    0.91 | 10.25    0.00
                 1.333   19.11 | 4.333   12.74 | 7.333    0.91 | 10.33    0.00
                 1.417   19.11 | 4.417   12.74 | 7.417    0.91 | 10.42    0.00
                 1.500   19.11 | 4.500   12.74 | 7.500    0.91 | 10.50    0.00
                 1.583   19.11 | 4.583   12.74 | 7.583    0.91 | 10.58    0.00
                 1.667   19.11 | 4.667   12.74 | 7.667    0.91 | 10.67    0.00
                 1.750   19.11 | 4.750   12.74 | 7.750    0.91 | 10.75    0.00
                 1.833   19.11 | 4.833   12.74 | 7.833    0.91 | 10.83    0.00
                 1.917   19.11 | 4.917   12.74 | 7.917    0.91 | 10.92    0.00
                 2.000   19.11 | 5.000   12.74 | 8.000    0.91 | 11.00    0.00
                 2.083   18.20 | 5.083    7.28 | 8.083    0.00 | 11.08    0.00
                 2.167   18.20 | 5.167    7.28 | 8.167    0.00 | 11.17    0.00
                 2.250   18.20 | 5.250    7.28 | 8.250    0.00 | 11.25    0.00
                 2.333   18.20 | 5.333    7.28 | 8.333    0.00 | 11.33    0.00
                 2.417   18.20 | 5.417    7.28 | 8.417    0.00 | 11.42    0.00
                 2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
                 2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
                 2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
                 2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
                 2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
                 2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
                 3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00
```



```
     Unit Hyd Qpeak  (cms)=   0.419

     PEAK FLOW       (cms)=   0.317 (i)
     TIME TO PEAK    (hrs)=   5.167
     RUNOFF VOLUME    (mm)=  45.405
     TOTAL RAINFALL   (mm)=  91.000
     RUNOFF COEFFICIENT   =   0.499

     (i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB             |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.14         6.37
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     311.02        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                           ---- TRANSFORMED HYETOGRAPH ----
                  TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.083   16.38 | 3.083   13.65 | 6.083    2.73 |  9.08    0.00
                 0.167   16.38 | 3.167   13.65 | 6.167    2.73 |  9.17    0.00
                 0.250   16.38 | 3.250   13.65 | 6.250    2.73 |  9.25    0.00
                 0.333   16.38 | 3.333   13.65 | 6.333    2.73 |  9.33    0.00
                 0.417   16.38 | 3.417   13.65 | 6.417    2.73 |  9.42    0.00
                 0.500   16.38 | 3.500   13.65 | 6.500    2.73 |  9.50    0.00
                 0.583   16.38 | 3.583   13.65 | 6.583    2.73 |  9.58    0.00
                 0.667   16.38 | 3.667   13.65 | 6.667    2.73 |  9.67    0.00
                 0.750   16.38 | 3.750   13.65 | 6.750    2.73 |  9.75    0.00
                 0.833   16.38 | 3.833   13.65 | 6.833    2.73 |  9.83    0.00
                 0.917   16.38 | 3.917   13.65 | 6.917    2.73 |  9.92    0.00
                 1.000   16.38 | 4.000   13.65 | 7.000    2.73 | 10.00    0.00
                 1.083   19.11 | 4.083   12.74 | 7.083    0.91 | 10.08    0.00
                 1.167   19.11 | 4.167   12.74 | 7.167    0.91 | 10.17    0.00
                 1.250   19.11 | 4.250   12.74 | 7.250    0.91 | 10.25    0.00
                 1.333   19.11 | 4.333   12.74 | 7.333    0.91 | 10.33    0.00
                 1.417   19.11 | 4.417   12.74 | 7.417    0.91 | 10.42    0.00
                 1.500   19.11 | 4.500   12.74 | 7.500    0.91 | 10.50    0.00
```



```
                 1.583   19.11 | 4.583   12.74 | 7.583    0.91 | 10.58    0.00
                 1.667   19.11 | 4.667   12.74 | 7.667    0.91 | 10.67    0.00
                 1.750   19.11 | 4.750   12.74 | 7.750    0.91 | 10.75    0.00
                 1.833   19.11 | 4.833   12.74 | 7.833    0.91 | 10.83    0.00
                 1.917   19.11 | 4.917   12.74 | 7.917    0.91 | 10.92    0.00
                 2.000   19.11 | 5.000   12.74 | 8.000    0.91 | 11.00    0.00
                 2.083   18.20 | 5.083    7.28 | 8.083    0.00 | 11.08    0.00
                 2.167   18.20 | 5.167    7.28 | 8.167    0.00 | 11.17    0.00
                 2.250   18.20 | 5.250    7.28 | 8.250    0.00 | 11.25    0.00
                 2.333   18.20 | 5.333    7.28 | 8.333    0.00 | 11.33    0.00
                 2.417   18.20 | 5.417    7.28 | 8.417    0.00 | 11.42    0.00
                 2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
                 2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
                 2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
                 2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
                 2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
                 2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
                 3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00

     Max.Eff.Inten.(mm/hr)=      19.11         12.04
                over (min)       10.00         30.00
     Storage Coeff.  (min)=       9.78 (ii)    26.25 (ii)
     Unit Hyd. Tpeak (min)=      10.00         30.00
     Unit Hyd. peak  (cms)=       0.11          0.04
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.43          0.19          0.601 (iii)
     TIME TO PEAK    (hrs)=       2.00          3.25           3.00
     RUNOFF VOLUME    (mm)=      90.00         49.47          72.21
     TOTAL RAINFALL   (mm)=      91.00         91.00          91.00
     RUNOFF COEFFICIENT   =       0.99          0.54           0.79


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  2002):    14.51   0.601     3.00    72.21
      + ID2= 2 (  2010):    12.18   0.317     5.17    45.40
        ==================================================
```



```
        ID = 3 (  2202):    26.69   0.804     3.00    59.98

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.2130      0.9700
                          0.0110     0.1350   |   1.6800      1.1170
                          0.0220     0.2700   |   2.1950      1.2650
                          0.0300     0.4050   |   2.7540      1.4120
                          0.1810     0.5400   |   6.1220      2.1920
                          0.4520     0.6750   |  10.2830      3.0160
                          0.8010     0.8230   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690     0.804      3.00      59.98
   OUTFLOW: ID= 1 (  2203)     26.690     0.659      5.33      59.80

                PEAK   FLOW   REDUCTION [Qout/Qin](%)= 81.96
                TIME SHIFT OF PEAK FLOW         (min)=140.00
                MAXIMUM  STORAGE   USED       (ha.m.)=  0.7629

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--------------------
| CALIB             |
| STANDHYD (  2001)|   Area    (ha)=  17.75
|ID= 1 DT= 5.0 min |   Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                           ---- TRANSFORMED HYETOGRAPH ----
                  TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.083   16.38 | 3.083   13.65 | 6.083    2.73 |  9.08    0.00
                 0.167   16.38 | 3.167   13.65 | 6.167    2.73 |  9.17    0.00
```

```
 0.250   16.38 | 3.250   13.65 | 6.250    2.73 |  9.25    0.00
 0.333   16.38 | 3.333   13.65 | 6.333    2.73 |  9.33    0.00
 0.417   16.38 | 3.417   13.65 | 6.417    2.73 |  9.42    0.00
 0.500   16.38 | 3.500   13.65 | 6.500    2.73 |  9.50    0.00
 0.583   16.38 | 3.583   13.65 | 6.583    2.73 |  9.58    0.00
 0.667   16.38 | 3.667   13.65 | 6.667    2.73 |  9.67    0.00
 0.750   16.38 | 3.750   13.65 | 6.750    2.73 |  9.75    0.00
 0.833   16.38 | 3.833   13.65 | 6.833    2.73 |  9.83    0.00
 0.917   16.38 | 3.917   13.65 | 6.917    2.73 |  9.92    0.00
 1.000   16.38 | 4.000   13.65 | 7.000    2.73 | 10.00    0.00
 1.083   19.11 | 4.083   12.74 | 7.083    0.91 | 10.08    0.00
 1.167   19.11 | 4.167   12.74 | 7.167    0.91 | 10.17    0.00
 1.250   19.11 | 4.250   12.74 | 7.250    0.91 | 10.25    0.00
 1.333   19.11 | 4.333   12.74 | 7.333    0.91 | 10.33    0.00
 1.417   19.11 | 4.417   12.74 | 7.417    0.91 | 10.42    0.00
 1.500   19.11 | 4.500   12.74 | 7.500    0.91 | 10.50    0.00
 1.583   19.11 | 4.583   12.74 | 7.583    0.91 | 10.58    0.00
 1.667   19.11 | 4.667   12.74 | 7.667    0.91 | 10.67    0.00
 1.750   19.11 | 4.750   12.74 | 7.750    0.91 | 10.75    0.00
 1.833   19.11 | 4.833   12.74 | 7.833    0.91 | 10.83    0.00
 1.917   19.11 | 4.917   12.74 | 7.917    0.91 | 10.92    0.00
 2.000   19.11 | 5.000   12.74 | 8.000    0.91 | 11.00    0.00
 2.083   18.20 | 5.083    7.28 | 8.083    0.00 | 11.08    0.00
 2.167   18.20 | 5.167    7.28 | 8.167    0.00 | 11.17    0.00
 2.250   18.20 | 5.250    7.28 | 8.250    0.00 | 11.25    0.00
 2.333   18.20 | 5.333    7.28 | 8.333    0.00 | 11.33    0.00
 2.417   18.20 | 5.417    7.28 | 8.417    0.00 | 11.42    0.00
 2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
 2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
 2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
 2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
 2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
 2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
 3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00

Max.Eff.Inten.(mm/hr)=      19.11        12.04
           over (min)       10.00        30.00
Storage Coeff.  (min)=      10.39 (ii)   26.86 (ii)
Unit Hyd. Tpeak (min)=      10.00        30.00
Unit Hyd. peak  (cms)=       0.11         0.04
                                                      *TOTALS*
PEAK FLOW       (cms)=       0.55         0.22         0.743 (iii)
TIME TO PEAK    (hrs)=       2.00         3.25          3.00
RUNOFF VOLUME    (mm)=      90.00        49.47         73.14
TOTAL RAINFALL   (mm)=      91.00        91.00         91.00
RUNOFF COEFFICIENT   =       0.99         0.54          0.80
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```
   (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  80.0    Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      0.74      3.00   73.14
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  17.75      0.74      3.00   73.14

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710     0.6240
                          0.0070     0.1010   |   2.8490     0.7400
                          0.0240     0.2030   |   4.3610     0.8560
                          0.0330     0.3040   |   6.0740     0.9730
                          0.0400     0.4060   |   7.9690     1.0890
                          0.5830     0.5070   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     17.750     0.743     3.00      73.14
   OUTFLOW: ID= 1 (  4003)     17.750     0.629     3.42      72.85

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 84.63
                   TIME SHIFT OF PEAK FLOW         (min)= 25.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.5125

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--------------------
| ADD HYD  (  2102)|
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|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   2101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   2102 = HYDROGRAPH 4003
        ID1= 1 (  2101):     0.00   0.000     0.00     0.00
      + ID2= 2 (  4003):    17.75   0.629     3.42    72.85
        ==================================================
        ID = 3 (  2102):    17.75   0.629     3.42    72.85

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                               ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083   16.38 | 3.083   13.65 | 6.083    2.73 |  9.08    0.00
               0.167   16.38 | 3.167   13.65 | 6.167    2.73 |  9.17    0.00
               0.250   16.38 | 3.250   13.65 | 6.250    2.73 |  9.25    0.00
               0.333   16.38 | 3.333   13.65 | 6.333    2.73 |  9.33    0.00
               0.417   16.38 | 3.417   13.65 | 6.417    2.73 |  9.42    0.00
               0.500   16.38 | 3.500   13.65 | 6.500    2.73 |  9.50    0.00
               0.583   16.38 | 3.583   13.65 | 6.583    2.73 |  9.58    0.00
               0.667   16.38 | 3.667   13.65 | 6.667    2.73 |  9.67    0.00
               0.750   16.38 | 3.750   13.65 | 6.750    2.73 |  9.75    0.00
               0.833   16.38 | 3.833   13.65 | 6.833    2.73 |  9.83    0.00
               0.917   16.38 | 3.917   13.65 | 6.917    2.73 |  9.92    0.00
               1.000   16.38 | 4.000   13.65 | 7.000    2.73 | 10.00    0.00
               1.083   19.11 | 4.083   12.74 | 7.083    0.91 | 10.08    0.00
               1.167   19.11 | 4.167   12.74 | 7.167    0.91 | 10.17    0.00
               1.250   19.11 | 4.250   12.74 | 7.250    0.91 | 10.25    0.00
               1.333   19.11 | 4.333   12.74 | 7.333    0.91 | 10.33    0.00
               1.417   19.11 | 4.417   12.74 | 7.417    0.91 | 10.42    0.00
               1.500   19.11 | 4.500   12.74 | 7.500    0.91 | 10.50    0.00
```



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 1.583   19.11 | 4.583   12.74 | 7.583    0.91 | 10.58    0.00
 1.667   19.11 | 4.667   12.74 | 7.667    0.91 | 10.67    0.00
 1.750   19.11 | 4.750   12.74 | 7.750    0.91 | 10.75    0.00
 1.833   19.11 | 4.833   12.74 | 7.833    0.91 | 10.83    0.00
 1.917   19.11 | 4.917   12.74 | 7.917    0.91 | 10.92    0.00
 2.000   19.11 | 5.000   12.74 | 8.000    0.91 | 11.00    0.00
 2.083   18.20 | 5.083    7.28 | 8.083    0.00 | 11.08    0.00
 2.167   18.20 | 5.167    7.28 | 8.167    0.00 | 11.17    0.00
 2.250   18.20 | 5.250    7.28 | 8.250    0.00 | 11.25    0.00
 2.333   18.20 | 5.333    7.28 | 8.333    0.00 | 11.33    0.00
 2.417   18.20 | 5.417    7.28 | 8.417    0.00 | 11.42    0.00
 2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
 2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
 2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
 2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
 2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
 2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
 3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00

Max.Eff.Inten.(mm/hr)=      19.11        12.04
           over (min)        5.00        25.00
Storage Coeff.  (min)=       6.23 (ii)   22.69 (ii)
Unit Hyd. Tpeak (min)=       5.00        25.00
Unit Hyd. peak  (cms)=       0.19         0.05
                                                      *TOTALS*
PEAK FLOW       (cms)=       0.09         0.05         0.131 (iii)
TIME TO PEAK    (hrs)=       2.00         3.17          3.00
RUNOFF VOLUME    (mm)=      90.00        49.47         69.98
TOTAL RAINFALL   (mm)=      91.00        91.00         91.00
RUNOFF COEFFICIENT   =       0.99         0.54          0.77


   (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN*  =  80.0    Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
        THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB            |
| NASHYD   (  1003)|   Area    (ha)=   7.60   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.01

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	16.38	3.083	13.65	6.083	2.73	9.08	0.00
0.167	16.38	3.167	13.65	6.167	2.73	9.17	0.00
0.250	16.38	3.250	13.65	6.250	2.73	9.25	0.00
0.333	16.38	3.333	13.65	6.333	2.73	9.33	0.00
0.417	16.38	3.417	13.65	6.417	2.73	9.42	0.00
0.500	16.38	3.500	13.65	6.500	2.73	9.50	0.00
0.583	16.38	3.583	13.65	6.583	2.73	9.58	0.00
0.667	16.38	3.667	13.65	6.667	2.73	9.67	0.00
0.750	16.38	3.750	13.65	6.750	2.73	9.75	0.00
0.833	16.38	3.833	13.65	6.833	2.73	9.83	0.00
0.917	16.38	3.917	13.65	6.917	2.73	9.92	0.00
1.000	16.38	4.000	13.65	7.000	2.73	10.00	0.00
1.083	19.11	4.083	12.74	7.083	0.91	10.08	0.00
1.167	19.11	4.167	12.74	7.167	0.91	10.17	0.00
1.250	19.11	4.250	12.74	7.250	0.91	10.25	0.00
1.333	19.11	4.333	12.74	7.333	0.91	10.33	0.00
1.417	19.11	4.417	12.74	7.417	0.91	10.42	0.00
1.500	19.11	4.500	12.74	7.500	0.91	10.50	0.00
1.583	19.11	4.583	12.74	7.583	0.91	10.58	0.00
1.667	19.11	4.667	12.74	7.667	0.91	10.67	0.00
1.750	19.11	4.750	12.74	7.750	0.91	10.75	0.00
1.833	19.11	4.833	12.74	7.833	0.91	10.83	0.00
1.917	19.11	4.917	12.74	7.917	0.91	10.92	0.00
2.000	19.11	5.000	12.74	8.000	0.91	11.00	0.00
2.083	18.20	5.083	7.28	8.083	0.00	11.08	0.00
2.167	18.20	5.167	7.28	8.167	0.00	11.17	0.00
2.250	18.20	5.250	7.28	8.250	0.00	11.25	0.00
2.333	18.20	5.333	7.28	8.333	0.00	11.33	0.00
2.417	18.20	5.417	7.28	8.417	0.00	11.42	0.00
2.500	18.20	5.500	7.28	8.500	0.00	11.50	0.00
2.583	18.20	5.583	7.28	8.583	0.00	11.58	0.00
2.667	18.20	5.667	7.28	8.667	0.00	11.67	0.00
2.750	18.20	5.750	7.28	8.750	0.00	11.75	0.00
2.833	18.20	5.833	7.28	8.833	0.00	11.83	0.00
2.917	18.20	5.917	7.28	8.917	0.00	11.92	0.00
3.000	18.20	6.000	7.28	9.000	0.00	12.00	0.00

```
Unit Hyd Qpeak  (cms)=   0.287

PEAK FLOW       (cms)=   0.209 (i)
TIME TO PEAK    (hrs)=   4.667
RUNOFF VOLUME    (mm)=  49.471
TOTAL RAINFALL   (mm)=  91.000
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RUNOFF COEFFICIENT   =   0.544

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1001)|   Area    (ha)=  10.47
|ID= 1 DT= 5.0 min |   Total Imp(%)=  66.90   Dir. Conn.(%)=  66.90
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       7.00         3.47
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     264.20        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	16.38	3.083	13.65	6.083	2.73	9.08	0.00
0.167	16.38	3.167	13.65	6.167	2.73	9.17	0.00
0.250	16.38	3.250	13.65	6.250	2.73	9.25	0.00
0.333	16.38	3.333	13.65	6.333	2.73	9.33	0.00
0.417	16.38	3.417	13.65	6.417	2.73	9.42	0.00
0.500	16.38	3.500	13.65	6.500	2.73	9.50	0.00
0.583	16.38	3.583	13.65	6.583	2.73	9.58	0.00
0.667	16.38	3.667	13.65	6.667	2.73	9.67	0.00
0.750	16.38	3.750	13.65	6.750	2.73	9.75	0.00
0.833	16.38	3.833	13.65	6.833	2.73	9.83	0.00
0.917	16.38	3.917	13.65	6.917	2.73	9.92	0.00
1.000	16.38	4.000	13.65	7.000	2.73	10.00	0.00
1.083	19.11	4.083	12.74	7.083	0.91	10.08	0.00
1.167	19.11	4.167	12.74	7.167	0.91	10.17	0.00
1.250	19.11	4.250	12.74	7.250	0.91	10.25	0.00
1.333	19.11	4.333	12.74	7.333	0.91	10.33	0.00
1.417	19.11	4.417	12.74	7.417	0.91	10.42	0.00
1.500	19.11	4.500	12.74	7.500	0.91	10.50	0.00
1.583	19.11	4.583	12.74	7.583	0.91	10.58	0.00
1.667	19.11	4.667	12.74	7.667	0.91	10.67	0.00
1.750	19.11	4.750	12.74	7.750	0.91	10.75	0.00
1.833	19.11	4.833	12.74	7.833	0.91	10.83	0.00
1.917	19.11	4.917	12.74	7.917	0.91	10.92	0.00
2.000	19.11	5.000	12.74	8.000	0.91	11.00	0.00

2.083	18.20	5.083	7.28	8.083	0.00	11.08	0.00
2.167	18.20	5.167	7.28	8.167	0.00	11.17	0.00
2.250	18.20	5.250	7.28	8.250	0.00	11.25	0.00
2.333	18.20	5.333	7.28	8.333	0.00	11.33	0.00
2.417	18.20	5.417	7.28	8.417	0.00	11.42	0.00
2.500	18.20	5.500	7.28	8.500	0.00	11.50	0.00
2.583	18.20	5.583	7.28	8.583	0.00	11.58	0.00
2.667	18.20	5.667	7.28	8.667	0.00	11.67	0.00
2.750	18.20	5.750	7.28	8.750	0.00	11.75	0.00
2.833	18.20	5.833	7.28	8.833	0.00	11.83	0.00
2.917	18.20	5.917	7.28	8.917	0.00	11.92	0.00
3.000	18.20	6.000	7.28	9.000	0.00	12.00	0.00

```
Max.Eff.Inten.(mm/hr)=      19.11        12.04
           over (min)       10.00        30.00
Storage Coeff.  (min)=       8.87 (ii)   25.33 (ii)
Unit Hyd. Tpeak (min)=      10.00        30.00
Unit Hyd. peak  (cms)=       0.12         0.04
                                                        *TOTALS*
PEAK FLOW       (cms)=       0.37         0.11          0.458 (iii)
TIME TO PEAK    (hrs)=       2.00         3.25           3.00
RUNOFF VOLUME    (mm)=      90.00        49.47          76.58
TOTAL RAINFALL   (mm)=      91.00        91.00          91.00
RUNOFF COEFFICIENT   =       0.99         0.54           0.84


  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
       CN*  =  80.0    Ia = Dep. Storage  (Above)
 (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| DUHYD    (  1101)|
| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      0.46      3.00   76.58
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  10.47      0.46      3.00   76.58

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| CALIB            |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.68         6.42
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     317.28        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	16.38	3.083	13.65	6.083	2.73	9.08	0.00
0.167	16.38	3.167	13.65	6.167	2.73	9.17	0.00
0.250	16.38	3.250	13.65	6.250	2.73	9.25	0.00
0.333	16.38	3.333	13.65	6.333	2.73	9.33	0.00
0.417	16.38	3.417	13.65	6.417	2.73	9.42	0.00
0.500	16.38	3.500	13.65	6.500	2.73	9.50	0.00
0.583	16.38	3.583	13.65	6.583	2.73	9.58	0.00
0.667	16.38	3.667	13.65	6.667	2.73	9.67	0.00
0.750	16.38	3.750	13.65	6.750	2.73	9.75	0.00
0.833	16.38	3.833	13.65	6.833	2.73	9.83	0.00
0.917	16.38	3.917	13.65	6.917	2.73	9.92	0.00
1.000	16.38	4.000	13.65	7.000	2.73	10.00	0.00
1.083	19.11	4.083	12.74	7.083	0.91	10.08	0.00
1.167	19.11	4.167	12.74	7.167	0.91	10.17	0.00
1.250	19.11	4.250	12.74	7.250	0.91	10.25	0.00
1.333	19.11	4.333	12.74	7.333	0.91	10.33	0.00
1.417	19.11	4.417	12.74	7.417	0.91	10.42	0.00
1.500	19.11	4.500	12.74	7.500	0.91	10.50	0.00
1.583	19.11	4.583	12.74	7.583	0.91	10.58	0.00
1.667	19.11	4.667	12.74	7.667	0.91	10.67	0.00
1.750	19.11	4.750	12.74	7.750	0.91	10.75	0.00
1.833	19.11	4.833	12.74	7.833	0.91	10.83	0.00
1.917	19.11	4.917	12.74	7.917	0.91	10.92	0.00
2.000	19.11	5.000	12.74	8.000	0.91	11.00	0.00
2.083	18.20	5.083	7.28	8.083	0.00	11.08	0.00
2.167	18.20	5.167	7.28	8.167	0.00	11.17	0.00
2.250	18.20	5.250	7.28	8.250	0.00	11.25	0.00
2.333	18.20	5.333	7.28	8.333	0.00	11.33	0.00
2.417	18.20	5.417	7.28	8.417	0.00	11.42	0.00

```
                2.500   18.20 | 5.500    7.28 | 8.500    0.00 | 11.50    0.00
                2.583   18.20 | 5.583    7.28 | 8.583    0.00 | 11.58    0.00
                2.667   18.20 | 5.667    7.28 | 8.667    0.00 | 11.67    0.00
                2.750   18.20 | 5.750    7.28 | 8.750    0.00 | 11.75    0.00
                2.833   18.20 | 5.833    7.28 | 8.833    0.00 | 11.83    0.00
                2.917   18.20 | 5.917    7.28 | 8.917    0.00 | 11.92    0.00
                3.000   18.20 | 6.000    7.28 | 9.000    0.00 | 12.00    0.00

     Max.Eff.Inten.(mm/hr)=      19.11        12.04
                over (min)       10.00        30.00
     Storage Coeff.  (min)=       9.90 (ii)   26.36 (ii)
     Unit Hyd. Tpeak (min)=      10.00        30.00
     Unit Hyd. peak  (cms)=       0.11         0.04
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.46         0.20          0.630 (iii)
     TIME TO PEAK    (hrs)=       2.00         3.25           3.00
     RUNOFF VOLUME    (mm)=      90.00        49.47          72.77
     TOTAL RAINFALL   (mm)=      91.00        91.00          91.00
     RUNOFF COEFFICIENT   =       0.99         0.54           0.80


       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| DUHYD    (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      0.63      3.00   72.77
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  15.10      0.63      3.00   72.77

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
```



```
        ID1= 1 (  1101):    10.47   0.458     3.00    76.58
      + ID2= 2 (  1102):    15.10   0.630     3.00    72.77
        ====================================================
        ID = 3 (  1103):    25.57   1.088     3.00    74.33

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1003):     7.60   0.209     4.67    49.47
      + ID2= 2 (  1103):    25.57   1.088     3.00    74.33
        ====================================================
        ID = 3 (  1105):    33.17   1.250     3.00    68.64

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730      0.9730
                          0.0140     0.1150   |   0.1410      1.1060
                          0.0280     0.2300   |   0.7220      1.2390
                          0.0390     0.3450   |   1.1780      1.5960
                          0.0480     0.4600   |   1.3260      1.9530
                          0.0520     0.5170   |   1.4580      2.3350
                          0.0550     0.5750   |   1.5800      2.7180
                          0.0620     0.7080   |   1.6920      3.1260
                          0.0680     0.8410   |   1.7980      3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     33.170      1.250      3.00      68.64
   OUTFLOW: ID= 1 (  1106)     33.170      0.841      5.25      68.57

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 67.26
                   TIME SHIFT OF PEAK FLOW         (min)=135.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  1.3322

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
```



```
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1102 <ID= 2> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1104 <ID= 3> IS ALSO DRY
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   1104 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   1107 = HYDROGRAPH 1106
        ID1= 1 (  1104):     0.00   0.000     0.00     0.00
      + ID2= 2 (  1106):    33.17   0.841     5.25    68.57
        ====================================================
        ID = 3 (  1107):    33.17   0.841     5.25    68.57

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

```
===================================================================================================================

       V    V   I    SSSSS  U   U    A    L              (v 6.2.2001)
       V    V   I    SS     U   U   A A   L
        V  V    I     SS    U   U  AAAAA  L
        V  V    I      SS   U   U  A   A  L
         VV     I    SSSSS  UUUUU  A   A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

Developed and Distributed by Smart City Water Inc

***** D E T A I L E D   O U T P U T *****

Input filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

Output filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\a79b97b8-f45f-4b98-ad64-85c5a9be8434\scenar

Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\a79b97b8-f45f-4b98-ad64-85c5a9be8434\scenar

DATE: 01-12-2023   TIME: 11:32:43

USER:

COMMENTS: ____

```
---------------------------------------------------------------------------------------------------------------
  **************************************************
  ** SIMULATION : Run 05                          **
  **************************************************
```



```
--------------------
|   READ STORM     |    Filename: C:\Users\zhouj\AppD
|                  |              ata\Local\Temp\
|                  |              d2870494-74fa-435e-8860-3b342214a80d\e9b114c2
| Ptotal=113.51 mm |    Comments: 100-yr 24-hr SCS_NiagaraFalls
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.25	1.25	6.25	2.27	12.25	16.34	18.25	2.04
0.50	1.25	6.50	2.27	12.50	16.34	18.50	2.04
0.75	1.25	6.75	2.27	12.75	8.40	18.75	2.04
1.00	1.25	7.00	2.27	13.00	8.40	19.00	2.04
1.25	1.25	7.25	2.27	13.25	1.59	19.25	2.04
1.50	1.25	7.50	2.27	13.50	1.59	19.50	2.04
1.75	1.25	7.75	2.27	13.75	9.31	19.75	2.04
2.00	1.25	8.00	2.27	14.00	9.31	20.00	2.04
2.25	1.48	8.25	3.06	14.25	3.41	20.25	1.36
2.50	1.48	8.50	3.06	14.50	3.41	20.50	1.36
2.75	1.48	8.75	3.06	14.75	3.41	20.75	1.36
3.00	1.48	9.00	3.06	15.00	3.41	21.00	1.36
3.25	1.48	9.25	3.63	15.25	3.41	21.25	1.36
3.50	1.48	9.50	3.63	15.50	3.41	21.50	1.36
3.75	1.48	9.75	4.09	15.75	3.41	21.75	1.36
4.00	1.48	10.00	4.09	16.00	3.41	22.00	1.36
4.25	1.82	10.25	5.22	16.25	2.04	22.25	1.36
4.50	1.82	10.50	5.22	16.50	2.04	22.50	1.36
4.75	1.82	10.75	7.04	16.75	2.04	22.75	1.36
5.00	1.82	11.00	7.04	17.00	2.04	23.00	1.36
5.25	1.82	11.25	10.90	17.25	2.04	23.25	1.36
5.50	1.82	11.50	10.90	17.50	2.04	23.50	1.36
5.75	1.82	11.75	47.22	17.75	2.04	23.75	1.36
6.00	1.82	12.00	125.30	18.00	2.04	24.00	1.36

```
-------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD ( 1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
```

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	13.92	9.13
Dep. Storage	(mm)=	1.00	5.00
Average Slope	(%)=	1.00	2.00
Length	(m)=	392.00	40.00
Mannings n	=	0.013	0.250

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.25	6.083	2.27	12.083	16.35	18.08	2.04
0.167	1.25	6.167	2.27	12.167	16.34	18.17	2.04
0.250	1.25	6.250	2.27	12.250	16.34	18.25	2.04
0.333	1.25	6.333	2.27	12.333	16.34	18.33	2.04
0.417	1.25	6.417	2.27	12.417	16.34	18.42	2.04
0.500	1.25	6.500	2.27	12.500	16.34	18.50	2.04
0.583	1.25	6.583	2.27	12.583	8.40	18.58	2.04
0.667	1.25	6.667	2.27	12.667	8.40	18.67	2.04
0.750	1.25	6.750	2.27	12.750	8.40	18.75	2.04
0.833	1.25	6.833	2.27	12.833	8.40	18.83	2.04
0.917	1.25	6.917	2.27	12.917	8.40	18.92	2.04
1.000	1.25	7.000	2.27	13.000	8.40	19.00	2.04
1.083	1.25	7.083	2.27	13.083	1.59	19.08	2.04
1.167	1.25	7.167	2.27	13.167	1.59	19.17	2.04
1.250	1.25	7.250	2.27	13.250	1.59	19.25	2.04
1.333	1.25	7.333	2.27	13.333	1.59	19.33	2.04
1.417	1.25	7.417	2.27	13.417	1.59	19.42	2.04
1.500	1.25	7.500	2.27	13.500	1.59	19.50	2.04
1.583	1.25	7.583	2.27	13.583	9.31	19.58	2.04
1.667	1.25	7.667	2.27	13.667	9.31	19.67	2.04
1.750	1.25	7.750	2.27	13.750	9.31	19.75	2.04
1.833	1.25	7.833	2.27	13.833	9.31	19.83	2.04
1.917	1.25	7.917	2.27	13.917	9.31	19.92	2.04
2.000	1.25	8.000	2.27	14.000	9.31	20.00	2.04
2.083	1.48	8.083	3.06	14.083	3.41	20.08	1.36
2.167	1.48	8.167	3.06	14.167	3.41	20.17	1.36
2.250	1.48	8.250	3.06	14.250	3.41	20.25	1.36
2.333	1.48	8.333	3.06	14.333	3.41	20.33	1.36
2.417	1.48	8.417	3.06	14.417	3.41	20.42	1.36
2.500	1.48	8.500	3.06	14.500	3.41	20.50	1.36
2.583	1.48	8.583	3.06	14.583	3.41	20.58	1.36
2.667	1.48	8.667	3.06	14.667	3.41	20.67	1.36
2.750	1.48	8.750	3.06	14.750	3.41	20.75	1.36
2.833	1.48	8.833	3.06	14.833	3.41	20.83	1.36
2.917	1.48	8.917	3.06	14.917	3.41	20.92	1.36
3.000	1.48	9.000	3.06	15.000	3.41	21.00	1.36
3.083	1.48	9.083	3.63	15.083	3.41	21.08	1.36
3.167	1.48	9.167	3.63	15.167	3.41	21.17	1.36
3.250	1.48	9.250	3.63	15.250	3.41	21.25	1.36
3.333	1.48	9.333	3.63	15.333	3.41	21.33	1.36
3.417	1.48	9.417	3.63	15.417	3.41	21.42	1.36

3.500	1.48	9.500	3.63	15.500	3.41	21.50	1.36
3.583	1.48	9.583	4.09	15.583	3.41	21.58	1.36
3.667	1.48	9.667	4.09	15.667	3.41	21.67	1.36
3.750	1.48	9.750	4.09	15.750	3.41	21.75	1.36
3.833	1.48	9.833	4.09	15.833	3.41	21.83	1.36
3.917	1.48	9.917	4.09	15.917	3.41	21.92	1.36
4.000	1.48	10.000	4.09	16.000	3.41	22.00	1.36
4.083	1.82	10.083	5.22	16.083	2.04	22.08	1.36
4.167	1.82	10.167	5.22	16.167	2.04	22.17	1.36
4.250	1.82	10.250	5.22	16.250	2.04	22.25	1.36
4.333	1.82	10.333	5.22	16.333	2.04	22.33	1.36
4.417	1.82	10.417	5.22	16.417	2.04	22.42	1.36
4.500	1.82	10.500	5.22	16.500	2.04	22.50	1.36
4.583	1.82	10.583	7.04	16.583	2.04	22.58	1.36
4.667	1.82	10.667	7.04	16.667	2.04	22.67	1.36
4.750	1.82	10.750	7.04	16.750	2.04	22.75	1.36
4.833	1.82	10.833	7.04	16.833	2.04	22.83	1.36
4.917	1.82	10.917	7.04	16.917	2.04	22.92	1.36
5.000	1.82	11.000	7.04	17.000	2.04	23.00	1.36
5.083	1.82	11.083	10.90	17.083	2.04	23.08	1.36
5.167	1.82	11.167	10.90	17.167	2.04	23.17	1.36
5.250	1.82	11.250	10.90	17.250	2.04	23.25	1.36
5.333	1.82	11.333	10.90	17.333	2.04	23.33	1.36
5.417	1.82	11.417	10.90	17.417	2.04	23.42	1.36
5.500	1.82	11.500	10.90	17.500	2.04	23.50	1.36
5.583	1.82	11.583	47.22	17.583	2.04	23.58	1.36
5.667	1.82	11.667	47.22	17.667	2.04	23.67	1.36
5.750	1.82	11.750	47.22	17.750	2.04	23.75	1.36
5.833	1.82	11.833	125.29	17.833	2.04	23.83	1.36
5.917	1.82	11.917	125.30	17.917	2.04	23.92	1.36
6.000	1.82	12.000	125.30	18.000	2.04	24.00	1.36

Max.Eff.Inten.(mm/hr)=		125.30	91.84	
over (min)		5.00	15.00	
Storage Coeff.	(min)=	5.30 (ii)	12.60 (ii)	
Unit Hyd. Tpeak	(min)=	5.00	15.00	
Unit Hyd. peak	(cms)=	0.21	0.08	
				TOTALS
PEAK FLOW	(cms)=	4.66	1.50	6.005 (iii)
TIME TO PEAK	(hrs)=	12.00	12.08	12.00
RUNOFF VOLUME	(mm)=	112.51	68.45	95.06
TOTAL RAINFALL	(mm)=	113.51	113.51	113.51
RUNOFF COEFFICIENT	=	0.99	0.60	0.84

(i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
CN* = 80.0   Ia = Dep. Storage (Above)

(ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

```
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      6.00     12.00   95.06
     =================================================
     MAJOR SYS.(ID= 2):   2.58      3.24     12.00   95.06
     MINOR SYS.(ID= 3):  20.47      2.77     11.83   95.06
```

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

```
--------------------
| RESERVOIR( 1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |
--------------------
```

OUTFLOW (cms)	STORAGE (ha.m.)	OUTFLOW (cms)	STORAGE (ha.m.)
0.0000	0.0000	1.5710	0.6240
0.0070	0.1010	2.8490	0.7400
0.0240	0.2030	4.3610	0.8560
0.0330	0.3040	6.0740	0.9730
0.0400	0.4060	7.9690	1.0890
0.5830	0.5070	0.0000	0.0000

	AREA (ha)	QPEAK (cms)	TPEAK (hrs)	R.V. (mm)
INFLOW : ID= 2 (1401)	20.471	2.767	11.83	95.06
OUTFLOW: ID= 1 (1403)	20.471	2.279	12.17	94.69

PEAK FLOW REDUCTION [Qout/Qin](%)= 82.37
TIME SHIFT OF PEAK FLOW (min)= 20.00
MAXIMUM STORAGE USED (ha.m.)= 0.6937

```
--------------------
| ADD HYD  (  1402)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  1401):      2.58   3.238    12.00    95.06
```



```
  + ID2= 2 (  1403):    20.47   2.279    12.17    94.69
    =================================================
    ID = 3 (  1402):    23.05   5.089    12.00    94.73
```

NOTE: PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

```
--------------------
| CALIB             |
| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11
```

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.25	6.083	2.27	12.083	16.35	18.08	2.04
0.167	1.25	6.167	2.27	12.167	16.34	18.17	2.04
0.250	1.25	6.250	2.27	12.250	16.34	18.25	2.04
0.333	1.25	6.333	2.27	12.333	16.34	18.33	2.04
0.417	1.25	6.417	2.27	12.417	16.34	18.42	2.04
0.500	1.25	6.500	2.27	12.500	16.34	18.50	2.04
0.583	1.25	6.583	2.27	12.583	8.40	18.58	2.04
0.667	1.25	6.667	2.27	12.667	8.40	18.67	2.04
0.750	1.25	6.750	2.27	12.750	8.40	18.75	2.04
0.833	1.25	6.833	2.27	12.833	8.40	18.83	2.04
0.917	1.25	6.917	2.27	12.917	8.40	18.92	2.04
1.000	1.25	7.000	2.27	13.000	8.40	19.00	2.04
1.083	1.25	7.083	2.27	13.083	1.59	19.08	2.04
1.167	1.25	7.167	2.27	13.167	1.59	19.17	2.04
1.250	1.25	7.250	2.27	13.250	1.59	19.25	2.04
1.333	1.25	7.333	2.27	13.333	1.59	19.33	2.04
1.417	1.25	7.417	2.27	13.417	1.59	19.42	2.04
1.500	1.25	7.500	2.27	13.500	1.59	19.50	2.04
1.583	1.25	7.583	2.27	13.583	9.31	19.58	2.04
1.667	1.25	7.667	2.27	13.667	9.31	19.67	2.04
1.750	1.25	7.750	2.27	13.750	9.31	19.75	2.04
1.833	1.25	7.833	2.27	13.833	9.31	19.83	2.04
1.917	1.25	7.917	2.27	13.917	9.31	19.92	2.04
2.000	1.25	8.000	2.27	14.000	9.31	20.00	2.04
2.083	1.48	8.083	3.06	14.083	3.41	20.08	1.36
2.167	1.48	8.167	3.06	14.167	3.41	20.17	1.36
2.250	1.48	8.250	3.06	14.250	3.41	20.25	1.36
2.333	1.48	8.333	3.06	14.333	3.41	20.33	1.36
2.417	1.48	8.417	3.06	14.417	3.41	20.42	1.36

2.500	1.48	8.500	3.06	14.500	3.41	20.50	1.36
2.583	1.48	8.583	3.06	14.583	3.41	20.58	1.36
2.667	1.48	8.667	3.06	14.667	3.41	20.67	1.36
2.750	1.48	8.750	3.06	14.750	3.41	20.75	1.36
2.833	1.48	8.833	3.06	14.833	3.41	20.83	1.36
2.917	1.48	8.917	3.06	14.917	3.41	20.92	1.36
3.000	1.48	9.000	3.06	15.000	3.41	21.00	1.36
3.083	1.48	9.083	3.63	15.083	3.41	21.08	1.36
3.167	1.48	9.167	3.63	15.167	3.41	21.17	1.36
3.250	1.48	9.250	3.63	15.250	3.41	21.25	1.36
3.333	1.48	9.333	3.63	15.333	3.41	21.33	1.36
3.417	1.48	9.417	3.63	15.417	3.41	21.42	1.36
3.500	1.48	9.500	3.63	15.500	3.41	21.50	1.36
3.583	1.48	9.583	4.09	15.583	3.41	21.58	1.36
3.667	1.48	9.667	4.09	15.667	3.41	21.67	1.36
3.750	1.48	9.750	4.09	15.750	3.41	21.75	1.36
3.833	1.48	9.833	4.09	15.833	3.41	21.83	1.36
3.917	1.48	9.917	4.09	15.917	3.41	21.92	1.36
4.000	1.48	10.000	4.09	16.000	3.41	22.00	1.36
4.083	1.82	10.083	5.22	16.083	2.04	22.08	1.36
4.167	1.82	10.167	5.22	16.167	2.04	22.17	1.36
4.250	1.82	10.250	5.22	16.250	2.04	22.25	1.36
4.333	1.82	10.333	5.22	16.333	2.04	22.33	1.36
4.417	1.82	10.417	5.22	16.417	2.04	22.42	1.36
4.500	1.82	10.500	5.22	16.500	2.04	22.50	1.36
4.583	1.82	10.583	7.04	16.583	2.04	22.58	1.36
4.667	1.82	10.667	7.04	16.667	2.04	22.67	1.36
4.750	1.82	10.750	7.04	16.750	2.04	22.75	1.36
4.833	1.82	10.833	7.04	16.833	2.04	22.83	1.36
4.917	1.82	10.917	7.04	16.917	2.04	22.92	1.36
5.000	1.82	11.000	7.04	17.000	2.04	23.00	1.36
5.083	1.82	11.083	10.90	17.083	2.04	23.08	1.36
5.167	1.82	11.167	10.90	17.167	2.04	23.17	1.36
5.250	1.82	11.250	10.90	17.250	2.04	23.25	1.36
5.333	1.82	11.333	10.90	17.333	2.04	23.33	1.36
5.417	1.82	11.417	10.90	17.417	2.04	23.42	1.36
5.500	1.82	11.500	10.90	17.500	2.04	23.50	1.36
5.583	1.82	11.583	47.22	17.583	2.04	23.58	1.36
5.667	1.82	11.667	47.22	17.667	2.04	23.67	1.36
5.750	1.82	11.750	47.22	17.750	2.04	23.75	1.36
5.833	1.82	11.833	125.29	17.833	2.04	23.83	1.36
5.917	1.82	11.917	125.30	17.917	2.04	23.92	1.36
6.000	1.82	12.000	125.30	18.000	2.04	24.00	1.36

Unit Hyd Qpeak (cms)= 0.419

PEAK FLOW (cms)= 0.598 (i)

TIME TO PEAK (hrs)= 13.083
RUNOFF VOLUME (mm)= 64.153
TOTAL RAINFALL (mm)= 113.510
RUNOFF COEFFICIENT = 0.565

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| CALIB             |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
```

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	8.14	6.37
Dep. Storage	(mm)=	1.00	5.00
Average Slope	(%)=	1.00	2.00
Length	(m)=	311.02	40.00
Mannings n	=	0.013	0.250

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.25	6.083	2.27	12.083	16.35	18.08	2.04
0.167	1.25	6.167	2.27	12.167	16.34	18.17	2.04
0.250	1.25	6.250	2.27	12.250	16.34	18.25	2.04
0.333	1.25	6.333	2.27	12.333	16.34	18.33	2.04
0.417	1.25	6.417	2.27	12.417	16.34	18.42	2.04
0.500	1.25	6.500	2.27	12.500	16.34	18.50	2.04
0.583	1.25	6.583	2.27	12.583	8.40	18.58	2.04
0.667	1.25	6.667	2.27	12.667	8.40	18.67	2.04
0.750	1.25	6.750	2.27	12.750	8.40	18.75	2.04
0.833	1.25	6.833	2.27	12.833	8.40	18.83	2.04
0.917	1.25	6.917	2.27	12.917	8.40	18.92	2.04
1.000	1.25	7.000	2.27	13.000	8.40	19.00	2.04
1.083	1.25	7.083	2.27	13.083	1.59	19.08	2.04
1.167	1.25	7.167	2.27	13.167	1.59	19.17	2.04
1.250	1.25	7.250	2.27	13.250	1.59	19.25	2.04
1.333	1.25	7.333	2.27	13.333	1.59	19.33	2.04
1.417	1.25	7.417	2.27	13.417	1.59	19.42	2.04
1.500	1.25	7.500	2.27	13.500	1.59	19.50	2.04
1.583	1.25	7.583	2.27	13.583	9.31	19.58	2.04
1.667	1.25	7.667	2.27	13.667	9.31	19.67	2.04
1.750	1.25	7.750	2.27	13.750	9.31	19.75	2.04

```
  1.833    1.25 | 7.833    2.27 |13.833    9.31 | 19.83    2.04
  1.917    1.25 | 7.917    2.27 |13.917    9.31 | 19.92    2.04
  2.000    1.25 | 8.000    2.27 |14.000    9.31 | 20.00    2.04
  2.083    1.48 | 8.083    3.06 |14.083    3.41 | 20.08    1.36
  2.167    1.48 | 8.167    3.06 |14.167    3.41 | 20.17    1.36
  2.250    1.48 | 8.250    3.06 |14.250    3.41 | 20.25    1.36
  2.333    1.48 | 8.333    3.06 |14.333    3.41 | 20.33    1.36
  2.417    1.48 | 8.417    3.06 |14.417    3.41 | 20.42    1.36
  2.500    1.48 | 8.500    3.06 |14.500    3.41 | 20.50    1.36
  2.583    1.48 | 8.583    3.06 |14.583    3.41 | 20.58    1.36
  2.667    1.48 | 8.667    3.06 |14.667    3.41 | 20.67    1.36
  2.750    1.48 | 8.750    3.06 |14.750    3.41 | 20.75    1.36
  2.833    1.48 | 8.833    3.06 |14.833    3.41 | 20.83    1.36
  2.917    1.48 | 8.917    3.06 |14.917    3.41 | 20.92    1.36
  3.000    1.48 | 9.000    3.06 |15.000    3.41 | 21.00    1.36
  3.083    1.48 | 9.083    3.63 |15.083    3.41 | 21.08    1.36
  3.167    1.48 | 9.167    3.63 |15.167    3.41 | 21.17    1.36
  3.250    1.48 | 9.250    3.63 |15.250    3.41 | 21.25    1.36
  3.333    1.48 | 9.333    3.63 |15.333    3.41 | 21.33    1.36
  3.417    1.48 | 9.417    3.63 |15.417    3.41 | 21.42    1.36
  3.500    1.48 | 9.500    3.63 |15.500    3.41 | 21.50    1.36
  3.583    1.48 | 9.583    4.09 |15.583    3.41 | 21.58    1.36
  3.667    1.48 | 9.667    4.09 |15.667    3.41 | 21.67    1.36
  3.750    1.48 | 9.750    4.09 |15.750    3.41 | 21.75    1.36
  3.833    1.48 | 9.833    4.09 |15.833    3.41 | 21.83    1.36
  3.917    1.48 | 9.917    4.09 |15.917    3.41 | 21.92    1.36
  4.000    1.48 |10.000    4.09 |16.000    3.41 | 22.00    1.36
  4.083    1.82 |10.083    5.22 |16.083    2.04 | 22.08    1.36
  4.167    1.82 |10.167    5.22 |16.167    2.04 | 22.17    1.36
  4.250    1.82 |10.250    5.22 |16.250    2.04 | 22.25    1.36
  4.333    1.82 |10.333    5.22 |16.333    2.04 | 22.33    1.36
  4.417    1.82 |10.417    5.22 |16.417    2.04 | 22.42    1.36
  4.500    1.82 |10.500    5.22 |16.500    2.04 | 22.50    1.36
  4.583    1.82 |10.583    7.04 |16.583    2.04 | 22.58    1.36
  4.667    1.82 |10.667    7.04 |16.667    2.04 | 22.67    1.36
  4.750    1.82 |10.750    7.04 |16.750    2.04 | 22.75    1.36
  4.833    1.82 |10.833    7.04 |16.833    2.04 | 22.83    1.36
  4.917    1.82 |10.917    7.04 |16.917    2.04 | 22.92    1.36
  5.000    1.82 |11.000    7.04 |17.000    2.04 | 23.00    1.36
  5.083    1.82 |11.083   10.90 |17.083    2.04 | 23.08    1.36
  5.167    1.82 |11.167   10.90 |17.167    2.04 | 23.17    1.36
  5.250    1.82 |11.250   10.90 |17.250    2.04 | 23.25    1.36
  5.333    1.82 |11.333   10.90 |17.333    2.04 | 23.33    1.36
  5.417    1.82 |11.417   10.90 |17.417    2.04 | 23.42    1.36
  5.500    1.82 |11.500   10.90 |17.500    2.04 | 23.50    1.36
  5.583    1.82 |11.583   47.22 |17.583    2.04 | 23.58    1.36
  5.667    1.82 |11.667   47.22 |17.667    2.04 | 23.67    1.36
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  5.750    1.82 |11.750   47.22 |17.750    2.04 | 23.75    1.36
  5.833    1.82 |11.833  125.29 |17.833    2.04 | 23.83    1.36
  5.917    1.82 |11.917  125.30 |17.917    2.04 | 23.92    1.36
  6.000    1.82 |12.000  125.30 |18.000    2.04 | 24.00    1.36

     Max.Eff.Inten.(mm/hr)=     125.30        91.84
               over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.61 (ii)   11.91 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.22         0.09
                                                          *TOTALS*
     PEAK FLOW       (cms)=       2.76         1.07          3.724 (iii)
     TIME TO PEAK    (hrs)=      12.00        12.08          12.00
     RUNOFF VOLUME    (mm)=     112.51        68.45          93.17
     TOTAL RAINFALL   (mm)=     113.51       113.51         113.51
     RUNOFF COEFFICIENT   =       0.99         0.60           0.82

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  2002):    14.51   3.724    12.00    93.17
      + ID2= 2 (  2010):    12.18   0.598    13.08    64.15
        ==================================================
        ID = 3 (  2202):    26.69   3.886    12.00    79.93

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.2130      0.9700
                          0.0110     0.1350   |   1.6800      1.1170
                          0.0220     0.2700   |   2.1950      1.2650
                          0.0300     0.4050   |   2.7540      1.4120
```



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                          0.1810     0.5400   |   6.1220      2.1920
                          0.4520     0.6750   |  10.2830      3.0160
                          0.8010     0.8230   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690      3.886     12.00      79.93
   OUTFLOW: ID= 1 (  2203)     26.690      0.896     13.00      79.66

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 23.06
                  TIME SHIFT OF PEAK FLOW         (min)= 60.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.8574

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--------------------
| CALIB            |
| STANDHYD (  2001)|   Area    (ha)=  17.75
|ID= 1 DT= 5.0 min |   Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n          =      0.013        0.250

          NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                          ---- TRANSFORMED HYETOGRAPH ----
                  TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                   hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                 0.083    1.25 | 6.083    2.27 |12.083   16.35 | 18.08    2.04
                 0.167    1.25 | 6.167    2.27 |12.167   16.34 | 18.17    2.04
                 0.250    1.25 | 6.250    2.27 |12.250   16.34 | 18.25    2.04
                 0.333    1.25 | 6.333    2.27 |12.333   16.34 | 18.33    2.04
                 0.417    1.25 | 6.417    2.27 |12.417   16.34 | 18.42    2.04
                 0.500    1.25 | 6.500    2.27 |12.500   16.34 | 18.50    2.04
                 0.583    1.25 | 6.583    2.27 |12.583    8.40 | 18.58    2.04
                 0.667    1.25 | 6.667    2.27 |12.667    8.40 | 18.67    2.04
                 0.750    1.25 | 6.750    2.27 |12.750    8.40 | 18.75    2.04
                 0.833    1.25 | 6.833    2.27 |12.833    8.40 | 18.83    2.04
                 0.917    1.25 | 6.917    2.27 |12.917    8.40 | 18.92    2.04
                 1.000    1.25 | 7.000    2.27 |13.000    8.40 | 19.00    2.04
                 1.083    1.25 | 7.083    2.27 |13.083    1.59 | 19.08    2.04
                 1.167    1.25 | 7.167    2.27 |13.167    1.59 | 19.17    2.04
                 1.250    1.25 | 7.250    2.27 |13.250    1.59 | 19.25    2.04
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  1.333    1.25 | 7.333    2.27 |13.333    1.59 | 19.33    2.04
  1.417    1.25 | 7.417    2.27 |13.417    1.59 | 19.42    2.04
  1.500    1.25 | 7.500    2.27 |13.500    1.59 | 19.50    2.04
  1.583    1.25 | 7.583    2.27 |13.583    9.31 | 19.58    2.04
  1.667    1.25 | 7.667    2.27 |13.667    9.31 | 19.67    2.04
  1.750    1.25 | 7.750    2.27 |13.750    9.31 | 19.75    2.04
  1.833    1.25 | 7.833    2.27 |13.833    9.31 | 19.83    2.04
  1.917    1.25 | 7.917    2.27 |13.917    9.31 | 19.92    2.04
  2.000    1.25 | 8.000    2.27 |14.000    9.31 | 20.00    2.04
  2.083    1.48 | 8.083    3.06 |14.083    3.41 | 20.08    1.36
  2.167    1.48 | 8.167    3.06 |14.167    3.41 | 20.17    1.36
  2.250    1.48 | 8.250    3.06 |14.250    3.41 | 20.25    1.36
  2.333    1.48 | 8.333    3.06 |14.333    3.41 | 20.33    1.36
  2.417    1.48 | 8.417    3.06 |14.417    3.41 | 20.42    1.36
  2.500    1.48 | 8.500    3.06 |14.500    3.41 | 20.50    1.36
  2.583    1.48 | 8.583    3.06 |14.583    3.41 | 20.58    1.36
  2.667    1.48 | 8.667    3.06 |14.667    3.41 | 20.67    1.36
  2.750    1.48 | 8.750    3.06 |14.750    3.41 | 20.75    1.36
  2.833    1.48 | 8.833    3.06 |14.833    3.41 | 20.83    1.36
  2.917    1.48 | 8.917    3.06 |14.917    3.41 | 20.92    1.36
  3.000    1.48 | 9.000    3.06 |15.000    3.41 | 21.00    1.36
  3.083    1.48 | 9.083    3.63 |15.083    3.41 | 21.08    1.36
  3.167    1.48 | 9.167    3.63 |15.167    3.41 | 21.17    1.36
  3.250    1.48 | 9.250    3.63 |15.250    3.41 | 21.25    1.36
  3.333    1.48 | 9.333    3.63 |15.333    3.41 | 21.33    1.36
  3.417    1.48 | 9.417    3.63 |15.417    3.41 | 21.42    1.36
  3.500    1.48 | 9.500    3.63 |15.500    3.41 | 21.50    1.36
  3.583    1.48 | 9.583    4.09 |15.583    3.41 | 21.58    1.36
  3.667    1.48 | 9.667    4.09 |15.667    3.41 | 21.67    1.36
  3.750    1.48 | 9.750    4.09 |15.750    3.41 | 21.75    1.36
  3.833    1.48 | 9.833    4.09 |15.833    3.41 | 21.83    1.36
  3.917    1.48 | 9.917    4.09 |15.917    3.41 | 21.92    1.36
  4.000    1.48 |10.000    4.09 |16.000    3.41 | 22.00    1.36
  4.083    1.82 |10.083    5.22 |16.083    2.04 | 22.08    1.36
  4.167    1.82 |10.167    5.22 |16.167    2.04 | 22.17    1.36
  4.250    1.82 |10.250    5.22 |16.250    2.04 | 22.25    1.36
  4.333    1.82 |10.333    5.22 |16.333    2.04 | 22.33    1.36
  4.417    1.82 |10.417    5.22 |16.417    2.04 | 22.42    1.36
  4.500    1.82 |10.500    5.22 |16.500    2.04 | 22.50    1.36
  4.583    1.82 |10.583    7.04 |16.583    2.04 | 22.58    1.36
  4.667    1.82 |10.667    7.04 |16.667    2.04 | 22.67    1.36
  4.750    1.82 |10.750    7.04 |16.750    2.04 | 22.75    1.36
  4.833    1.82 |10.833    7.04 |16.833    2.04 | 22.83    1.36
  4.917    1.82 |10.917    7.04 |16.917    2.04 | 22.92    1.36
  5.000    1.82 |11.000    7.04 |17.000    2.04 | 23.00    1.36
  5.083    1.82 |11.083   10.90 |17.083    2.04 | 23.08    1.36
  5.167    1.82 |11.167   10.90 |17.167    2.04 | 23.17    1.36
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    5.250    1.82 |11.250   10.90 |17.250    2.04 | 23.25    1.36
    5.333    1.82 |11.333   10.90 |17.333    2.04 | 23.33    1.36
    5.417    1.82 |11.417   10.90 |17.417    2.04 | 23.42    1.36
    5.500    1.82 |11.500   10.90 |17.500    2.04 | 23.50    1.36
    5.583    1.82 |11.583   47.22 |17.583    2.04 | 23.58    1.36
    5.667    1.82 |11.667   47.22 |17.667    2.04 | 23.67    1.36
    5.750    1.82 |11.750   47.22 |17.750    2.04 | 23.75    1.36
    5.833    1.82 |11.833  125.29 |17.833    2.04 | 23.83    1.36
    5.917    1.82 |11.917  125.30 |17.917    2.04 | 23.92    1.36
    6.000    1.82 |12.000  125.30 |18.000    2.04 | 24.00    1.36

     Max.Eff.Inten.(mm/hr)=     125.30        91.84
               over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.90 (ii)   12.20 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.22         0.09
                                                             *TOTALS*
     PEAK FLOW       (cms)=       3.50         1.23           4.602 (iii)
     TIME TO PEAK    (hrs)=      12.00        12.08           12.00
     RUNOFF VOLUME    (mm)=     112.51        68.45           94.18
     TOTAL RAINFALL   (mm)=     113.51       113.51          113.51
     RUNOFF COEFFICIENT   =       0.99         0.60            0.83

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
            THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      4.60     12.00   94.18
     ====================================================
     MAJOR SYS.(ID= 2):   1.20      1.86     12.00   94.18
     MINOR SYS.(ID= 3):  16.55      2.74     11.83   94.18

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     16.549     2.740     11.83      94.18
   OUTFLOW: ID= 1 (  4003)     16.549     1.857     12.17      93.73

                PEAK   FLOW   REDUCTION [Qout/Qin](%)= 67.77
                TIME SHIFT OF PEAK FLOW         (min)= 20.00
                MAXIMUM  STORAGE   USED       (ha.m.)=  0.6521

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--------------------
| ADD HYD  (  2102)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  2101):     1.20   1.862    12.00    94.18
      + ID2= 2 (  4003):    16.55   1.857    12.17    93.73
        ====================================================
        ID = 3 (  2102):    17.75   3.178    12.00    93.76

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```



```
                    ---- TRANSFORMED HYETOGRAPH ----
     TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
      hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
    0.083    1.25 | 6.083    2.27 |12.083   16.35 | 18.08    2.04
    0.167    1.25 | 6.167    2.27 |12.167   16.34 | 18.17    2.04
    0.250    1.25 | 6.250    2.27 |12.250   16.34 | 18.25    2.04
    0.333    1.25 | 6.333    2.27 |12.333   16.34 | 18.33    2.04
    0.417    1.25 | 6.417    2.27 |12.417   16.34 | 18.42    2.04
    0.500    1.25 | 6.500    2.27 |12.500   16.34 | 18.50    2.04
    0.583    1.25 | 6.583    2.27 |12.583    8.40 | 18.58    2.04
    0.667    1.25 | 6.667    2.27 |12.667    8.40 | 18.67    2.04
    0.750    1.25 | 6.750    2.27 |12.750    8.40 | 18.75    2.04
    0.833    1.25 | 6.833    2.27 |12.833    8.40 | 18.83    2.04
    0.917    1.25 | 6.917    2.27 |12.917    8.40 | 18.92    2.04
    1.000    1.25 | 7.000    2.27 |13.000    8.40 | 19.00    2.04
    1.083    1.25 | 7.083    2.27 |13.083    1.59 | 19.08    2.04
    1.167    1.25 | 7.167    2.27 |13.167    1.59 | 19.17    2.04
    1.250    1.25 | 7.250    2.27 |13.250    1.59 | 19.25    2.04
    1.333    1.25 | 7.333    2.27 |13.333    1.59 | 19.33    2.04
    1.417    1.25 | 7.417    2.27 |13.417    1.59 | 19.42    2.04
    1.500    1.25 | 7.500    2.27 |13.500    1.59 | 19.50    2.04
    1.583    1.25 | 7.583    2.27 |13.583    9.31 | 19.58    2.04
    1.667    1.25 | 7.667    2.27 |13.667    9.31 | 19.67    2.04
    1.750    1.25 | 7.750    2.27 |13.750    9.31 | 19.75    2.04
    1.833    1.25 | 7.833    2.27 |13.833    9.31 | 19.83    2.04
    1.917    1.25 | 7.917    2.27 |13.917    9.31 | 19.92    2.04
    2.000    1.25 | 8.000    2.27 |14.000    9.31 | 20.00    2.04
    2.083    1.48 | 8.083    3.06 |14.083    3.41 | 20.08    1.36
    2.167    1.48 | 8.167    3.06 |14.167    3.41 | 20.17    1.36
    2.250    1.48 | 8.250    3.06 |14.250    3.41 | 20.25    1.36
    2.333    1.48 | 8.333    3.06 |14.333    3.41 | 20.33    1.36
    2.417    1.48 | 8.417    3.06 |14.417    3.41 | 20.42    1.36
    2.500    1.48 | 8.500    3.06 |14.500    3.41 | 20.50    1.36
    2.583    1.48 | 8.583    3.06 |14.583    3.41 | 20.58    1.36
    2.667    1.48 | 8.667    3.06 |14.667    3.41 | 20.67    1.36
    2.750    1.48 | 8.750    3.06 |14.750    3.41 | 20.75    1.36
    2.833    1.48 | 8.833    3.06 |14.833    3.41 | 20.83    1.36
    2.917    1.48 | 8.917    3.06 |14.917    3.41 | 20.92    1.36
    3.000    1.48 | 9.000    3.06 |15.000    3.41 | 21.00    1.36
    3.083    1.48 | 9.083    3.63 |15.083    3.41 | 21.08    1.36
    3.167    1.48 | 9.167    3.63 |15.167    3.41 | 21.17    1.36
    3.250    1.48 | 9.250    3.63 |15.250    3.41 | 21.25    1.36
    3.333    1.48 | 9.333    3.63 |15.333    3.41 | 21.33    1.36
    3.417    1.48 | 9.417    3.63 |15.417    3.41 | 21.42    1.36
    3.500    1.48 | 9.500    3.63 |15.500    3.41 | 21.50    1.36
    3.583    1.48 | 9.583    4.09 |15.583    3.41 | 21.58    1.36
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    3.667    1.48 | 9.667    4.09 |15.667    3.41 | 21.67    1.36
    3.750    1.48 | 9.750    4.09 |15.750    3.41 | 21.75    1.36
    3.833    1.48 | 9.833    4.09 |15.833    3.41 | 21.83    1.36
    3.917    1.48 | 9.917    4.09 |15.917    3.41 | 21.92    1.36
    4.000    1.48 |10.000    4.09 |16.000    3.41 | 22.00    1.36
    4.083    1.82 |10.083    5.22 |16.083    2.04 | 22.08    1.36
    4.167    1.82 |10.167    5.22 |16.167    2.04 | 22.17    1.36
    4.250    1.82 |10.250    5.22 |16.250    2.04 | 22.25    1.36
    4.333    1.82 |10.333    5.22 |16.333    2.04 | 22.33    1.36
    4.417    1.82 |10.417    5.22 |16.417    2.04 | 22.42    1.36
    4.500    1.82 |10.500    5.22 |16.500    2.04 | 22.50    1.36
    4.583    1.82 |10.583    7.04 |16.583    2.04 | 22.58    1.36
    4.667    1.82 |10.667    7.04 |16.667    2.04 | 22.67    1.36
    4.750    1.82 |10.750    7.04 |16.750    2.04 | 22.75    1.36
    4.833    1.82 |10.833    7.04 |16.833    2.04 | 22.83    1.36
    4.917    1.82 |10.917    7.04 |16.917    2.04 | 22.92    1.36
    5.000    1.82 |11.000    7.04 |17.000    2.04 | 23.00    1.36
    5.083    1.82 |11.083   10.90 |17.083    2.04 | 23.08    1.36
    5.167    1.82 |11.167   10.90 |17.167    2.04 | 23.17    1.36
    5.250    1.82 |11.250   10.90 |17.250    2.04 | 23.25    1.36
    5.333    1.82 |11.333   10.90 |17.333    2.04 | 23.33    1.36
    5.417    1.82 |11.417   10.90 |17.417    2.04 | 23.42    1.36
    5.500    1.82 |11.500   10.90 |17.500    2.04 | 23.50    1.36
    5.583    1.82 |11.583   47.22 |17.583    2.04 | 23.58    1.36
    5.667    1.82 |11.667   47.22 |17.667    2.04 | 23.67    1.36
    5.750    1.82 |11.750   47.22 |17.750    2.04 | 23.75    1.36
    5.833    1.82 |11.833  125.29 |17.833    2.04 | 23.83    1.36
    5.917    1.82 |11.917  125.30 |17.917    2.04 | 23.92    1.36
    6.000    1.82 |12.000  125.30 |18.000    2.04 | 24.00    1.36

     Max.Eff.Inten.(mm/hr)=     125.30        91.84
               over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.94 (ii)   10.24 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.28         0.09
                                                             *TOTALS*
     PEAK FLOW       (cms)=       0.56         0.28           0.821 (iii)
     TIME TO PEAK    (hrs)=      12.00        12.08           12.00
     RUNOFF VOLUME    (mm)=     112.51        68.45           90.74
     TOTAL RAINFALL   (mm)=     113.51       113.51          113.51
     RUNOFF COEFFICIENT   =       0.99         0.60            0.80

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
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THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB |
| NASHYD (1003)| Area (ha)= 7.60 Curve Number (CN)= 80.0
|ID= 1 DT= 5.0 min | Ia (mm)= 5.00 # of Linear Res.(N)= 3.00
-------------------- U.H. Tp(hrs)= 1.01

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.25	6.083	2.27	12.083	16.35	18.08	2.04
0.167	1.25	6.167	2.27	12.167	16.34	18.17	2.04
0.250	1.25	6.250	2.27	12.250	16.34	18.25	2.04
0.333	1.25	6.333	2.27	12.333	16.34	18.33	2.04
0.417	1.25	6.417	2.27	12.417	16.34	18.42	2.04
0.500	1.25	6.500	2.27	12.500	16.34	18.50	2.04
0.583	1.25	6.583	2.27	12.583	8.40	18.58	2.04
0.667	1.25	6.667	2.27	12.667	8.40	18.67	2.04
0.750	1.25	6.750	2.27	12.750	8.40	18.75	2.04
0.833	1.25	6.833	2.27	12.833	8.40	18.83	2.04
0.917	1.25	6.917	2.27	12.917	8.40	18.92	2.04
1.000	1.25	7.000	2.27	13.000	8.40	19.00	2.04
1.083	1.25	7.083	2.27	13.083	1.59	19.08	2.04
1.167	1.25	7.167	2.27	13.167	1.59	19.17	2.04
1.250	1.25	7.250	2.27	13.250	1.59	19.25	2.04
1.333	1.25	7.333	2.27	13.333	1.59	19.33	2.04
1.417	1.25	7.417	2.27	13.417	1.59	19.42	2.04
1.500	1.25	7.500	2.27	13.500	1.59	19.50	2.04
1.583	1.25	7.583	2.27	13.583	9.31	19.58	2.04
1.667	1.25	7.667	2.27	13.667	9.31	19.67	2.04
1.750	1.25	7.750	2.27	13.750	9.31	19.75	2.04
1.833	1.25	7.833	2.27	13.833	9.31	19.83	2.04
1.917	1.25	7.917	2.27	13.917	9.31	19.92	2.04
2.000	1.25	8.000	2.27	14.000	9.31	20.00	2.04
2.083	1.48	8.083	3.06	14.083	3.41	20.08	1.36
2.167	1.48	8.167	3.06	14.167	3.41	20.17	1.36
2.250	1.48	8.250	3.06	14.250	3.41	20.25	1.36
2.333	1.48	8.333	3.06	14.333	3.41	20.33	1.36
2.417	1.48	8.417	3.06	14.417	3.41	20.42	1.36
2.500	1.48	8.500	3.06	14.500	3.41	20.50	1.36
2.583	1.48	8.583	3.06	14.583	3.41	20.58	1.36

2.667	1.48	8.667	3.06	14.667	3.41	20.67	1.36
2.750	1.48	8.750	3.06	14.750	3.41	20.75	1.36
2.833	1.48	8.833	3.06	14.833	3.41	20.83	1.36
2.917	1.48	8.917	3.06	14.917	3.41	20.92	1.36
3.000	1.48	9.000	3.06	15.000	3.41	21.00	1.36
3.083	1.48	9.083	3.63	15.083	3.41	21.08	1.36
3.167	1.48	9.167	3.63	15.167	3.41	21.17	1.36
3.250	1.48	9.250	3.63	15.250	3.41	21.25	1.36
3.333	1.48	9.333	3.63	15.333	3.41	21.33	1.36
3.417	1.48	9.417	3.63	15.417	3.41	21.42	1.36
3.500	1.48	9.500	3.63	15.500	3.41	21.50	1.36
3.583	1.48	9.583	4.09	15.583	3.41	21.58	1.36
3.667	1.48	9.667	4.09	15.667	3.41	21.67	1.36
3.750	1.48	9.750	4.09	15.750	3.41	21.75	1.36
3.833	1.48	9.833	4.09	15.833	3.41	21.83	1.36
3.917	1.48	9.917	4.09	15.917	3.41	21.92	1.36
4.000	1.48	10.000	4.09	16.000	3.41	22.00	1.36
4.083	1.82	10.083	5.22	16.083	2.04	22.08	1.36
4.167	1.82	10.167	5.22	16.167	2.04	22.17	1.36
4.250	1.82	10.250	5.22	16.250	2.04	22.25	1.36
4.333	1.82	10.333	5.22	16.333	2.04	22.33	1.36
4.417	1.82	10.417	5.22	16.417	2.04	22.42	1.36
4.500	1.82	10.500	5.22	16.500	2.04	22.50	1.36
4.583	1.82	10.583	7.04	16.583	2.04	22.58	1.36
4.667	1.82	10.667	7.04	16.667	2.04	22.67	1.36
4.750	1.82	10.750	7.04	16.750	2.04	22.75	1.36
4.833	1.82	10.833	7.04	16.833	2.04	22.83	1.36
4.917	1.82	10.917	7.04	16.917	2.04	22.92	1.36
5.000	1.82	11.000	7.04	17.000	2.04	23.00	1.36
5.083	1.82	11.083	10.90	17.083	2.04	23.08	1.36
5.167	1.82	11.167	10.90	17.167	2.04	23.17	1.36
5.250	1.82	11.250	10.90	17.250	2.04	23.25	1.36
5.333	1.82	11.333	10.90	17.333	2.04	23.33	1.36
5.417	1.82	11.417	10.90	17.417	2.04	23.42	1.36
5.500	1.82	11.500	10.90	17.500	2.04	23.50	1.36
5.583	1.82	11.583	47.22	17.583	2.04	23.58	1.36
5.667	1.82	11.667	47.22	17.667	2.04	23.67	1.36
5.750	1.82	11.750	47.22	17.750	2.04	23.75	1.36
5.833	1.82	11.833	125.29	17.833	2.04	23.83	1.36
5.917	1.82	11.917	125.30	17.917	2.04	23.92	1.36
6.000	1.82	12.000	125.30	18.000	2.04	24.00	1.36

Unit Hyd Qpeak (cms)= 0.287

PEAK FLOW (cms)= 0.423 (i)
TIME TO PEAK (hrs)= 12.917
RUNOFF VOLUME (mm)= 68.451

TOTAL RAINFALL (mm)= 113.510
RUNOFF COEFFICIENT = 0.603

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

| CALIB |
| STANDHYD (1001)| Area (ha)= 10.47
|ID= 1 DT= 5.0 min | Total Imp(%)= 66.90 Dir. Conn.(%)= 66.90

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	7.00	3.47
Dep. Storage	(mm)=	1.00	5.00
Average Slope	(%)=	1.00	2.00
Length	(m)=	264.20	40.00
Mannings n	=	0.013	0.250

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	1.25	6.083	2.27	12.083	16.35	18.08	2.04
0.167	1.25	6.167	2.27	12.167	16.34	18.17	2.04
0.250	1.25	6.250	2.27	12.250	16.34	18.25	2.04
0.333	1.25	6.333	2.27	12.333	16.34	18.33	2.04
0.417	1.25	6.417	2.27	12.417	16.34	18.42	2.04
0.500	1.25	6.500	2.27	12.500	16.34	18.50	2.04
0.583	1.25	6.583	2.27	12.583	8.40	18.58	2.04
0.667	1.25	6.667	2.27	12.667	8.40	18.67	2.04
0.750	1.25	6.750	2.27	12.750	8.40	18.75	2.04
0.833	1.25	6.833	2.27	12.833	8.40	18.83	2.04
0.917	1.25	6.917	2.27	12.917	8.40	18.92	2.04
1.000	1.25	7.000	2.27	13.000	8.40	19.00	2.04
1.083	1.25	7.083	2.27	13.083	1.59	19.08	2.04
1.167	1.25	7.167	2.27	13.167	1.59	19.17	2.04
1.250	1.25	7.250	2.27	13.250	1.59	19.25	2.04
1.333	1.25	7.333	2.27	13.333	1.59	19.33	2.04
1.417	1.25	7.417	2.27	13.417	1.59	19.42	2.04
1.500	1.25	7.500	2.27	13.500	1.59	19.50	2.04
1.583	1.25	7.583	2.27	13.583	9.31	19.58	2.04
1.667	1.25	7.667	2.27	13.667	9.31	19.67	2.04
1.750	1.25	7.750	2.27	13.750	9.31	19.75	2.04
1.833	1.25	7.833	2.27	13.833	9.31	19.83	2.04
1.917	1.25	7.917	2.27	13.917	9.31	19.92	2.04

2.000	1.25	8.000	2.27	14.000	9.31	20.00	2.04
2.083	1.48	8.083	3.06	14.083	3.41	20.08	1.36
2.167	1.48	8.167	3.06	14.167	3.41	20.17	1.36
2.250	1.48	8.250	3.06	14.250	3.41	20.25	1.36
2.333	1.48	8.333	3.06	14.333	3.41	20.33	1.36
2.417	1.48	8.417	3.06	14.417	3.41	20.42	1.36
2.500	1.48	8.500	3.06	14.500	3.41	20.50	1.36
2.583	1.48	8.583	3.06	14.583	3.41	20.58	1.36
2.667	1.48	8.667	3.06	14.667	3.41	20.67	1.36
2.750	1.48	8.750	3.06	14.750	3.41	20.75	1.36
2.833	1.48	8.833	3.06	14.833	3.41	20.83	1.36
2.917	1.48	8.917	3.06	14.917	3.41	20.92	1.36
3.000	1.48	9.000	3.06	15.000	3.41	21.00	1.36
3.083	1.48	9.083	3.63	15.083	3.41	21.08	1.36
3.167	1.48	9.167	3.63	15.167	3.41	21.17	1.36
3.250	1.48	9.250	3.63	15.250	3.41	21.25	1.36
3.333	1.48	9.333	3.63	15.333	3.41	21.33	1.36
3.417	1.48	9.417	3.63	15.417	3.41	21.42	1.36
3.500	1.48	9.500	3.63	15.500	3.41	21.50	1.36
3.583	1.48	9.583	4.09	15.583	3.41	21.58	1.36
3.667	1.48	9.667	4.09	15.667	3.41	21.67	1.36
3.750	1.48	9.750	4.09	15.750	3.41	21.75	1.36
3.833	1.48	9.833	4.09	15.833	3.41	21.83	1.36
3.917	1.48	9.917	4.09	15.917	3.41	21.92	1.36
4.000	1.48	10.000	4.09	16.000	3.41	22.00	1.36
4.083	1.82	10.083	5.22	16.083	2.04	22.08	1.36
4.167	1.82	10.167	5.22	16.167	2.04	22.17	1.36
4.250	1.82	10.250	5.22	16.250	2.04	22.25	1.36
4.333	1.82	10.333	5.22	16.333	2.04	22.33	1.36
4.417	1.82	10.417	5.22	16.417	2.04	22.42	1.36
4.500	1.82	10.500	5.22	16.500	2.04	22.50	1.36
4.583	1.82	10.583	7.04	16.583	2.04	22.58	1.36
4.667	1.82	10.667	7.04	16.667	2.04	22.67	1.36
4.750	1.82	10.750	7.04	16.750	2.04	22.75	1.36
4.833	1.82	10.833	7.04	16.833	2.04	22.83	1.36
4.917	1.82	10.917	7.04	16.917	2.04	22.92	1.36
5.000	1.82	11.000	7.04	17.000	2.04	23.00	1.36
5.083	1.82	11.083	10.90	17.083	2.04	23.08	1.36
5.167	1.82	11.167	10.90	17.167	2.04	23.17	1.36
5.250	1.82	11.250	10.90	17.250	2.04	23.25	1.36
5.333	1.82	11.333	10.90	17.333	2.04	23.33	1.36
5.417	1.82	11.417	10.90	17.417	2.04	23.42	1.36
5.500	1.82	11.500	10.90	17.500	2.04	23.50	1.36
5.583	1.82	11.583	47.22	17.583	2.04	23.58	1.36
5.667	1.82	11.667	47.22	17.667	2.04	23.67	1.36
5.750	1.82	11.750	47.22	17.750	2.04	23.75	1.36
5.833	1.82	11.833	125.29	17.833	2.04	23.83	1.36

```
              5.917    1.82 |11.917  125.30 |17.917    2.04 | 23.92    1.36
              6.000    1.82 |12.000  125.30 |18.000    2.04 | 24.00    1.36

     Max.Eff.Inten.(mm/hr)=     125.30        91.84
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       4.18 (ii)    9.05 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.24         0.12
                                                          *TOTALS*
     PEAK FLOW       (cms)=       2.40         0.68         3.074 (iii)
     TIME TO PEAK    (hrs)=      12.00        12.00         12.00
     RUNOFF VOLUME    (mm)=     112.51        68.45         97.93
     TOTAL RAINFALL   (mm)=     113.51       113.51        113.51
     RUNOFF COEFFICIENT   =       0.99         0.60          0.86

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1101)|
| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      3.07      12.00   97.93
     ==================================================
     MAJOR SYS.(ID= 2):   1.18      1.59      12.00   97.93
     MINOR SYS.(ID= 3):   9.29      1.48      11.83   97.93

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       8.68         6.42
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
```



```
     Length           (m)=     317.28        40.00
     Mannings n          =      0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                             ---- TRANSFORMED HYETOGRAPH ----
                    TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                     hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
                   0.083    1.25 | 6.083    2.27 |12.083   16.35 | 18.08    2.04
                   0.167    1.25 | 6.167    2.27 |12.167   16.34 | 18.17    2.04
                   0.250    1.25 | 6.250    2.27 |12.250   16.34 | 18.25    2.04
                   0.333    1.25 | 6.333    2.27 |12.333   16.34 | 18.33    2.04
                   0.417    1.25 | 6.417    2.27 |12.417   16.34 | 18.42    2.04
                   0.500    1.25 | 6.500    2.27 |12.500   16.34 | 18.50    2.04
                   0.583    1.25 | 6.583    2.27 |12.583    8.40 | 18.58    2.04
                   0.667    1.25 | 6.667    2.27 |12.667    8.40 | 18.67    2.04
                   0.750    1.25 | 6.750    2.27 |12.750    8.40 | 18.75    2.04
                   0.833    1.25 | 6.833    2.27 |12.833    8.40 | 18.83    2.04
                   0.917    1.25 | 6.917    2.27 |12.917    8.40 | 18.92    2.04
                   1.000    1.25 | 7.000    2.27 |13.000    8.40 | 19.00    2.04
                   1.083    1.25 | 7.083    2.27 |13.083    1.59 | 19.08    2.04
                   1.167    1.25 | 7.167    2.27 |13.167    1.59 | 19.17    2.04
                   1.250    1.25 | 7.250    2.27 |13.250    1.59 | 19.25    2.04
                   1.333    1.25 | 7.333    2.27 |13.333    1.59 | 19.33    2.04
                   1.417    1.25 | 7.417    2.27 |13.417    1.59 | 19.42    2.04
                   1.500    1.25 | 7.500    2.27 |13.500    1.59 | 19.50    2.04
                   1.583    1.25 | 7.583    2.27 |13.583    9.31 | 19.58    2.04
                   1.667    1.25 | 7.667    2.27 |13.667    9.31 | 19.67    2.04
                   1.750    1.25 | 7.750    2.27 |13.750    9.31 | 19.75    2.04
                   1.833    1.25 | 7.833    2.27 |13.833    9.31 | 19.83    2.04
                   1.917    1.25 | 7.917    2.27 |13.917    9.31 | 19.92    2.04
                   2.000    1.25 | 8.000    2.27 |14.000    9.31 | 20.00    2.04
                   2.083    1.48 | 8.083    3.06 |14.083    3.41 | 20.08    1.36
                   2.167    1.48 | 8.167    3.06 |14.167    3.41 | 20.17    1.36
                   2.250    1.48 | 8.250    3.06 |14.250    3.41 | 20.25    1.36
                   2.333    1.48 | 8.333    3.06 |14.333    3.41 | 20.33    1.36
                   2.417    1.48 | 8.417    3.06 |14.417    3.41 | 20.42    1.36
                   2.500    1.48 | 8.500    3.06 |14.500    3.41 | 20.50    1.36
                   2.583    1.48 | 8.583    3.06 |14.583    3.41 | 20.58    1.36
                   2.667    1.48 | 8.667    3.06 |14.667    3.41 | 20.67    1.36
                   2.750    1.48 | 8.750    3.06 |14.750    3.41 | 20.75    1.36
                   2.833    1.48 | 8.833    3.06 |14.833    3.41 | 20.83    1.36
                   2.917    1.48 | 8.917    3.06 |14.917    3.41 | 20.92    1.36
                   3.000    1.48 | 9.000    3.06 |15.000    3.41 | 21.00    1.36
                   3.083    1.48 | 9.083    3.63 |15.083    3.41 | 21.08    1.36
                   3.167    1.48 | 9.167    3.63 |15.167    3.41 | 21.17    1.36
```



```
              3.250    1.48 | 9.250    3.63 |15.250    3.41 | 21.25    1.36
              3.333    1.48 | 9.333    3.63 |15.333    3.41 | 21.33    1.36
              3.417    1.48 | 9.417    3.63 |15.417    3.41 | 21.42    1.36
              3.500    1.48 | 9.500    3.63 |15.500    3.41 | 21.50    1.36
              3.583    1.48 | 9.583    4.09 |15.583    3.41 | 21.58    1.36
              3.667    1.48 | 9.667    4.09 |15.667    3.41 | 21.67    1.36
              3.750    1.48 | 9.750    4.09 |15.750    3.41 | 21.75    1.36
              3.833    1.48 | 9.833    4.09 |15.833    3.41 | 21.83    1.36
              3.917    1.48 | 9.917    4.09 |15.917    3.41 | 21.92    1.36
              4.000    1.48 |10.000    4.09 |16.000    3.41 | 22.00    1.36
              4.083    1.82 |10.083    5.22 |16.083    2.04 | 22.08    1.36
              4.167    1.82 |10.167    5.22 |16.167    2.04 | 22.17    1.36
              4.250    1.82 |10.250    5.22 |16.250    2.04 | 22.25    1.36
              4.333    1.82 |10.333    5.22 |16.333    2.04 | 22.33    1.36
              4.417    1.82 |10.417    5.22 |16.417    2.04 | 22.42    1.36
              4.500    1.82 |10.500    5.22 |16.500    2.04 | 22.50    1.36
              4.583    1.82 |10.583    7.04 |16.583    2.04 | 22.58    1.36
              4.667    1.82 |10.667    7.04 |16.667    2.04 | 22.67    1.36
              4.750    1.82 |10.750    7.04 |16.750    2.04 | 22.75    1.36
              4.833    1.82 |10.833    7.04 |16.833    2.04 | 22.83    1.36
              4.917    1.82 |10.917    7.04 |16.917    2.04 | 22.92    1.36
              5.000    1.82 |11.000    7.04 |17.000    2.04 | 23.00    1.36
              5.083    1.82 |11.083   10.90 |17.083    2.04 | 23.08    1.36
              5.167    1.82 |11.167   10.90 |17.167    2.04 | 23.17    1.36
              5.250    1.82 |11.250   10.90 |17.250    2.04 | 23.25    1.36
              5.333    1.82 |11.333   10.90 |17.333    2.04 | 23.33    1.36
              5.417    1.82 |11.417   10.90 |17.417    2.04 | 23.42    1.36
              5.500    1.82 |11.500   10.90 |17.500    2.04 | 23.50    1.36
              5.583    1.82 |11.583   47.22 |17.583    2.04 | 23.58    1.36
              5.667    1.82 |11.667   47.22 |17.667    2.04 | 23.67    1.36
              5.750    1.82 |11.750   47.22 |17.750    2.04 | 23.75    1.36
              5.833    1.82 |11.833  125.29 |17.833    2.04 | 23.83    1.36
              5.917    1.82 |11.917  125.30 |17.917    2.04 | 23.92    1.36
              6.000    1.82 |12.000  125.30 |18.000    2.04 | 24.00    1.36

     Max.Eff.Inten.(mm/hr)=     125.30        91.84
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.67 (ii)   11.97 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.22         0.09
                                                          *TOTALS*
     PEAK FLOW       (cms)=       2.94         1.07         3.910 (iii)
     TIME TO PEAK    (hrs)=      12.00        12.08         12.00
     RUNOFF VOLUME    (mm)=     112.51        68.45         93.78
     TOTAL RAINFALL   (mm)=     113.51       113.51        113.51
     RUNOFF COEFFICIENT   =       0.99         0.60          0.83
```



```
***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

--------------------------------------------------------------------------------
--------------------
| DUHYD    (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      3.91      12.00   93.78
     ==================================================
     MAJOR SYS.(ID= 2):   1.70      2.11      12.00   93.78
     MINOR SYS.(ID= 3):  13.40      1.80      11.83   93.78

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     9.29   1.484    11.83    97.93
      + ID2= 2 (  1102):    13.40   1.796    11.83    93.78
        ===================================================
        ID = 3 (  1103):    22.69   3.280    11.83    95.48

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1003):     7.60   0.423    12.92    68.45
      + ID2= 2 (  1103):    22.69   3.280    11.83    95.48
        ===================================================
        ID = 3 (  1105):    30.29   3.454    12.08    88.70

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
```

```
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730     0.9730
                          0.0140     0.1150   |   0.1410     1.1060
                          0.0280     0.2300   |   0.7220     1.2390
                          0.0390     0.3450   |   1.1780     1.5960
                          0.0480     0.4600   |   1.3260     1.9530
                          0.0520     0.5170   |   1.4580     2.3350
                          0.0550     0.5750   |   1.5800     2.7180
                          0.0620     0.7080   |   1.6920     3.1260
                          0.0680     0.8410   |   1.7980     3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     30.290      3.454     12.08      88.70
   OUTFLOW: ID= 1 (  1106)     30.290      0.872     13.08      88.60

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 25.24
                   TIME SHIFT OF PEAK FLOW         (min)= 60.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  1.3579

------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     1.18   1.590    12.00    97.93
      + ID2= 2 (  1102):     1.70   2.114    12.00    93.78
        ====================================================
        ID = 3 (  1104):     2.88   3.704    12.00    95.48

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1104):     2.88   3.704    12.00    95.48
      + ID2= 2 (  1106):    30.29   0.872    13.08    88.60
        ====================================================
        ID = 3 (  1107):    33.17   3.776    12.00    89.20
```



```
     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
------------------------------------------------------------------------------
```

```
=====================================================================================
========================

       V    V   I    SSSSS  U    U    A    L              (v 6.2.2001)
       V    V   I    SS     U    U   A A   L
        V  V    I     SS    U    U  AAAAA  L
        V  V    I      SS   U    U  A   A  L
         VV     I    SSSSS  UUUUU  A    A  LLLLL

        OOO   TTTTT  TTTTT  H   H  Y   Y  M   M   OOO    TM
       O   O    T      T    H   H   Y Y   MM MM  O   O
       O   O    T      T    H   H    Y    M   M  O   O
        OOO     T      T    H   H    Y    M   M   OOO
```

Developed and Distributed by Smart City Water Inc

***** D E T A I L E D   O U T P U T *****

Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat

Output filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\d7f602
84-f211-4f5d-b9fb-cc876b356ee7\scenar
Summary filename:
C:\Users\zhouj\AppData\Local\Civica\VH5\642fa701-08f9-4281-a674-e9ad409f1aac\d7f602
84-f211-4f5d-b9fb-cc876b356ee7\scenar

DATE: 01-12-2023   TIME: 11:32:43

USER:

COMMENTS: ____

```
-------------------------------------------------------------------------------------
------------------------
  ************************************************
  ** SIMULATION : Run 06                        **
  ************************************************
```



```
--------------------
|    READ STORM    |    Filename: C:\Users\zhouj\AppD
|                  |              ata\Local\Temp\
|                  |              d2870494-74fa-435e-8860-3b342214a80d\81c039b0
| Ptotal=285.00 mm |    Comments: Regional Storm (48hr )
--------------------
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
1.00	2.00	13.00	2.00	25.00	2.00	37.00	6.00
2.00	2.00	14.00	2.00	26.00	2.00	38.00	4.00
3.00	2.00	15.00	2.00	27.00	2.00	39.00	6.00
4.00	2.00	16.00	2.00	28.00	2.00	40.00	13.00
5.00	2.00	17.00	2.00	29.00	2.00	41.00	17.00
6.00	2.00	18.00	2.00	30.00	2.00	42.00	13.00
7.00	2.00	19.00	2.00	31.00	2.00	43.00	23.00
8.00	2.00	20.00	2.00	32.00	2.00	44.00	13.00
9.00	2.00	21.00	2.00	33.00	2.00	45.00	13.00
10.00	2.00	22.00	2.00	34.00	2.00	46.00	53.00
11.00	2.00	23.00	2.00	35.00	2.00	47.00	38.00
12.00	2.00	24.00	2.00	36.00	3.00	48.00	13.00

```
--------------------------------------------------------------------------------

--------------------
| CALIB            |
| STANDHYD ( 1004)|   Area    (ha)=  23.05
|ID= 1 DT= 5.0 min |   Total Imp(%)=  60.40   Dir. Conn.(%)=  60.40
--------------------
```

		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	13.92	9.13
Dep. Storage	(mm)=	1.00	5.00
Average Slope	(%)=	1.00	2.00
Length	(m)=	392.00	40.00
Mannings n	=	0.013	0.250

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00

0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00

4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00

8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

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Max.Eff.Inten.(mm/hr)=      53.00        50.42
           over (min)        5.00        20.00
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Storage Coeff.  (min)=      7.47 (ii)   16.76 (ii)
Unit Hyd. Tpeak (min)=      5.00        20.00
Unit Hyd. peak  (cms)=      0.17         0.06
                                                  *TOTALS*
PEAK FLOW       (cms)=      2.05         1.22        3.272 (iii)
TIME TO PEAK    (hrs)=     46.00        46.00        46.00
RUNOFF VOLUME    (mm)=    284.00       228.24       261.92
TOTAL RAINFALL   (mm)=    285.00       285.00       285.00
RUNOFF COEFFICIENT   =      1.00         0.80         0.92

  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN* =  80.0    Ia = Dep. Storage  (Above)
 (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
--------------------
| DUHYD    (  1401)|
| Inlet Cap.= 2.767|
| #of Inlets=     1|
| Total(cms)=   2.8|     AREA     QPEAK     TPEAK    R.V.
--------------------     (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  23.05      3.27     46.00  261.92
     ==================================================
     MAJOR SYS.(ID= 2):   0.37      0.51     46.00  261.92
     MINOR SYS.(ID= 3):  22.68      2.77     45.42  261.92

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1403)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |   OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |    (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710      0.6240
                          0.0070     0.1010   |   2.8490      0.7400
                          0.0240     0.2030   |   4.3610      0.8560
                          0.0330     0.3040   |   6.0740      0.9730
                          0.0400     0.4060   |   7.9690      1.0890
                          0.5830     0.5070   |   0.0000      0.0000

                               AREA     QPEAK     TPEAK       R.V.
                               (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1401)     22.684     2.767     45.42     261.92
```



```
   OUTFLOW: ID= 1 (  1403)     22.684      2.729     46.25     261.29

                 PEAK   FLOW   REDUCTION [Qout/Qin](%)= 98.63
                 TIME SHIFT OF PEAK FLOW         (min)= 50.00
                 MAXIMUM  STORAGE   USED       (ha.m.)=  0.7295

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--------------------
| ADD HYD  (  1402)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  1401):     0.37   0.505    46.00   261.92
     + ID2= 2 (  1403):    22.68   2.729    46.25   261.29
       ==================================================
       ID = 3 (  1402):    23.05   3.194    46.00   261.30

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
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--------------------
| CALIB            |
| NASHYD   (  2010)|   Area    (ha)=  12.18   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=  10.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.11

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	' TIME ' hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00

1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00

5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00

9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

```
Unit Hyd Qpeak  (cms)=   0.419

PEAK FLOW       (cms)=   1.208 (i)
TIME TO PEAK    (hrs)=  47.250
RUNOFF VOLUME    (mm)= 223.412
TOTAL RAINFALL   (mm)= 285.001
RUNOFF COEFFICIENT   =   0.784

(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.
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| CALIB              |
| STANDHYD (  2002)|   Area    (ha)=  14.51
|ID= 1 DT= 5.0 min |   Total Imp(%)=  56.10   Dir. Conn.(%)=  56.10
--------------------
                         IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      8.14          6.37
     Dep. Storage     (mm)=      1.00          5.00
     Average Slope     (%)=      1.00          2.00
     Length            (m)=    311.02         40.00
     Mannings n          =      0.013         0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
```

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	' TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00

2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00

6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00

10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

```
Max.Eff.Inten.(mm/hr)=      53.00        50.42
           over (min)        5.00        20.00
Storage Coeff.  (min)=       6.51 (ii)   15.79 (ii)
Unit Hyd. Tpeak (min)=       5.00        20.00
Unit Hyd. peak  (cms)=       0.18         0.07
                                                     *TOTALS*
PEAK FLOW       (cms)=       1.20         0.86         2.057 (iii)
TIME TO PEAK    (hrs)=      46.00        46.00        46.00
RUNOFF VOLUME    (mm)=     284.00       228.24       259.52
TOTAL RAINFALL   (mm)=     285.00       285.00       285.00
RUNOFF COEFFICIENT   =       1.00         0.80         0.91

  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
       CN* =  80.0    Ia = Dep. Storage  (Above)
 (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------

--------------------
| ADD HYD  (  2202)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  2002):    14.51   2.057    46.00   259.52
```



```
      + ID2= 2 (  2010):    12.18   1.208    47.25   223.41
        ===================================================
        ID = 3 (  2202):    26.69   2.851    46.00   243.04

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 2203)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |      OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------       (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000    |   1.2130     0.9700
                          0.0110     0.1350    |   1.6800     1.1170
                          0.0220     0.2700    |   2.1950     1.2650
                          0.0300     0.4050    |   2.7540     1.4120
                          0.1810     0.5400    |   6.1220     2.1920
                          0.4520     0.6750    |  10.2830     3.0160
                          0.8010     0.8230    |   0.0000     0.0000

                                AREA      QPEAK      TPEAK       R.V.
                                (ha)      (cms)      (hrs)       (mm)
   INFLOW : ID= 2 (  2202)     26.690      2.851     46.00     243.04
   OUTFLOW: ID= 1 (  2203)     26.690      2.492     47.08     242.43

                 PEAK   FLOW   REDUCTION [Qout/Qin](%)= 87.42
                 TIME SHIFT OF PEAK FLOW         (min)= 65.00
                 MAXIMUM  STORAGE   USED       (ha.m.)=  1.3447

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD ( 2001)|    Area    (ha)=  17.75
|ID= 1 DT= 5.0 min |    Total Imp(%)=  58.40   Dir. Conn.(%)=  58.40
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      10.37         7.38
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     344.00        40.00
     Mannings n          =       0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                                  ---- TRANSFORMED HYETOGRAPH ----
```

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	' TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr

0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00

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 4.000    2.00 |16.000    2.00 |28.000    2.00 |  40.00   13.00
 4.083    2.00 |16.083    2.00 |28.083    2.00 |  40.08   17.00
 4.167    2.00 |16.167    2.00 |28.167    2.00 |  40.17   17.00
 4.250    2.00 |16.250    2.00 |28.250    2.00 |  40.25   17.00
 4.333    2.00 |16.333    2.00 |28.333    2.00 |  40.33   17.00
 4.417    2.00 |16.417    2.00 |28.417    2.00 |  40.42   17.00
 4.500    2.00 |16.500    2.00 |28.500    2.00 |  40.50   17.00
 4.583    2.00 |16.583    2.00 |28.583    2.00 |  40.58   17.00
 4.667    2.00 |16.667    2.00 |28.667    2.00 |  40.67   17.00
 4.750    2.00 |16.750    2.00 |28.750    2.00 |  40.75   17.00
 4.833    2.00 |16.833    2.00 |28.833    2.00 |  40.83   17.00
 4.917    2.00 |16.917    2.00 |28.917    2.00 |  40.92   17.00
 5.000    2.00 |17.000    2.00 |29.000    2.00 |  41.00   17.00
 5.083    2.00 |17.083    2.00 |29.083    2.00 |  41.08   13.00
 5.167    2.00 |17.167    2.00 |29.167    2.00 |  41.17   13.00
 5.250    2.00 |17.250    2.00 |29.250    2.00 |  41.25   13.00
 5.333    2.00 |17.333    2.00 |29.333    2.00 |  41.33   13.00
 5.417    2.00 |17.417    2.00 |29.417    2.00 |  41.42   13.00
 5.500    2.00 |17.500    2.00 |29.500    2.00 |  41.50   13.00
 5.583    2.00 |17.583    2.00 |29.583    2.00 |  41.58   13.00
 5.667    2.00 |17.667    2.00 |29.667    2.00 |  41.67   13.00
 5.750    2.00 |17.750    2.00 |29.750    2.00 |  41.75   13.00
 5.833    2.00 |17.833    2.00 |29.833    2.00 |  41.83   13.00
 5.917    2.00 |17.917    2.00 |29.917    2.00 |  41.92   13.00
 6.000    2.00 |18.000    2.00 |30.000    2.00 |  42.00   13.00
 6.083    2.00 |18.083    2.00 |30.083    2.00 |  42.08   22.99
 6.167    2.00 |18.167    2.00 |30.167    2.00 |  42.17   23.00
 6.250    2.00 |18.250    2.00 |30.250    2.00 |  42.25   23.00
 6.333    2.00 |18.333    2.00 |30.333    2.00 |  42.33   23.00
 6.417    2.00 |18.417    2.00 |30.417    2.00 |  42.42   23.00
 6.500    2.00 |18.500    2.00 |30.500    2.00 |  42.50   23.00
 6.583    2.00 |18.583    2.00 |30.583    2.00 |  42.58   23.00
 6.667    2.00 |18.667    2.00 |30.667    2.00 |  42.67   23.00
 6.750    2.00 |18.750    2.00 |30.750    2.00 |  42.75   23.00
 6.833    2.00 |18.833    2.00 |30.833    2.00 |  42.83   23.00
 6.917    2.00 |18.917    2.00 |30.917    2.00 |  42.92   23.00
 7.000    2.00 |19.000    2.00 |31.000    2.00 |  43.00   23.00
 7.083    2.00 |19.083    2.00 |31.083    2.00 |  43.08   13.01
 7.167    2.00 |19.167    2.00 |31.167    2.00 |  43.17   13.00
 7.250    2.00 |19.250    2.00 |31.250    2.00 |  43.25   13.00
 7.333    2.00 |19.333    2.00 |31.333    2.00 |  43.33   13.00
 7.417    2.00 |19.417    2.00 |31.417    2.00 |  43.42   13.00
 7.500    2.00 |19.500    2.00 |31.500    2.00 |  43.50   13.00
 7.583    2.00 |19.583    2.00 |31.583    2.00 |  43.58   13.00
 7.667    2.00 |19.667    2.00 |31.667    2.00 |  43.67   13.00
 7.750    2.00 |19.750    2.00 |31.750    2.00 |  43.75   13.00
 7.833    2.00 |19.833    2.00 |31.833    2.00 |  43.83   13.00
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 7.917    2.00 |19.917    2.00 |31.917    2.00 |  43.92   13.00
 8.000    2.00 |20.000    2.00 |32.000    2.00 |  44.00   13.00
 8.083    2.00 |20.083    2.00 |32.083    2.00 |  44.08   13.00
 8.167    2.00 |20.167    2.00 |32.167    2.00 |  44.17   13.00
 8.250    2.00 |20.250    2.00 |32.250    2.00 |  44.25   13.00
 8.333    2.00 |20.333    2.00 |32.333    2.00 |  44.33   13.00
 8.417    2.00 |20.417    2.00 |32.417    2.00 |  44.42   13.00
 8.500    2.00 |20.500    2.00 |32.500    2.00 |  44.50   13.00
 8.583    2.00 |20.583    2.00 |32.583    2.00 |  44.58   13.00
 8.667    2.00 |20.667    2.00 |32.667    2.00 |  44.67   13.00
 8.750    2.00 |20.750    2.00 |32.750    2.00 |  44.75   13.00
 8.833    2.00 |20.833    2.00 |32.833    2.00 |  44.83   13.00
 8.917    2.00 |20.917    2.00 |32.917    2.00 |  44.92   13.00
 9.000    2.00 |21.000    2.00 |33.000    2.00 |  45.00   13.00
 9.083    2.00 |21.083    2.00 |33.083    2.00 |  45.08   52.95
 9.167    2.00 |21.167    2.00 |33.167    2.00 |  45.17   53.00
 9.250    2.00 |21.250    2.00 |33.250    2.00 |  45.25   53.00
 9.333    2.00 |21.333    2.00 |33.333    2.00 |  45.33   53.00
 9.417    2.00 |21.417    2.00 |33.417    2.00 |  45.42   53.00
 9.500    2.00 |21.500    2.00 |33.500    2.00 |  45.50   53.00
 9.583    2.00 |21.583    2.00 |33.583    2.00 |  45.58   53.00
 9.667    2.00 |21.667    2.00 |33.667    2.00 |  45.67   53.00
 9.750    2.00 |21.750    2.00 |33.750    2.00 |  45.75   53.00
 9.833    2.00 |21.833    2.00 |33.833    2.00 |  45.83   53.00
 9.917    2.00 |21.917    2.00 |33.917    2.00 |  45.92   53.00
10.000    2.00 |22.000    2.00 |34.000    2.00 |  46.00   53.00
10.083    2.00 |22.083    2.00 |34.083    2.00 |  46.08   38.02
10.167    2.00 |22.167    2.00 |34.167    2.00 |  46.17   38.00
10.250    2.00 |22.250    2.00 |34.250    2.00 |  46.25   38.00
10.333    2.00 |22.333    2.00 |34.333    2.00 |  46.33   38.00
10.417    2.00 |22.417    2.00 |34.417    2.00 |  46.42   38.00
10.500    2.00 |22.500    2.00 |34.500    2.00 |  46.50   38.00
10.583    2.00 |22.583    2.00 |34.583    2.00 |  46.58   38.00
10.667    2.00 |22.667    2.00 |34.667    2.00 |  46.67   38.00
10.750    2.00 |22.750    2.00 |34.750    2.00 |  46.75   38.00
10.833    2.00 |22.833    2.00 |34.833    2.00 |  46.83   38.00
10.917    2.00 |22.917    2.00 |34.917    2.00 |  46.92   38.00
11.000    2.00 |23.000    2.00 |35.000    2.00 |  47.00   38.00
11.083    2.00 |23.083    2.00 |35.083    3.00 |  47.08   13.04
11.167    2.00 |23.167    2.00 |35.167    3.00 |  47.17   13.00
11.250    2.00 |23.250    2.00 |35.250    3.00 |  47.25   13.00
11.333    2.00 |23.333    2.00 |35.333    3.00 |  47.33   13.00
11.417    2.00 |23.417    2.00 |35.417    3.00 |  47.42   13.00
11.500    2.00 |23.500    2.00 |35.500    3.00 |  47.50   13.00
11.583    2.00 |23.583    2.00 |35.583    3.00 |  47.58   13.00
11.667    2.00 |23.667    2.00 |35.667    3.00 |  47.67   13.00
11.750    2.00 |23.750    2.00 |35.750    3.00 |  47.75   13.00
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    11.833    2.00 |23.833    2.00 |35.833    3.00 |  47.83   13.00
    11.917    2.00 |23.917    2.00 |35.917    3.00 |  47.92   13.00
    12.000    2.00 |24.000    2.00 |36.000    3.00 |  48.00   13.00

 Max.Eff.Inten.(mm/hr)=      53.00        50.42
            over (min)        5.00        20.00
 Storage Coeff.  (min)=       6.91 (ii)   16.19 (ii)
 Unit Hyd. Tpeak (min)=       5.00        20.00
 Unit Hyd. peak  (cms)=       0.17         0.06
                                                      *TOTALS*
 PEAK FLOW       (cms)=       1.53         0.99          2.519 (iii)
 TIME TO PEAK    (hrs)=      46.00        46.00         46.00
 RUNOFF VOLUME    (mm)=     284.00       228.24        260.80
 TOTAL RAINFALL   (mm)=     285.00       285.00        285.00
 RUNOFF COEFFICIENT   =       1.00         0.80          0.92


   (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
        CN* =  80.0    Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
       THAN THE STORAGE COEFFICIENT.
 (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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--------------------
| DUHYD    (  2101)|
| Inlet Cap.= 2.740|
| #of Inlets=     1|
| Total(cms)=   2.7|     AREA     QPEAK     TPEAK    R.V.
--------------------     (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  17.75      2.52     46.00  260.80
     ====================================================
     MAJOR SYS.(ID= 2):   0.00      0.00      0.00    0.00
     MINOR SYS.(ID= 3):  17.75      2.52     46.00  260.80

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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--------------------
| RESERVOIR(  4003)|     OVERFLOW IS OFF
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   1.5710     0.6240
                          0.0070     0.1010   |   2.8490     0.7400
                          0.0240     0.2030   |   4.3610     0.8560
                          0.0330     0.3040   |   6.0740     0.9730
```



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                          0.0400     0.4060   |   7.9690     1.0890
                          0.5830     0.5070   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  2101)     17.750     2.519     46.00     260.80
   OUTFLOW: ID= 1 (  4003)     17.750     2.375     46.08     260.00

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 94.30
                  TIME SHIFT OF PEAK FLOW        (min)=  5.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.6982

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--------------------
| ADD HYD  (  2102)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
*** W A R N I N G :  HYDROGRAPH   2101 <ID= 1> IS DRY.
*** W A R N I N G :  HYDROGRAPH   2102 = HYDROGRAPH 4003
       ID1= 1 (  2101):      0.00   0.000     0.00     0.00
     + ID2= 2 (  4003):    17.75   2.375    46.08   260.00
       ===============================================
       ID = 3 (  2102):    17.75   2.375    46.08   260.00

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
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--------------------
| CALIB            |
| STANDHYD (  2003)|   Area    (ha)=   3.22
|ID= 1 DT= 5.0 min |   Total Imp(%)=  50.60   Dir. Conn.(%)=  50.60
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.63         1.59
     Dep. Storage     (mm)=       1.00         5.00
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     146.52        40.00
     Mannings n          =       0.013        0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.


                              ---- TRANSFORMED HYETOGRAPH ----
                TIME    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
                 hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
               0.083    2.00 |12.083    2.00 |24.083    2.00 | 36.08    6.00
               0.167    2.00 |12.167    2.00 |24.167    2.00 | 36.17    6.00
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0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00

4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00

8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00

12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

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     Max.Eff.Inten.(mm/hr)=      53.00        50.42
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       4.14 (ii)   13.42 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.24         0.08
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.24         0.22          0.459 (iii)
     TIME TO PEAK    (hrs)=      46.00        46.00         46.00
     RUNOFF VOLUME    (mm)=     284.00       228.24        256.45
     TOTAL RAINFALL   (mm)=     285.00       285.00        285.00
     RUNOFF COEFFICIENT   =       1.00         0.80          0.90

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  80.0    Ia = Dep. Storage  (Above)
      (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
           THAN THE STORAGE COEFFICIENT.
     (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

------------------------------------------------------------------------------
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| CALIB              |
| NASHYD   (  1003)|   Area    (ha)=   7.60   Curve Number   (CN)= 80.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   1.01

    NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
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---- TRANSFORMED HYETOGRAPH ----

TIME	RAIN	TIME	RAIN	' TIME	RAIN	TIME	RAIN
hrs	mm/hr	hrs	mm/hr	' hrs	mm/hr	hrs	mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00

1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00

5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00

8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

```
Unit Hyd Qpeak  (cms)=   0.287

PEAK FLOW       (cms)=   0.779 (i)
TIME TO PEAK    (hrs)=  47.167
RUNOFF VOLUME    (mm)= 228.239
TOTAL RAINFALL   (mm)= 285.001
RUNOFF COEFFICIENT  =    0.801
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(i) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| CALIB              |
| STANDHYD (  1001)|   Area    (ha)=  10.47
|ID= 1 DT= 5.0 min |   Total Imp(%)=  66.90   Dir. Conn.(%)=  66.90
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		IMPERVIOUS	PERVIOUS (i)
Surface Area	(ha)=	7.00	3.47
Dep. Storage	(mm)=	1.00	5.00
Average Slope	(%)=	1.00	2.00
Length	(m)=	264.20	40.00
Mannings n	=	0.013	0.250

NOTE: RAINFALL WAS TRANSFORMED TO 5.0 MIN. TIME STEP.

---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00
1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00

2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00
5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99

6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00
9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00

10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

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Max.Eff.Inten.(mm/hr)=      53.00         50.42
          over (min)         5.00         20.00
Storage Coeff.  (min)=       5.90 (ii)    15.18 (ii)
Unit Hyd. Tpeak (min)=       5.00         20.00
Unit Hyd. peak  (cms)=       0.19          0.07
                                                       *TOTALS*
PEAK FLOW       (cms)=       1.03          0.47          1.500 (iii)
TIME TO PEAK    (hrs)=      46.00         46.00         46.00
RUNOFF VOLUME    (mm)=     284.00        228.24        265.54
TOTAL RAINFALL   (mm)=     285.00        285.00        285.00
RUNOFF COEFFICIENT   =       1.00          0.80          0.93


  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
       CN* =  80.0    Ia = Dep. Storage  (Above)
 (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
      THAN THE STORAGE COEFFICIENT.
(iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

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| DUHYD    (  1101)|
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| Inlet Cap.= 1.484|
| #of Inlets=     1|
| Total(cms)=   1.5|     AREA     QPEAK     TPEAK    R.V.
--------------------     (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  10.47      1.50     46.00  265.54
     ==================================================
     MAJOR SYS.(ID= 2):   0.00      0.02     46.00  265.54
     MINOR SYS.(ID= 3):  10.47      1.48     45.83  265.54

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

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| CALIB            |
| STANDHYD (  1002)|   Area    (ha)=  15.10
|ID= 1 DT= 5.0 min |   Total Imp(%)=  57.50   Dir. Conn.(%)=  57.50
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                        IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      8.68          6.42
     Dep. Storage     (mm)=      1.00          5.00
     Average Slope     (%)=      1.00          2.00
     Length            (m)=    317.28         40.00
     Mannings n          =     0.013         0.250

         NOTE:  RAINFALL WAS TRANSFORMED TO   5.0 MIN. TIME STEP.
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---- TRANSFORMED HYETOGRAPH ----

TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr	TIME hrs	RAIN mm/hr
0.083	2.00	12.083	2.00	24.083	2.00	36.08	6.00
0.167	2.00	12.167	2.00	24.167	2.00	36.17	6.00
0.250	2.00	12.250	2.00	24.250	2.00	36.25	6.00
0.333	2.00	12.333	2.00	24.333	2.00	36.33	6.00
0.417	2.00	12.417	2.00	24.417	2.00	36.42	6.00
0.500	2.00	12.500	2.00	24.500	2.00	36.50	6.00
0.583	2.00	12.583	2.00	24.583	2.00	36.58	6.00
0.667	2.00	12.667	2.00	24.667	2.00	36.67	6.00
0.750	2.00	12.750	2.00	24.750	2.00	36.75	6.00
0.833	2.00	12.833	2.00	24.833	2.00	36.83	6.00
0.917	2.00	12.917	2.00	24.917	2.00	36.92	6.00
1.000	2.00	13.000	2.00	25.000	2.00	37.00	6.00
1.083	2.00	13.083	2.00	25.083	2.00	37.08	4.00
1.167	2.00	13.167	2.00	25.167	2.00	37.17	4.00
1.250	2.00	13.250	2.00	25.250	2.00	37.25	4.00
1.333	2.00	13.333	2.00	25.333	2.00	37.33	4.00
1.417	2.00	13.417	2.00	25.417	2.00	37.42	4.00

1.500	2.00	13.500	2.00	25.500	2.00	37.50	4.00
1.583	2.00	13.583	2.00	25.583	2.00	37.58	4.00
1.667	2.00	13.667	2.00	25.667	2.00	37.67	4.00
1.750	2.00	13.750	2.00	25.750	2.00	37.75	4.00
1.833	2.00	13.833	2.00	25.833	2.00	37.83	4.00
1.917	2.00	13.917	2.00	25.917	2.00	37.92	4.00
2.000	2.00	14.000	2.00	26.000	2.00	38.00	4.00
2.083	2.00	14.083	2.00	26.083	2.00	38.08	6.00
2.167	2.00	14.167	2.00	26.167	2.00	38.17	6.00
2.250	2.00	14.250	2.00	26.250	2.00	38.25	6.00
2.333	2.00	14.333	2.00	26.333	2.00	38.33	6.00
2.417	2.00	14.417	2.00	26.417	2.00	38.42	6.00
2.500	2.00	14.500	2.00	26.500	2.00	38.50	6.00
2.583	2.00	14.583	2.00	26.583	2.00	38.58	6.00
2.667	2.00	14.667	2.00	26.667	2.00	38.67	6.00
2.750	2.00	14.750	2.00	26.750	2.00	38.75	6.00
2.833	2.00	14.833	2.00	26.833	2.00	38.83	6.00
2.917	2.00	14.917	2.00	26.917	2.00	38.92	6.00
3.000	2.00	15.000	2.00	27.000	2.00	39.00	6.00
3.083	2.00	15.083	2.00	27.083	2.00	39.08	13.00
3.167	2.00	15.167	2.00	27.167	2.00	39.17	13.00
3.250	2.00	15.250	2.00	27.250	2.00	39.25	13.00
3.333	2.00	15.333	2.00	27.333	2.00	39.33	13.00
3.417	2.00	15.417	2.00	27.417	2.00	39.42	13.00
3.500	2.00	15.500	2.00	27.500	2.00	39.50	13.00
3.583	2.00	15.583	2.00	27.583	2.00	39.58	13.00
3.667	2.00	15.667	2.00	27.667	2.00	39.67	13.00
3.750	2.00	15.750	2.00	27.750	2.00	39.75	13.00
3.833	2.00	15.833	2.00	27.833	2.00	39.83	13.00
3.917	2.00	15.917	2.00	27.917	2.00	39.92	13.00
4.000	2.00	16.000	2.00	28.000	2.00	40.00	13.00
4.083	2.00	16.083	2.00	28.083	2.00	40.08	17.00
4.167	2.00	16.167	2.00	28.167	2.00	40.17	17.00
4.250	2.00	16.250	2.00	28.250	2.00	40.25	17.00
4.333	2.00	16.333	2.00	28.333	2.00	40.33	17.00
4.417	2.00	16.417	2.00	28.417	2.00	40.42	17.00
4.500	2.00	16.500	2.00	28.500	2.00	40.50	17.00
4.583	2.00	16.583	2.00	28.583	2.00	40.58	17.00
4.667	2.00	16.667	2.00	28.667	2.00	40.67	17.00
4.750	2.00	16.750	2.00	28.750	2.00	40.75	17.00
4.833	2.00	16.833	2.00	28.833	2.00	40.83	17.00
4.917	2.00	16.917	2.00	28.917	2.00	40.92	17.00
5.000	2.00	17.000	2.00	29.000	2.00	41.00	17.00
5.083	2.00	17.083	2.00	29.083	2.00	41.08	13.00
5.167	2.00	17.167	2.00	29.167	2.00	41.17	13.00
5.250	2.00	17.250	2.00	29.250	2.00	41.25	13.00
5.333	2.00	17.333	2.00	29.333	2.00	41.33	13.00

5.417	2.00	17.417	2.00	29.417	2.00	41.42	13.00
5.500	2.00	17.500	2.00	29.500	2.00	41.50	13.00
5.583	2.00	17.583	2.00	29.583	2.00	41.58	13.00
5.667	2.00	17.667	2.00	29.667	2.00	41.67	13.00
5.750	2.00	17.750	2.00	29.750	2.00	41.75	13.00
5.833	2.00	17.833	2.00	29.833	2.00	41.83	13.00
5.917	2.00	17.917	2.00	29.917	2.00	41.92	13.00
6.000	2.00	18.000	2.00	30.000	2.00	42.00	13.00
6.083	2.00	18.083	2.00	30.083	2.00	42.08	22.99
6.167	2.00	18.167	2.00	30.167	2.00	42.17	23.00
6.250	2.00	18.250	2.00	30.250	2.00	42.25	23.00
6.333	2.00	18.333	2.00	30.333	2.00	42.33	23.00
6.417	2.00	18.417	2.00	30.417	2.00	42.42	23.00
6.500	2.00	18.500	2.00	30.500	2.00	42.50	23.00
6.583	2.00	18.583	2.00	30.583	2.00	42.58	23.00
6.667	2.00	18.667	2.00	30.667	2.00	42.67	23.00
6.750	2.00	18.750	2.00	30.750	2.00	42.75	23.00
6.833	2.00	18.833	2.00	30.833	2.00	42.83	23.00
6.917	2.00	18.917	2.00	30.917	2.00	42.92	23.00
7.000	2.00	19.000	2.00	31.000	2.00	43.00	23.00
7.083	2.00	19.083	2.00	31.083	2.00	43.08	13.01
7.167	2.00	19.167	2.00	31.167	2.00	43.17	13.00
7.250	2.00	19.250	2.00	31.250	2.00	43.25	13.00
7.333	2.00	19.333	2.00	31.333	2.00	43.33	13.00
7.417	2.00	19.417	2.00	31.417	2.00	43.42	13.00
7.500	2.00	19.500	2.00	31.500	2.00	43.50	13.00
7.583	2.00	19.583	2.00	31.583	2.00	43.58	13.00
7.667	2.00	19.667	2.00	31.667	2.00	43.67	13.00
7.750	2.00	19.750	2.00	31.750	2.00	43.75	13.00
7.833	2.00	19.833	2.00	31.833	2.00	43.83	13.00
7.917	2.00	19.917	2.00	31.917	2.00	43.92	13.00
8.000	2.00	20.000	2.00	32.000	2.00	44.00	13.00
8.083	2.00	20.083	2.00	32.083	2.00	44.08	13.00
8.167	2.00	20.167	2.00	32.167	2.00	44.17	13.00
8.250	2.00	20.250	2.00	32.250	2.00	44.25	13.00
8.333	2.00	20.333	2.00	32.333	2.00	44.33	13.00
8.417	2.00	20.417	2.00	32.417	2.00	44.42	13.00
8.500	2.00	20.500	2.00	32.500	2.00	44.50	13.00
8.583	2.00	20.583	2.00	32.583	2.00	44.58	13.00
8.667	2.00	20.667	2.00	32.667	2.00	44.67	13.00
8.750	2.00	20.750	2.00	32.750	2.00	44.75	13.00
8.833	2.00	20.833	2.00	32.833	2.00	44.83	13.00
8.917	2.00	20.917	2.00	32.917	2.00	44.92	13.00
9.000	2.00	21.000	2.00	33.000	2.00	45.00	13.00
9.083	2.00	21.083	2.00	33.083	2.00	45.08	52.95
9.167	2.00	21.167	2.00	33.167	2.00	45.17	53.00
9.250	2.00	21.250	2.00	33.250	2.00	45.25	53.00

9.333	2.00	21.333	2.00	33.333	2.00	45.33	53.00
9.417	2.00	21.417	2.00	33.417	2.00	45.42	53.00
9.500	2.00	21.500	2.00	33.500	2.00	45.50	53.00
9.583	2.00	21.583	2.00	33.583	2.00	45.58	53.00
9.667	2.00	21.667	2.00	33.667	2.00	45.67	53.00
9.750	2.00	21.750	2.00	33.750	2.00	45.75	53.00
9.833	2.00	21.833	2.00	33.833	2.00	45.83	53.00
9.917	2.00	21.917	2.00	33.917	2.00	45.92	53.00
10.000	2.00	22.000	2.00	34.000	2.00	46.00	53.00
10.083	2.00	22.083	2.00	34.083	2.00	46.08	38.02
10.167	2.00	22.167	2.00	34.167	2.00	46.17	38.00
10.250	2.00	22.250	2.00	34.250	2.00	46.25	38.00
10.333	2.00	22.333	2.00	34.333	2.00	46.33	38.00
10.417	2.00	22.417	2.00	34.417	2.00	46.42	38.00
10.500	2.00	22.500	2.00	34.500	2.00	46.50	38.00
10.583	2.00	22.583	2.00	34.583	2.00	46.58	38.00
10.667	2.00	22.667	2.00	34.667	2.00	46.67	38.00
10.750	2.00	22.750	2.00	34.750	2.00	46.75	38.00
10.833	2.00	22.833	2.00	34.833	2.00	46.83	38.00
10.917	2.00	22.917	2.00	34.917	2.00	46.92	38.00
11.000	2.00	23.000	2.00	35.000	2.00	47.00	38.00
11.083	2.00	23.083	2.00	35.083	3.00	47.08	13.04
11.167	2.00	23.167	2.00	35.167	3.00	47.17	13.00
11.250	2.00	23.250	2.00	35.250	3.00	47.25	13.00
11.333	2.00	23.333	2.00	35.333	3.00	47.33	13.00
11.417	2.00	23.417	2.00	35.417	3.00	47.42	13.00
11.500	2.00	23.500	2.00	35.500	3.00	47.50	13.00
11.583	2.00	23.583	2.00	35.583	3.00	47.58	13.00
11.667	2.00	23.667	2.00	35.667	3.00	47.67	13.00
11.750	2.00	23.750	2.00	35.750	3.00	47.75	13.00
11.833	2.00	23.833	2.00	35.833	3.00	47.83	13.00
11.917	2.00	23.917	2.00	35.917	3.00	47.92	13.00
12.000	2.00	24.000	2.00	36.000	3.00	48.00	13.00

Max.Eff.Inten.(mm/hr)=	53.00	50.42	
over (min)	5.00	20.00	
Storage Coeff. (min)=	6.58 (ii)	15.87 (ii)	
Unit Hyd. Tpeak (min)=	5.00	20.00	
Unit Hyd. peak (cms)=	0.18	0.07	
			TOTALS
PEAK FLOW (cms)=	1.28	0.86	2.143 (iii)
TIME TO PEAK (hrs)=	46.00	46.00	46.00
RUNOFF VOLUME (mm)=	284.00	228.24	260.30
TOTAL RAINFALL (mm)=	285.00	285.00	285.00
RUNOFF COEFFICIENT =	1.00	0.80	0.91


```
  (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
       CN* =  80.0    Ia = Dep. Storage  (Above)
  (ii) TIME STEP (DT) SHOULD BE SMALLER OR EQUAL
       THAN THE STORAGE COEFFICIENT.
  (iii) PEAK FLOW DOES NOT INCLUDE BASEFLOW IF ANY.

-------------------------------------------------------------------------------
--------------------
| DUHYD   (  1102)|
| Inlet Cap.= 1.796|
| #of Inlets=     1|
| Total(cms)=   1.8|      AREA     QPEAK     TPEAK    R.V.
--------------------      (ha)     (cms)     (hrs)    (mm)
     TOTAL HYD.(ID= 1):  15.10      2.14      46.00  260.30
     ===================================================
     MAJOR SYS.(ID= 2):   0.26      0.35      46.00  260.30
     MINOR SYS.(ID= 3):  14.84      1.80      45.42  260.30

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.

-------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1103)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  1101):    10.47   1.484    45.83   265.54
     + ID2= 2 (  1102):    14.84   1.796    45.42   260.30
       =================================================
       ID = 3 (  1103):    25.31   3.280    45.83   262.47

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1105)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
       ID1= 1 (  1003):     7.60   0.779    47.17   228.24
     + ID2= 2 (  1103):    25.31   3.280    45.83   262.47
       =================================================
       ID = 3 (  1105):    32.91   3.814    46.00   254.56

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1106)|     OVERFLOW IS OFF
```

```
| IN= 2---> OUT= 1 |
| DT=  5.0 min     |     OUTFLOW    STORAGE   |  OUTFLOW    STORAGE
--------------------      (cms)     (ha.m.)   |   (cms)     (ha.m.)
                          0.0000     0.0000   |   0.0730     0.9730
                          0.0140     0.1150   |   0.1410     1.1060
                          0.0280     0.2300   |   0.7220     1.2390
                          0.0390     0.3450   |   1.1780     1.5960
                          0.0480     0.4600   |   1.3260     1.9530
                          0.0520     0.5170   |   1.4580     2.3350
                          0.0550     0.5750   |   1.5800     2.7180
                          0.0620     0.7080   |   1.6920     3.1260
                          0.0680     0.8410   |   1.7980     3.5350

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  1105)     32.908      3.814     46.00     254.56
   OUTFLOW: ID= 1 (  1106)     32.908      1.720     47.67     254.22

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 45.11
                   TIME SHIFT OF PEAK FLOW         (min)=100.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  3.2360

--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1104)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1101):     0.00   0.016    46.00   265.54
      + ID2= 2 (  1102):     0.26   0.347    46.00   260.30
        ====================================================
        ID = 3 (  1104):     0.26   0.363    46.00   260.37

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------

--------------------
| ADD HYD  (  1107)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1104):     0.26   0.363    46.00   260.37
      + ID2= 2 (  1106):    32.91   1.720    47.67   254.22
        ====================================================
        ID = 3 (  1107):    33.17   1.849    46.00   254.27

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
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 FINISH
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APPENDIX

C

OGS CERTIFICATION STATEMENT AND SIZING REPORTS

Stormceptor®

FORTERRA

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	Catchment 2004
Drainage Area (ha):	1.30
Runoff Coefficient 'c':	0.55
Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0
Estimated Water Quality Flow Rate (L/s):	22.23
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	51
EFO6	59
EFO8	63
EFO10	66
EFO12	68

Recommended Stormceptor EFO Model: EFO8

Estimated Net Annual Sediment (TSS) Load Reduction (%): 63

Water Quality Runoff Volume Capture (%): > 90

imbrium

THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

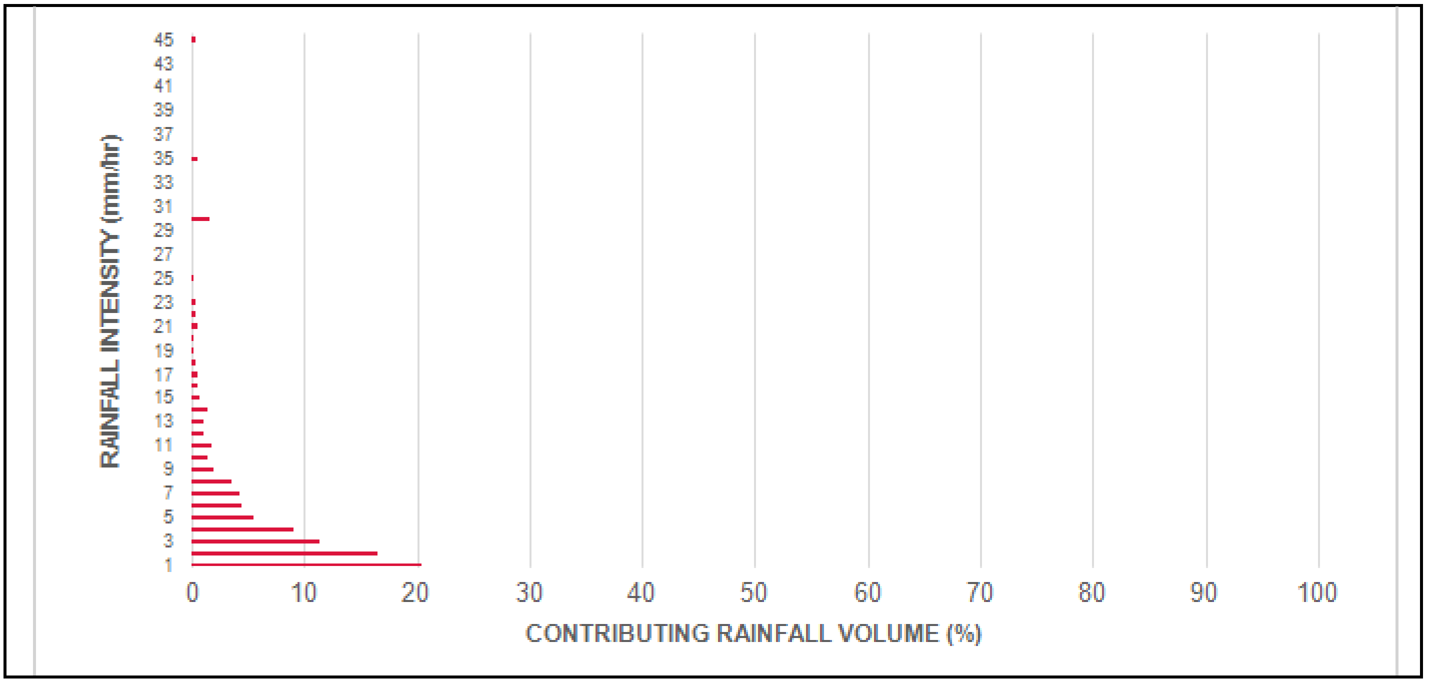
Particle Size (μm)	Percent Less Than	Particle Size Fraction (μm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Stormceptor® EF Sizing Report

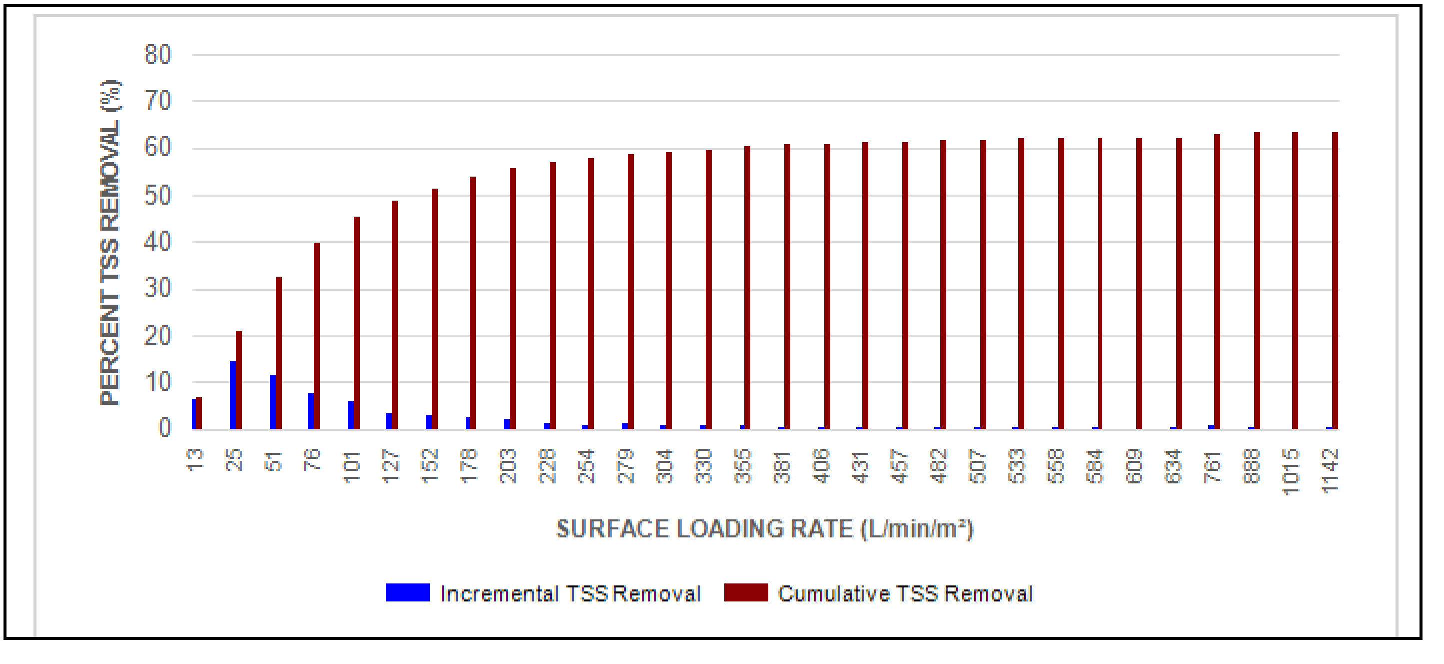
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	0.99	60.0	13.0	70	6.5	6.5
1	20.5	29.7	1.99	119.0	25.0	70	14.4	20.9
2	16.5	46.2	3.98	239.0	51.0	69	11.4	32.3
3	11.3	57.5	5.96	358.0	76.0	66	7.4	39.7
4	9.1	66.7	7.95	477.0	101.0	62	5.7	45.4
5	5.5	72.2	9.94	596.0	127.0	61	3.3	48.7
6	4.5	76.7	11.93	716.0	152.0	58	2.6	51.4
7	4.2	80.9	13.91	835.0	178.0	57	2.4	53.8
8	3.5	84.4	15.90	954.0	203.0	54	1.9	55.7
9	2.0	86.5	17.89	1073.0	228.0	53	1.1	56.7
10	1.5	88.0	19.88	1193.0	254.0	53	0.8	57.5
11	1.8	89.8	21.86	1312.0	279.0	52	1.0	58.5
12	1.1	90.9	23.85	1431.0	304.0	51	0.6	59.0
13	1.1	92.0	25.84	1550.0	330.0	50	0.5	59.6
14	1.4	93.4	27.83	1670.0	355.0	50	0.7	60.3
15	0.8	94.2	29.82	1789.0	381.0	49	0.4	60.7
16	0.6	94.8	31.80	1908.0	406.0	48	0.3	60.9
17	0.5	95.3	33.79	2027.0	431.0	47	0.2	61.2
18	0.3	95.6	35.78	2147.0	457.0	47	0.2	61.3
19	0.2	95.9	37.77	2266.0	482.0	46	0.1	61.4
20	0.2	96.1	39.75	2385.0	507.0	45	0.1	61.5
21	0.5	96.6	41.74	2505.0	533.0	44	0.2	61.8
22	0.4	97.0	43.73	2624.0	558.0	44	0.2	61.9
23	0.3	97.3	45.72	2743.0	584.0	43	0.1	62.1
24	0.0	97.3	47.70	2862.0	609.0	42	0.0	62.1
25	0.2	97.4	49.69	2982.0	634.0	42	0.1	62.1
30	1.6	99.1	59.63	3578.0	761.0	41	0.7	62.8
35	0.6	99.7	69.57	4174.0	888.0	41	0.3	63.1
40	0.0	99.7	79.51	4770.0	1015.0	40	0.0	63.1
45	0.3	100.0	89.45	5367.0	1142.0	38	0.1	63.2
Estimated Net Annual Sediment (TSS) Load Reduction =								**63 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter (m)	Model Diameter (ft)	Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter (mm)	Max Inlet Pipe Diameter (in)	Max Outlet Pipe Diameter (mm)	Max Outlet Pipe Diameter (in)	Peak Conveyance Flow Rate (L/s)	Peak Conveyance Flow Rate (cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

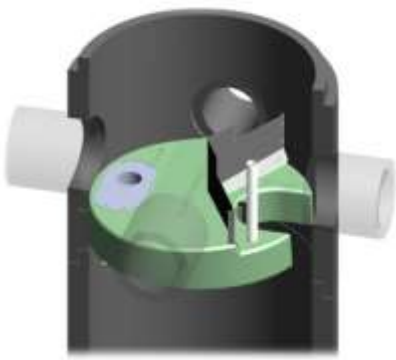
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

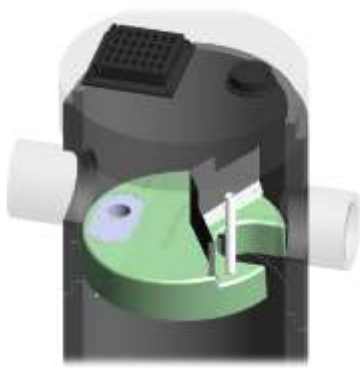
DESIGN FLEXIBILITY

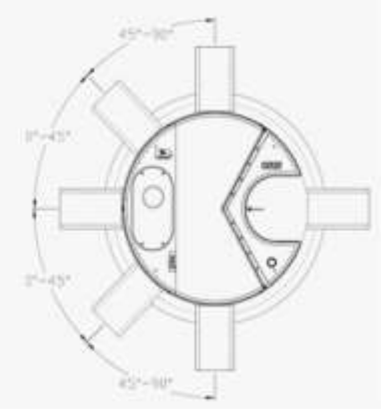
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.







INLET-TO-OUTLET DROP

Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.
0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.
45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS

The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
EF8 / EFO8	2.4	8	2.59	8.5	1070	280	610	24	8780	310	14048	38750
EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity
** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS

For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

STANDARD STORMCEPTOR EF/EFO SPECIFICATION

For specifications, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor®

FORTERRA

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	Catchment 2005
Drainage Area (ha):	2.18
Runoff Coefficient 'c':	0.75
Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0
Estimated Water Quality Flow Rate (L/s):	50.84
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	41
EFO6	50
EFO8	57
EFO10	60
EFO12	63

Recommended Stormceptor EFO Model: EFO10

Estimated Net Annual Sediment (TSS) Load Reduction (%): 60

Water Quality Runoff Volume Capture (%): > 90

imbrium

THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

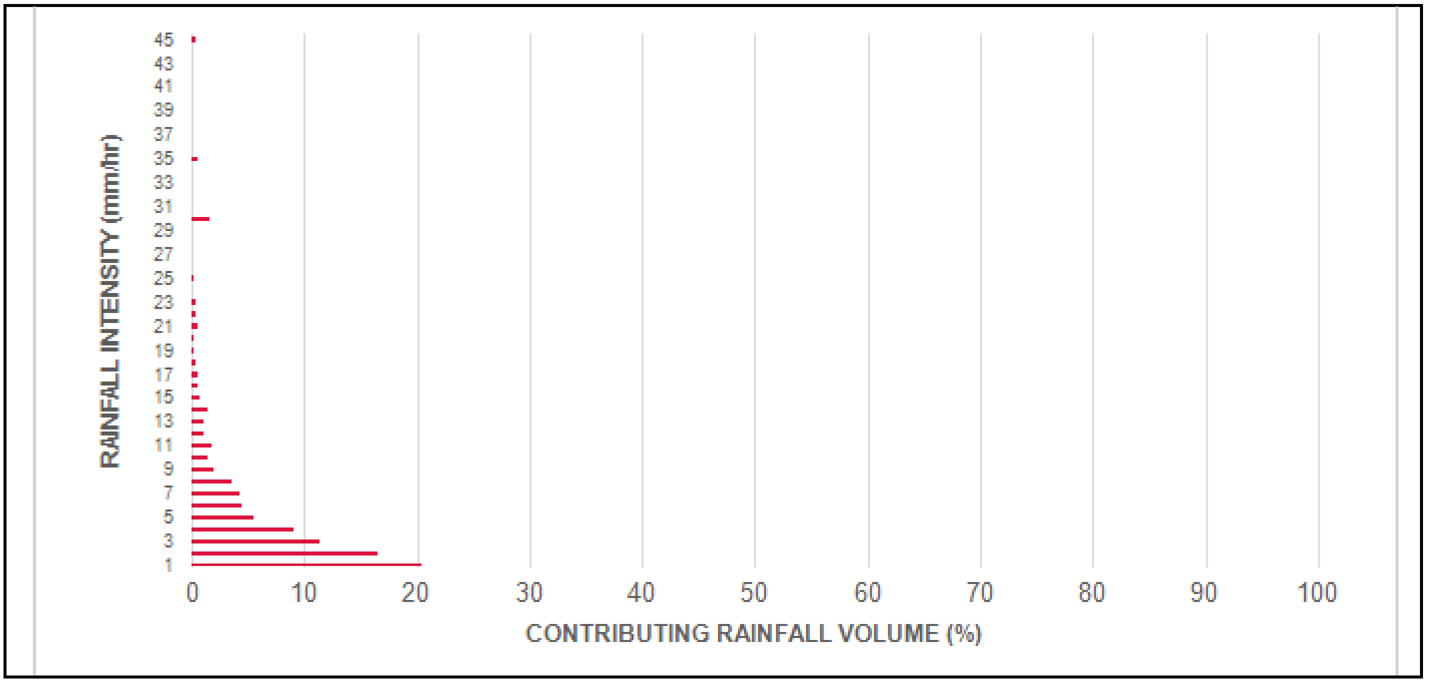
►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

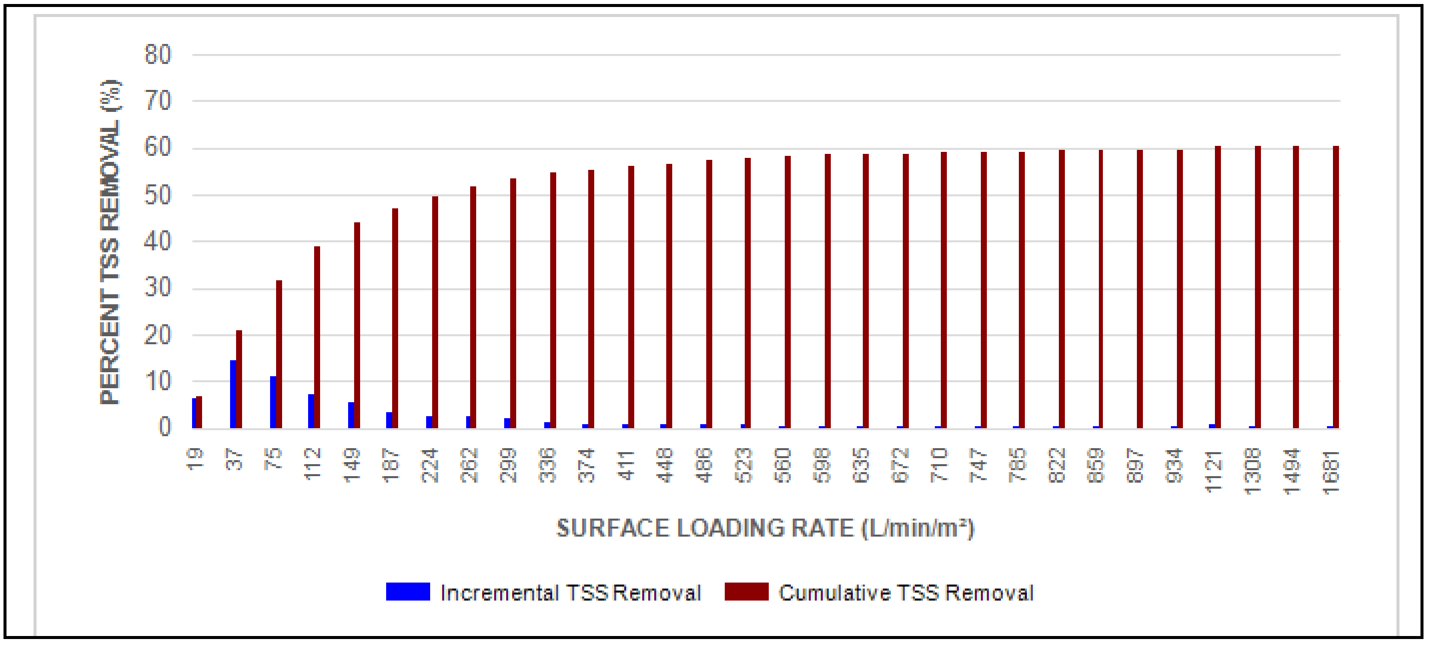
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	2.27	136.0	19.0	70	6.5	6.5
1	20.5	29.7	4.55	273.0	37.0	70	14.4	20.9
2	16.5	46.2	9.09	545.0	75.0	66	10.8	31.7
3	11.3	57.5	13.64	818.0	112.0	62	7.0	38.7
4	9.1	66.7	18.18	1091.0	149.0	58	5.3	44.0
5	5.5	72.2	22.73	1364.0	187.0	56	3.1	47.1
6	4.5	76.7	27.27	1636.0	224.0	53	2.4	49.5
7	4.2	80.9	31.82	1909.0	262.0	52	2.2	51.7
8	3.5	84.4	36.36	2182.0	299.0	51	1.8	53.5
9	2.0	86.5	40.91	2454.0	336.0	50	1.0	54.5
10	1.5	88.0	45.45	2727.0	374.0	49	0.7	55.2
11	1.8	89.8	50.00	3000.0	411.0	48	0.9	56.1
12	1.1	90.9	54.54	3273.0	448.0	47	0.5	56.6
13	1.1	92.0	59.09	3545.0	486.0	46	0.5	57.1
14	1.4	93.4	63.63	3818.0	523.0	44	0.6	57.8
15	0.8	94.2	68.18	4091.0	560.0	43	0.3	58.1
16	0.6	94.8	72.72	4363.0	598.0	42	0.2	58.4
17	0.5	95.3	77.27	4636.0	635.0	42	0.2	58.6
18	0.3	95.6	81.82	4909.0	672.0	42	0.1	58.7
19	0.2	95.9	86.36	5182.0	710.0	41	0.1	58.8
20	0.2	96.1	90.91	5454.0	747.0	41	0.1	58.9
21	0.5	96.6	95.45	5727.0	785.0	41	0.2	59.1
22	0.4	97.0	100.00	6000.0	822.0	41	0.2	59.3
23	0.3	97.3	104.54	6273.0	859.0	41	0.1	59.4
24	0.0	97.3	109.09	6545.0	897.0	41	0.0	59.4
25	0.2	97.4	113.63	6818.0	934.0	40	0.1	59.5
30	1.6	99.1	136.36	8182.0	1121.0	38	0.6	60.1
35	0.6	99.7	159.09	9545.0	1308.0	36	0.2	60.3
40	0.0	99.7	181.81	10909.0	1494.0	32	0.0	60.3
45	0.3	100.0	204.54	12272.0	1681.0	28	0.1	60.4
Estimated Net Annual Sediment (TSS) Load Reduction =								**60 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL
FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter		Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter		Max Outlet Pipe Diameter		Peak Conveyance Flow Rate	
	(m)	(ft)		(mm)	(in)	(mm)	(in)	(L/s)	(cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

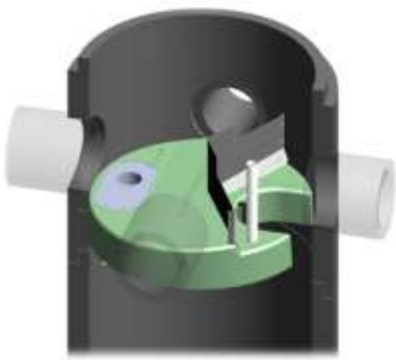
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

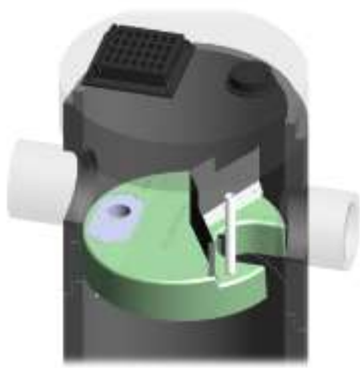
DESIGN FLEXIBILITY

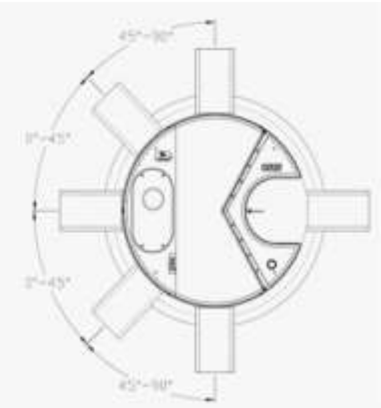
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.







INLET-TO-OUTLET DROP
Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.
0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.
45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS
The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
EF8 / EFO8	2.4	8	2.59	8.5	1070	280	610	24	8780	310	14048	38750
EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity
** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS
For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef
STANDARD STORMCEPTOR EF/EFO SPECIFICATION
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Stormceptor® EFO

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1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor®

FORTERRA

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	Catchment 3001-1
Drainage Area (ha):	2.85
Runoff Coefficient 'c':	0.75
Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0
Estimated Water Quality Flow Rate (L/s):	66.47
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	37
EFO6	48
EFO8	54
EFO10	58
EFO12	61

Recommended Stormceptor EFO Model: EFO12

Estimated Net Annual Sediment (TSS) Load Reduction (%): 61

Water Quality Runoff Volume Capture (%): > 90

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THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

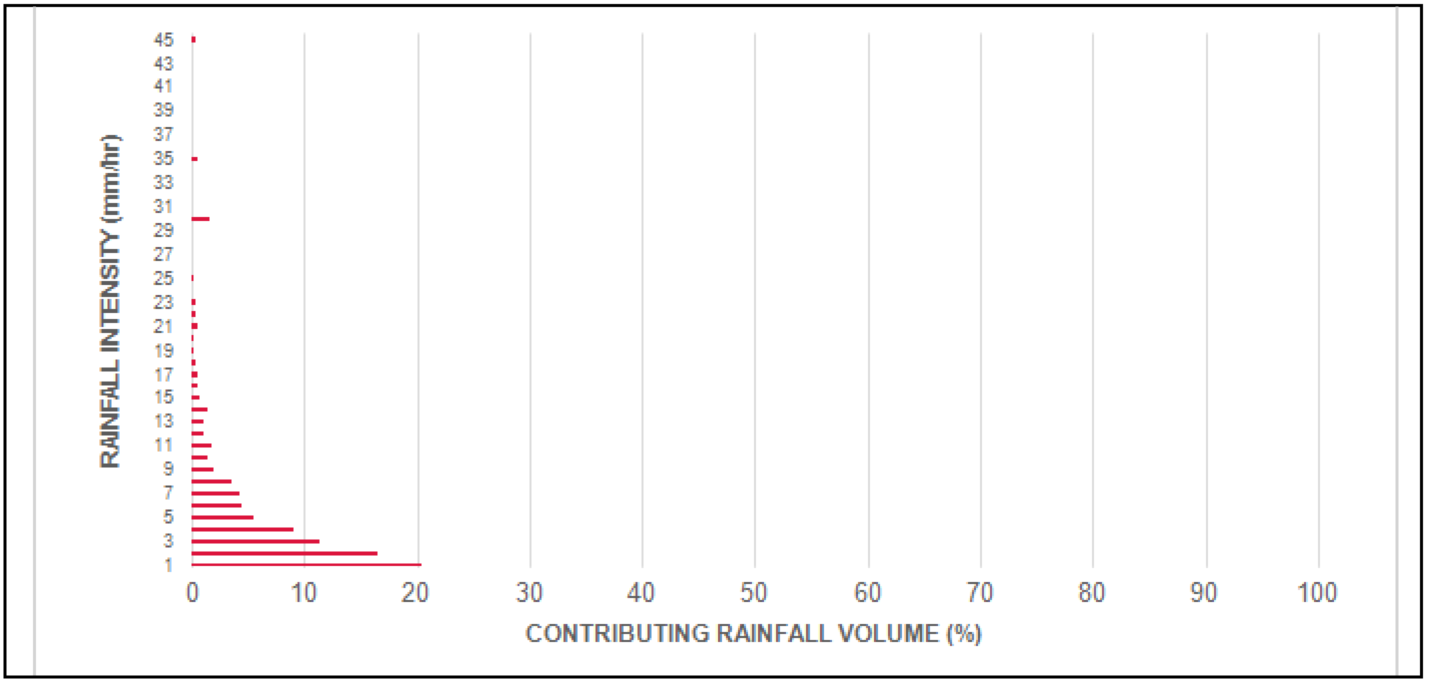
►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

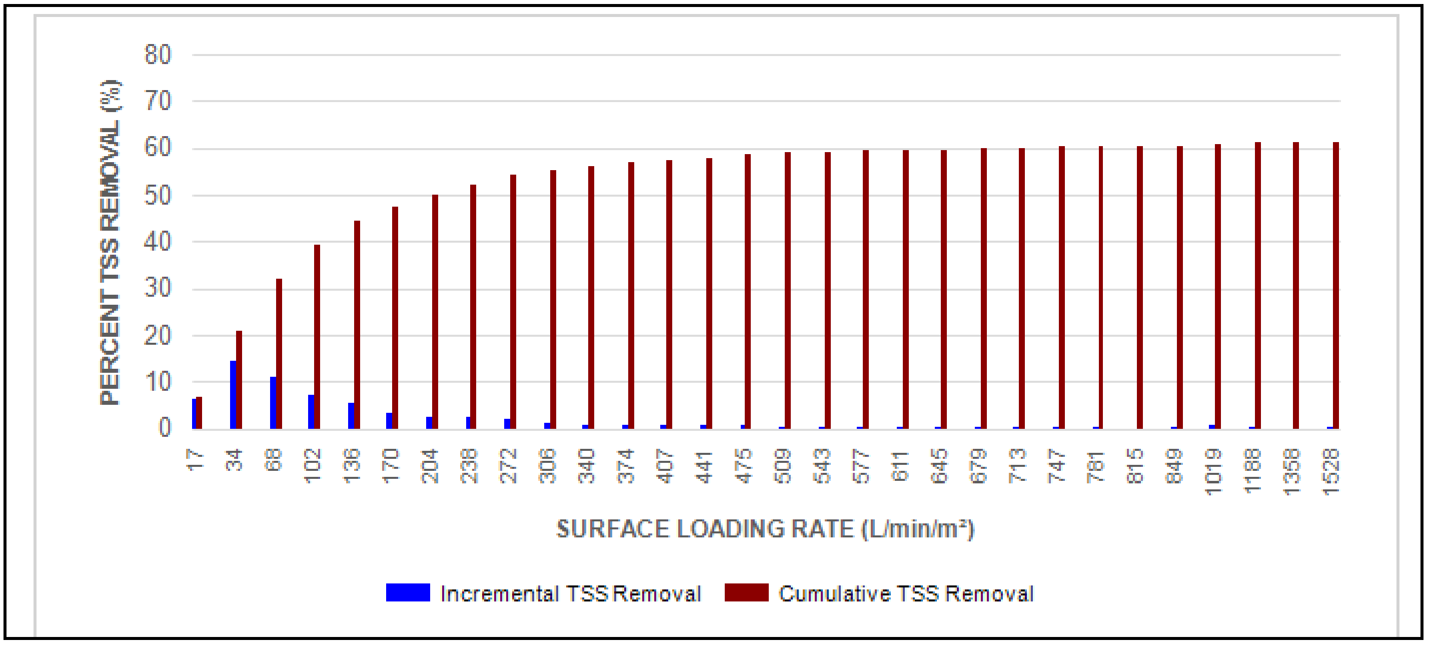
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	2.97	178.0	17.0	70	6.5	6.5
1	20.5	29.7	5.94	357.0	34.0	70	14.4	20.9
2	16.5	46.2	11.88	713.0	68.0	67	11.1	32.0
3	11.3	57.5	17.83	1070.0	102.0	62	7.1	39.1
4	9.1	66.7	23.77	1426.0	136.0	60	5.4	44.5
5	5.5	72.2	29.71	1783.0	170.0	57	3.1	47.6
6	4.5	76.7	35.65	2139.0	204.0	54	2.4	50.1
7	4.2	80.9	41.60	2496.0	238.0	53	2.3	52.3
8	3.5	84.4	47.54	2852.0	272.0	52	1.8	54.2
9	2.0	86.5	53.48	3209.0	306.0	51	1.0	55.2
10	1.5	88.0	59.42	3565.0	340.0	50	0.7	55.9
11	1.8	89.8	65.36	3922.0	374.0	49	0.9	56.8
12	1.1	90.9	71.31	4278.0	407.0	48	0.5	57.3
13	1.1	92.0	77.25	4635.0	441.0	47	0.5	57.9
14	1.4	93.4	83.19	4991.0	475.0	46	0.7	58.5
15	0.8	94.2	89.13	5348.0	509.0	45	0.4	58.9
16	0.6	94.8	95.08	5705.0	543.0	44	0.3	59.1
17	0.5	95.3	101.02	6061.0	577.0	43	0.2	59.3
18	0.3	95.6	106.96	6418.0	611.0	42	0.1	59.5
19	0.2	95.9	112.90	6774.0	645.0	42	0.1	59.6
20	0.2	96.1	118.85	7131.0	679.0	42	0.1	59.7
21	0.5	96.6	124.79	7487.0	713.0	41	0.2	59.9
22	0.4	97.0	130.73	7844.0	747.0	41	0.2	60.1
23	0.3	97.3	136.67	8200.0	781.0	41	0.1	60.2
24	0.0	97.3	142.61	8557.0	815.0	41	0.0	60.2
25	0.2	97.4	148.56	8913.0	849.0	41	0.1	60.2
30	1.6	99.1	178.27	10696.0	1019.0	40	0.6	60.9
35	0.6	99.7	207.98	12479.0	1188.0	37	0.2	61.1
40	0.0	99.7	237.69	14261.0	1358.0	35	0.0	61.1
45	0.3	100.0	267.40	16044.0	1528.0	31	0.1	61.2
Estimated Net Annual Sediment (TSS) Load Reduction =								**61 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL
FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter		Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter		Max Outlet Pipe Diameter		Peak Conveyance Flow Rate	
	(m)	(ft)		(mm)	(in)	(mm)	(in)	(L/s)	(cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

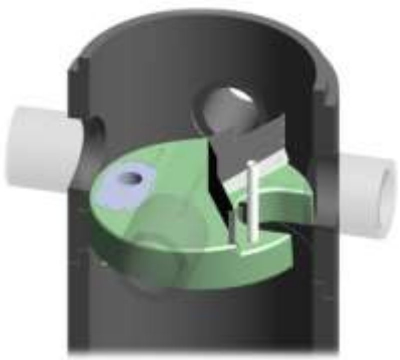
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

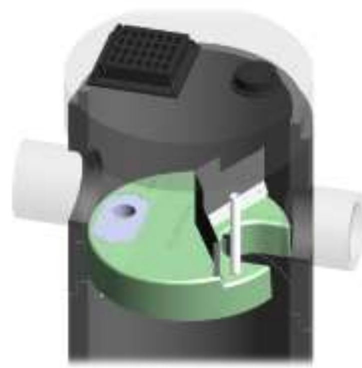
DESIGN FLEXIBILITY

►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.





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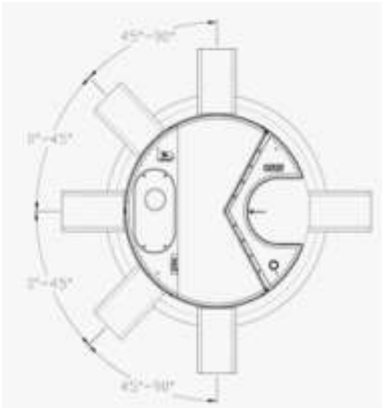


INLET-TO-OUTLET DROP

Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.

0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.
45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS

The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
EF8 / EFO8	2.4	8	2.59	8.5	1070	280	610	24	8780	310	14048	38750
EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity
** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS

For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

STANDARD STORMCEPTOR EF/EFO SPECIFICATION

For specifications, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	Catchment 3001-2 (Split 2)
Drainage Area (ha):	2.16
Runoff Coefficient 'c':	0.75
Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0
Estimated Water Quality Flow Rate (L/s):	50.37
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	41
EFO6	50
EFO8	57
EFO10	60
EFO12	63

Recommended Stormceptor EFO Model: **EFO10**

Estimated Net Annual Sediment (TSS) Load Reduction (%): **60**

Water Quality Runoff Volume Capture (%): **> 90**

THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

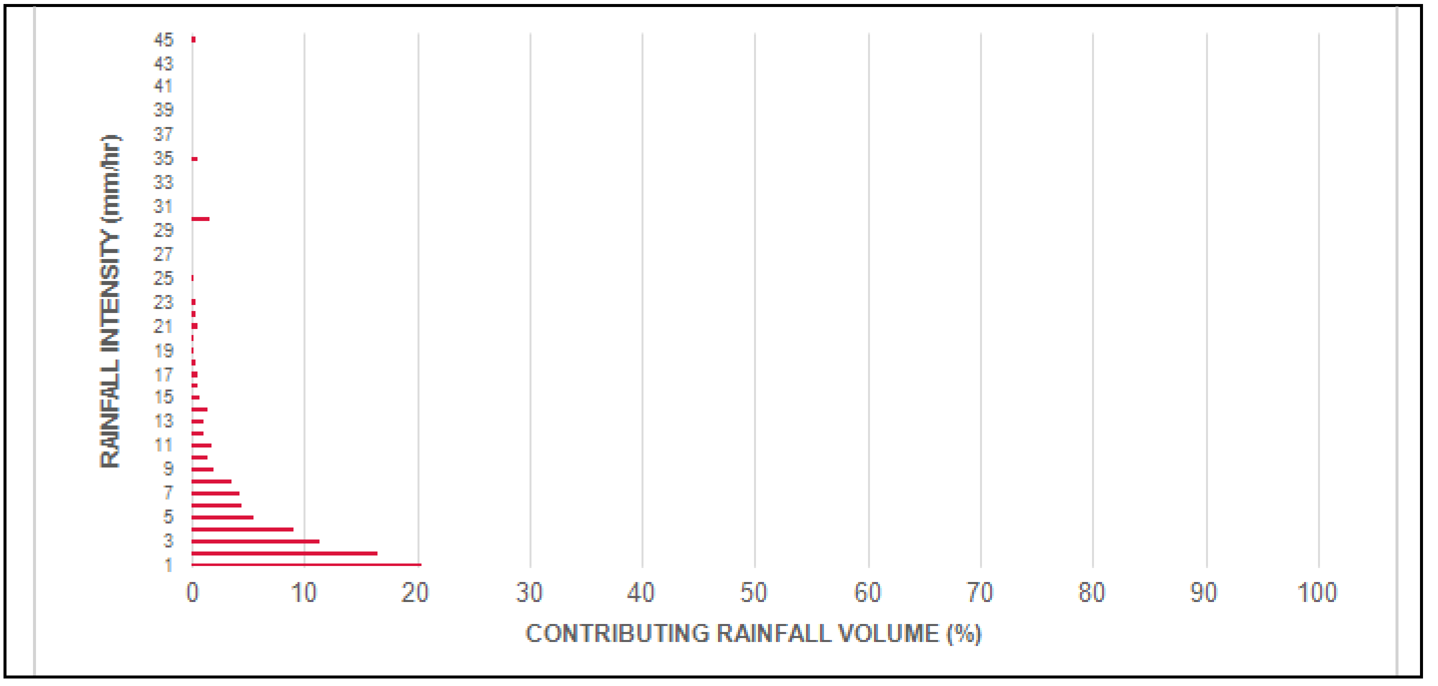
►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

Particle Size (μm)	Percent Less Than	Particle Size Fraction (μm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

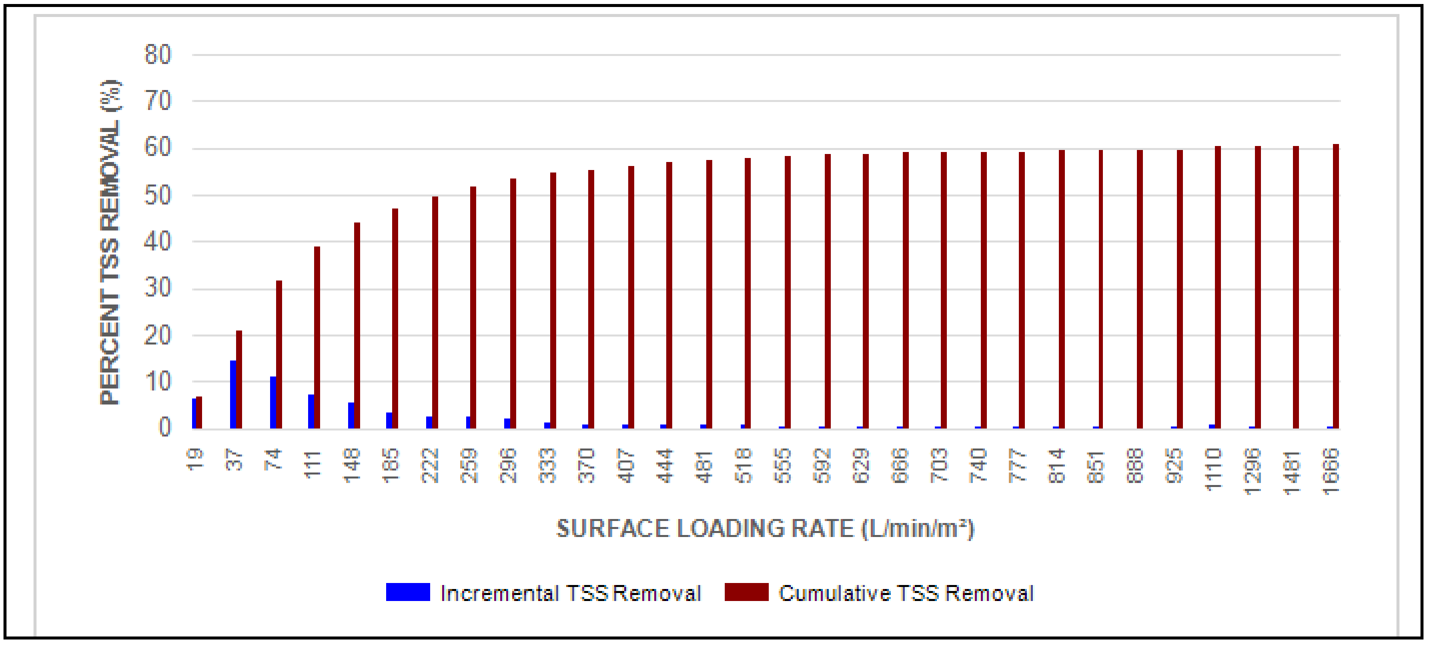
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	2.25	135.0	19.0	70	6.5	6.5
1	20.5	29.7	4.50	270.0	37.0	70	14.4	20.9
2	16.5	46.2	9.01	540.0	74.0	66	10.8	31.7
3	11.3	57.5	13.51	811.0	111.0	62	7.0	38.7
4	9.1	66.7	18.01	1081.0	148.0	59	5.4	44.1
5	5.5	72.2	22.52	1351.0	185.0	56	3.1	47.2
6	4.5	76.7	27.02	1621.0	222.0	53	2.4	49.6
7	4.2	80.9	31.53	1892.0	259.0	52	2.2	51.8
8	3.5	84.4	36.03	2162.0	296.0	51	1.8	53.6
9	2.0	86.5	40.53	2432.0	333.0	50	1.0	54.6
10	1.5	88.0	45.04	2702.0	370.0	49	0.7	55.3
11	1.8	89.8	49.54	2972.0	407.0	48	0.9	56.2
12	1.1	90.9	54.04	3243.0	444.0	47	0.5	56.7
13	1.1	92.0	58.55	3513.0	481.0	46	0.5	57.2
14	1.4	93.4	63.05	3783.0	518.0	45	0.6	57.9
15	0.8	94.2	67.55	4053.0	555.0	44	0.4	58.2
16	0.6	94.8	72.06	4323.0	592.0	42	0.2	58.5
17	0.5	95.3	76.56	4594.0	629.0	42	0.2	58.7
18	0.3	95.6	81.06	4864.0	666.0	42	0.1	58.8
19	0.2	95.9	85.57	5134.0	703.0	42	0.1	58.9
20	0.2	96.1	90.07	5404.0	740.0	41	0.1	59.0
21	0.5	96.6	94.58	5675.0	777.0	41	0.2	59.2
22	0.4	97.0	99.08	5945.0	814.0	41	0.2	59.4
23	0.3	97.3	103.58	6215.0	851.0	41	0.1	59.5
24	0.0	97.3	108.09	6485.0	888.0	41	0.0	59.5
25	0.2	97.4	112.59	6755.0	925.0	40	0.1	59.5
30	1.6	99.1	135.11	8106.0	1110.0	38	0.6	60.2
35	0.6	99.7	157.63	9458.0	1296.0	36	0.2	60.4
40	0.0	99.7	180.14	10809.0	1481.0	32	0.0	60.4
45	0.3	100.0	202.66	12160.0	1666.0	29	0.1	60.5
Estimated Net Annual Sediment (TSS) Load Reduction =								**60 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter		Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter		Max Outlet Pipe Diameter		Peak Conveyance Flow Rate	
	(m)	(ft)		(mm)	(in)	(mm)	(in)	(L/s)	(cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

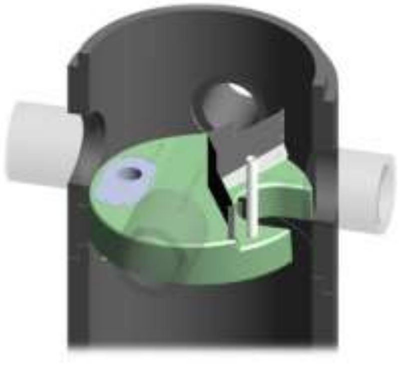
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

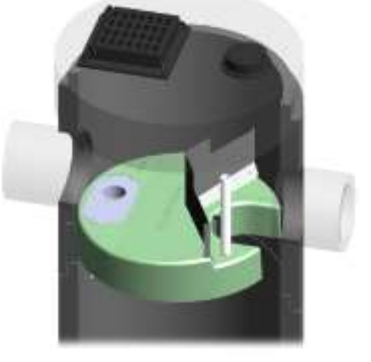
DESIGN FLEXIBILITY

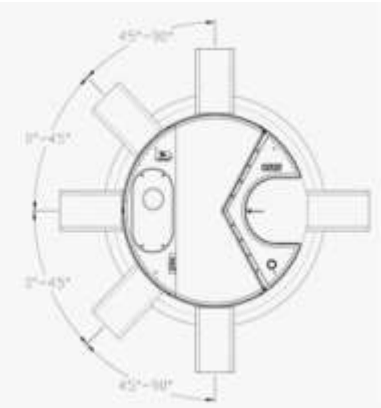
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.







INLET-TO-OUTLET DROP

Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.

0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.

45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS

The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
EF8 / EFO8	2.4	8	2.59	8.5	1070	280	610	24	8780	310	14048	38750
EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity

** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS

For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

STANDARD STORMCEPTOR EF/EFO SPECIFICATION

For specifications, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	Catchment 3001-3
Drainage Area (ha):	0.90
Runoff Coefficient 'c':	0.60
Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0
Estimated Water Quality Flow Rate (L/s):	16.79
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	54
EFO6	61
EFO8	65
EFO10	67
EFO12	68

Recommended Stormceptor EFO Model: EFO6

Estimated Net Annual Sediment (TSS) Load Reduction (%): 61

Water Quality Runoff Volume Capture (%): > 90

THIRD-PARTY TESTING AND VERIFICATION

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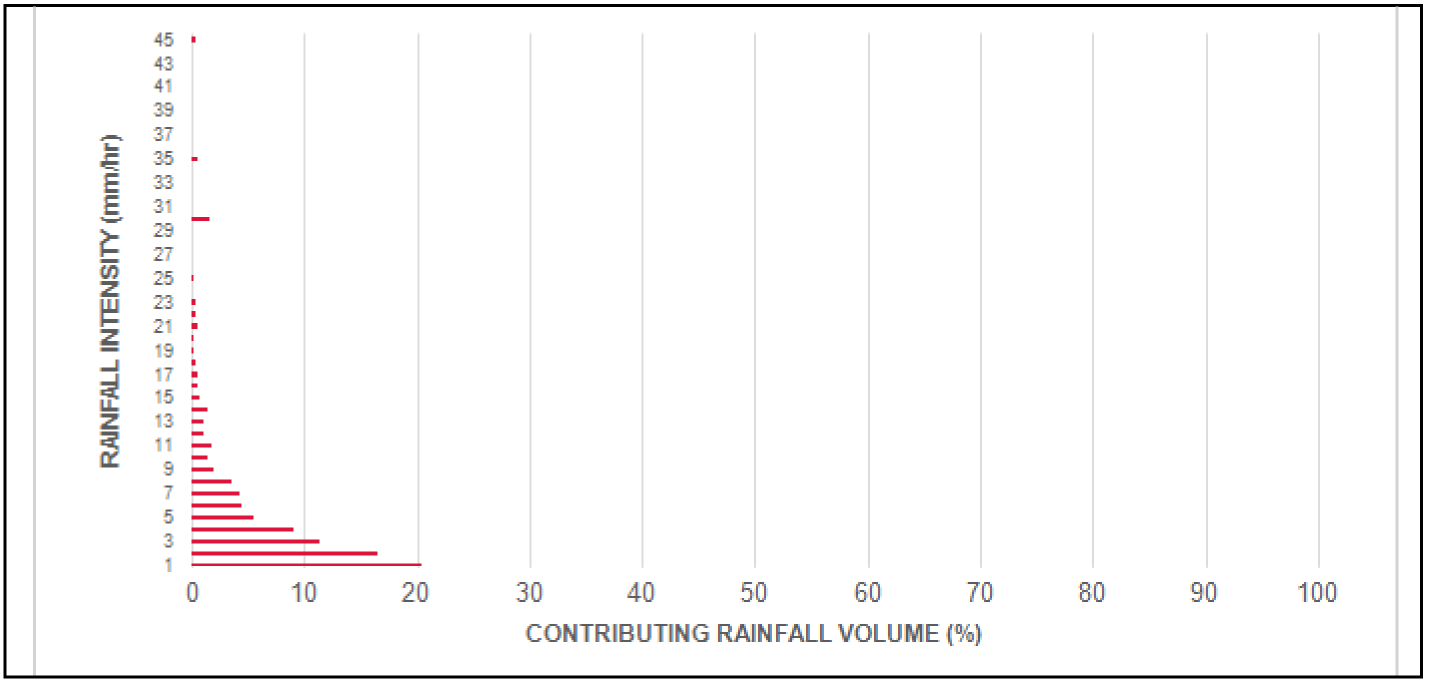
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

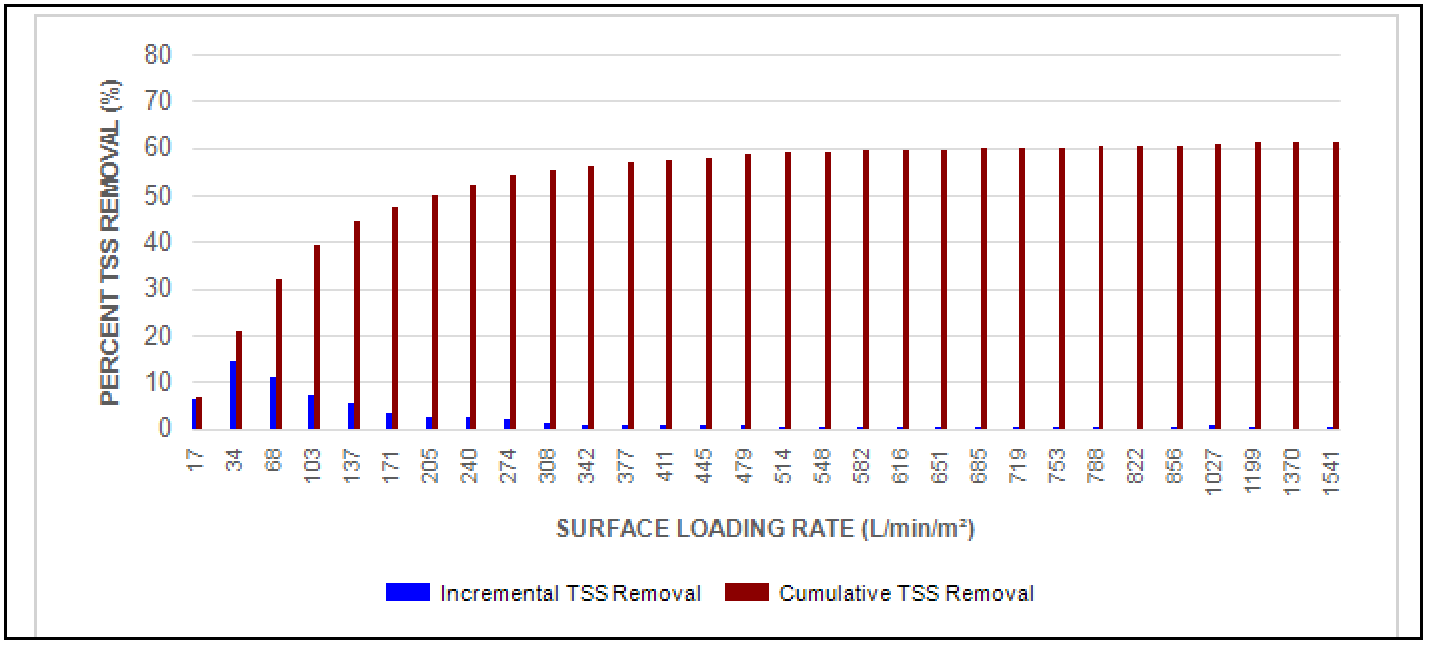
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	0.75	45.0	17.0	70	6.5	6.5
1	20.5	29.7	1.50	90.0	34.0	70	14.4	20.9
2	16.5	46.2	3.00	180.0	68.0	67	11.1	32.0
3	11.3	57.5	4.50	270.0	103.0	62	7.1	39.1
4	9.1	66.7	6.00	360.0	137.0	60	5.4	44.5
5	5.5	72.2	7.51	450.0	171.0	57	3.1	47.6
6	4.5	76.7	9.01	540.0	205.0	54	2.4	50.1
7	4.2	80.9	10.51	631.0	240.0	53	2.2	52.3
8	3.5	84.4	12.01	721.0	274.0	52	1.8	54.1
9	2.0	86.5	13.51	811.0	308.0	51	1.0	55.2
10	1.5	88.0	15.01	901.0	342.0	50	0.7	55.9
11	1.8	89.8	16.51	991.0	377.0	49	0.9	56.8
12	1.1	90.9	18.01	1081.0	411.0	48	0.5	57.3
13	1.1	92.0	19.52	1171.0	445.0	47	0.5	57.8
14	1.4	93.4	21.02	1261.0	479.0	46	0.7	58.5
15	0.8	94.2	22.52	1351.0	514.0	45	0.4	58.9
16	0.6	94.8	24.02	1441.0	548.0	44	0.3	59.1
17	0.5	95.3	25.52	1531.0	582.0	43	0.2	59.3
18	0.3	95.6	27.02	1621.0	616.0	42	0.1	59.5
19	0.2	95.9	28.52	1711.0	651.0	42	0.1	59.6
20	0.2	96.1	30.02	1801.0	685.0	42	0.1	59.7
21	0.5	96.6	31.53	1892.0	719.0	41	0.2	59.9
22	0.4	97.0	33.03	1982.0	753.0	41	0.2	60.0
23	0.3	97.3	34.53	2072.0	788.0	41	0.1	60.1
24	0.0	97.3	36.03	2162.0	822.0	41	0.0	60.1
25	0.2	97.4	37.53	2252.0	856.0	41	0.1	60.2
30	1.6	99.1	45.04	2702.0	1027.0	40	0.6	60.9
35	0.6	99.7	52.54	3153.0	1199.0	37	0.2	61.1
40	0.0	99.7	60.05	3603.0	1370.0	34	0.0	61.1
45	0.3	100.0	67.55	4053.0	1541.0	31	0.1	61.2
Estimated Net Annual Sediment (TSS) Load Reduction =								**61 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL
FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter (m)	Model Diameter (ft)	Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter (mm)	Max Inlet Pipe Diameter (in)	Max Outlet Pipe Diameter (mm)	Max Outlet Pipe Diameter (in)	Peak Conveyance Flow Rate (L/s)	Peak Conveyance Flow Rate (cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

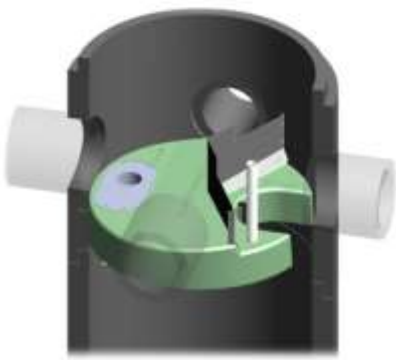
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

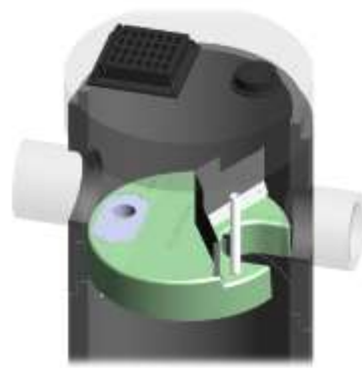
DESIGN FLEXIBILITY

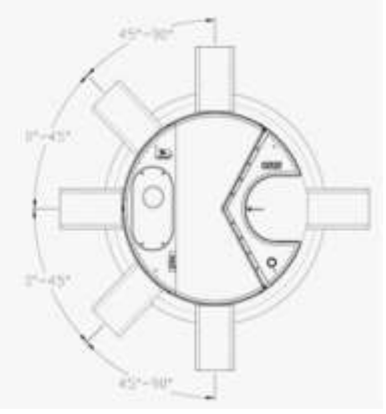
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.







INLET-TO-OUTLET DROP

Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.

0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.

45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS

The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
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EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity

** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft^3)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS

For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

STANDARD STORMCEPTOR EF/EFO SPECIFICATION

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Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

> 3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.
>
> 3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.
>
> 3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.
>
> 3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor®

FORTERRA

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33

Site Name:	Catchment 3002

Drainage Area (ha):	2.20
Runoff Coefficient 'c':	0.75

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0

Estimated Water Quality Flow Rate (L/s):	51.31
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	41
EFO6	50
EFO8	57
EFO10	60
EFO12	63

Recommended Stormceptor EFO Model: EFO10

Estimated Net Annual Sediment (TSS) Load Reduction (%): 60

Water Quality Runoff Volume Capture (%): > 90

imbrium

THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

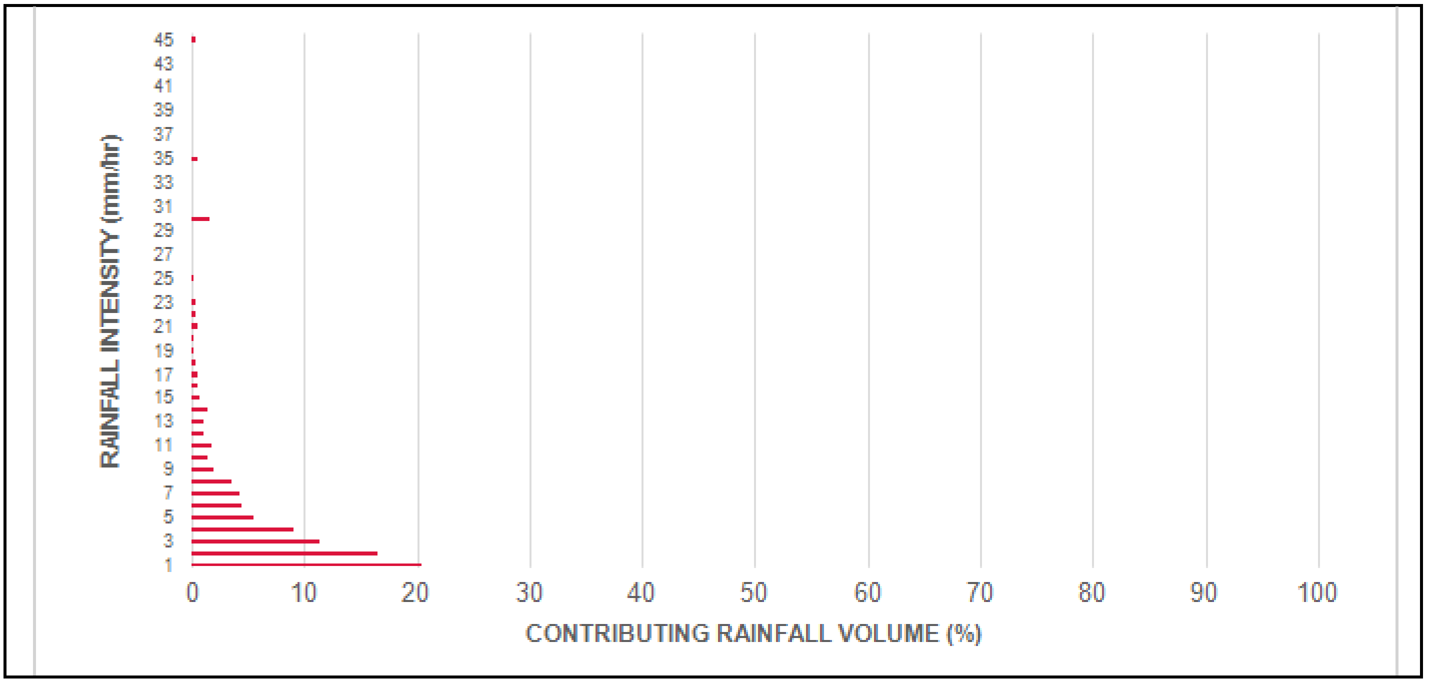
►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

Particle Size (μm)	Percent Less Than	Particle Size Fraction (μm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	2.29	138.0	19.0	70	6.5	6.5
1	20.5	29.7	4.59	275.0	38.0	70	14.4	20.9
2	16.5	46.2	9.17	550.0	75.0	66	10.8	31.7
3	11.3	57.5	13.76	826.0	113.0	62	7.0	38.7
4	9.1	66.7	18.35	1101.0	151.0	58	5.3	44.0
5	5.5	72.2	22.94	1376.0	189.0	56	3.1	47.1
6	4.5	76.7	27.52	1651.0	226.0	53	2.4	49.5
7	4.2	80.9	32.11	1927.0	264.0	52	2.2	51.7
8	3.5	84.4	36.70	2202.0	302.0	51	1.8	53.5
9	2.0	86.5	41.28	2477.0	339.0	50	1.0	54.5
10	1.5	88.0	45.87	2752.0	377.0	49	0.7	55.2
11	1.8	89.8	50.46	3027.0	415.0	48	0.9	56.1
12	1.1	90.9	55.04	3303.0	452.0	47	0.5	56.6
13	1.1	92.0	59.63	3578.0	490.0	45	0.5	57.1
14	1.4	93.4	64.22	3853.0	528.0	44	0.6	57.7
15	0.8	94.2	68.81	4128.0	566.0	43	0.3	58.1
16	0.6	94.8	73.39	4404.0	603.0	42	0.2	58.3
17	0.5	95.3	77.98	4679.0	641.0	42	0.2	58.6
18	0.3	95.6	82.57	4954.0	679.0	42	0.1	58.7
19	0.2	95.9	87.15	5229.0	716.0	41	0.1	58.8
20	0.2	96.1	91.74	5504.0	754.0	41	0.1	58.9
21	0.5	96.6	96.33	5780.0	792.0	41	0.2	59.1
22	0.4	97.0	100.91	6055.0	829.0	41	0.2	59.3
23	0.3	97.3	105.50	6330.0	867.0	41	0.1	59.4
24	0.0	97.3	110.09	6605.0	905.0	41	0.0	59.4
25	0.2	97.4	114.68	6881.0	943.0	40	0.1	59.4
30	1.6	99.1	137.61	8257.0	1131.0	38	0.6	60.0
35	0.6	99.7	160.55	9633.0	1320.0	35	0.2	60.3
40	0.0	99.7	183.48	11009.0	1508.0	32	0.0	60.3
45	0.3	100.0	206.42	12385.0	1697.0	28	0.1	60.4
							Estimated Net Annual Sediment (TSS) Load Reduction =	**60 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL
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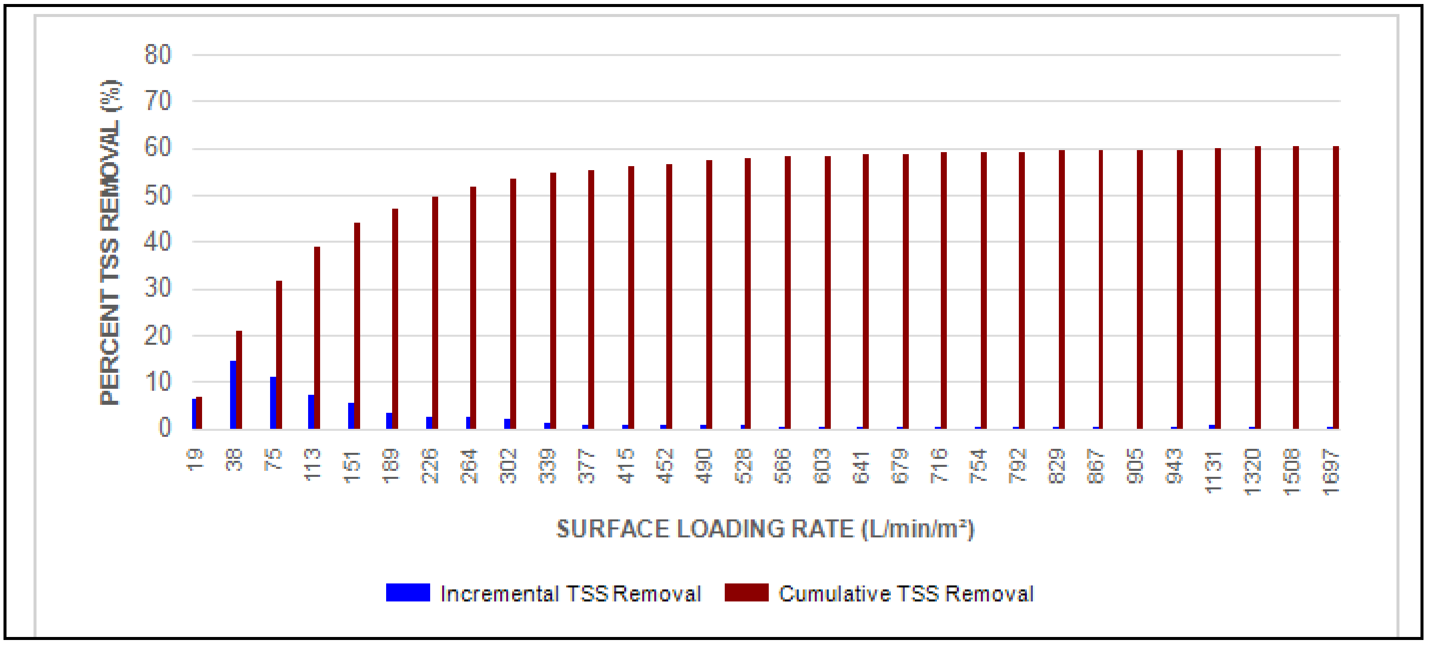

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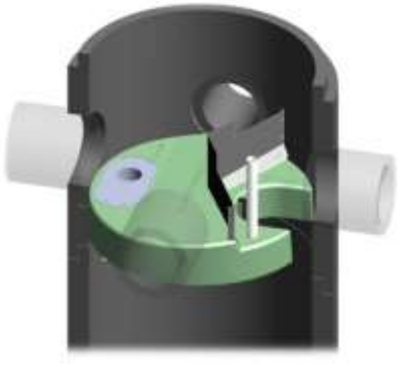

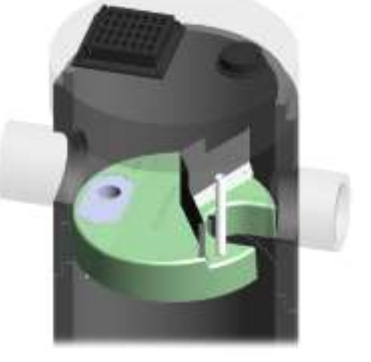

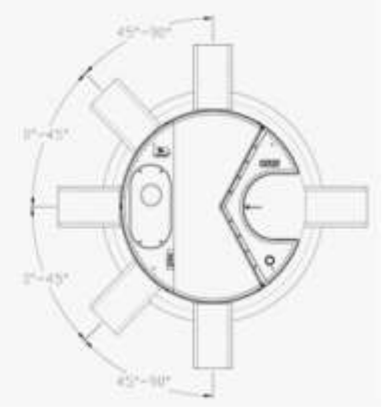

INLET-TO-OUTLET DROP
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Pollutant Capacity

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EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
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*Increased sump depth may be added to increase sediment storage capacity
** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS
For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef
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Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
1	70	660	42	1320	35	1980	24
30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
120	61	780	41	1440	33	2100	23
150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

Stormceptor®

FORTERRA

Stormceptor® EF Sizing Report

STORMCEPTOR®
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

01/10/2023

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33

Site Name:	Catchment 3003

Drainage Area (ha):	1.81
Runoff Coefficient 'c':	0.69

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.0

Estimated Water Quality Flow Rate (L/s):	38.83
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	

Project Name:	Grand Niagara
Project Number:	-
Designer Name:	Brandon O'Leary
Designer Company:	Forterra
Designer Email:	brandon.oleary@forterrabp.com
Designer Phone:	905-630-0359
EOR Name:	James Zhou
EOR Company:	WSP Canada Group Ltd.
EOR Email:	james.zhou@wsp.com
EOR Phone:	289-982-4533

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	44
EFO6	53
EFO8	59
EFO10	62
EFO12	65

Recommended Stormceptor EFO Model:	**EFO10**
Estimated Net Annual Sediment (TSS) Load Reduction (%):	**62**
Water Quality Runoff Volume Capture (%):	**> 90**

imbrium

THIRD-PARTY TESTING AND VERIFICATION

►**Stormceptor® EF and Stormceptor® EFO** are the latest evolutions in the Stormceptor® oil-grit separator (OGS) technology series, and are designed to remove a wide variety of pollutants from stormwater and snowmelt runoff. These technologies have been third-party tested in accordance with the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators** and performance has been third-party verified in accordance with the **ISO 14034 Environmental Technology Verification (ETV)** protocol.

PERFORMANCE

►**Stormceptor® EF and EFO** remove stormwater pollutants through gravity separation and floatation, and feature a patent-pending design that generates positive removal of total suspended solids (TSS) throughout each storm event, including high-intensity storms. Captured pollutants include sediment, free oils, and sediment-bound pollutants such as nutrients, heavy metals, and petroleum hydrocarbons. Stormceptor is sized to remove a high level of TSS from the frequent rainfall events that contribute the vast majority of annual runoff volume and pollutant load. The technology incorporates an internal bypass to convey excessive stormwater flows from high-intensity storms through the device without resuspension and washout (scour) of previously captured pollutants. Proper routine maintenance ensures high pollutant removal performance and protection of downstream waterways.

PARTICLE SIZE DISTRIBUTION (PSD)

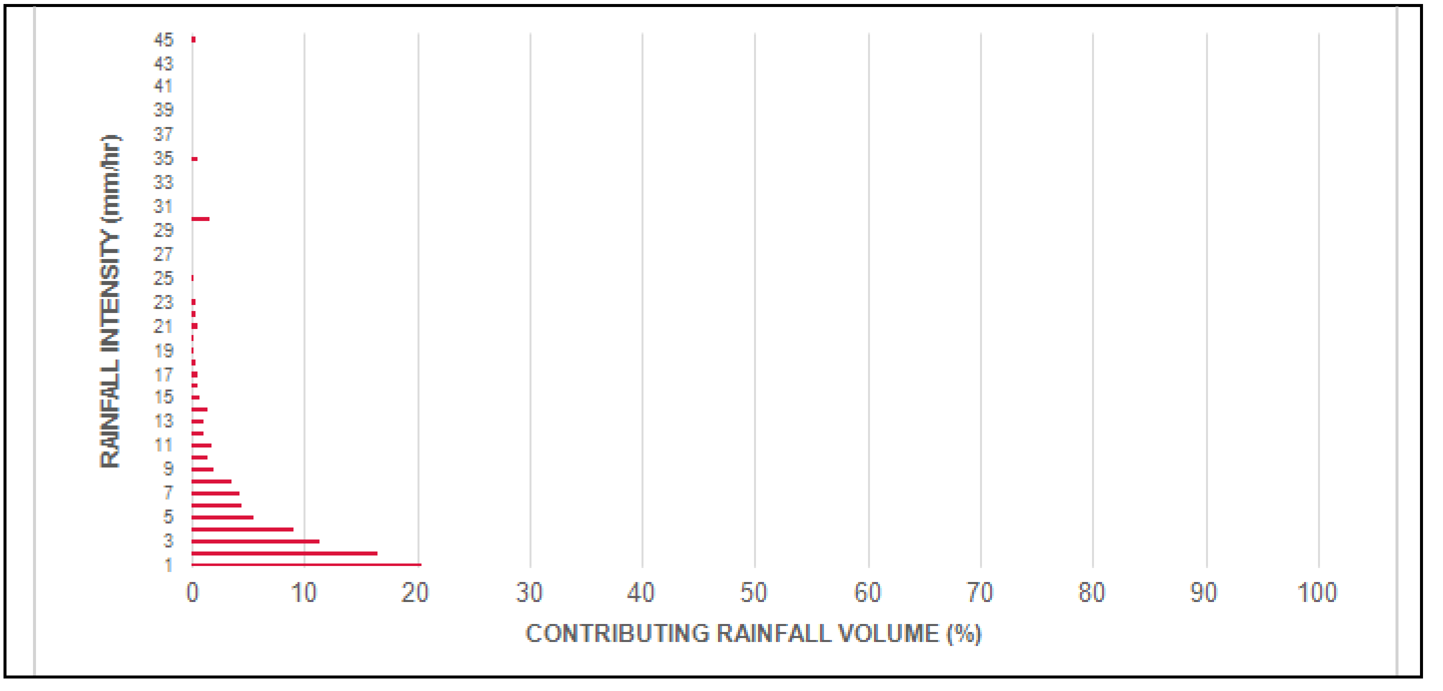
►The **Canadian ETV PSD** shown in the table below was used, or in part, for this sizing. This is the identical PSD that is referenced in the Canadian ETV ***Procedure for Laboratory Testing of Oil-Grit Separators*** for both sediment removal testing and scour testing. The Canadian ETV PSD contains a wide range of particle sizes in the sand and silt fractions, and is considered reasonably representative of the particle size fractions found in typical urban stormwater runoff.

Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

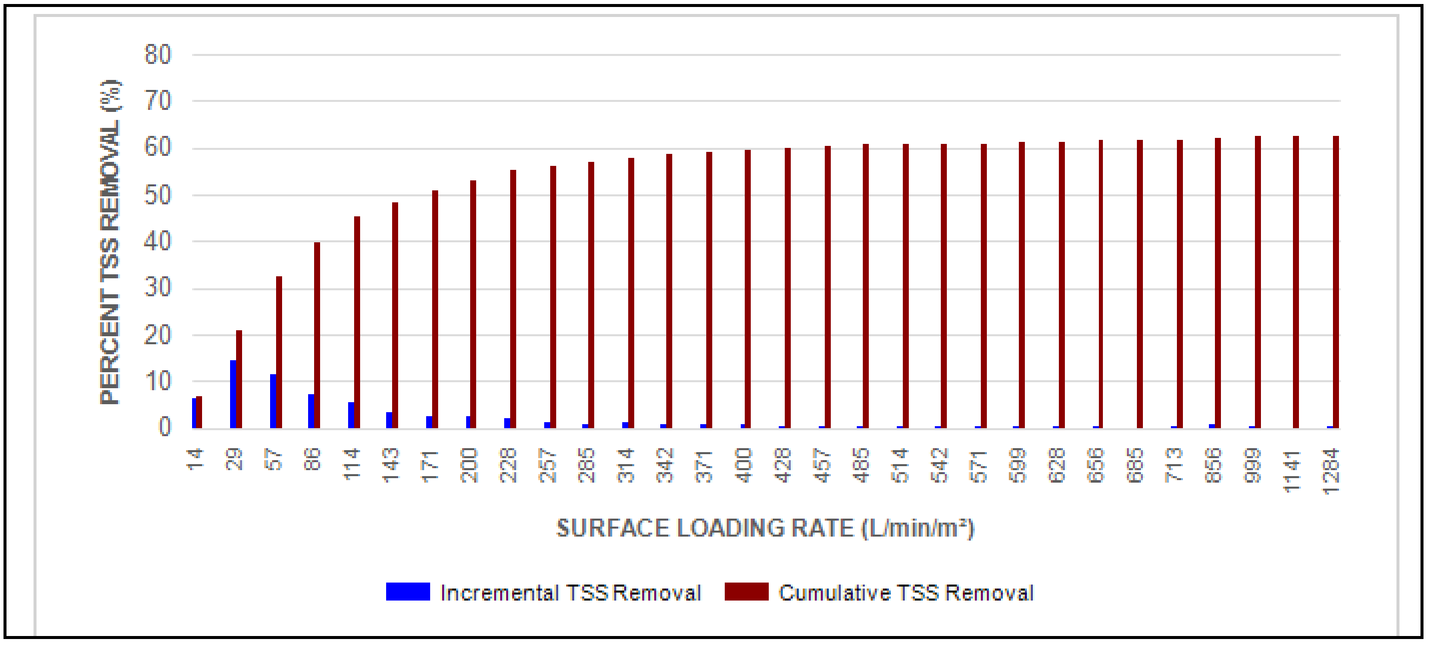
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.5	9.2	9.2	1.74	104.0	14.0	70	6.5	6.5
1	20.5	29.7	3.47	208.0	29.0	70	14.4	20.9
2	16.5	46.2	6.94	417.0	57.0	69	11.4	32.3
3	11.3	57.5	10.42	625.0	86.0	64	7.3	39.5
4	9.1	66.7	13.89	833.0	114.0	62	5.6	45.1
5	5.5	72.2	17.36	1042.0	143.0	59	3.3	48.4
6	4.5	76.7	20.83	1250.0	171.0	57	2.6	50.9
7	4.2	80.9	24.30	1458.0	200.0	54	2.3	53.2
8	3.5	84.4	27.78	1667.0	228.0	53	1.9	55.1
9	2.0	86.5	31.25	1875.0	257.0	53	1.1	56.2
10	1.5	88.0	34.72	2083.0	285.0	52	0.8	56.9
11	1.8	89.8	38.19	2291.0	314.0	51	0.9	57.9
12	1.1	90.9	41.66	2500.0	342.0	50	0.5	58.4
13	1.1	92.0	45.14	2708.0	371.0	49	0.5	58.9
14	1.4	93.4	48.61	2916.0	400.0	48	0.7	59.6
15	0.8	94.2	52.08	3125.0	428.0	47	0.4	60.0
16	0.6	94.8	55.55	3333.0	457.0	47	0.3	60.3
17	0.5	95.3	59.02	3541.0	485.0	46	0.2	60.5
18	0.3	95.6	62.49	3750.0	514.0	45	0.1	60.7
19	0.2	95.9	65.97	3958.0	542.0	44	0.1	60.8
20	0.2	96.1	69.44	4166.0	571.0	43	0.1	60.9
21	0.5	96.6	72.91	4375.0	599.0	42	0.2	61.1
22	0.4	97.0	76.38	4583.0	628.0	42	0.2	61.2
23	0.3	97.3	79.85	4791.0	656.0	42	0.1	61.4
24	0.0	97.3	83.33	5000.0	685.0	42	0.0	61.4
25	0.2	97.4	86.80	5208.0	713.0	41	0.1	61.4
30	1.6	99.1	104.16	6249.0	856.0	41	0.7	62.1
35	0.6	99.7	121.52	7291.0	999.0	40	0.3	62.3
40	0.0	99.7	138.88	8333.0	1141.0	38	0.0	62.3
45	0.3	100.0	156.24	9374.0	1284.0	36	0.1	62.4
Estimated Net Annual Sediment (TSS) Load Reduction =								**62 %**

Climate Station ID: 6137287 *Years of Rainfall Data*: 33

RAINFALL DATA FROM ST CATHARINES AP RAINFALL STATION



INCREMENTAL AND CUMULATIVE TSS REMOVAL
FOR THE RECOMMENDED STORMCEPTOR® MODEL



Maximum Pipe Diameter / Peak Conveyance

Stormceptor EF / EFO	Model Diameter		Min Angle Inlet / Outlet Pipes	Max Inlet Pipe Diameter		Max Outlet Pipe Diameter		Peak Conveyance Flow Rate	
	(m)	(ft)		(mm)	(in)	(mm)	(in)	(L/s)	(cfs)
EF4 / EFO4	1.2	4	90	609	24	609	24	425	15
EF6 / EFO6	1.8	6	90	914	36	914	36	990	35
EF8 / EFO8	2.4	8	90	1219	48	1219	48	1700	60
EF10 / EFO10	3.0	10	90	1828	72	1828	72	2830	100
EF12 / EFO12	3.6	12	90	1828	72	1828	72	2830	100

SCOUR PREVENTION AND ONLINE CONFIGURATION

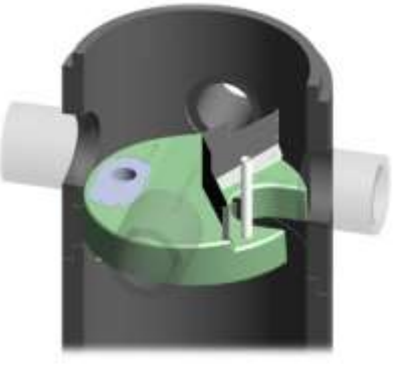
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test performance has been third-party verified in accordance with the ISO 14034 ETV protocol. As a result, Stormceptor EF and EFO are approved for online installation, eliminating the need for costly additional bypass structures, piping, and installation expense.

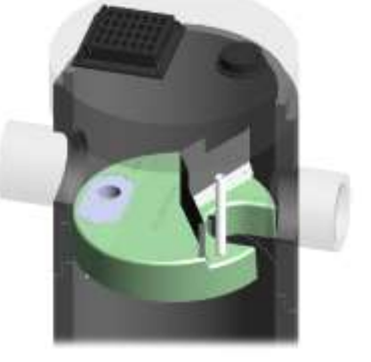
DESIGN FLEXIBILITY

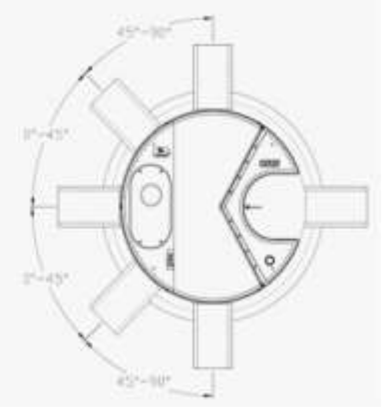
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend angle, and can be modified to ensure performance in submerged conditions.

OIL CAPTURE AND RETENTION

►While Stormceptor® EF will capture and retain oil from dry weather spills and low intensity runoff, **Stormceptor® EFO** has demonstrated superior oil capture and greater than 99% oil retention in third-party testing according to the light liquid re-entrainment testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**. Stormceptor EFO is recommended for sites where oil capture and retention is a requirement.







INLET-TO-OUTLET DROP

Elevation differential between inlet and outlet pipe inverts is dictated by the angle at which the inlet pipe(s) enters the unit.
0° - 45° : The inlet pipe is 1-inch (25mm) higher than the outlet pipe.
45° - 90° : The inlet pipe is 2-inches (50mm) higher than the outlet pipe.

HEAD LOSS

The head loss through Stormceptor EF is similar to that of a 60-degree bend structure. The applicable K value for calculating minor losses through the unit is 1.1. For submerged conditions the applicable K value is 3.0.

Pollutant Capacity

Stormceptor EF / EFO	Model Diameter		Depth (Outlet Pipe Invert to Sump Floor)		Oil Volume		Recommended Sediment Maintenance Depth *		Maximum Sediment Volume *		Maximum Sediment Mass **	
	(m)	(ft)	(m)	(ft)	(L)	(Gal)	(mm)	(in)	(L)	(ft³)	(kg)	(lb)
EF4 / EFO4	1.2	4	1.52	5.0	265	70	203	8	1190	42	1904	5250
EF6 / EFO6	1.8	6	1.93	6.3	610	160	305	12	3470	123	5552	15375
EF8 / EFO8	2.4	8	2.59	8.5	1070	280	610	24	8780	310	14048	38750
EF10 / EFO10	3.0	10	3.25	10.7	1670	440	610	24	17790	628	28464	78500
EF12 / EFO12	3.6	12	3.89	12.8	2475	655	610	24	31220	1103	49952	137875

*Increased sump depth may be added to increase sediment storage capacity
** Average density of wet packed sediment in sump = 1.6 kg/L (100 lb/ft³)

Feature	Benefit	Feature Appeals To
Patent-pending enhanced flow treatment and scour prevention technology	Superior, verified third-party performance	Regulator, Specifying & Design Engineer
Third-party verified light liquid capture and retention for EFO version	Proven performance for fuel/oil hotspot locations	Regulator, Specifying & Design Engineer, Site Owner
Functions as bend, junction or inlet structure	Design flexibility	Specifying & Design Engineer
Minimal drop between inlet and outlet	Site installation ease	Contractor
Large diameter outlet riser for inspection and maintenance	Easy maintenance access from grade	Maintenance Contractor & Site Owner

STANDARD STORMCEPTOR EF/EFO DRAWINGS

For standard details, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

STANDARD STORMCEPTOR EF/EFO SPECIFICATION

For specifications, please visit http://www.imbriumsystems.com/stormwater-treatment-solutions/stormceptor-ef

Table of TSS Removal vs Surface Loading Rate Based on Third-Party Test Results
Stormceptor® EFO

SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL	SLR (L/min/m²)	TSS % REMOVAL
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30	70	690	42	1350	35	2010	24
60	67	720	41	1380	34	2040	23
90	63	750	41	1410	34	2070	23
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150	58	810	41	1470	32	2130	22
180	56	840	41	1500	32	2160	22
210	54	870	41	1530	31	2190	22
240	53	900	41	1560	31	2220	21
270	52	930	40	1590	30	2250	21
300	51	960	40	1620	29	2280	21
330	50	990	40	1650	29	2310	21
360	49	1020	40	1680	28	2340	20
390	48	1050	39	1710	28	2370	20
420	47	1080	39	1740	27	2400	20
450	47	1110	38	1770	27	2430	20
480	46	1140	38	1800	26	2460	19
510	45	1170	37	1830	26	2490	19
540	44	1200	37	1860	26	2520	19
570	43	1230	37	1890	25	2550	19
600	42	1260	36	1920	25	2580	18
630	42	1290	36	1950	24		

STANDARD PERFORMANCE SPECIFICATION FOR "OIL GRIT SEPARATOR" (OGS) STORMWATER QUALITY TREATMENT DEVICE

PART 1 – GENERAL

1.1 WORK INCLUDED

This section specifies requirements for selecting, sizing, and designing an underground Oil Grit Separator (OGS) device for stormwater quality treatment, with third-party testing results and a Statement of Verification in accordance with ISO 14034 Environmental Management – Environmental Technology Verification (ETV).

1.2 REFERENCE STANDARDS & PROCEDURES

ISO 14034:2016 Environmental management – Environmental technology verification (ETV)

Canadian Environmental Technology Verification (ETV) Program's **Procedure for Laboratory Testing of Oil-Grit Separators**

1.3 SUBMITTALS

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

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

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

PART 2 – PRODUCTS

2.1 OGS POLLUTANT STORAGE

The OGS device shall include a sump for sediment storage, and a protected volume for the capture and storage of petroleum hydrocarbons and buoyant gross pollutants. The minimum sediment & petroleum hydrocarbon storage capacity shall be as follows:

2.1.1	4 ft (1219 mm) Diameter OGS Units:	1.19 m^3 sediment / 265 L oil
	6 ft (1829 mm) Diameter OGS Units:	3.48 m^3 sediment / 609 L oil
	8 ft (2438 mm) Diameter OGS Units:	8.78 m^3 sediment / 1,071 L oil
	10 ft (3048 mm) Diameter OGS Units:	17.78 m^3 sediment / 1,673 L oil
	12 ft (3657 mm) Diameter OGS Units:	31.23 m^3 sediment / 2,476 L oil

PART 3 – PERFORMANCE & DESIGN

3.1 GENERAL

The OGS stormwater quality treatment device shall be verified in accordance with ISO 14034:2016 Environmental management – Environmental technology verification (ETV). The OGS stormwater quality treatment device shall remove oil, sediment and gross pollutants from stormwater runoff during frequent wet weather events, and retain these pollutants during less frequent high flow wet weather events below the insert within the OGS for later removal during maintenance. The Manufacturer shall have at least ten (10) years of local experience, history and success in engineering design, manufacturing and production and supply of OGS stormwater quality treatment device systems, acceptable to the Engineer of Record.

3.2 SIZING METHODOLOGY

The OGS device shall be engineered, designed and sized to provide stormwater quality treatment based on treating a minimum of 90 percent of the average annual runoff volume and a minimum removal of an annual average 60% of the sediment (TSS) load based on the Particle Size Distribution (PSD) specified in the sizing report for the specified device. Sizing of the OGS shall be determined by use of a minimum ten (10) years of local historical rainfall data provided by Environment Canada. Sizing shall also be determined by use of the sediment removal performance data derived from the ISO 14034 ETV third-party verified laboratory testing data from testing conducted in accordance with the Canadian ETV protocol Procedure for Laboratory Testing of Oil-Grit Separators, as follows:

3.2.1 Sediment removal efficiency for a given surface loading rate and its associated flow rate shall be based on sediment removal efficiency demonstrated at the seven (7) tested surface loading rates specified in the protocol, ranging 40 L/min/m^2 to 1400 L/min/m^2, and as stated in the ISO 14034 ETV Verification Statement for the OGS device.

3.2.2 Sediment removal efficiency for surface loading rates between 40 L/min/m^2 and 1400 L/min/m^2 shall be based on linear interpolation of data between consecutive tested surface loading rates.

3.2.3 Sediment removal efficiency for surface loading rates less than the lowest tested surface loading rate of 40 L/min/m^2 shall be assumed to be identical to the sediment removal efficiency at 40 L/min/m^2. No extrapolation shall be allowed that results in a sediment removal efficiency that is greater than that demonstrated at 40 L/min/m^2.

3.2.4 Sediment removal efficiency for surface loading rates greater than the highest tested surface loading rate of 1400 L/min/m^2 shall assume zero sediment removal for the portion of flow that exceeds 1400 L/min/m^2, and shall be calculated using a simple proportioning formula, with 1400 L/min/m^2 in the numerator and the higher surface loading rate in the denominator, and multiplying the resulting fraction times the sediment removal efficiency at 1400 L/min/m^2.

The OGS device shall also have sufficient annual sediment storage capacity as specified and calculated in Section 2.1.

3.3 CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of third-party scour testing conducted in

accordance with the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.**

3.3.1 To be acceptable for on-line installation, the OGS device must demonstrate an average scour test effluent concentration less than 10 mg/L at each surface loading rate tested, up to and including 2600 L/min/m^2.

3.4 LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING

The OGS device shall have Canadian ETV or ISO 14034 ETV Verification of completed third-party Light Liquid Re-entrainment Simulation Testing in accordance with the Canadian ETV **Program's Procedure for Laboratory Testing of Oil-Grit Separators,** with results reported within the Canadian ETV or ISO 14034 ETV verification. This re-entrainment testing is conducted with the device pre-loaded with low density polyethylene (LDPE) plastic beads as a surrogate for light liquids such as oil and fuel. Testing is conducted on the same OGS unit tested for sediment removal to assess whether light liquids captured after a spill are effectively retained at high flow rates.

3.4.1 For an OGS device to be an acceptable stormwater treatment device on a site where vehicular traffic occurs and the potential for an oil or fuel spill exists, the OGS device must have reported verified performance results of greater than 99% cumulative retention of LDPE plastic beads for the five specified surface loading rates (ranging 200 L/min/m^2 to 2600 L/min/m^2) in accordance with the Light Liquid Re-entrainment Simulation Testing within the Canadian ETV Program's **Procedure for Laboratory Testing of Oil-Grit Separators.** However, an OGS device shall not be allowed if the Light Liquid Re-entrainment Simulation Testing was performed with screening components within the OGS device that are effective at retaining the LDPE plastic beads, but would not be expected to retain light liquids such as oil and fuel.

APPENDIX

D

REFERENCE INFORMATION

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

DATA INTEGRATION DIVISION
LA DIVISION DU TRAITEMENT DES DONNEES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990

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TABLE 1 NIAGARA FALLS ONT 6135638

LATITUDE 4308 LONGITUDE 7905 ELEVATION/ALTITUDE 183 M

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YEAR ANNEE	5 MIN	10 MIN	15 MIN	30 MIN	1 H	2 H	6 H	12 H	24 H
1965	14.0	16.8	19.3	20.8	23.9	26.7	30.5	34.0	44.4
1966	6.1	12.2	13.7	15.7	15.7	17.5	24.6	34.0	34.0
1967	6.9	11.7	12.2	17.5	17.5	18.0	27.2	42.7	63.0
1968	5.1	6.1	7.4	11.7	21.8	26.4	58.2	70.1	75.7
1969	6.3	12.7	18.8	18.8	18.8	19.8	37.6	41.7	47.5
1970	8.6	9.4	13.5	14.5	15.7	19.0	29.2	29.2	37.3
1971	9.1	12.2	15.7	19.6	27.2	48.3	53.8	53.8	53.8
1972	9.4	15.5	21.1	31.0	39.1	47.8	48.0	48.0	48.8
1973	6.6	11.4	15.0	25.7	31.5	35.6	37.8	37.8	38.9
1974	5.6	7.4	9.9	14.2	14.7	22.4	30.7	30.7	36.8
1975	8.9	13.0	16.0	19.0	19.0	30.7	36.1	45.7	46.0
1976	6.9	11.7	14.5	17.8	18.8	21.6	39.1	40.9	50.3
1977	8.4	14.2	18.8	27.9	31.2	34.8	46.7	63.5	83.1
1978	8.6	12.8	15.8	21.0	26.1	31.5	52.2	52.2	56.2
1979	6.1	10.3	12.8	16.6	17.8	26.4	48.4	81.6	86.2
1980	6.7	9.0	12.9	22.1	24.3	24.8	25.4	35.2	41.0
1981	6.5	9.0	11.9	15.8	22.4	31.7	46.3	68.9	68.9
1982	3.9	6.0	6.4	8.7	11.6	15.1	20.8	25.2	29.8
1983	12.6	18.1	23.5	26.0	47.0	47.4	53.0	54.4	57.4
1984	7.6	8.6	12.5	13.9	14.4	19.8	33.0	38.8	41.0
1985	7.5	10.6	13.5	17.2	20.2	21.7	30.2	37.0	42.7
1986	9.6	10.2	11.4	14.7	18.5	23.2	34.9	34.9	51.7
1987	12.2	14.4	18.2	30.2	36.9	36.9	50.8	54.4	66.4
1988	3.8	6.3	8.8	15.6	21.2	25.4	33.7	59.6	62.1
1989	3.9	5.5	7.3	11.8	19.2	23.3	38.6	41.6	42.0
1990	5.1	8.6	9.6	11.3	12.3	18.2	27.0	39.3	45.8

NOTE:-99.9 INDICATES MSG DATA
DONNEES MANQUANTES

# YRS. ANNEES	26	26	26	26	26	26	26	26	26
MEAN	7.5	10.9	13.9	18.4	22.6	27.5	38.2	46.0	52.0

MOYENNE									
STD. DEV. ECART-TYPE	2.6	3.3	4.3	5.8	8.6	9.5	10.5	14.0	14.8
SKEW DISSYMETRIE	.81	.24	.27	.68	1.30	1.04	.29	.88	.84
KURTOSIS KURTOSIS	3.80	2.90	2.99	3.16	4.74	3.59	2.23	3.53	3.36

NOTE: -99.9 INDICATES LESS THAN 10 YEARS OF DATA AVAILABLE
INDIQUE MOINS DE 10 ANNEES DE DONNEES DISPONIBLES
ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990
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TABLE 2 NIAGARA FALLS ONT 6135638

LATITUDE 4308 LONGITUDE 7905 ELEVATION/ALTITUDE 183 M
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RETURN PERIOD RAINFALL AMOUNTS (MM)
PERIODE DE RETOUR QUANTITIES DE PLUIE (MM)

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS	# YEARS ANNEES
5 MIN	7.1	9.4	10.9	12.9	14.3	15.7	26
10 MIN	10.4	13.3	15.3	17.7	19.6	21.4	26
15 MIN	13.2	17.0	19.5	22.8	25.1	27.5	26
30 MIN	17.5	22.6	26.1	30.4	33.6	36.8	26
1 H	21.2	28.7	33.8	40.1	44.8	49.5	26
2 H	25.9	34.3	39.9	46.9	52.1	57.3	26
6 H	36.5	45.8	52.0	59.8	65.5	71.3	26
12 H	43.7	56.0	64.2	74.6	82.3	89.9	26
24 H	49.5	62.6	71.3	82.3	90.4	98.5	26

RETURN PERIOD RAINFALL RATES (MM/HR)-95% CONFIDENCE' LIMITS
INTENSITE DE LA PLUIE PAR PERIODE DE RETOUR (MM/H)-LIMITES DE CONFIANCE DE 95%

DURATION DUREE	2 YR/ANS	5 YR/ANS	10 YR/ANS	25 YR/ANS	50 YR/ANS	100 YR/ANS
5 MIN	85.3	112.9	131.2	154.3	171.4	188.4
	+/- 11.0	+/- 18.6	+/- 25.1	+/- 33.8	+/- 40.4	+/- 47.1
10 MIN	62.2	79.8	91.6	106.3	117.3	128.2
	+/- 7.1	+/- 11.9	+/- 16.1	+/- 21.6	+/- 25.9	+/- 30.2
15 MIN	52.6	68.0	78.2	91.0	100.5	110.0
	+/- 6.1	+/- 10.3	+/- 14.0	+/- 18.8	+/- 22.5	+/- 26.2
30 MIN	34.9	45.3	52.1	60.8	67.2	73.5

	+/- 4.1	+/- 6.9	+/- 9.4	+/- 12.7	+/- 15.1	+/- 17.6
1 H	21.2	28.7	33.8	40.1	44.8	49.5
	+/- 3.0	+/- 5.1	+/- 6.9	+/- 9.3	+/- 11.1	+/- 13.0
2 H	13.0	17.1	19.9	23.4	26.0	28.6
	+/- 1.7	+/- 2.8	+/- 3.8	+/- 5.1	+/- 6.2	+/- 7.2
6 H	6.1	7.6	8.7	10.0	10.9	11.9
	+/- .6	+/- 1.0	+/- 1.4	+/- 1.9	+/- 2.3	+/- 2.7
12 H	3.6	4.7	5.4	6.2	6.9	7.5
	+/- .4	+/- .7	+/- .9	+/- 1.3	+/- 1.5	+/- 1.8
24 H	2.1	2.6	3.0	3.4	3.8	4.1
	+/- .2	+/- .4	+/- .5	+/- .7	+/- .8	+/- .9

ATMOSPHERIC ENVIRONMENT SERVICE
SERVICE DE L"ENVIRONNEMENT ATMOSPHERIQUE

RAINFALL INTENSITY-DURATION FREQUENCY VALUES
INTENSITE, DUREE ET FREQUENCE DES PLUIES

GUMBEL - METHOD OF MOMENTS/METHODE DES MOMENTS - 1990
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TABLE 3 NIAGARA FALLS ONT 6135638

LATITUDE 4308 LONGITUDE 7905 ELEVATION/ALTITUDE 183 M
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INTERPOLATION EQUATION / EQUATION D"INTERPOLATION: R = A * T ** B
R = RAINFALL RATE / INTENSITE DE LA PLUIE (MM /HR)
T = TIME IN HOURS / TEMPS EN HEURES

STATISTICS STATISTIQUES	2 YR ANS	5 YR ANS	10 YR ANS	25 YR ANS	50 YR ANS	100 YR ANS
MEAN OF R MOYENNE DE R	31.2	40.7	47.0	55.0	60.9	66.8
STD. DEV. R ECART-TYPE	29.6	38.8	44.8	52.5	58.2	63.9
STD. ERROR ERREUR STANDARD	6.8	8.9	10.3	12.1	13.4	14.7
COEFF. (A) COEFFICIENT (A)	19.4	25.3	29.1	34.0	37.6	41.2
EXPONENT (B) EXPOSANT (B)	-.668	-.673	-.676	-.678	-.680	-.681
MEAN % ERROR % D'ERREUR	8.1	8.6	8.8	9.2	9.5	9.7

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Revisiting Design Criteria for Stormwater Treatment Systems, Part 3

Flow-through treatment swales & strips

By Gary R. Minton

This is the third of a four-part series examining design criteria for stormwater treatment systems. Basins and fine-media filters were the focus of the first two articles. In this article, the focus is on grass-covered, flow-through treatment swales and strips. Stormwater is treated as it passes through the swale. Infiltration may occur but is not relied upon to contribute to performance.

In the 25 years since US communities first began requiring post-development treatment of stormwater, local, regional, and state governments have published many manuals and handbooks identifying acceptable treatment systems (structural best management practices, or BMPs) and design criteria. As noted in the first part of this series, few of the criteria were initially supported by laboratory or field research, and engineers relied on their best professional judgment in choosing design criteria.

Moreover, treatment strategy is evolving from a focus on the general removal of pollutants using total suspended solids (TSS) as the surrogate for all pollutants to the more recent trend to consider specific pollutants. In certain situations, some states now emphasize removal of total phosphorus, total nitrogen, and dissolved metals. Design criteria can vary depending on which pollutants are targeted.

Terminology

With a flow-through swale, the bulk of the stormwater passes through and exits at the downslope end of the swale. A strip, a lateral swale in which water enters along its longitudinal length, is considered by many to be a viable BMP for roads without curbs. The term *biofiltration* is commonly used to identify swales and strips—e.g., biofilters and filter strips. However, the grass covering does not filter out the particulates. Sedimentation is the dominant removal process for sediment and attached pollutants. Swales and strips are more appropriately characterized as biosettlers: they are shallow settling basins (Minton 2002).

Flow-through swales are designed based on the peak flow of the design event. Several states, most particularly along the East Coast, design swales to capture and retain the design event volume. The bulk of the water exits either through underdrains or by infiltration. These types are referred to as wet and dry swales, respectively. Here the swale is, in effect, either a long, shallow, extended detention basin or an infiltration basin. Sometimes swales whose method of discharge is infiltration are referred to as infiltration or bioinfiltration swales. Some manuals specify 0.5 in/hr as a precondition for the use of a swale or strip, the same criterion used for infiltration basins and trenches. Significant infiltration as a precondition prevents the use of swales and strips with more restrictive soils, while the opposite is the case with flow-through swales. Alternative definitions for the same terminology can lead to confusion regarding suitable design criteria and observed performance. This article focuses solely on swales and strips in which the bulk, if not all of the stormwater, exits the downslope end.

With flow-through swales and strips, grass is critical to success. Grass must remain erect through all storms up to the peak of the design event with the water surface below the top of the grass. Erect grass provides high resistance to flow. The resistance increases the depth of the water in the grass while decreasing flow velocity. The outcome is settling of sediment and attached pollutants (Minton 2002). Table 1 provides design criteria for flow-through swales from representative manuals.

Determining the Width

Sizing a flow-through swale consists of two steps: determining the bottom width and then determining the length. The width reflects the peak flow rate up to which effective treatment is desired based upon a management goal of treating the majority—e.g., 90%—of the stormwater generated over time. However, the length determines the performance.

Equation 1. Manning's Equation

$$Q = VA = \frac{kAR^{2/3}S^{1/2}}{n}$$

Where:

Q = discharge
V = velocity
R = hydraulic radius
A = cross-sectional area of flow
S = longitudinal slope of the swale
n = Manning's coefficient
k = 1 (Metric) or 1.49 (Imperial)

Several equations are available to calculate the appropriate bottom width of a channel or swale (Minton 2002). Commonly used is Manning's equation, presented at right.

Width appears twice on the right side of the equation: as part of *A*, the vertical cross-sectional area of the flow, and as part of *R*, the hydraulic radius. The mathematical form of the hydraulic radius differs with the cross-sectional shape. The most common shape is trapezoidal, expressed in Figure 1.

Solving for bottom width is an iterative process, easily done with a spreadsheet program. Known are the peak flow of the design event, the design resistance coefficient, and the slope. Water depth at the peak flow is either selected by the design engineer or specified by the manual. The proper selection of the resistance coefficient, discussed later in this article, is critical to ensure that the depth of water at the peak design flow remains below the top of the grass and that the grass remains essentially erect. The appropriate value for Manning's coefficient, *n*, is discussed later.

Determining the Length

Once the bottom width is determined, the length is determined. Early manuals in the 1980s specified a swale length of 200 feet (about 60 meters). The origin of this specification was the study of a freeway ditch not designed to treat stormwater (Wang et al. 1982). In this study, removal efficiency was evaluated along the length of the grassed ditch. By happenstance, about 80% removal occurred at 200 feet with little apparent additional removal beyond this distance. Controlled flow tests of field swales have found 65 meters (about 215 feet) and 75 meters (about 246 feet) effective (Kuo et al. 1999; Fletcher et al. 2001, respectively). Some recently published manuals use detention time to determine the length, but specify a minimum length of 100 feet (about 30 meters).

Using the nominal detention or hydraulic residence time to define the length was introduced (Washington 1992) based on Kahn et al. (1992). The length is determined with Equation 2. The nominal detention time in Equation 2 is at the peak flow of the design event.

Equation 2

$$L = 60VD_t$$

D_t = nominal detention or residence time (min)

V = water velocity at the peak of the design event (ft/sec) = Q_d/A

Q_d = design peak flow (ft^3/sec)

A = vertical cross-sectional area of flow at the peak of the design event (ft^2)

The information required to determine the water velocity is known: peak of the design event, bottom width, and depth of water at the peak of the design event. The term nominal is used because the above equation ignores the effects of the cross-sectional area of the grass on flow velocity (Backstrom 2002) and longitudinal dispersion, and in turn the real detention time. The actual detention time is likely to be considerably less than the calculated nominal detention time. Values currently used for detention time and their origin are presented later in this article.

Resistance Coefficient: Manning's *n*

The specification of Manning's *n*, the resistance coefficient, establishes the bottom width of the swale: The greater the value selected, the greater the bottom width. As noted previously, to function the vegetation must remain erect up to the depth of the peak flow of the design event. As such, the resistance to flow is significant. For a channel whose sole purpose is to carry water, with prone grass at high flows, the coefficient is typically taken to be 0.03. Initially, manuals specified this value not recognizing the importance of erect grass. At this value, the swale is too narrow and the result is that the grass becomes prone at a flow rate considerably less than the peak of the design event. Velocities are too high, and sediments do not settle in the grass. This is likely the reason why studies of some swales found unsatisfactory performance. These swales were likely sized with low resistance coefficients. The grass became prone in the storms sampled. In any given swale or strip, Manning's coefficient likely increases with flow depth. The value of interest is at the point of maximum water depth, occurring at the peak of the design event.

Unknown until recently to stormwater engineers, field studies conducted in the 1940s by agricultural engineers found resistance coefficients are very high when the grass remains erect and the water surface is below the top of the grass, on the order of 0.25 to 0.50 (Minton 2002). Once the grass begins to lie down in the direction of the flow, the resistance decreases and flow velocities increase, reducing treatment effectiveness. The relationship between water depth, grass height, and resistance is illustrated in Figure 2. Note that as the water level rises the resistance increases to the point where the grass begins to lie down. From this point resistance decreases as the water level continues to rise. Eventually the grass becomes prone where it offers the least resistance. The increase in resistance with water depth below the height of the grass is probably because the grass blades are thicker at their upper ends, offering greater resistance to flow. Note that the grass begins to bend over at a water depth considerably below the top of the grass. This will be discussed in more depth later in this article.

Currently, most manuals specify a value on the order of 0.20 to 0.25, apparently based on one study of a treatment swale (Kahn et al. 1992). These values are consistent with prior work by agricultural engineers. Laboratory studies found Manning's coefficient values of 0.20 to 0.50 (Johnson et al. 2003). The authors reaffirmed the classic relationship between the coefficient and the product of the hydraulic radius and flow velocity (Ree 1949), but for flows where the water is below the top of the grass. A recent study of 14 field swales found the coefficient to vary from 0.19 to 0.53 with a median value of 0.28 (Colwell 2001). Colwell recommended a design value of 0.30. Interestingly, the study found that the resistance coefficient was high even in swales with patchy grass cover. Some manuals specify two values for Manning's coefficient based on the recommendation of Kahn et al. (1992): mowed, 0.20, and unmowed, 0.24. However, it is not certain that the observed difference was real, given the limited number of tests and the inaccuracy of measurements of low flow as noted by Kahn et al. (1992). It should be noted that *mowed* in this context does not mean regular mowing but rather that the grass is cut occasionally, perhaps only once after the early spring surge of growth. In this context, the true distinction should be between tall and short grass, not mowed and unmowed. Regardless, given the findings of Colwell (2001), distinguishing between unmowed and occasionally mowed grass is likely pointless. As pointed out by Kahn et al. (1992), regularly mowing may result in increased grass-stem density or thickness in its lower stems (taller grass tends to thin due to shading), increasing the resistance to flow. This has been the apparent reasoning for specifying a greater value for strips (Table 1). However, it seems more appropriate to distinguish between swales and strips that are unmowed or occasionally mowed with those regularly mowed to relatively short heights. The latter, in which the resistance coefficient is likely much higher, tends to occur in retail commercial developments where property owners are concerned about the aesthetics of the landscaping.

Note that regardless of the value selected for Manning's coefficient, the total area of the swale remains the same, for the same design peak flow and longitudinal slope. Using a higher Manning's coefficient increases the width of the swale, but correspondingly decreases its length. Hence, selecting a higher value does not increase the land dedicated to the treatment system. However, with a high Manning's coefficient, the width of the swale increases to a point of impracticality. If the swale is too wide, the stormwater cannot effectively spread across the entire width. Recognizing this point, some manuals specify a maximum width (Table 1). Others specify that lateral flow spreaders be placed at 50-foot intervals along the swale. There are, however, no data indicating the effects of either criterion on the hydraulic efficiency of swales. Regardless, specifying a maximum width limits the drainage area that can be served by a swale. A value in the range of 0.20 to 0.30 is recommended based on current knowledge. Values toward the higher end of this range should be used if the grass is kept relatively short (e.g., 6 inches) and well maintained.

Maximum Water Depth
Few manuals specify a maximum water depth at the design peak flow. Therefore, design engineers might choose a substantial depth (e.g., 12 inches) to minimize the width. In such cases, the requirement for erect grass is not likely to be met, particularly if the grass is regularly mowed. It is prudent to specify a maximum depth (Table 1).

Furthermore, grass becomes prone at water depths less than the grass height. Some manuals specify a water depth at the design flow but not a corresponding grass height, although they might, in a maintenance section, recommend the height or height range to which the grass should be cut. The latter is usually greater than the former. But the relationship between the two is not stated in the manual. Perhaps the relationship should be stated more explicitly in design manuals. Failure to specify the grass height in relationship to the water depth at design flow may result in the grass lying down at flows less than the design flow. Studies (Samani and Kouwen 2002, Ree 1949) suggest that significant bending and decline of the resistance to flow occurs when the water depth is less than half the height of the grass (Figure 2). Therefore, both the maximum water depth and grass height should be specified, with the grass height twice the depth of the water depth at the peak of the design event.

Detention Time
The concept of detention time derives from one study (Kahn et al. 1992) of a properly designed and constructed treatment swale. Performance was evaluated at two sets of average detention times: one of 4.3 to 5.6 minutes, taken as

4.5 minutes, and the second set of 8.3 to 9.5 minutes, taken as 9 minutes. The detention times represented samples taken at 100 and 200 feet, respectively, of a 200-foot swale. It was concluded that there was no statistically significant difference in performance between the two detention times, although the data suggest that performance was poorer at the lower detention time. Kahn et al. (1992) suggested "that a residence time of 9 minutes is sufficient to assure good pollutant removals. A minimum hydraulic residence cannot be given with certainty, although it can be said that with residence times of 4.5 minutes, deterioration in performance is likely, especially during larger storms."

The conclusions of Kahn et al. (1992) were based on only six storms sampled at each length. Furthermore, they were not identical storms; that is, during each storm sampling occurred at either 100 or 200 feet, not both. Recognizing the considerable uncertainty inherent to the study, the State of Washington chose 9 minutes as the peak rather than the average flow of the design event. Although this decision appears overly conservative, the detention time does not vary substantially with flow rate. This is because the water depth—and therefore volume in the swale—rises and falls with the flow rate. The detention time remains relatively constant during the storm, given that the resistance to flow is less at lower water depths (Figure 1). Hence, calculating the length based on the average flow of the design event would produce essentially the same length of swale.

Some manuals have included the range of 5 to 9 minutes as the design criterion, based on the qualified conclusions of Kahn et al. (1992). However, if given a range, it is reasonable to expect the design engineer will select 5 minutes as it gives a shorter swale. Jurisdictions should identify one value for the detention time if they use this criterion.

The work of Yu et al. (2001) is reasonably consistent with Kahn et al. (1999). They tested swales with controlled flows at detention times of 5.5, 7, 10, and 18 minutes. Removal efficiencies for TSS were 48%, 70%, 67%, and 86% respectively. These are mass reductions. The role of infiltration was not defined. Backstrom (2002) developed a relationship between performance and detention time using laboratory and field swales. The relationship suggests that if high (about 90%) removal of particles down to 15 microns is desired, a detention time on the order of 8 minutes is necessary for swales with modest or no infiltration. Consistent removal of particles smaller than 15 microns requires a considerably larger detention time according to Backstrom (2002). A swale with high infiltration appears to require a lower detention time (Backstrom 2002) to obtain the desired performance.

The classic kinetic removal equation has been proposed for sizing swales (Fletcher et al. 2001). The weakness of this approach, however, is the selection of the "average" influent and apparent background (lowest possible) concentrations, and the kinetic removal rate constant. Furthermore, the kinetic rate constant likely varies with the influent concentration and hydraulic loading rate (Kadlec 2000), complicating the use of the concept. Nonetheless, the concept should continue to be evaluated in field or laboratory studies.

Although detention time has become the common criterion to specify length, the proper design criterion may be hydraulic loading rate (Mazer 1998). As noted previously, a swale or strip is a shallow settling basin. As such, performance during a storm is a function of the hydraulic loading rate (Minton 2002): effectively, the flow rate divided by the plan view (width times length) of the swale or strip. However, most studies do not include the information necessary to calculate the hydraulic loading rate and in turn its relationship to performance. One study of swales under controlled flows found the performance decreased with increasing hydraulic loading (Fletcher et al. 2001). Values ranged from about 0.04 to about 0.23 ft/ft2. Performance dropped from about 95% to about 75% at the upper end of the loading range.

Longitudinal Slope and Internal Flow Control

Concerns for flow convergence and erosion led early to the specification of the maximum longitudinal slope. Maximum slopes vary widely in manuals: 1% to 5%. Some manuals specify that swales not be used unless the slope is less than the maximum allowed. Other manuals allow their use if check dams are included. Check dams reduce velocities and the potential for flow convergence. They retain some water, which may infiltrate and increase performance (Kaighn and Yu 1996, Yousef et al. 1985). One study found convergence in swales with slopes greater than 1% unless check dams were present (Mazer 1998). Another (Colwell 2001) found sufficient flow convergence at slopes greater than 2.5% to result in channelization. Some manuals include lateral flow spreaders regardless of the slope. Flow spreaders differ from check dams in that the top elevation is just slightly above the invert of the swale, facilitating mowing. However, there are no data or visual observations indicating that flow spreaders (or check dams) prevent flow convergence. Certainly a flow spreader should be placed at the entrance of the swale to spread the water as it exits the drainage pipe.

Filter Strips

Table 1 indicates that design criteria differ greatly for strips. Many manuals do not allow filter strips as "standalone" treatment systems. They do not view filter strips as equivalent in performance to other treatment systems such as basins, swales, and filters. However, performance data suggest otherwise (Caltrans 2004a and 2004b), indicating effective removal of TSS and attached pollutants occurs within a few meters of the pavement edge. The issue is maintaining sheet flow into and through the strip. Attention to pavement edge design and construction is important. Curbs with curb cuts should be avoided as convergent flow occurs. Exposing the entire length of the strip to inflow is preferred. Manuals should specify the maximum width of pavement allowed to drain to the strip. Failure to do so could result in large lateral flows into the strip per lineal foot or meter, exacerbating tendencies toward concentration of flow and rutting of the strip.

Not well established is the appropriate specification of the maximum width of pavement that should drain to a strip. This is likely a function of rainfall intensity; that is, the maximum allowable pavement width should be lower for regions with high-intensity rainfall like the southeastern and south-central United States. One jurisdiction specifies the maximum lineal flow rate to the strip (Table 1). Rainfall intensity is also a factor to consider when establishing the maximum slope. Values differ greatly according to Table 1. Satisfactory performance has been found with slopes exceeding 15% (Caltrans 2004b).

Final Observations

Researchers have found performance to be highly variable, from relatively poor to above 80% of the TSS, meeting the more common performance goals of many manuals. In some cases, poor performance can be attributed to the test facility being a roadside ditch not specifically designed to treat stormwater. It is, however, not possible to relate the variation in performance to alternative design criteria (e.g., detention time or hydraulic loading rate) as most researchers have failed to include the necessary information. This has made a comparative analysis impossible. Key information missing depending on the study may be the swale width; length and/or longitudinal slope; condition of the grass; and key attributes of each sampled storm, such as flow rates, maximum water depth relative to grass height (whether the grass remained erect), and the amount of infiltration. Confusion can also occur because of the varying role of infiltration in each study, and whether the researcher is reporting reductions in concentrations or loadings. To arrive at the appropriate design criteria requires that researchers report more than just influent and effluent concentrations.

Of concern is the erosion of swales due to excessive shear forces, reducing performance. This can be avoided with dense grass and consideration to the hydraulic radius-velocity product. Procedures to consider this question are provided in some manuals. Johnson et al. (2003) recently updated this concept based on laboratory and fieldwork. Resuspension during extreme events of previously removed sediment and pollutants is of concern but remains undefined. Some manuals recommend or require the swale to be offline, bypassing flows greater than the treatment design event. Inadequate maintenance leads to degraded and patchy grass, channelization, and erosion. The performance of swales and strips is more sensitive to poor maintenance than that of basins.

The most extensive studies relating internal characteristics such as grass density and cover to flow and performance outcomes are Colwell (2001) and Mazer (1998). These studies found that grass can experience extended periods of submergence with modest declines in density and health. Neither the detention time nor the resistance coefficient could be correlated to the extent of density of grass cover, to species mix, or to a wide range of flow resistance values. However, another researcher (Backstrom 2002) found that TSS removal improved with denser grass.

Whether swales and strips remove dissolved pollutants remains an open question. Field performances provide differing results. There remains a conflict between the desire to have thick grass to achieve a suitable resistance to flow and to protect the system from erosion with the desire to have the stormwater contact the soil where dissolved pollutants are removed. Without infiltration, the removal of dissolved pollutants is likely minor. Fertilization appears to cause the export of dissolved phosphorus (Caltrans 2004a). Plant die-off may release nutrients. Dissolved pollutant removal will be further explored in the last article of this series.

An inherent limitation of flow-through swales may be that regardless of the design value selected for Manning's coefficient, the actual resistance for most constructed swales at the peak design flow differs from the design value, either higher or lower (Colwell 2001). If the actual value is greater than the design value, the grass becomes prone at flows less than the design flow. As a consequence, the management goal of treating, for example, 90% of the stormwater over time is not met. If the actual value is less than the design value, the depth of water at the design peak rate (and each flow rate) is less than expected and in turn the flow velocity is greater than expected. As a consequence, the detention time and therefore performance is less than expected.

Practical limitations on system width and grass height constrain the use of swales to small drainage areas of a few acres or less. They become less practical in regions with high intensity rainfall such as the southeastern and south-central United States. In such areas, the combined effect of a maximum bottom width and a substantial design peak flow is to limit use to small drainage areas. Swales and strips may not be appropriate for regions with cold winters. Treatment of snowmelt and spring storms may be severely compromised by the temporary degraded condition of the grass.

Summary

With respect to the removal of sediment and attached pollutants, flow-through swales and strips can provide an acceptable level of treatment as a standalone system. They should be able to meet the performance goal of most manuals, 80% removal of TSS. However, less confidence can be placed in the performance of swales in contrast to wet basins and sand filters, particularly if regular maintenance is not performed. Given the uncertainties expressed in this article, it is not unreasonable that some jurisdictions do not find them to be an acceptable treatment system unless significant infiltration is involved.

Satisfactory performance requires that the systems be properly sized. The specified Manning's coefficient should be at least 0.20, and possibly 0.30 where it is expected that the swale will be mowed frequently, as is the case with retail commercial developments. Maximum and minimum longitudinal slopes should be specified. The specification of the maximum slope absent check dams may differ with the climate, being less in areas with higher-intensity storms. The relationship between flow depth and grass height should be recognized in design and maintenance criteria. The manual should specify a maximum water depth at the peak of the design event and a minimum grass height. The latter should be at least twice the former. Most uncertain of the design criteria is length. Our understanding of the relationship between detention time and performance, and the effect of infiltration on this relationship, is poorly understood. A detention time of 9 or 10 minutes is reasonable.

Hydraulic loading rate may be a more appropriate design criterion, but more data on its relationship to performance are needed.

Swales and strips are not "biofilters," as the primary process of particulate pollutant removal is sedimentation. The terms *biofiltration* and *filter* should be dropped. The author recommends the terms *vegetated swale* and *vegetated strip*.

Topics: Research,BMP Manufactured,BMP Post Construction

Prepared for:
Grand Niagara Co-Owners and
City of Niagara Falls

STORMWATER MANAGEMENT PLAN

GRAND NIAGARA SECONDARY PLAN

14.15039.001 | November 2016

WSP | MMM GROUP

Contents

1 INTRODUCTION

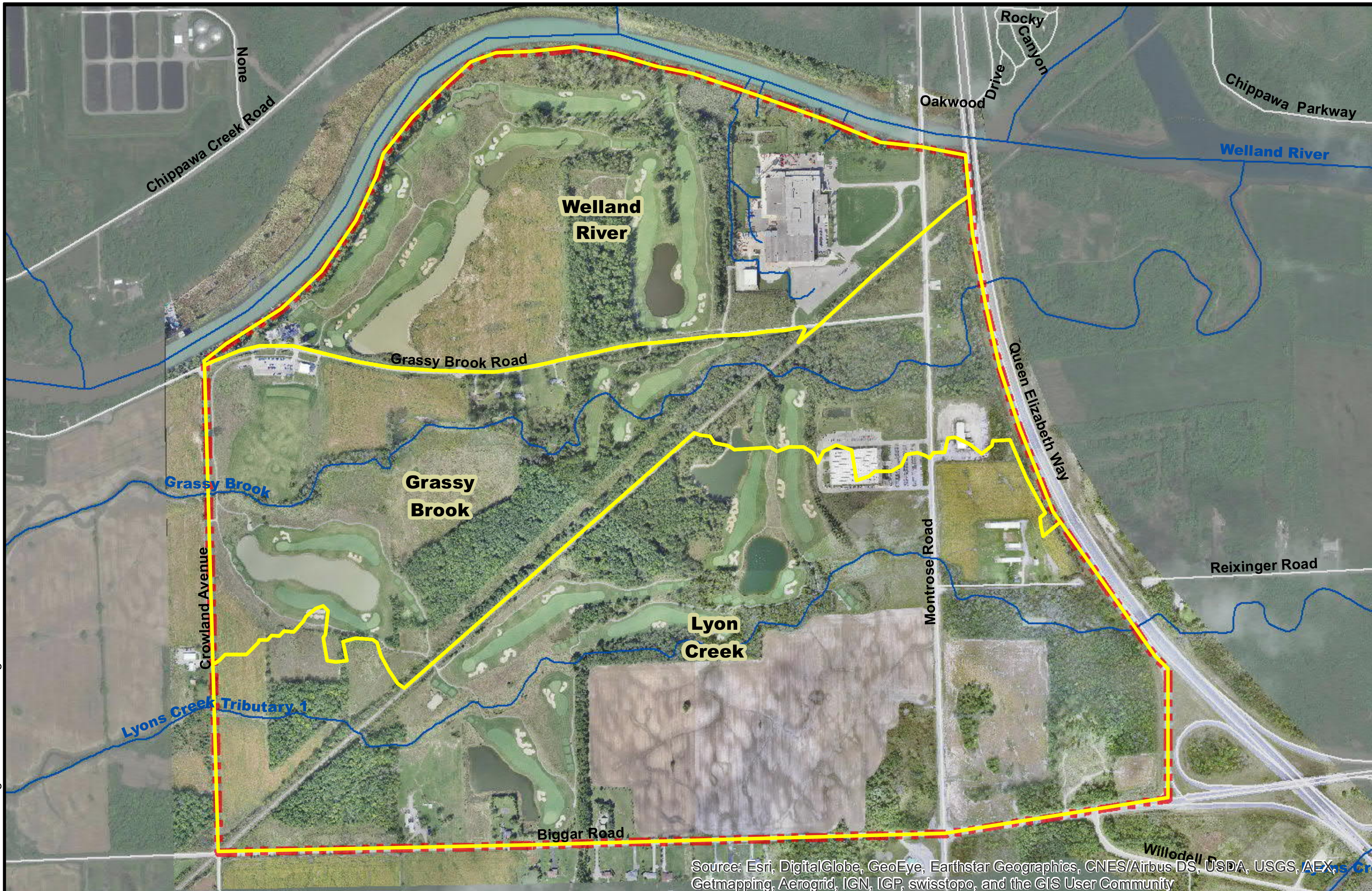
WSP/MMM Group Limited was retained by the Grand Niagara Co-Owners to provide professional services to obtain the approval of a Secondary Plan for the lands currently occupied by the Grand Niagara golf course in the City of Niagara Falls. The project - Grand Niagara Secondary Plan Area (Grand Niagara, in brief) is boundary by Welland River at the north, Biggar Road to the south, Crowland Avenue to the west and Queen Elizabeth Way (QEW) to the east (see Figure 1.1). The proposed development mainly consists of residential, commercial, employment and a hospital.

As shown in Figure 1.1, three watercourses – Welland River, Grassy Brook and Lyons Creek Tributary 1 drain the Grand Niagara from west to east. These watercourses are located within the jurisdiction of Niagara Peninsula Conservation Authority (NPCA).

This Stormwater Management Report is one of the technical documents required to support the Secondary Plan approval. The report was prepared to include the following contents:

- Review background
- Summary of the existing hydrology conditions
- Floodplain limit delineation – existing and proposed conditions
- Development of stormwater management (SWM) criteria
- Proposed SWM strategy to mitigate the development impacts on watercourses.

The preliminary land use of Grand Niagara development is included in Appendix A.



Legend

- Drainage Catchment
- Grand Niagara Limit
- Watercourse
- Roads

N W E S

0 70 140 280 420 560 Meters

CLIENT

GRAND NIAGARA CO-OWNERS

TITLE

GRAND NIAGARA SECONDARY PLAN AREA

SITE LOCATION

WSP | MMM GROUP

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M.D.	S.Y
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2 REVIEW OF BACKGROUND

2.1 General

The majority of Grand Niagara is situated in the South Niagara Falls Watershed and located within Grassy Brook sub-watershed and Lyons Creek sub-watershed. The remaining area of the subject project is located in Lower Welland River Watershed. The following documents were collected and reviewed:

- Soils of Regional Niagara (Kigston and Present 1989) by the Ontario Ministry of Agriculture and Food and Agriculture Canada
- South Niagara Falls Watershed Report dated 2008 by NPCA
- Lower Welland River Characterization Report dated May 2011 by NPCA
- Stormwater Management Guidelines dated March 17, 2010 prepared by AECOM for NPCA
- Flood Plain Mapping – Lyon Creek including Tee Creek dated December 2009 Revised March 2011 by NPCA
- Floodline Analysis for the Grand Niagara Resort dated October 2000 prepared by Burnside Golf Services
- Letter Re: Grand Niagara Golf Resort Additional Hydraulic Analyses at Watercourse Crossings dated April 20, 2004 from Burside to NPCA

2.2 Soil Information

The soil map (Figure 2.1) was prepared based on the Soils of Regional Niagara. The majority of the study area is covered by soils – Niagara and Welland. These type soils have combined problems of imperfectly or poor drainage and high water table. They fall in Hydraulic Soil Group D, which means high runoff volume generation from a storm.

2.3 Watershed Reports

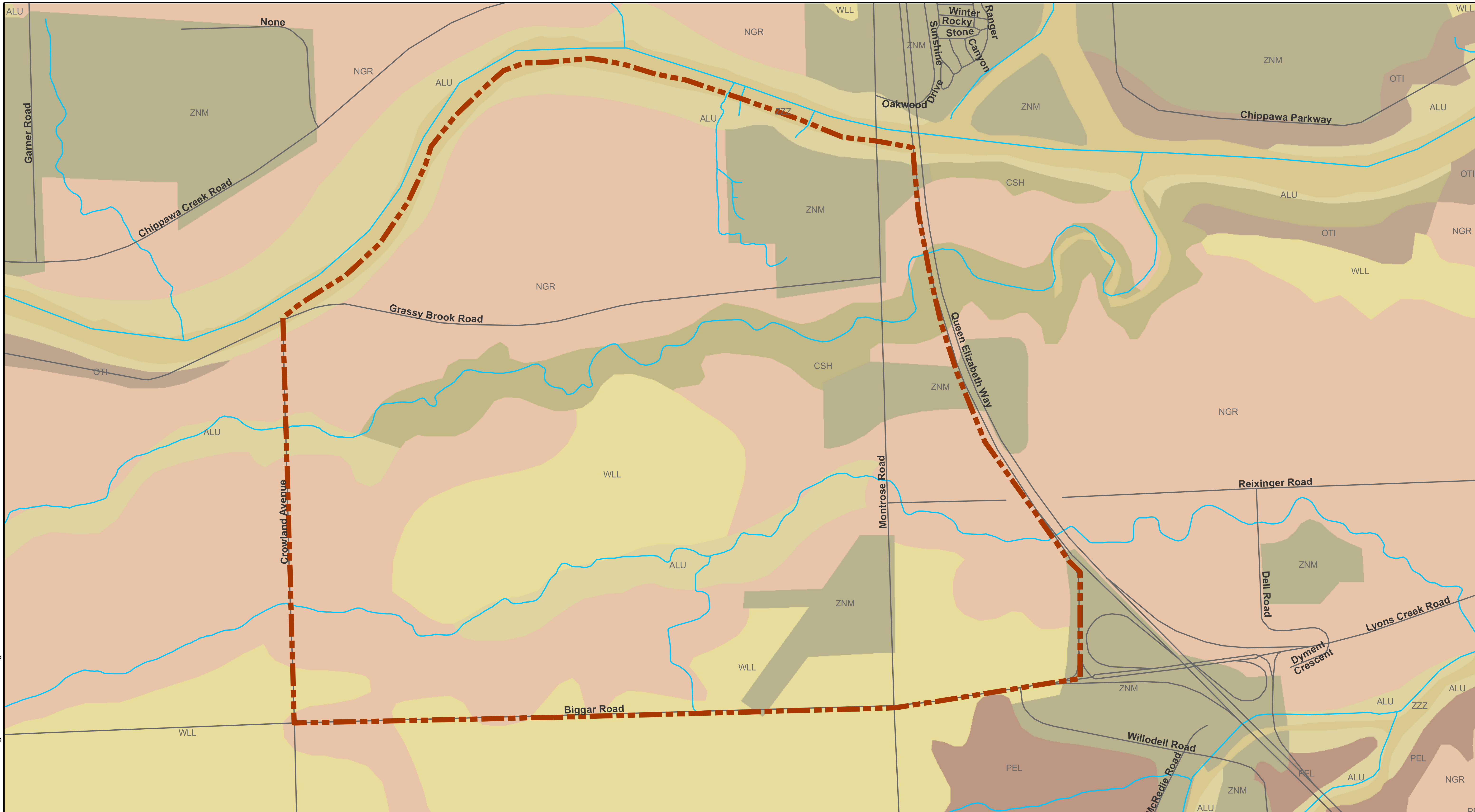
The South Niagara Falls Watershed Report and Lower Welland River Characterization Report were reviewed. The main information relevant to the drainage conditions of Grand Niagara were outlined below.

South Niagara Falls Watershed Report

- The primary physiographic region is the Haldimand Clay Plain, which was overlaid by post-glacial Lake Warren and much of it is covered by lacustrine clay deposits.
- Grassy Brook subwatershed is primarily agricultural in nature. The main channel have been classed as Type 1 Fish Habitat where requires the highest level of protection. It is reported to be experiencing exceedances of phosphorus and algae were observed at Crowland Avenue and Montrose Road during the summer months. The Restoration Strategy indicates that a riparian planting program at Grassy Brook north of Carl Road would to assist in the enhancement of water quality and fish habitat.
- No hydrology analysis was provided in the report.

Lower Welland River Characterization Report

- The river drains 800 km^2 from Ancaster to Niagara Falls. The watershed is located at the Haldimand Clay Plain.
- Due to climate change, changes are expected to the hydrologic cycle



Legend

GRAND NIAGARA LIMIT
ROADS
WATERCOURSE

Soils

ALU
CSH
NGR
OTI
PEL
WLL
ZNM
ZZZ

0 62.5 125 250 375 500 Meters

N S E W

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SOILS

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- Winter runoff expected to increase; total runoff expected to decrease
- Groundwater recharge expected to decrease
- Water temperature expected to rise
- Decreased runoff may lead to reduced water quality
- No Significant Groundwater Recharge Areas are identified in the Lower Welland River study area but it exists in an area south of the study area in the Grassy Brook subwatershed but is outside the Grand Niagara limit
- The watercourse in the Grand Niagara Secondary Plan Area falls under a “Critical: Type 1” fish habitat

2.4 NPCA Stormwater Management Guidelines

General policy slated on the guidelines is “Sufficient SWM controls are required by the NPCA to ensure that flooding, pollution, surface erosion and conservation of land impacts due to development do not occur.” Detailed requirements with regards to Flood/Quality Control, Quality Control, Water Balance, Erosion/Geomorphologic Consideration, etc. are included in the Appendix A. Note, with regard to flooding/quantity control, “Consideration may be given to not requiring peak flow controls if the assessment of receiving system capacity demonstrates little or no benefit to such controls. This would include situations such as discharge to major river systems or directly to a Lake. Pre-consultation with the NPCA and additional approval requirements are necessary for this to be considered”.

2.5 NPCA Flood Plain Mapping – Lyon Creek

The NPCA conducted hydrologic and hydraulic analyses to investigate the 100-year peak flow rates and floodplain limits of Lyons Creek and its tributaries.
Lyons Creek Tributary 1 drains the south portion of Grand Niagara in an easterly direction to join the main branch of Lyons Creek at the east of QEW. Figure 2.2 shows the locations of Tributary 1 catchments and the boundary of Grand Niagara. Grand Niagara occupies about 49.5% of the total area of the Catchment Trib1_10.

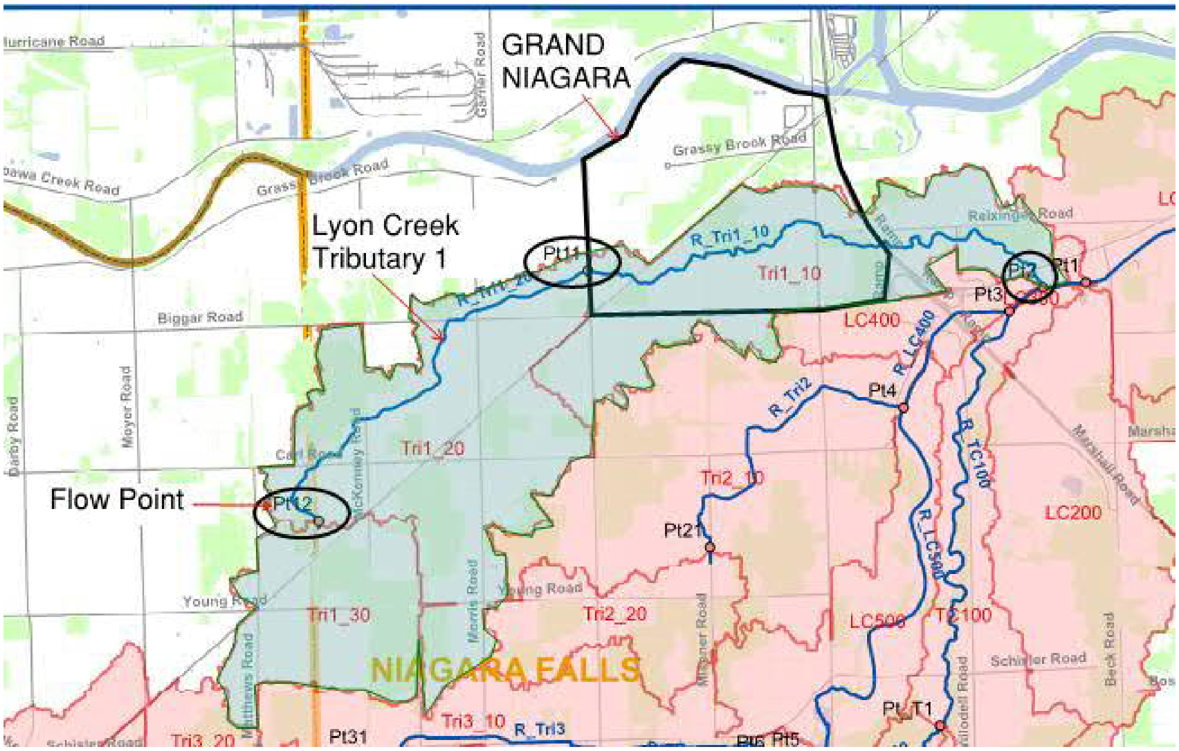


Figure 2.2 CATCHMENTS AND FLOW POINTS OF LYON CREEK TRIBUTARY 1

The general information of the NPCA study was summarized as below:

- Rainfall Data: Intensity-Duration-Frequency (IDF) of Niagara Falls (#6135638)
- Design Storm: 12 hour AES distribution and 100-year rainfall depth is 89.9 mm
- Hydrology Model: Hydrologic Engineering Center – Hydrologic Modelling System (HEC-HMS) was selected to investigate the flows.
- Catchment Parameters: the parameters used in the hydrology modeling for the catchments of Tributary 1 were copied from the report and shown in Table 2.1.

Table 2.1 Parameters of Catchments to Lyon Creek Tributary 1

Sub-Watershed	Area (km^2)	Imperviousness (%)	Initial Abstraction (mm)	SCS Curve Number	Time of Concentration (hour)	Channel Slope (%)
Trib1_10	3.02	6.844	10.64	82.69	2.85	0.06
Trib1_20	3.79	3.832	10.70	82.61	2.62	0
Trib1_30	1.66	2.4384	11.54	81.49	2.02	0

- Hydrologic Model Results: the 100-year flood rates (i.e. the regulatory flood) of Tributary 1 are shown in Table 2.2.

Table 2.2 100-year Peak Flow Rates

Flow Point	Drainage Area (km²)	Peak Flow Rate (m³/s)
Pt12	1.66	4.5
Pt11	5.45	10.3
Confluence to Main Branch*	8.47	13.4

Note: *- the flow point was added to the original model.

- Crossings of Lyon Creek Tributary 1: Culverts at the creek were inspected and surveyed in NPCA study. The detailed information excerpted from the report is included in Appendix B.

- Hydraulic Model and Results: a HEC-RAS model was used to investigate the 100-year flood elevations of Tributary 1. The modelling results are provided in Appendix B. Note, the flow rate of flow point Pt_11 (at the Crownland Avenue) was used for the river reach from Crownland Ave. to QEW.

- The model results demonstrate that crossings – at the railway (Model ID 107) and Carl Road (Model ID 113) have insufficient conveyance capacity (i.e. aggravate flooding).

2.6 Floodplain Analysis for the Grand Niagara Resort

Burnside conducted the hydrology and hydraulic analyses for Grassy Brook to support the Grand Niagara Golf Resort development. Per the report, the total drainage area of Grass Brook is 12.83 km^2. A 11.92 km^2 parcel (catchments 401,402, 403, 404 and 405) is located at the upstream of Grand Niagara. The NPCA verified that the Regulatory design storm is a 100-year storm (i.e. a storm that has the possibility of occurring one in every one hundred years). A HEC-RAS model was obtained from the NPCA. The information provided in the report is summarized below:

- Hydrology Model: SWM-HYMO
- Design Storm: SCS 24-hour storm, 100-year rainfall depth is 98.5 mm
- Catchment Parameters: the drainage area, time of peak, etc. are excerpted from the report and tabulated in Table 2.3. The highlighted catchments cover the study area. Note, the initial abstraction used in the model is 1.5 mm per the model output.

Table 2.3 Catchment Information

Catchment	Area (ha)	Length (m)	Slope (%)	Tc (min)	Tp (hr)	CN
401	288.8	2650	0.36	200	2.23	77
402	500.2	5910	0.19	366	4.08	78
403	149.4	1500	0.13	209	2.33	79
404	197.3	2300	0.20	226	2.52	81
405	56.1	878	0.17	147	1.64	81
406	65.3	1593	0.13	219	2.45	81
407	16.7	415	0.12	113	1.27	81
408	9.3	255	0.10	95	1.06	81

* highlighted areas are located in Grand Niagara.

- Hydrologic Modeling Results: the 100-year flow rates obtained from the modelling were copied from the report and shown in Table 2.4.

Table 2.4 Peak Flow Rates (100-year Storm)

Location (Flow Point)	Area (ha)	Flow Rate (m^3/s)
At Confluence (NPAC pt 327005) -411	938	16.0
At Site Limit (NPCA pt 227003)-412	1136	16.7
at Culvert – 413	1192	16.9
At CON rail line – 414	1257	16.7
At Morris Road – 415	1273	16.7
At QEW (NPCA pt 227002) -416	1283	16.7

* highlighted areas are located in Grand Niagara.

- Hydraulic Model: a HEC-RAS model (Version 2.1) was developed to investigate flood elevations.

- Crossing Information: the dimensions and parameters of culverts used in the hydraulic model (HEC-RAS) are provided in Appendix B. Note, the crossing at QEW is excluded from the HEC-RAS model.

- Floodplain Mapping: The flood elevations copied from the report is provided in Appendix B.

- In year 2004, Burnside updated the HEC-RAS model to demonstrate that the construction of two pedestrian crossings (designed for a 5-year flood) in golf resorts would not impact the upstream and downstream floodplain limits. The HEC-RAS model obtained from the NPCA doesn’t have the two crossings.

3 FLOODPLAIN LIMITS

3.1 Existing Flood Plain Limits

Three watercourses – Welland River, Grassy Brook and Lyon Creek Tributary drain Grand Niagara from west to east. The floodplain limits of the Grassy Brook and Lyon Creek Tributary 1 had been determined by the following studies and are illustrated in the NPCA's online information system:

- Flood Plain Mapping – Lyon Creek including Tee Creek, NPCA, December 2009 (revised March 2011)
- Floodline Analysis for the Grand Niagara Resort , Burnside Golf Services, October 2000

The floodplain limits of Welland River are also available on the NPAC's online database. Figure 3.1 shows the flood limits downloaded from the NPCA's online information system.

3.2 Development Impacts on Floodplain Limits

The urbanization in Grand Niagara will increase the impervious coverage, therefore, the investigation of the development impacts on the current floodplain limits was carried out.

3.2.1 Lyon Creek Tributary 1

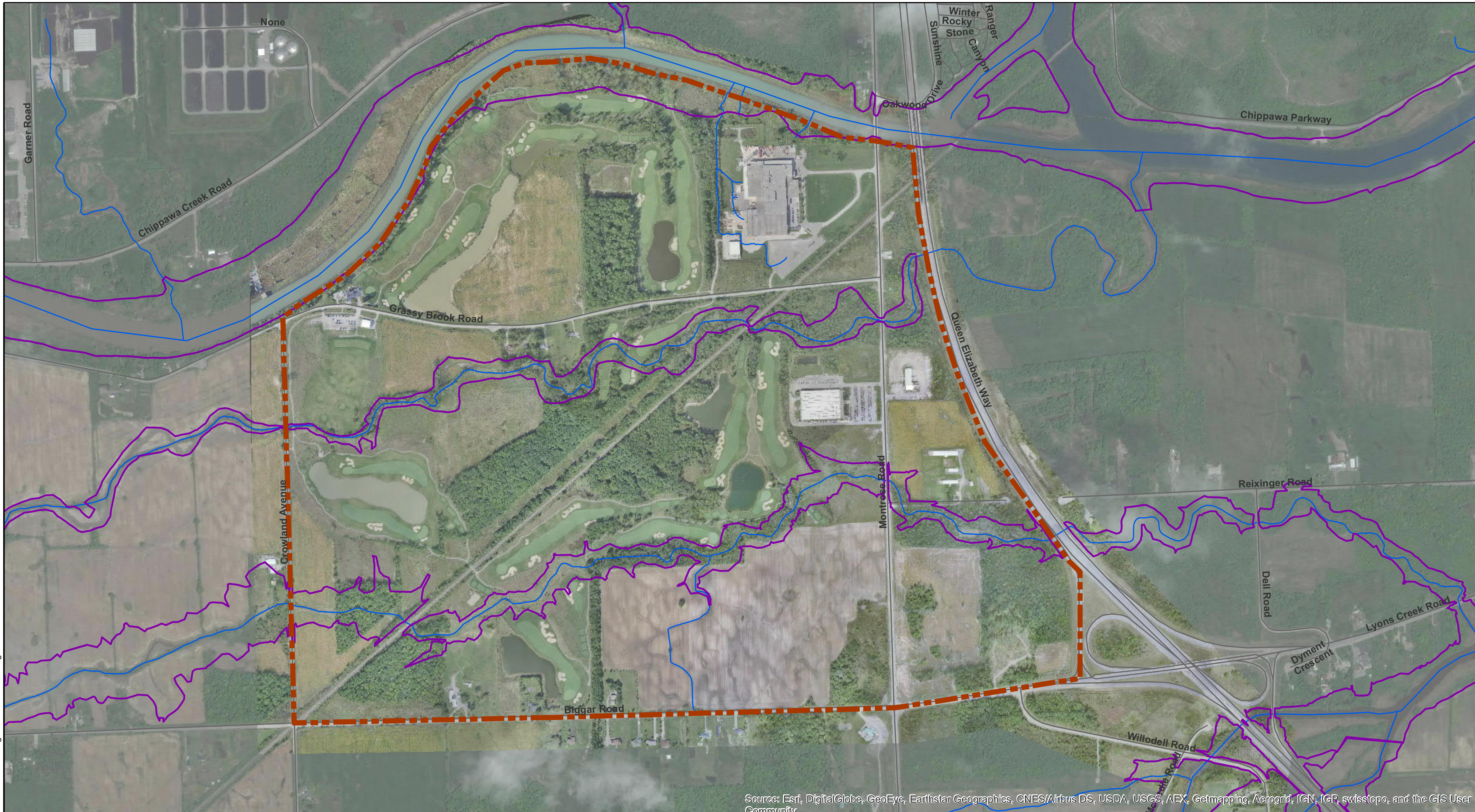
As mentioned in Section 2.4, Grand Niagara is situated in Catchment Trib_10 and covers about 50% area of this catchment. In the future, the 150 ha Grand Niagara in the catchment will be hospital, commercial, mixed and residential (see preliminary land use plan in Appendix A) . The estimate imperviousness level of the development is 80%. With the alteration of land use, the overall imperviousness of Catchment Trib_10 will increase. The revision of imperviousness is shown in Table 3.1.

Table 3.1 Revision of Catchment Imperviousness

Catchment	Area (ha)	Current Imperviousness (%)	Future Imperviousness (%)
Trib1_10	302	6.844	43.1

The HEC-HMS model used for the NPCA's hydrology study was revised to reflect the imperviousness increase of Catchment Trib1_10. The other parameters of the model remained. At the Tributary confluence to the Lyon Creek, the 100-year flow rate is 14.0 m^3/s. Compare to the original model result 13.4 m^3/s, the 4% flow increase is minor. At the confluence of Tributary 1 to Lyon Creek (flow point Pt2) and the downstream (flow point Pt1), the flow alterations are more negligible. For example, the flow rate at the confluence is originally 88.9 m^3/s; with Grand Niagara development, it is 89.2 m^3/s. The revised HEC-HMS model output is included in Appendix B.

As per the NPCA's hydraulic analysis (i.e. HEC-RAS model), the flood elevations of Catchment Trib_10 were computed with the flow rate of Catchment Trib1_20 which is located at the upstream of Trib_10. Therefore, the minor flow change in Catchment Trib_10 will not impact the current floodplain limits. It was confirmed that the minor change of flow rates at the confluence and the downstream will not impact the flood elevations at Tributary 1. The detailed HEC-RAS model results are provided in Appendix B.



Legend

- GRAND NIAGARA LIMIT
- 100 YR FLOODLINE
- ROADS
- WATERCOURSE

N / E / S / W

0 62.5 125 250 375 500 Meters

CLIENT: GRAND NIAGARA CO-OWNERS

TITLE: GRAND NIAGARA SECONDARY PLAN AREA

FLOOD PLAIN LIMITS

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3.2.2 Grassy Brook

The Grand Niagara within the Grass Brook drainage basin is 88.4 ha. As per the Burnside Floodline Analysis, the total area of Catchments 406, 407 and 408 is 91.3 ha. The proposed Grand Niagara development will impact the imperviousness level of these catchments.

A SWMHYMO model was used in the Burnside Floodline Analysis to investigate the flow rates of the drainage catchments. This model was converted to a state-of-art window interface model - VisualHYMO (VO2) as both programs have the same core processor -HYMO (hydrologic simulation method). Using the same hydrologic parameters of original model, the flow rates obtained from the VO2 model match up to the original model results. The model output is included in Appendix B. The comparison of flow rates obtained from these two models is shown in Table 3.2.

The proposed Grand Niagara development within Grassy Brook watershed will be residential and employment (see preliminary land use plan in Appendix A), therefore an imperviousness of 70% ~ 85% is appropriate to represent the future landuse conditions. Under the future conditions, the estimate of imperviousness in catchments 406 and 407 is to be 70%; and 85% in catchment 408. The VO2 model was revised to reflect the future conditions in these catchments. The model results are shown in Table 3.2. The model output is included in Appendix B. It demonstrates that the 100-year peak flows used in the floodplain limit delineation will not be impacted by the proposed development in Grand Niagara.

Table 3.2 Comparison of 100-Year Flow Rates (m^3/s)

Location	Area (ha)	Original Model Results used in Floodplain Delineation	Converted VO2 Model Results – Existing Conditions	Converted VO2 Model – Proposed Conditions
Crownland Ave	1191.8	16.86	16.88	16.88
CN Railway	1257.1	16.72	16.73	16.44
Montrose Road	1273.8	16.74	16.75	16.23
QEW	1283.1	16.73	16.70	16.15

Although the increase in the proposed impervious land surface (proposed Grand Niagara development) will increase the frequency and magnitude of the flows, the peak flow rate in the receiving Grassy Brook will not increase. This is primarily due to the timing effects. Figure 3.1 provides an explanation of this hydrograph mechanism. The majority of the Grassy Brook watershed is located upstream of the study area. Thus, the peak flow in the Grassy Brook through the study area occurs well after the peak intensity of the storm event. Following development, the increase in impervious area results in local increases in peak flows, but also tends to decrease the time to peak of these areas in response to a rainfall event. As a result, the peak flows from the developed areas are discharged to the watercourses earlier compared to the pre-development condition, considerably ahead of the time of the peak flows in the receiving water course.

3.2.2 Lower Welland River

The total drainage area of the watercourse is 20.7 km^2. The Grand Niagara development within the watershed is 82 hectares, it covers a negligible downstream portion of the overall drainage catchment, the development will not impact the current floodplain limits.

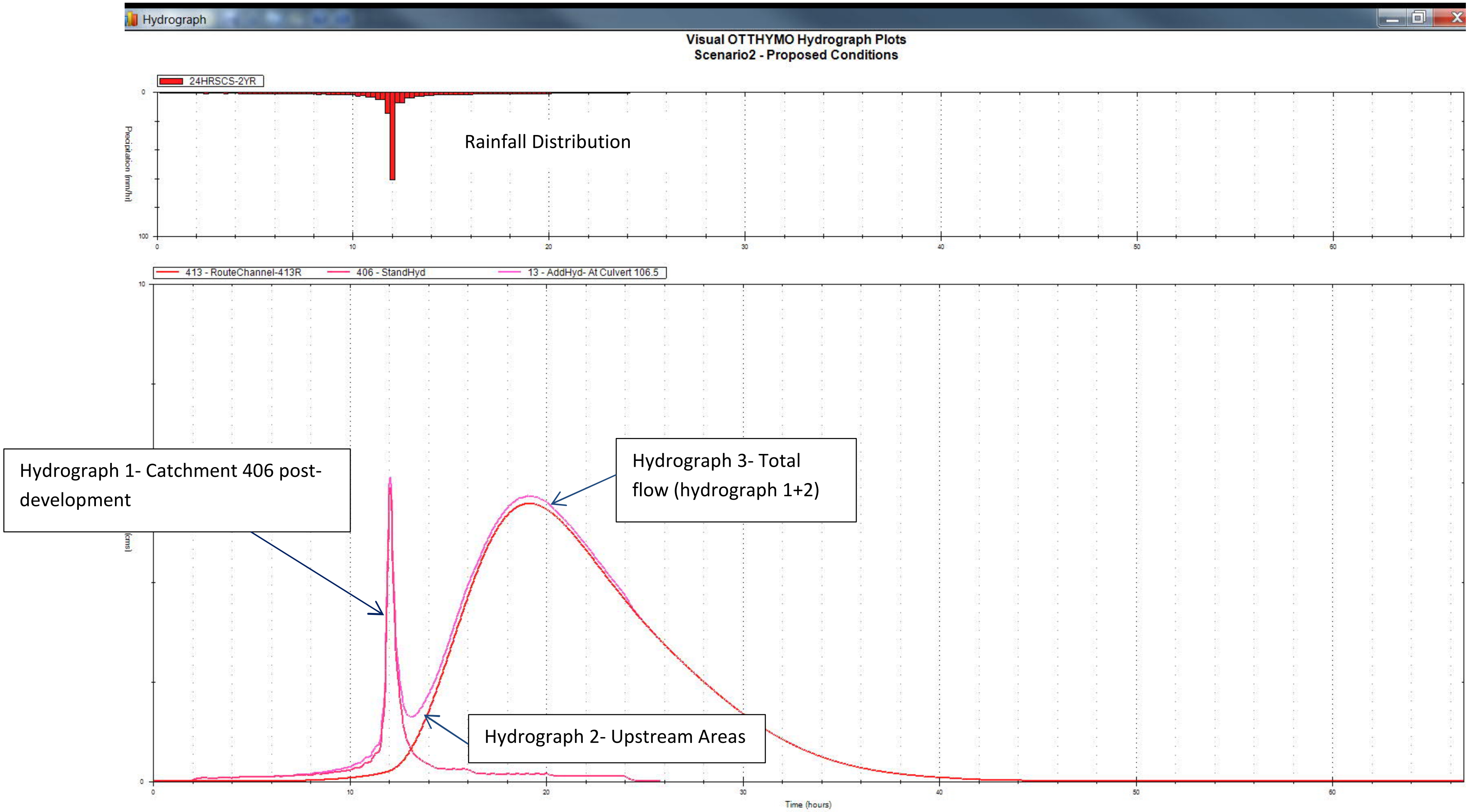

FIGURE 3.1 COMPARISON OF HYDROGRAPH

4 STORMWATER MANAGEMENT

4.1 Drainage Conditions

Total 318 hectares Grand Niagara situates in three drainage basins, namely Lower Welland River, Grass Brook and Lyon Creek Tributary 1 watershed. Currently the land use of these watersheds is mainly agricultural. The site is located over Clay Plain. The imperfect or poor drainage soils at the site location imply the high water table and high runoff volume. Soil CN value ranges from 78 to 82.

Except the Welland River, hydrologic studies for the other two streams had been carried out. Generally, the site is located at the downstream end of the watercourses and occupies a limited portion of the entire drainage areas (see Table 4.1). With respect to hydrology regime, the drainage areas at the upstream of Grand Niagara have the dominant impacts.

Table 4.1 Areas of Grand Niagara and Drainage Basins

Watershed	Watershed Area (ha)	Area (ha) within Grand Niagara	Percentage (%)
Lower Welland River	2070	82.3	4.0
Grassy Brook	1283	88.4	7.0
Lyon Creek Tributary 1	847	147.6	17

As per the previous hydrological analyses, the floodplain limits are determined by a 100-year flood at Grassy Brook and Lyon Creek Tributary 1. As discussed in Section 3.0, the impacts to the peak flows rates of the three receiving water courses are negligible. Therefore the floodplain limits will remain unchanged.

4.2 Investigation of Water Quantity Control Strategy

4.2.1 General

Conventionally, water quantity control, in other words, limit post-development flow rates to pre-development levels, is required to mitigate the runoff increase due to the impervious cover increase by the development. However, the Grand Niagara development is located at the downstream of the receiving watercourses and covers relatively small portion of the entire watershed. Therefore, generally speaking, the flow characteristics such as the timing of flow peak and peak flow rates at the Grand Niagara outlet are dominated by the upstream areas. An investigation of the detailed strategy of water quantity control was carried out and discussed in the following sections.

4.2.2 Lyon Creek Tributary 1

About 147 hectares parcel of Grand Niagara is situated in Catchment Trib_10. To investigate the flood control strategy, this catchment was split into three areas based on the upstream/downstream of Grand Niagara. Two flow points were added into the NPCA's HEC-HMS model: one (Junction-1) is the total flow of three split areas of Catchment Trib1_10; the other one (Pt Trib1 confluence) is the total flow of Tributary 1. This revised HEC-HMS model was used to examine the proposed storage needed for flood control. The following model scenarios were investigated:

- Scenario 1: pre-development condition
- Scenario 2: without flood control
- Scenario 3: control post-development flow to pre-development level
- Scenario 4: provide 25 mm rainfall-runoff detention for 24 hours

The modelling results are summarized in Table 4.2. Model output is provided in Appendix B.

Table 4.2 Comparison of Modelling Results

Flow Point	100-Year Peak Flow Rate (m^3/s)			
	Sc 1: Pre-development	Sc 2: No Flood Control	Sc 3: Control Post- to Pre-	Sc 4: 25mm Runoff Detention
Junction-1	8.9	10.7	7.8	10.7
Pt Trib 1 confluence	11.2	11.5	13.2	11.9
Pt2	87.8	87.9	89.7	88.1

The results of Sc.3 indicate that although the post-development flow is lower than the pre-development flow level (flow point "Junction-1"), the peak flows in the downstream receiving water courses are increased (at flow points "Pt Trib 1 confluence" and "Pt2"). This is because the flood control would delay the flow "time to peak" from the development area, which will then add up with the peak flow of the receiving watercourse. Without any quantity controls, the sediment and pollutant loaded from the development area will be directly washed into the creek. As per the MOE design manual, the detention of 25 mm rainfall-runoff for 24 hours in a wet pond (Sc.4) can effectively remove sediment from stormwater and mitigate the erosion potential to the receiving watercourse, therefore, it is proposed for the subject study area within Lyon Creek watershed.

4.2.3 Grassy Brook

As mentioned in Section 3, Grand Niagara development in Grassy Brook catchments 406-408 will not cause flood flow increase due to the timing of peak flow between the upstream areas and development areas is different and the peak flows from the upstream areas are the greatest. To establish an appropriate plan of water quantity control, for investigating purposes, the following VO2 modelling scenarios were used:

- Scenario 1: pre-development condition
- Scenario 2: without flood control
- Scenario 3: control post-development flow to pre-development level
- Scenario 4: provide 25 mm rainfall-runoff detention for 24 hours

The modelling results compare to the pre-development conditions are summarized in Table 4.3. Model output is provided in Appendix B.

Table 4.3 Modelling Results – Grassy Brook

Flow Point	100-Year Peak Flow Rate (m^3/s)			
	Sc 1 Pre-development	Sc 2 No Flood Control	Sc 3 Control Post- to Pre-	Sc 4 25mm Runoff Detention
CN Railway - 415	16.73	16.44	16.84	16.44
Montrose Rd – 416	16.75	16.23	16.93	16.45
QEW – 417	16.74	16.15	16.97	16.44

The table shows that the significant upstream areas govern the stream flow rates. To control the post-development flows from the study area (Sc 3) would result in the increases of the peak flow rates in the downstream receiving water course. Therefore, it is recommended that providing detention storage for runoff from a 25 mm rainfall event for erosion control (Sc 4), i.e. providing treatment for the first flush, be implemented in the wet ponds servicing development areas within Grassy Brook watershed.

4.2.4 Welland River

As the development is only a negligible portion of the watershed, the development will not alter the stream hydrology regime. In addition, the site is close to the outlet of a major river, water quantity control is not required per the NPCA guidelines.

Based on the above investigation, water quantity control is not required for this development.

4.3 Summary

4.3.1 Stormwater Management Criteria

Based on the section 4.2 investigation, water quantity control is not required for this development. In compliance with the NPCA's SWM Stormwater Management Guidelines approved by NPCA on March 2010, and the MOE Stormwater Management Planning and Design Manual (2003), the following criteria were development for this development:

- Quantity / Flood Control
  - Flood control, i.e. control post-development flow to the pre-development levels is not recommended.
  - Major overland flow routes are to be designed to have sufficient capacity for the Regulatory event (100-year storm)
  - A 3-hour Chicago Storm and a 12-hour AES distribution storm should be used to calculate peak flows, the greater results should be used for check convey capacity

- Erosion Control
  - Detention and release of the 25mm, 4-hour Chicago design storm over a 24-hour period shall be provided for all receiving systems.

- Water Quality Control
  - "Enhanced" level (Level I) of water quality treatment (80% TSS reduction) will be required for all development area draining to the receiving watercourses (e.g., Grassy Brook, Lyons Creek and associated section of Welland River)
  - Properly sized oil/grit separators for stormwater treatment may be considered for commercial, industrial, or infill developments.

- Water Balance
  - Water balance impacts should be evaluated during the design of a site stormwater management system. Best efforts should be made to match pre-development infiltration volumes to the practically feasible extent
  - Hydrogeologically sensitive areas shall be identified as part of the SWM plan.

- Untreated stormwater shall be prevented from being directly infiltrated.

4.3.2 Stormwater Management Implementation Plan

The key objectives of stormwater management are:

- To provide water quality control to meet MOE Level I protection ;
- To maintain the existing watershed hydrological features, and avoid downstream flooding and potential erosion problems;
- To evaluate the site conditions and develop potential Low Impact Development (LID) strategy for the proposed site, in order to maintain the existing water balance to a feasible degree ;
- To integrate the stormwater management system with the overall grading and storm drainage plan for the site; and
- To ensure that the design of the stormwater management facilities conform to the stormwater management objectives and criteria

The flowing measures are proposed be implemented to achieve the objectives:

1. LID Practices

Low impact development (LID) is a sustainable stormwater management strategy that emphasizes conservation and use of existing natural site features integrated with distributed, small-scale stormwater controls to more closely mimic natural hydrologic patterns in residential, commercial and industrial settings. A variety of sustainable stormwater management techniques, including the controls at the lot-level and through conveyance followed by end-of-pipe controls, should be examined to evaluate the feasibility of implementation of these controls. Some feasible SWM practices for the proposed study area are listed as follows:

- Implement flat grading (1%~2%) wherever feasible at the development to promote natural infiltration;
- Direct roof leaders to pervious areas where possible, such as lawns/gardens prior to being collected by storm sewers, in order to enhance infiltration and runoff retention;
- Implement the infiltration practices such as using infiltration trenches and thicker topsoil placement in order to maximize the groundwater recharge and preserve water balance. Infiltration trenches can be located at the rear yards of properties backing onto watercourses
- Implement bioswale and permeable pavers at parking areas to remove sediment and pollutant and enhance groundwater recharge.

Due to the soil conditions imply high water table and low infiltration rate, the site may have the challenge of employing the LID practices that depends on infiltration mechanism. Pending on future detail geotechnical investigation, should recharge groundwater would be impelled by high water table, bioswale, permeable pavers still can be used with sub-drains to address water quality prior to discharge to watercourses.

The characterization of water balance under pre-development conditions should be also evaluated. The post-development plan should maintain the hydrogeological regime to the maximum feasible extent. Rain water reuse (grey water system) and/or green roofs would be considered in the development of commercial, industrial and institute areas. Furthermore, the policies of encourage using rain barrels at lot level will also help to enhance water balance.

2. Wet Ponds

The end-of-pipe SWM facilities are required to only provide water quality control and erosion control for the development area. It is proposed that the wet ponds be designed to detain 25 mm rainfall – runoff for at least 24 hours. The details of pond configuration such as length-width ratio, depth, safety bench, etc. should conform to the MOE's design manual. The preliminary analyses show that the pond footprint will be about 5%-10% of the drainage area.

3. Water Quality Treatment Devices

Oil- grit separator (OGS) units that achieve 80% TSS removal can be used for the areas where water can't be practically directed to wet ponds. Efforts should be taken to prove pre-treatment prior to the OGS unit or the followed treatment at the OGS outlet prior to the receiving watercourses.

The integration of these SWM practices should be reflected in the site development plan. In addition, a mitigation plan to minimize the development impacts on the Provincial Significant Wetland (PSW) should be considered in the next design stage. A feature based water balance study may need to determine if the reduction in surface flows to the wetland caused by the proposed development would have significant impact to the wetland. It would be necessary to direct post-development surface runoff to the wetland to maintain surface flow contribution, if the wetland is mainly fed by surface water.