FUNCTIONAL SERVICING AND STORMWATER MANAGEMENT REPORT

WILLOUGHBY DRIVE
CITY OF NIAGRA FALLS

PREPARED FOR:
LAWRENCE AVENUE GROUP LIMITED
21 DUNDAS SQUARE, 11TH FLOOR
TORONTO, ON, M5B 1B7

DATE: OCTOBER 2024

PROJECT NO. 221377

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1.0 INTRODUCTION

The purpose of this report is to provide site servicing and stormwater management (SWM) design information in support of the Zoning By-law Amendment (ZBA) for the site at Willoughby Drive in the City of Niagara Falls.

Specifically, this report will demonstrate the SWM measures that will be undertaken to deal with the quantity and quality requirements for the site. As well, the capacity of the existing municipal servicing systems to accommodate the site is reviewed.

1.1 Site Description

The site is located on the east side of Willoughby Drive, north of Weinbrenner Road in the City of Niagara Falls. The site is currently vacant and has an area of 11.0ha. The site location is shown on **Figure 1**.

The proposed development includes 3 multi-storey apartment blocks (660 units), 13 front loaded Towns (91 units), 12 back-to-back towns (146units),10 stacked towns (81 units), 1 park block and 4 new municipal roads as per Concept P1 prepared by Fotenn Planning + Design. The development includes a total of 318 townhouse units and 660 apartments.

1.2 Background

The Servicing and SWM design for the site has been prepared to meet the requirements of the City of Niagara Falls and Niagara Region. The following materials were referenced in the preparation of this report:

- The Stormwater Management Planning and Design Manual (MECP Guidelines), prepared by the Ministry of the Environment, March 2003, were referenced in the preparation of the stormwater management plan.
- The Engineering Design Guidelines Manual, prepared by the City of Niagara Falls, April 2016.
- The Niagara Peninsula Conservation Authority Stormwater Management Guidelines, prepared by the Niagara Peninsula Conservation Authority and Aecom, March 2010.
- The Niagara Region Water and Wastewater Master Servicing Plan Updates, prepared by the Niagara Region, December 2023.
- The Development Charges Background Study, prepared by Regional Municipality of Niagara, May 2022.
- Willoughby Drive Road Reconstruction drawings and design sheets, prepared by MTE, dated June 2024.
- The Preliminary Sanitary and Water Servicing Investigation memorandum for Willoughby Drive Development, prepared by Husson Limited dated February 10, 2023.

2.0 STORM DRAINAGE

2.1 Existing Drainage

The following is a summary of the existing services and storm drainage features around the perimeter of the site:

- Storm sewers on Willoughby Drive ending at a 1050mm diameter sewer at the proposed Caronpost Road.
- 675mm diameter storm sewer on Cattell Drive.
- Drainage ditch along the future Caronpost Road conveying drainage from Willoughby Drive to the Little Mississippi Drain.
- Drainage ditch on Weinbrenner Road conveying drainage to the Little Mississippi Drain.

The existing site has been divided in to two catchment areas, 100 and 101. Catchment 100 represents the drainage from north of Caronpost, and Catchment 101 represents the drainage from south of Caronpost Drive. Both catchments generally drain to the existing channel on Caronpost Road. Some perimeter drainage will be directed to Cattell Drive or Weinbrenner Road, but all drainage ultimately drains to the Mississippi Drain. Refer to **Figure 2** for the existing site drainage.

An analysis of the existing storm sewer on Cattell Drive was completed to determine if there was any surplus capacity in the sewer to accept drainage from the site. The analysis was completed using the 5-year Niagara Falls design storm and catchment plan as shown on **Figure 3**. The analysis shows that there is no surplus capacity. Refer to **Appendix A** for the Cattell Road storm sewer design sheet.

2.2 Site Grading

All grading will be completed in a manner to satisfy the following goals:

- Enable gravity storm connection (where possible) to the outlet at the Little Mississippi Drain.
- Meet the stormwater management objectives for the site.

The development will be graded such that the surface flows from the development will be directed to municipal boulevards and captured by catchbasins and directed to the proposed storm sewers. It is proposed to construct Caronpost Road; a dedicated right-of-way which currently has a section of the channel which conveys flows from Willoughby Drive to the Little Mississippi Drain the flows towards the Niagara River. As part of the development, it is proposed to construct Caronpost Road through our development and the channel will be replaced with a municipal storm sewer. Caronpost Road will not be controlled but all of the other private developments and proposed municipal roads that are being constructed will be controlled before the storm sewer connects to the mainline sewer on Caronpost.

The site will be graded to suit the City's design criteria and accommodate any constraints imposed by the storm drainage and servicing objectives.

2.3 Minor System Drainage

The development will include the extension of Caronpost Road. This will require filling in the existing drainage ditch and construction of a new storm sewer system out letting to the Little Mississippi Drain.

The internal storm sewer system will be designed to collect drainage from the proposed rooftops and driveways for a 5-year design storm, as per the City's criteria. The majority storm drainage will drain to the Little Mississippi Drain.

The proposed storm sewer will collect drainage from Willoughby Drive. An inlet flow rate of 848L/s has been included from the external catchment area as per the MTE design sheets.

Rainwater leaders from the townhouse units will discharge at grade. The storm sewer systems from the private blocks will convey drainage to oil/grit separators which will provide pre-treatment for drainage entering the stormwater chambers. The storm connections from the municipal roads connecting to the Caronpost Road storm sewer will also be conveyed through oil/grit separators for quality control.

Peak flow controls will be provided on the proposed private development blocks. Further controls will be provided within the proposed municipal roads to further reduce flows to meet the pre-development target flow rates.

Refer to **Figure 4** for the proposed minor system design and **Section 3.0** for details on the on-site controls.

2.4 Major System Drainage

The development blocks will be designed to convey all flows on-site up to the 100-year event and discharge to the minor system at a controlled rate. For storms in excess of the 100-year event, or in the case of a blockage, overland flow will be directed to the adjacent municipal roads.

The municipal road has been designed with saw-toothed grading, such that for storms up to the 100-year event, runoff will pond above the catchbasins and discharge to the minor-system, where it can be controlled by the stormwater chambers.

Refer to **Figure 5** for the grading and major system drainage design.

3.0 STORMWATER MANAGEMENT PLAN

3.1 Stormwater Management Criteria

The City and Niagara Peninsula Conservation Authority (NPCA) have indicated that the stormwater management criteria are as follows:

- Water quality - *Enhanced* control is required based on MECP Guidelines. This requires removal of 80 percent of total suspended solids on an annual basis.
- Water quantity – Peak flow controls for all storm events, if existing channel does not have capacity for the uncontrolled flows. Peak flow controls will be required to control private developments and for new municipal roads to the allowable flow to the storm sewers.
- Water Balance – Niagara Region strongly encourages the use of Low Impact Development (LID) practices to retain water on-site for re-use or infiltration.
- Erosion Control – Niagara Region typically requires the retention of the 25mm design storm to be released over 24 hours to mitigate downstream erosion impacts.

We note that the proposed Caronpost Road is not considered in the storm water management design for the site. It has a large upstream catchment area with limited stormwater management controls. It would be challenging to implement controls within the proposed roadway to service the large upstream catchment area.

3.2 Stormwater Management Facilities

For the storm drainage and stormwater management design for the site, three options were investigated.

1. Provide no peak flow controls on-site and either confirm capacity in the Little Mississippi Drain, or up-size it to convey drainage to the Niagara River.

2. Review the capacity of the storm sewer on Cattell Drive and discharge a portion of the flow to this outlet.
3. Provide peak flow controls to control the post development peak flow to pre-development levels on site.

For the first option, it was noted that downstream improvements to the channel had recently been completed. The cross section was approximately 15m wide and provided a low flow channel and floodplain. It was determined that the longitudinal grade of the channel near the Caronpost outlet will be about 0.1 percent, compared to 0.2 percent or greater where the channel was improved downstream. As well, the downstream section was greater than 2m deep downstream whereas it is approximately 1.5m deep near the Caronpost outlet. These two factors resulted in a channel section that would be greater than 30m in width. It was therefore, determined not to pursue this option.

For the second option, a design sheet for Cattell Drive was prepared based on the proposed reduction in the catchment area, resulting from the Willoughby Drive improvements. It was determined that the existing sewers are at or over capacity based on the 5-year storm. Therefore, it is not proposed to direct any additional flow to this sewer.

Therefore, on-site controls to pre-development rates have been selected as the preferred option.

A treatment train approach will be used to meet the stormwater management objectives for the site, as follows:

- Private development blocks (apartment and townhouse) will be required to provide on-site controls to meet unit flow target release rates (refer to section 3.4). For the preliminary design, it is assumed that an underground storage chamber and orifice control will be provided on each block; however, at the detailed design stage, alternatives such as controlled flow roof drainage, surface storage or oversized pipes can be investigated.
- Private development blocks will be required to provide Normal quality control (80 percent TSS removal). The specific mechanism can be determined at the detailed design stage for each block.
- Oil/grit separators will be provided at each connection point to the mainline sewer on Caronpost Road.
- Peak Flow controls for the municipal roads will be provided by underground storage chambers located within the municipal roadways.
- The proposed stormwater chambers will have an open bottom capable of infiltration. At the detailed design stage, the feasibility of infiltration will be investigated. This will be dependent on the depth and permeability of the soils.

The proposed controls within the municipal roads are described below:

3.3 Quality Control

As per the Niagara Region criteria, Normal quality control (70 percent TSS removal is required for the site. For the proposed municipal roads, this will be provided by 4 oil/grit separators located upstream of the connections to Caronpost Road. Preliminary sizing is based on Stormceptor EF oil/grit separators using ETV particle size distribution. The locations are shown on **Figure 6** and preliminary sizing is provided in **Table 1**.

Table 1. Oil/Grit Separator Sizing

Catchment	Area (ha)	Imperviousness	Unit	TSS Removal
103+108	3.0	65%	EF12	62
104	0.56	65%	EF06	63
105	0.27	65%	EF04	63
106	0.53	65%	EF06	64

Therefore, the proposed oil/grit separators provide greater than 60 percent quality control.

As noted above, it is proposed to investigate infiltration to meet water balance objectives for the site. This will be reviewed at the detailed design stage when soil and groundwater information is available.

With the proposed oil/grit separators and infiltration facilities in place, the requirement for 70 percent TSS removal will be met. In the event that infiltration is not feasible on the site, an ETV verified filter unit will be required for each connection point. While this is feasible for the site, they typically have increased long-term maintenance requirements, compared to oil/grit separators.

OGS unit sizing and details are provided in **Appendix B**.

3.4 Quantity Control

3.4.1 Quantity Control Measures

Quantity control will be provided in the stormwater chambers in conjunction with orifice controls which allow for excess runoff to be stored and released at a controlled rate.

Uncontrolled Drainage

There will be one catchment, Catchment 110, which will discharge to Caronpost Road uncontrolled. This has an area of 0.18ha, and consists of townhouse rooftop and rear yard areas. All other areas of the site will be overcontrolled to account for this uncontrolled drainage.

Stormwater Chamber Storage

For the functional design of the stormwater management facilities, it was assumed that a crate storage system would be used. The crates will have a height of 1.0m and a width up to 2.4m wide, when located within the municipal right-of-ways.

Orifice controls will be provided at the outlet for each catchment to meet the target release rates. **Table 2** provides a summary of the storage-discharge for each catchment. Refer to **Appendix C** for storage-discharge calculations.

Table 2. Catchment Storage-Discharge

Catchment	Pipe/Chamber Storage (m^3)	Orifice Size (mm)	Peak Flow (L/s)
103+108	1,290	120	48
104	120	204	86
105	120	74*	9
106	195	152	48

* Use inlet control device for orifice less than 75mm diameter.

For the private development blocks, unit flow rates will be implemented for the 5- and 100-year design storms. as shown in **Table 3**.

Table 3. Unit Flow Rates

Storm Event	Unit Flow Rate (L/s/ha)
5 Year	14
100 Year	35

3.4.2 Hydrology Modelling

The Visual OTTHYMO 6 (VO) model was used to calculate the flows for the site for the pre and post development conditions. VO is a single event hydrologic model that is based on unit hydrograph theory. The simulation for this site uses the StandHyd method for the primarily impervious catchments and NasHyd method for landscape catchments. The Route Reservoir command is used to simulate the peak flow controls for the site to estimate the storage requirements. Rainfall is based on a 4-hour Chicago Storm using the latest NPCA SWM Guideline IDF curves for the 100-year storm.

The following additional parameters were assumed for the modelling:

- CN for pervious areas of 77.
- Initial abstraction of 5mm for pervious areas and 1mm for impervious areas.
- Rain fall distribution was based on the 5- and 100-year 4-hour Chicago storm and the NPCA SWM Guideline IDF curves.

An existing conditions VO model was prepared to estimate to the peak flow from the site to the Caronpost outlet. **Table 4** provides a summary for each catchment and the target flow.

Table 4. Peak Development Model Summary

Catchment	Area (ha)	5-Year Peak Flow (L/s)	100-Year Peak Flow (L/s)
100	6.88	92	230
101	3.39	55	137
Total	**10.27**	**144**	**361**

Table 5 provides a summary of the catchment parameters for the post development scenario.

Table 5. Post Development Catchment Summary

Catchment	Area (ha)	Development Type	Imperviousness
103	2.50	Townhouse	65%
104	0.65	Townhouse	65%
105	0.27	Townhouse	65%
106	0.53	Townhouse	65%
107	1.81	Private Townhouse	65%
108	0.50	Park	
109	0.57	Private Townhouse	65%
110	0.18	Townhouse	65%
111	0.58	Private Townhouse	65%
112	0.34	Private Townhouse	65%
113	0.68	Private Apartment	75%
114	0.80	Private Apartment	75%
115	0.86	Private Apartment	75%
Total	**10.27**		

The post development model was prepared using the parameters in **Table 5** for each catchment and the proposed stormwater controls as outlined in **Table 2**. For the private blocks, an estimate is included in the model for the required storage. This will depend on the final site layout and availability of rooftop and parking lot storage.

Table 6 provides a summary of the post development storage requirements.

Table 6. Post Development Storage Summary

Catchment	Storage Provided (m^3)	100-year Storage Required (m^3)
103+108	1290	1285
104	220	218
105	120	101
106	190	172
107*		615
109*		220
110*		Uncontrolled
111*		225
112*		130
113*		274
114*		335
115*		350

* Required storage is an estimate, subject to site design.

Table 7 provides a comparison of the 5- and 100-year peak flows from the site in the pre and post development scenarios.

Table 7. Peak Flow Comparison

Storm Event	Pre-Development (L/s)	Post Development (L/s)
5 Year	144	144
100 Year	361	250

As shown in **Table 7**, the peak flows for the 5 and 100 year storms in the post development scenario will be equal or less than pre-development.

Figure 6 shows the proposed catchment plan. Hydrology calculations are provided in **Appendix D**.

The existing municipal storm infrastructure can support the proposed site without the need for external upgrades or retrofit.

3.5 Water Balance

As per the Niagara Region criteria, (LID) practices to retain water on-site for re-use or infiltration. This will be investigated at the detailed design stage when geotechnical and groundwater information is available.

3.6 Erosion Control

Niagara Region typically requires the retention of the 25mm design storm to be released over 24 hours to mitigate downstream erosion impacts. Another option frequently implemented for erosion control is to retain or infiltrate runoff from frequent storm events. This can reduce the overall volume of surface runoff to the receiving watercourse. This will be investigated at the detailed design stage when geotechnical and groundwater information is available.

4.0 WASTEWATER

4.1 Receiving Systems

The City is in the process of reconstructing Willoughby Drive (90% detailed design stage was just completed by MTE Consultants) and as part of that work new sanitary sewer is being installed on Willoughby Drive through the entire frontage of the proposed development. There is a proposed 200mm diameter sanitary sewer from Willguard Court, flowing north to Cattell Drive and a 300mm diameter sanitary sewer from Willguard Court, flowing south to Weinbrenner Road. A 300mm diameter service stub is being provided for the proposed development at the beginning (west side) of the Caronpost right-of-way; which is currently a drainage ditch, but will need to be constructed as a municipal road as part of the proposed subdivision.

In addition, there is an existing 375mm diameter sanitary sewer on Cattell Drive flowing west to the new sewer on Willoughby Drive, and an existing 250mm diameter sanitary sewer on Weinbrenner Road flowing west which connects with the new sanitary sewer on Willoughby Drive and then to the existing 450mm diameter sanitary sewer on Weinbrenner Road which flows westward and eventually discharges to the Low Lift Pumping Station for South Niagara Falls.

The Niagara Region Water and Wastewater Master Servicing Plan (2023) was used to calculate the contributing peak flow from the site to the existing sewer. The Harmon equation was used to calculate the peaking factor for the apartment buildings and townhouse dwellings. The existing and proposed sanitary flows from the site are shown in **Table 8.**

Table 8. Sanitary Flow Comparison

Land Use	Equivalent Population[1]	Peaking Factor[2]	Equivalent Peak Flow (L/s)[2]
Pre-Development: • Undeveloped	-	-	-
Post Development:			
• Residential: 660 Apartment Units[1]	1,314		
• Residential: 318 Townhouse Units	<u>665</u>		
	1,979	3.58	20.9

++1 Equivalent population as per the latest Niagara Region *DC Study- Table 6-1b – Residential D.C. by Unit Type (2022)* (2.92 persons/unit: Single and Semi-Detached Dwelling, 2.09 persons/ unit: Other Multiples, 1.99 persons/unit: Apartments 2+Bedrooms, 1.21 persons/unit: Apartments 1 Bedroom; Apartment units are considered 2+bedrooms to be conservative.

2 Equivalent Flow as per the Niagara Region *Water and Wastewater Master Servicing Plan (2021)* (Average wastewater flow = 255 litres/capita/day, Harmon formula with values between 2 and 4)

The sanitary flows are summarized in **Table 9** below.

Table 9. Sanitary Flow Summary

Scenario	Population	Sanitary Flow (L/s)	Infiltration Flow (L/s)*	Total (L/s)
Post Development	1,979	20.9	3.2	**24.1**

*Infiltration flows are based off a site area of 11.0ha and a design flow rate of 0.286L/s/ha.

Therefore, the proposed development of the site will result in a peak sanitary flow of 24.1L/s. The existing 300mm diameter sanitary sewer on Willoughby Drive is adequate to convey these flows (full flow capacity of the existing 300mm diameter sanitary adjacent to the site is 59.6L/s of which our site accounts for 42% of the capacity).

4.2 Sanitary Sewer Downstream Capacity Analysis

A <u>Preliminary Sanitary and Watermain Servicing Investigation</u> memorandum (memorandum) for the proposed development was prepared by Husson Limited on February 10, 2023; which was approved by the City. As part of the servicing memo, a downstream sanitary assessment (DSA) was completed based on a contributing equivalent population of 2,497 people from the development. As noted in Option 2 in the memorandum, there was capacity in the existing sanitary sewer if the development was connected to the existing 450mm diameter sanitary sewer on Weinbrenner Road. This has also been taken in to account with the reconstruction work for Willoughby Drive that is being completed by the City (detailed design by MTE Consultants) and as part of that work the City is providing a 300mm sanitary sewer stub at the future Caronpost Road; which is sufficient for the proposed development.

The proposed development has an equivalent population of 1,979 people which is less than the 2,497 people that was accounted for in the memorandum, and so no further analysis was required. Refer to **Appendix E** for the memorandum.

4.3 Internal Sanitary Drainage

A private gravity sanitary sewer can be extended into the site to provide services to each townhouse and apartment buildings within the development. The detailed design of the sanitary sewers within the subdivision will be completed at the detailed design stage but it should be noted that the sanitary sewer on Willoughby Drive is over 3m deeper than the storm sewer on Caronpost Road and so crossing conflicts are not anticipated.

Refer to **Figure 7** for the detailed site servicing information.

5.0 WATER DISTRIBUTION

5.1 Water Servicing

The City is in the process of reconstructing Willoughby Drive (90% detailed design stage was just completed by MTE Consultants) and as part of that work new watermain is being installed on Willoughby Drive. There is a proposed 300mm diameter watermain through the frontage of the proposed development. A 300mm diameter service stub is being provided for the proposed development at the beginning (west side) of the Caronpost right-of-way; which is currently a drainage ditch, but will need to be constructed as a municipal road as part of the proposed subdivision.

In addition, here is an existing 250mm diameter watermain on Cattell Drive and a 200mm diameter watermain on Weinbrenner Drive.

It is proposed to service the development off of the 300mm diameter watermain on Willoughby Drive; and will be looped with a second connection to the existing 250mm diameter watermain on Cattell Drive. The watermain design will follow the Niagara Region Water and Wastewater Master Servicing Plan (2023).

Refer to **Figure 8** for the proposed watermain design.

In addition, a hydrant flow test was completed by L&D Waterworks on November 14, 2022 for the hydrant located in front of 8563 Willoughby Drive which is across the road from the proposed development, refer to **Appendix E** for information.

5.2 Watermain Analysis

The following calculations for water demand and fire flow for the proposed development are based on the Niagara Region's design criteria and the Fire Underwriters Survey (FUS).

Persons per unit (ppu):	Single and Semi-Detached Dwelling	2.92
Persons per unit (ppu):	Other Multiples	2.09
Persons per unit (ppu):	Apartments 2+Bedrooms	1.99
Residential average day demand:		240L/cap/day
Peaking Factor (pf):	Peak Hour	2.5

Maximum Day	1.3
Acceptable pressure range	40 – 100 psi

Fire Flow: 250L/s on Regional watermains at residual pressure of 30 psi

Average Daily Demand:

Apartment	= 1,314 (eq. population from **Table 8**) x 240L/cap/day
	= 315,360 L/day
	= 219L/min
Townhouse	= 665 (eq. population from **Table 8**) x 240L/cap/day
	= 159,600 L/day
	= 110.8L/min

Maximum Hour Demand:

Apartment	= 219L/m x 2.5(pf)
	= 547.5L/min
Townhouse	= 110.8L/min x 2.5(pf)
	= 277L/min

Maximum Day Demand:

Apartment	= 219L/m x 1.3(pf)
	= 284.7L/min
Townhouse Development	= 110.8L/min x 1.3(pf)
	= 144L/min

Interpolating on the hydrant flow test graph demonstrates that under peak hour and maximum day demand flow conditions, the pressure in the watermain will be approximately 607kPa (88psi); therefore, the proposed site will meet the City's minimum pressure of 275kPa (40psi).

Fire Analysis:

The existing watermain had a residual static pressure of 90psi and theoretical minimum fire flow of 5,625GPM (21,300L/min) at 20psi. Based on the information in the hydrant flow test, and the City's minimum fire flow requirement of 250L/s (15,000L/min) on Regional watermains at residual pressure of 30psi, there are no concerns regarding adequate water supply for the proposed development; however, a fire/booster pump may be required for the internal fire protection systems for the proposed townhouse and apartment blocks. This will need to be determined by the mechanical engineer at the detailed design stage.

6.0 CONCLUSIONS

The proposed development meets the City's requirements as follows:

- A treatment train approach including infiltration measures and oil/grit separators will be implemented within the municipal right-of-ways to provide the required Normal quality control. The infiltration design will be confirmed at the detailed design stage.
- Normal quality control will be provided on each of the private development blocks.
- Orifice controls in conjunction with stormwater chambers will provide the storage required to limit the release rate to the capacity of the storm sewer in the easement, up to the 100-year storm.
- Private development blocks will be required to implement peak flow controls based on 14L/s/ha for the 5-year storm and 35L/s/ha for the 100-year storm.
- Water balance and erosion controls measures will be investigated at the detailed design stage when soil and groundwater information is available.
- Gravity sanitary sewers through the subdivision are proposed to connect to the 300mm diameter sanitary sewer stub that is being provided by the City at Caronpost Road and Willoughby Drive.
- The receiving sanitary sewer has adequate capacity for the proposed development as determined by the City on approval of the Preliminary Sanitary and Water Servicing Investigation memorandum for Willoughby Drive Development, prepared by Husson Limited dated February 10, 2023.
- Watermain for the subdivision will be extended from the existing watermain on Cattell Road and the proposed watermain on Willoughby Drive. The watermain will be looped internally within the proposed subdivision.
- A hydrant flow has been completed to confirm that the existing watermain has sufficient pressure to provide fire and domestic flows to the proposed development.

With the proposed controls in place, the site design will meet the requirements of the City with respect to the current zoning application.

Greg Rapp, P.Eng.

FIGURES

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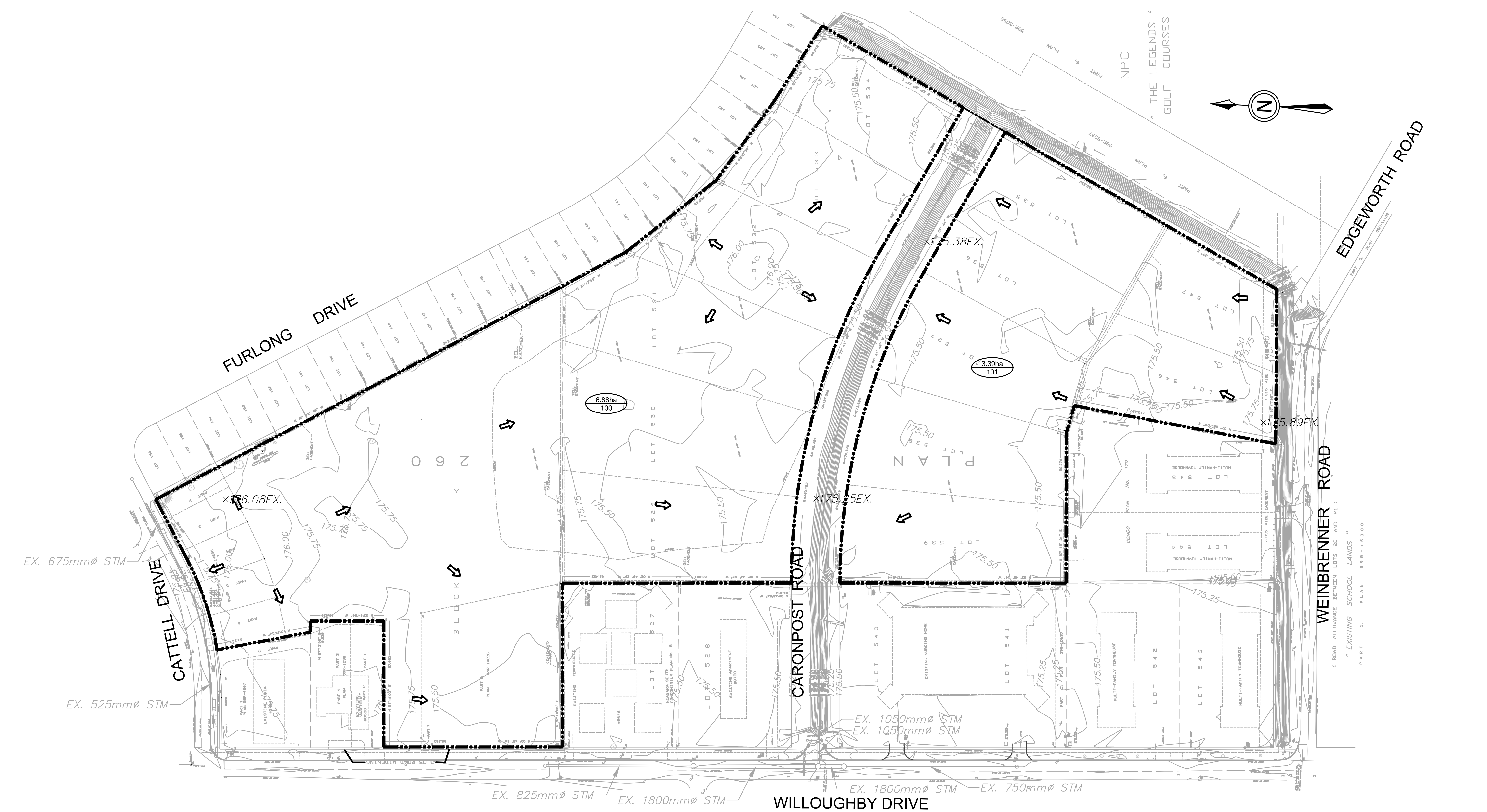
FIGURE 1
WILLOUGHBY DRIVE
SITE LOCATION PLAN

DATE: OCTOBER 2024 SCALE: 1:5000 PROJECT: 221377



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LEGEND

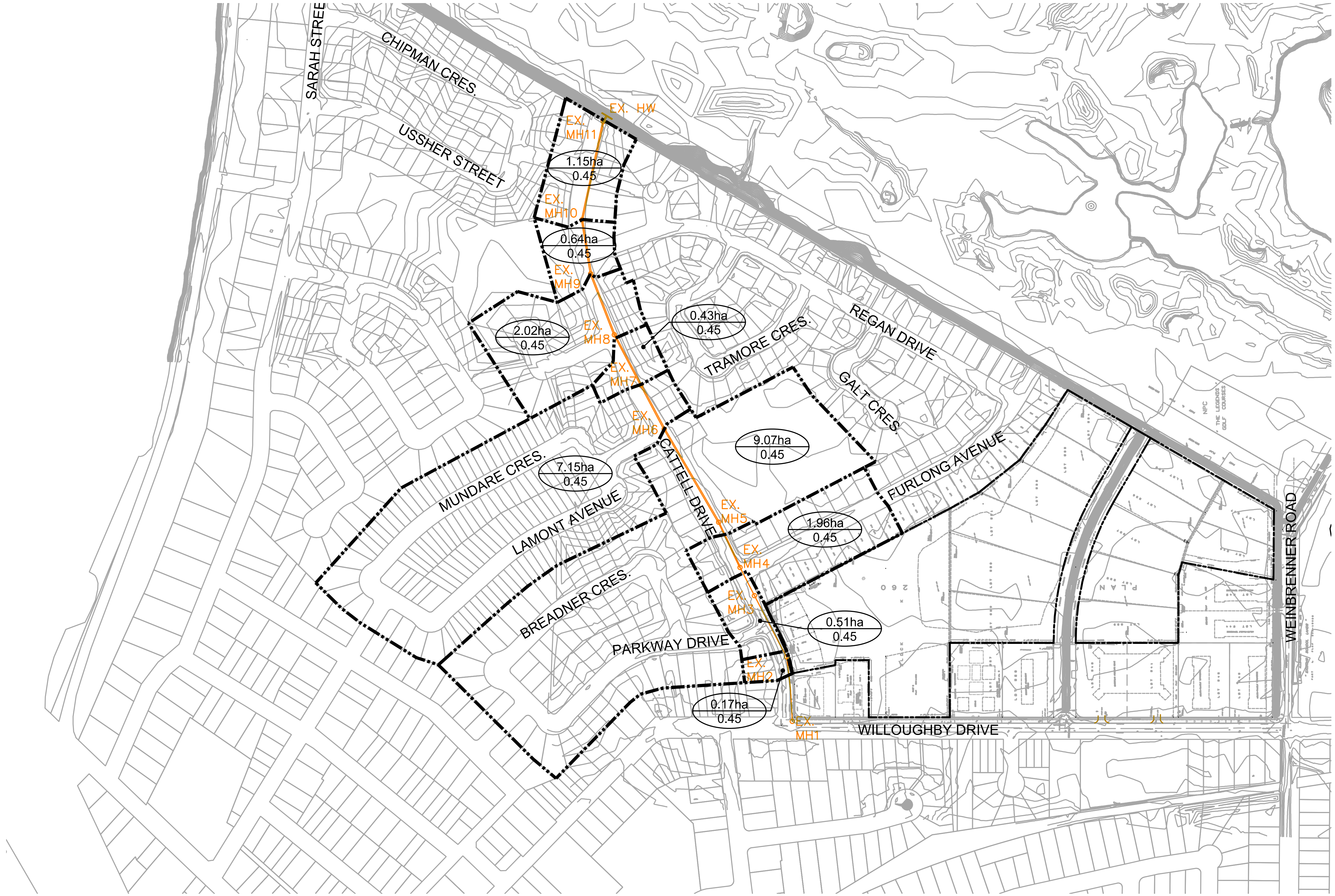
DIRECTION OF OVERLAND FLOW

10.97ha / 101 — PROPOSED CATCHMENT AREA (ha); CATCHMENT ID

DRAINAGE BOUNDARY

FIGURE 2
WILLOUGHBY DRIVE
EXISTING DRAINAGE PLAN

DATE: OCTOBER 2024 SCALE: 1:2000 PROJECT: 221377



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LEGEND

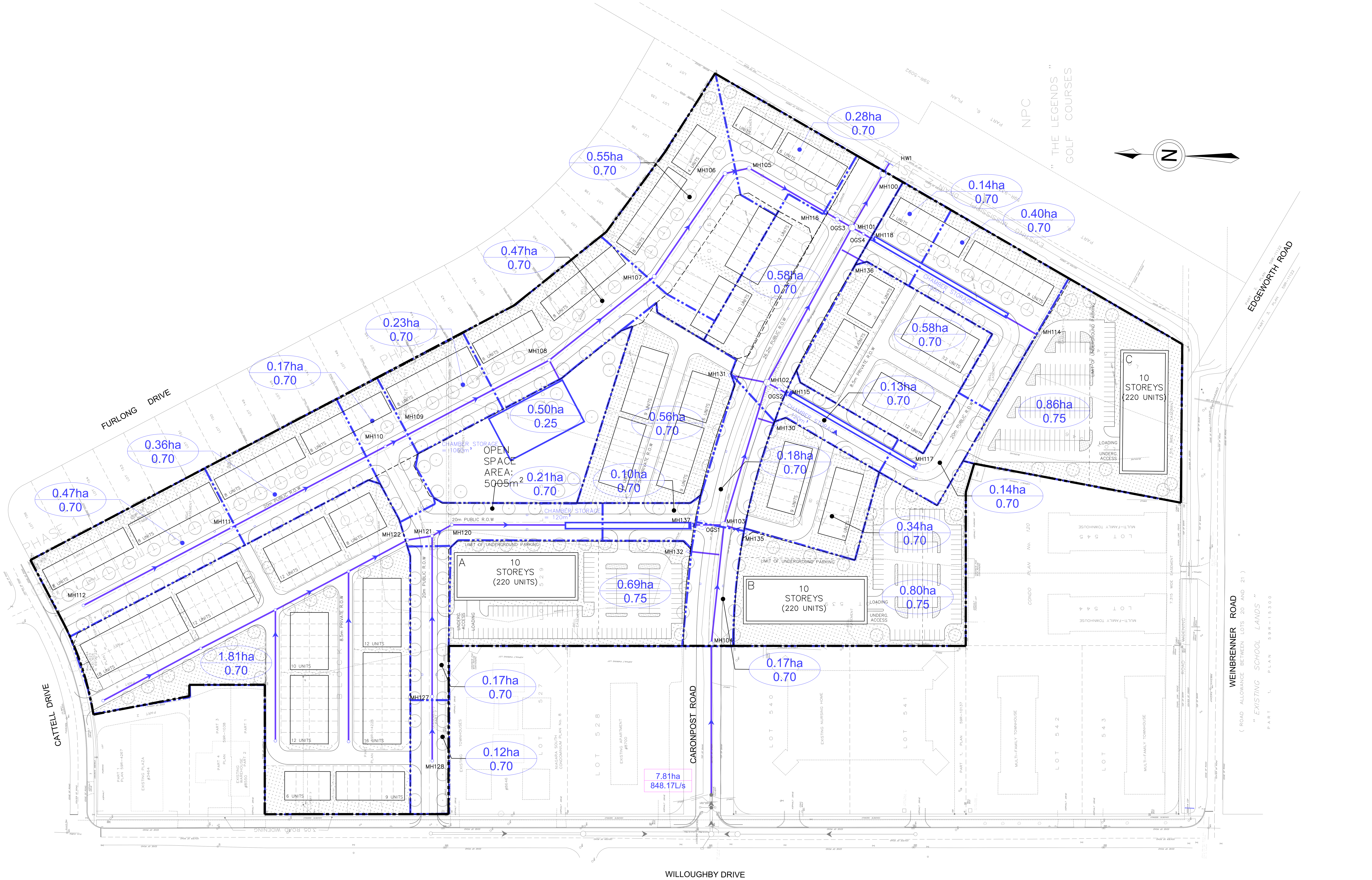
DIRECTION OF OVERLAND FLOW

10.97ha / 0.45 — PROPOSED CATCHMENT AREA (ha) / RUNOFF COEFFICIENT

DRAINAGE BOUNDARY

FIGURE 3
WILLOUGHBY DRIVE
CATTELL STORM DRAINAGE PLAN

DATE: OCTOBER 2024 SCALE: 1:5000 PROJECT: 221377



LEGEND

- EXISTING STORM SEWER SYSTEM
- STORM SEWER SYSTEM
- CATCH BASIN AND LEAD
- EXISTING 100mmø GAS SERVICE
- EXISTING GAS LINES
- EXISTING CTV LINES
- EXISTING BELL LINES
- PROPERTY LINE
- 13.03ha 0.65 — AREA (ha), RUNOFF COEFFICIENT
- 7.81ha 848.17L/s — EXTERNAL DRAINAGE AREA (ha), EXTERNAL FLOW

WILLOUGHBY DRIVE,
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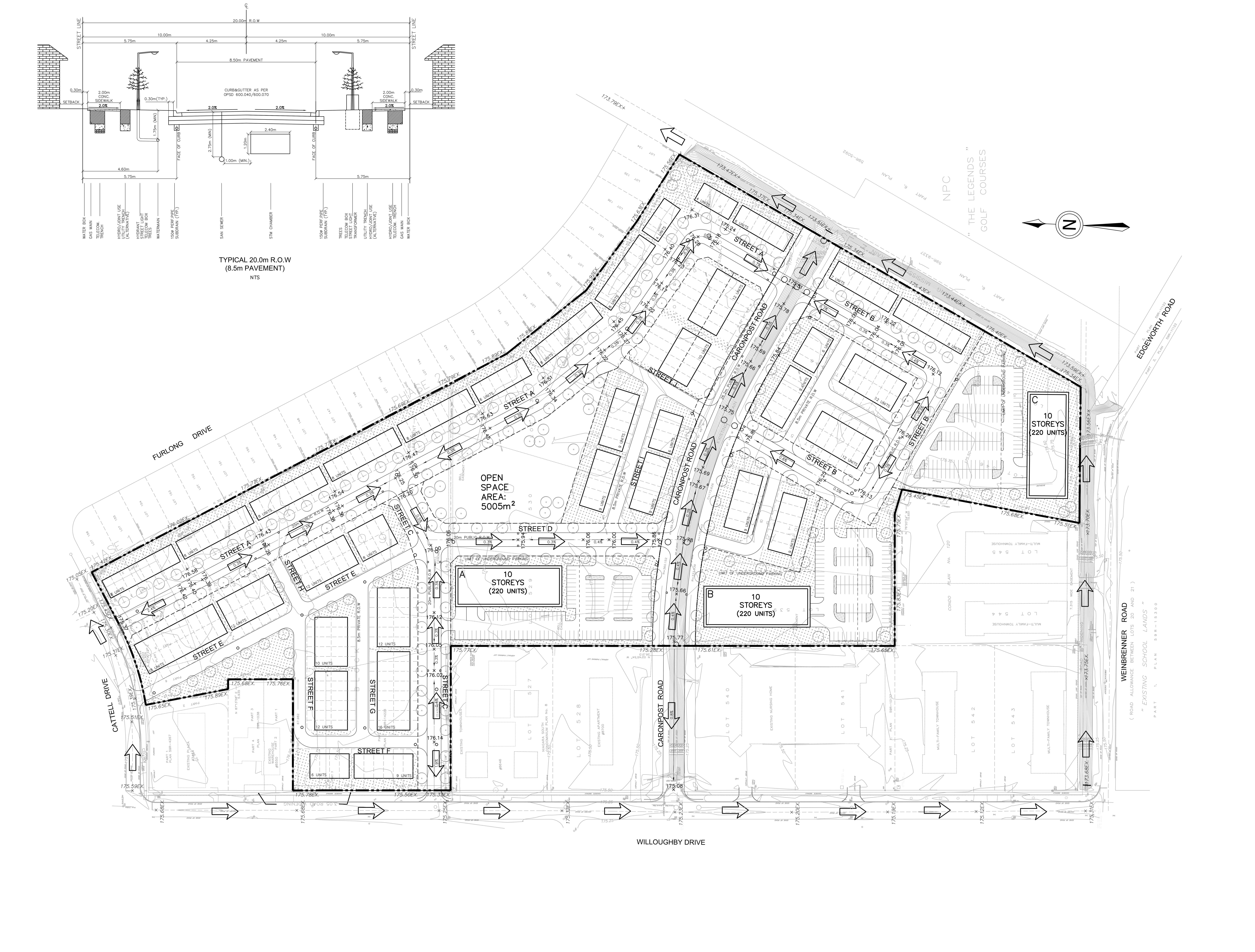
FIGURE 4
WILLOUGHBY DRIVE
MINOR SYSTEM DRAINAGE PLAN

DATE: OCTOBER 2024 SCALE: 1:1000 PROJECT: 221377



LEGEND

175.00	EXISTING ELEVATION
175.00	PROPOSED ELEVATION
175.00TW	PROPOSED TOP OF WALL ELEVATION
175.00BW	PROPOSED BOTTOM OF WALL ELEVATION
2.0%	SLOPE
	MAX 3:1 EMBANKMENT
⇨	OVERLAND FLOW ROUTE
○	PROPOSED STORM MANHOLE
□	PROPOSED STORM CAHBASIN
●	PROPOSED SANITARY
⋈	VALVE
✧	HYDRANT AND VALVE
□	EXISTING STORM CAHBASIN
○	EXISTING STORM MANHOLE
●	EXISTING SANITARY MANHOLE
⋈	EXISTING VALVE
✧	EXISTING HYDRANT

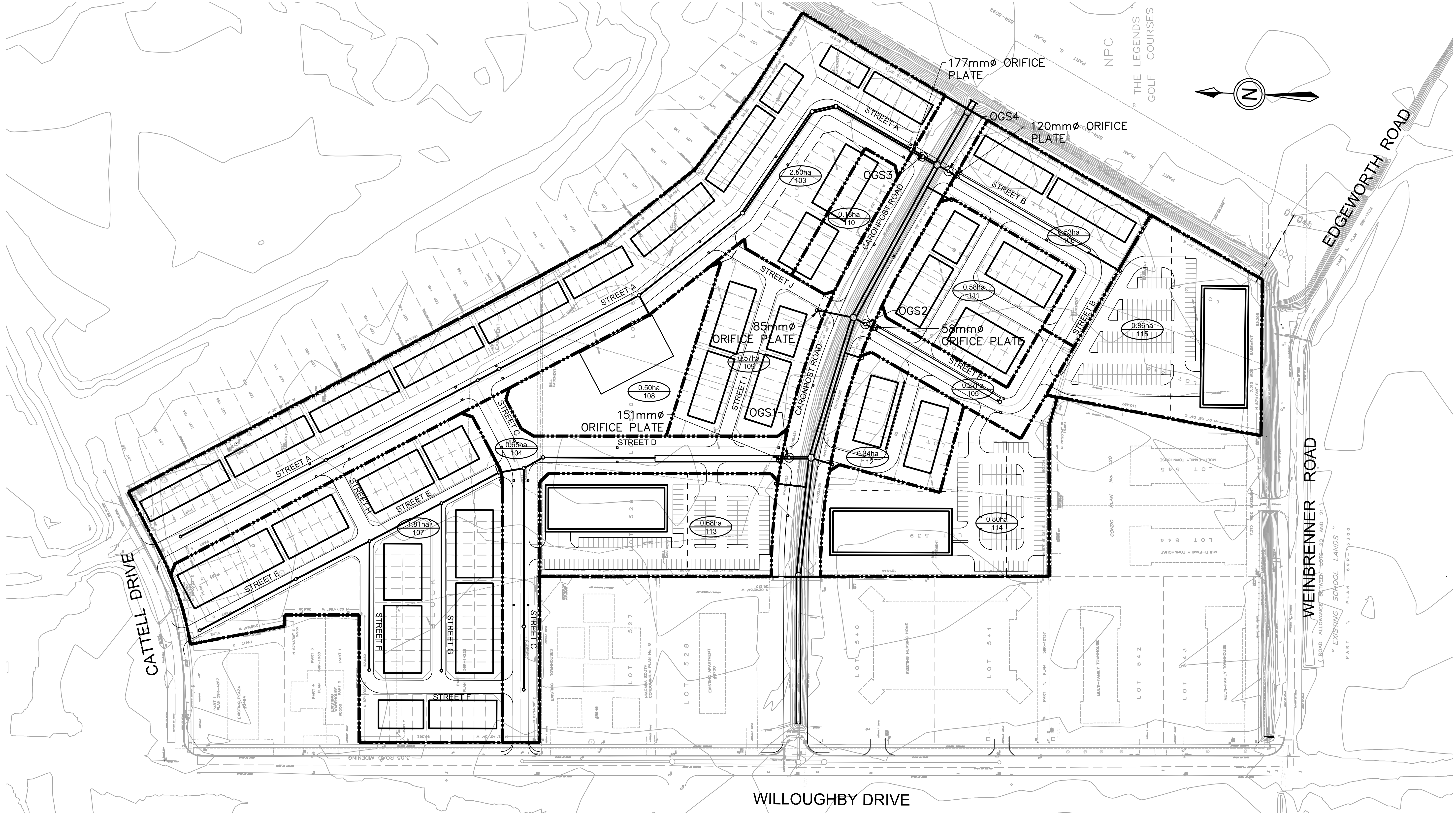
WILLOUGHBY DRIVE,
NIAGARA FALLS, ON

HUSSON
ENGINEERING + MANAGEMENT
P 905.709.5825
200 CACHET WOODS COURT, SUITE 204
MARKHAM, ON L6C 0Z8
HUSSON.CA

FIGURE 5

WILLOUGHBY DRIVE
MAJOR SYSTEM DRAINAGE PLAN

DATE: OCTOBER 2024 SCALE: 1:1000 PROJECT: 221377



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LEGEND

DIRECTION OF OVERLAND FLOW

DRAINAGE BOUNDARY

10.97ha / 201 — PROPOSED CATCHMENT AREA (ha) / CATCHMENT ID

FIGURE 6
WILLOUGHBY DRIVE
SWM PLAN

DATE: OCTOBER 2024 SCALE: 1:2000 PROJECT: 221377

LEGEND

EXISTING SANITARY SEWER SYSTEM

SANITARY SEWER SYSTEM

EXISTING 100mmø GAS SERVICE

EXISTING GAS LINES

EXISTING CTV LINES

EXISTING BELL LINES

PROPERTY LINE

11.0ha AREA (ha)
978 RESIDENTIAL UNITS

WILLOUGHBY DRIVE,
NIAGARA FALLS, ON

HUSSON
ENGINEERING + MANAGEMENT
P 905.709.5825
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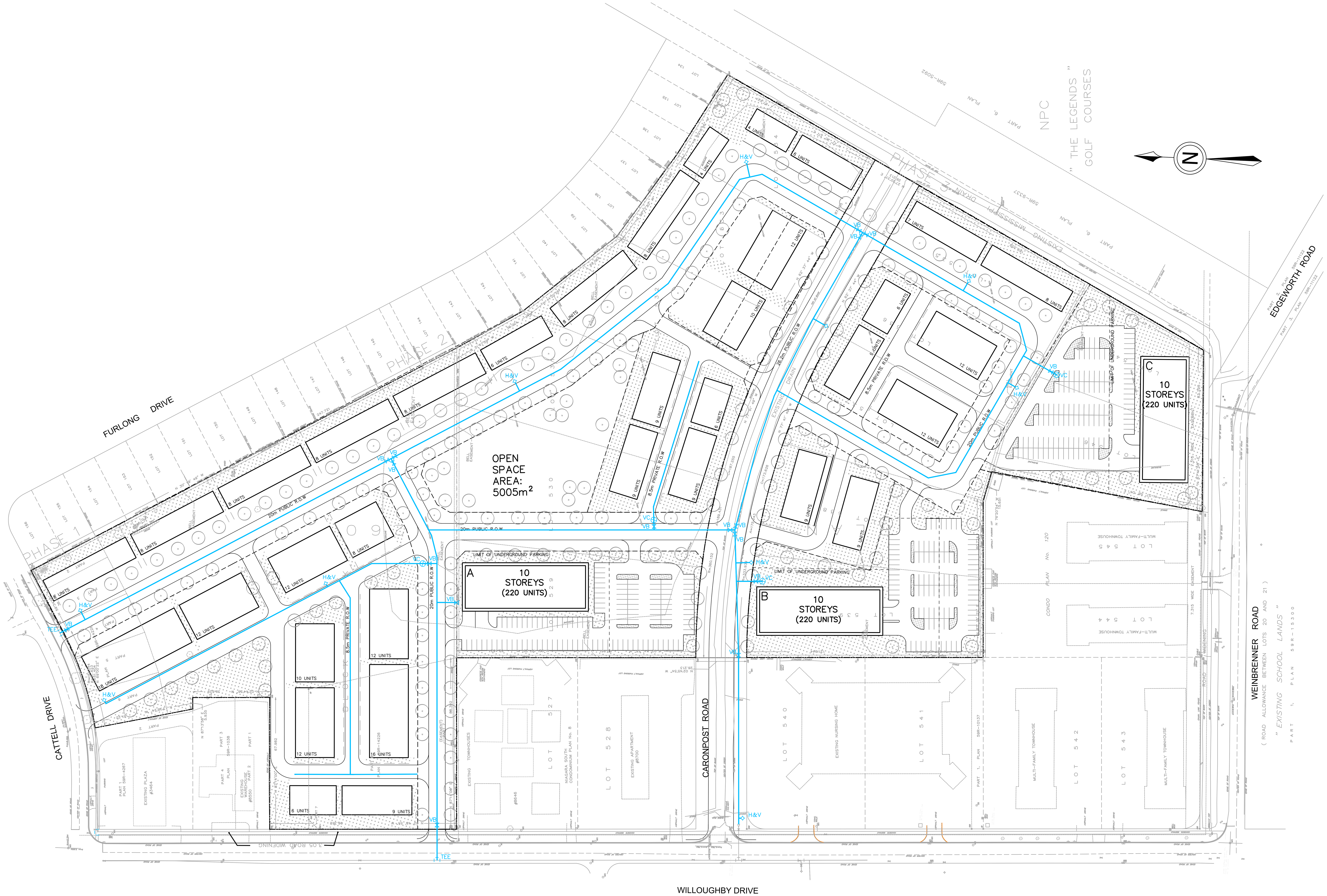
MARKHAM, ON L6C 0Z8
HUSSON.CA

FIGURE 7
WILLOUGHBY DRIVE
SANITARY DRAINAGE PLAN

DATE: OCTOBER 2024 SCALE: 1:1000 PROJECT: 221377



LEGEND

- EXISTING WATERMAIN
- WATERMAIN
- VB — VALVE AND BOX
- H&V — HYDRANT AND VALVE
- EXISTING 100mmø GAS SERVICE
- EXISTING GAS LINES
- EXISTING CTV LINES
- EXISTING BELL LINES
- PROPERTY LINE
- TEMPORARY WELL
- VC — VALVE CHAMBER

WILLOUGHBY DRIVE,
NIAGARA FALLS, ON

HUSSON
ENGINEERING + MANAGEMENT

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MARKHAM, ON L6C 0Z8
HUSSON.CA

FIGURE 8

WILLOUGHBY DRIVE WATER DISTRIBUTION PLAN

DATE: OCTOBER 2024 SCALE: 1:1000 PROJECT: 221377

HUSSON

APPENDIX A

STORM SEWER DESIGN SHEETS

Storm Design Sheet
5-Year Storm

HUSSON

Rainfall Intensity = $\frac{A}{(Tc+B)^c}$

	5-YEAR
A =	719.5
B =	6.34
c =	0.7687

Project #: 221377
Date: October 7, 2024
Designed by: JA

Starting Tc = 10 min

STREET	FROM MH	TO MH	5-YEAR AREA (ha)	5-YEAR RUNOFF COEFFICIENT "R"	5-YEAR "AR"	5-YEAR ACCUM. "AR"	5-YEAR RAINFALL INTENSITY (mm/hr)	5-YEAR ACCUM. FLOW (m3/s)	TOTAL FLOW (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	Manning's "n"	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	% FULL	UPSTREAM TIME OF CONC. (min)	TIME OF CONC. (min)	DOWNSTREAM TIME OF CONC. (min)
Cattell Drive	1	2		0.45			84.02			76.8	0.50	525	0.013	0.304	1.405		10.000	0.911	10.911
Cattell Drive	2	3	0.17	0.45	0.08	0.08	84.02	0.018	0.018	82.4	0.40	675	0.013	0.531	1.486	3%	10.000	0.925	10.925
Cattell Drive	3	4	0.51	0.45	0.23	0.31	80.54	0.068	0.068	37.6	0.40	750	0.013	0.704	1.594	10%	10.925	0.394	11.318
Cattell Drive	4	5	1.96	0.45	0.88	1.19	79.16	0.261	0.261	59.5	0.30	825	0.013	0.786	1.471	33%	11.318	0.674	11.993
Cattell Drive	5	6	9.07	0.45	4.08	5.27	76.91	1.126	1.126	129.4	0.10	1200	0.013	1.232	1.090	91%	11.993	1.978	13.971
Cattell Drive	6	7	7.15	0.45	3.22	8.49	71.09	1.676	1.676	57.9	0.10	1200	0.013	1.232	1.090	136%	13.971	0.885	14.856
Cattell Drive	7	8	0.43	0.45	0.19	8.68	68.79	1.659	1.659	67.7	0.10	1200	0.013	1.232	1.090	135%	14.856	1.034	15.890
Cattell Drive	8	9	2.02	0.45	0.91	9.59	66.32	1.767	1.767	77.7	0.10	1200	0.013	1.232	1.090	143%	15.890	1.187	17.078
Cattell Drive	9	10	0.64	0.45	0.29	9.88	63.72	1.748	1.748	64.9	0.10	1200	0.013	1.232	1.090	142%	17.078	0.993	18.070
Cattell Drive	10	11	1.15	0.45	0.52	10.40	61.72	1.782	1.782	119.6	0.10	1200	0.013	1.232	1.090	145%	18.070	1.829	19.899
Cattell Drive	11	HW		0.45		10.40	58.38	1.686	1.686	10.0	0.10	1200	0.013	1.232	1.090	137%	19.899	0.153	20.052

Willoughby Drive
Niagara Falls, ON

HUSSON

Rainfall Intensity = $\frac{A}{(Tc+B)^c}$

	5-Year
A =	719.5
B =	6.34
c =	0.769

Starting Tc = 10 min

Project: Willoughby Drive
Project #: 221377
Date: October 7, 2024
Designed by: JT

STREET	FROM MH	TO MH	5-YR AREA (ha)	5-YR RUNOFF COEFFICIENT "R"	5-YR "AR"	5-YR ACCUM. "AR"	5-YR RAINFALL INTENSITY (mm/hr)	5-YR ACCUM. FLOW (m3/s)	EXT or BLDG Area (ha)	EXT/BLDG FLOW RATE (l/s/ha)	EXT or BLDG FLOW (m3/s)	ACCUM. EXT/BLDG FLOW (m3/s)	100-YR RUNOFF COEFF. "R"	100-YR RAINFALL INTENSITY (mm/hr)	Total Flow (m3/s)	LENGTH (m)	SLOPE (%)	PIPE DIAMETER (mm)	FULL FLOW CAPACITY (m3/s)	FULL FLOW VELOCITY (m/s)	TIME OF CONCENTRATION (min)	ACC. TIME OF CONC. (min)	% Full
	MH122	MH121	1.81	0.70	1.27	1.27	83.95	0.295					0.850	200.63	0.295	13.3	0.15	675	0.325	0.910	0.244	10.244	91%
	MH128	MH127	0.12	0.70	0.08	0.08	83.95	0.020					0.850	200.63	0.020	33.7	0.30	375	0.096	0.869	0.646	10.646	20%
	MH127	MH121	0.17	0.70	0.12	0.20	81.49	0.046					0.850	193.89	0.046	84.3	0.20	450	0.127	0.802	1.753	12.399	36%
	MH121	MH120	0.17	0.70	0.12	1.59	75.56	0.334					0.850	177.91	0.334	11.8	0.15	750	0.431	0.976	0.202	12.601	77%
	MH120	MH137	0.21	0.70	0.15	1.74	74.94	0.361					0.850	176.26	0.361	126.0	0.15	750	0.431	0.976	2.152	14.753	84%
	MH137	OGS1	0.10	0.70	0.07	1.81	68.99	0.346					0.850	160.54	0.346	4.9	0.10	825	0.454	0.849	0.096	14.849	76%
	OGS1	MH103				1.81	68.75	0.345					0.500	159.91	0.345	11.7	0.10	825	0.454	0.849	0.230	15.078	76%
	EX.MH	MH104		0.70			83.95		1.000	848.170	0.848	0.848	0.850	200.63	0.848	79.2	0.05	1200x2400	2.690	0.930	1.420	19.560	32%
	MH132	MH104	0.69	0.75	0.52	0.52	83.95	0.121					0.875	200.63	0.121	16.4	0.10	600	0.194	0.687	0.398	10.398	62%
	MH104	MH103	0.17	0.70	0.12	0.64	58.91	0.104				0.848	0.850	134.57	0.952	62.9	0.05	1200x2400	2.690	0.930	1.126	20.686	35%
	MH135	MH103	0.80	0.75	0.60	0.60	83.95	0.140					0.875	200.63	0.140	12.0	0.15	600	0.238	0.841	0.238	10.238	59%
	MH130	MH103	0.34	0.70	0.24	0.24	83.95	0.056					0.850	200.63	0.056	9.6	0.20	375	0.078	0.710	0.225	10.225	71%
	MH103	MH102	0.18	0.70	0.13	3.41	57.01	0.540				0.848	0.850	129.77	1.388	78.1	0.05	1200x2400	2.690	0.930	1.400	22.086	52%
	MH117	MH115	0.14	0.70	0.10	0.10	83.95	0.023					0.850	200.63	0.023	77.9	0.25	375	0.088	0.794	1.636	11.636	26%
	MH115	OGS2	0.13	0.70	0.09	0.19	78.01	0.041					0.850	184.50	0.041	5.1	0.25	375	0.088	0.794	0.107	11.743	47%
	OGS2	MH102				0.19	77.66	0.041					0.500	183.54	0.041	7.3	0.30	375	0.096	0.869	0.140	11.883	42%
	MH131	MH102	0.56	0.70	0.39	0.39	83.95	0.091					0.850	200.63	0.091	20.0	0.20	450	0.127	0.802	0.416	10.416	72%
	MH136	MH102	0.58	0.70	0.41	0.41	83.95	0.095					0.850	200.63	0.095	14.9	0.20	450	0.127	0.802	0.310	10.310	74%
	MH102	MH101	0.58	0.70	0.41	4.80	54.84	0.731				0.848	0.850	124.31	1.579	92.8	0.05	1200x2400	2.690	0.930	1.663	23.749	59%
	MH112	MH111	0.47	0.70	0.33	0.33	83.95	0.077					0.850	200.63	0.077	87.7	0.15	525	0.166	0.769	1.900	11.900	46%
	MH111	MH110	0.36	0.70	0.25	0.58	77.15	0.125					0.850	182.16	0.125	91.5	0.15	600	0.238	0.841	1.813	13.713	52%
	MH110	MH109	0.23	0.70	0.16	0.74	71.72	0.148					0.850	167.72	0.148	12.9	0.15	600	0.238	0.841	0.255	13.968	62%
	MH109	MH108				0.74	71.03	0.146					0.500	165.89	0.146	84.4	0.15	750	0.431	0.976	1.440	15.409	34%
	MH108	MH107	0.47	0.70	0.33	1.20	67.38	0.224					0.850	156.34	0.224	70.5	0.15	750	0.431	0.976	1.204	16.612	52%
	Chamber	MH108	0.50	0.25	0.13	0.13	83.95	0.029					0.625	200.63	0.029	12.5	0.50	300	0.068	0.967	0.215	10.215	43%
	MH107	MH106	0.55	0.70	0.39	1.58	64.65	0.284					0.850	149.25	0.284	65.5	0.10	825	0.454	0.849	1.286	17.899	63%
	MH106	MH105				1.58	61.99	0.272					0.500	142.42	0.272	13.1	0.10	825	0.454	0.849	0.257	18.155	60%
	MH105	MH116	0.28	0.70	0.20	1.78	61.49	0.304					0.850	141.15	0.304	46.2	0.10	825	0.454	0.849	0.907	19.062	67%
	MH116	OGS3				1.78	59.80	0.295					0.500	136.82	0.295	7.2	0.10	825	0.454	0.849	0.141	19.203	65%
	OGS3	MH101		0.70		1.78	59.54	0.294					0.850	136.17	0.294	8.9	0.10	825	0.454	0.849	0.175	19.378	65%
	Site	MH114	0.88	0.75	0.66	0.66	83.95	0.154					0.875	200.63	0.154	10.0	0.50	600	0.434	1.536	0.109	10.109	35%
	MH114	MH118	0.40	0.70	0.28	0.94	83.53	0.218					0.850	199.46	0.218	100.9	0.60	525	0.333	1.539	1.093	11.201	66%
	MH118	OGS4	0.14	0.70	0.10	1.04	79.50	0.229					0.850	188.49	0.229	58.9	0.30	600	0.336	1.189	0.825	12.026	68%
	OGS4	MH101				1.04	76.74	0.221					0.500	181.06	0.221	13.3	0.15	675	0.325	0.910	0.244	12.270	68%
	MH101	MH100				7.61	52.50	1.110				0.848	0.500	118.45	1.959	32.5	0.05	1200x2400	2.690	0.930	0.583	24.332	73%

APPENDIX B

OIL/GRIT SEPARATOR DETAILS

Imbrium® Systems

ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

10/07/2024

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	103
Drainage Area (ha):	3.0
% Imperviousness:	65.00
Runoff Coefficient 'c':	0.69

Project Name:	Willoughby
Project Number:	221377
Designer Name:	Greg Rapp
Designer Company:	Husson Limited
Designer Email:	greg.rapp@husson.ca
Designer Phone:	416-788-1414
EOR Name:	
EOR Company:	
EOR Email:	
EOR Phone:	

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.00
Estimated Water Quality Flow Rate (L/s):	64.37
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	
Influent TSS Concentration (mg/L):	200
Estimated Average Annual Sediment Load (kg/yr):	1641
Estimated Average Annual Sediment Volume (L/yr):	1334

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	38
EFO6	48
EFO8	54
EFO10	59
EFO12	62

Recommended Stormceptor EFO Model:	**EFO12**
Estimated Net Annual Sediment (TSS) Load Reduction (%):	**62**
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.

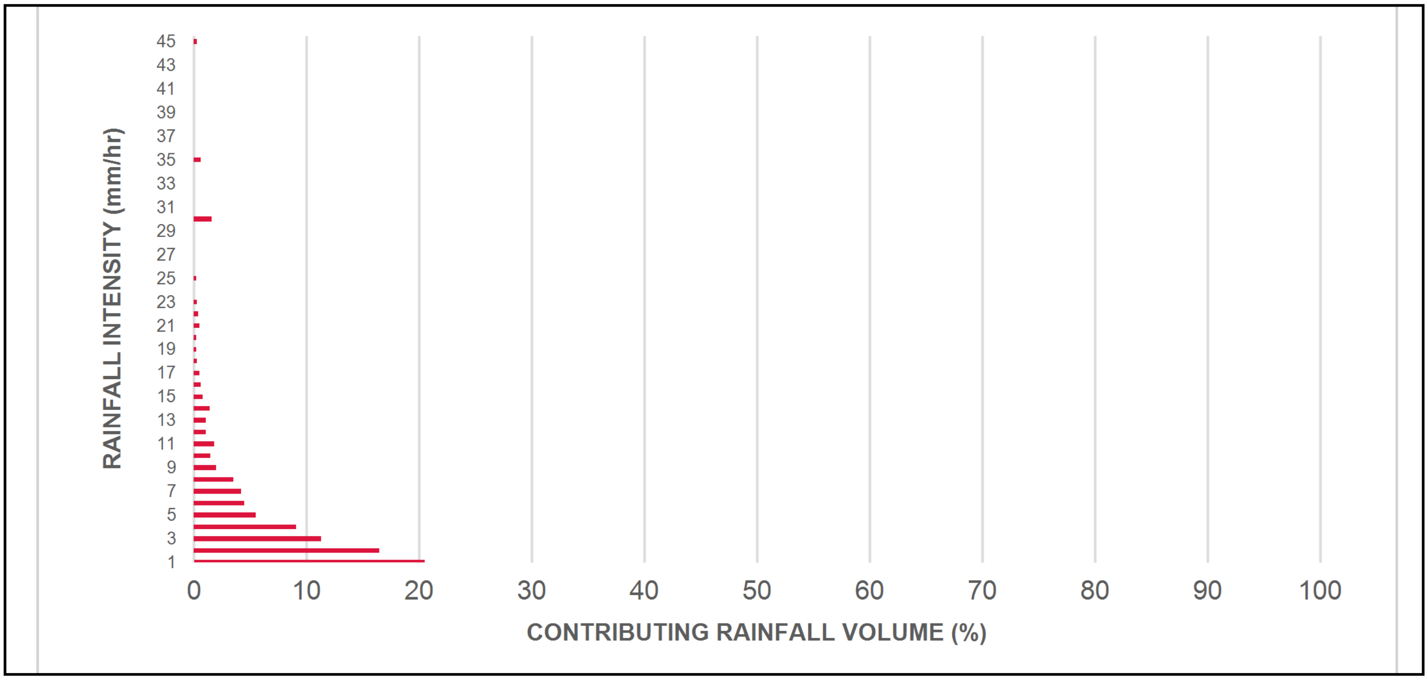
Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Stormceptor® EF Sizing Report

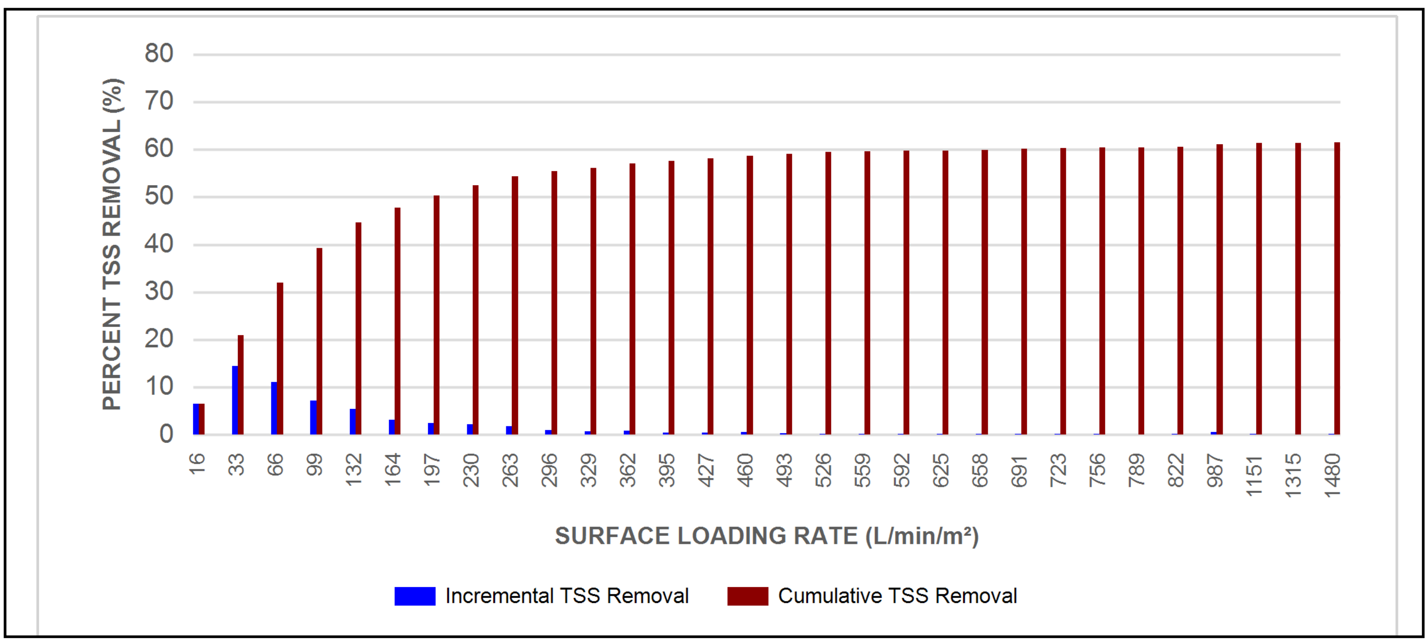
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.50	9.2	9.2	2.88	173.0	16.0	70	6.5	6.5
1.00	20.5	29.7	5.75	345.0	33.0	70	14.4	20.9
2.00	16.5	46.2	11.51	691.0	66.0	67	11.1	32.0
3.00	11.3	57.5	17.26	1036.0	99.0	63	7.2	39.2
4.00	9.1	66.7	23.02	1381.0	132.0	60	5.4	44.6
5.00	5.5	72.2	28.77	1726.0	164.0	57	3.2	47.8
6.00	4.5	76.7	34.53	2072.0	197.0	55	2.5	50.3
7.00	4.2	80.9	40.28	2417.0	230.0	53	2.3	52.5
8.00	3.5	84.4	46.04	2762.0	263.0	52	1.8	54.3
9.00	2.0	86.5	51.79	3107.0	296.0	51	1.1	55.4
10.00	1.5	88.0	57.55	3453.0	329.0	50	0.7	56.1
11.00	1.8	89.8	63.30	3798.0	362.0	49	0.9	57.0
12.00	1.1	90.9	69.06	4143.0	395.0	48	0.5	57.6
13.00	1.1	92.0	74.81	4489.0	427.0	47	0.5	58.1
14.00	1.4	93.4	80.56	4834.0	460.0	46	0.7	58.7
15.00	0.8	94.2	86.32	5179.0	493.0	45	0.4	59.1
16.00	0.6	94.8	92.07	5524.0	526.0	44	0.3	59.4
17.00	0.5	95.3	97.83	5870.0	559.0	43	0.2	59.6
18.00	0.3	95.6	103.58	6215.0	592.0	42	0.1	59.7
19.00	0.2	95.9	109.34	6560.0	625.0	42	0.1	59.8
20.00	0.2	96.1	115.09	6906.0	658.0	42	0.1	59.9
21.00	0.5	96.6	120.85	7251.0	691.0	42	0.2	60.1
22.00	0.4	97.0	126.60	7596.0	723.0	41	0.2	60.3
23.00	0.3	97.3	132.36	7941.0	756.0	41	0.1	60.4
24.00	0.0	97.3	138.11	8287.0	789.0	41	0.0	60.4
25.00	0.2	97.4	143.87	8632.0	822.0	41	0.1	60.5
30.00	1.6	99.1	172.64	10358.0	987.0	40	0.7	61.1
35.00	0.6	99.7	201.41	12085.0	1151.0	38	0.2	61.4
40.00	0.0	99.7	230.18	13811.0	1315.0	35	0.0	61.4
45.00	0.3	100.0	258.96	15537.0	1480.0	32	0.1	61.5
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



Stormceptor® EF Sizing Report

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

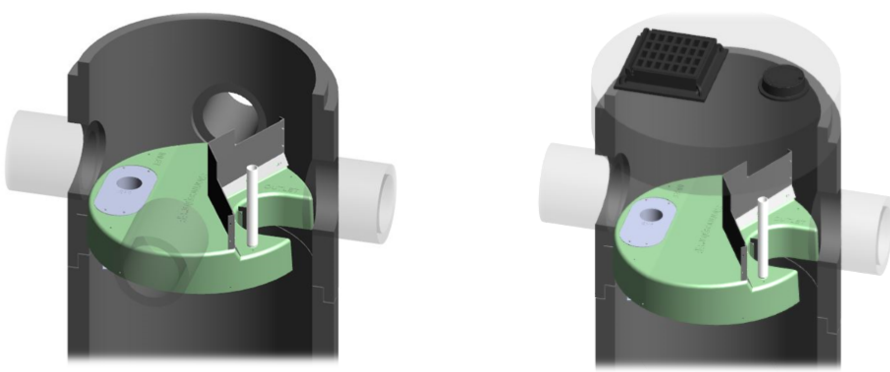
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test 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.

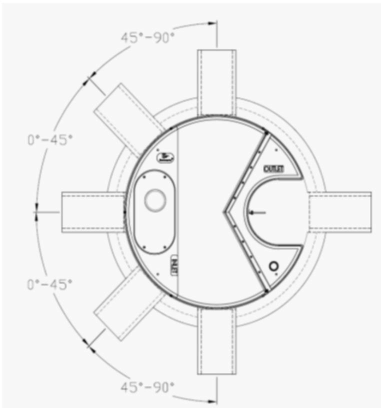
DESIGN FLEXIBILITY

►**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	2600	26

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

Imbrium® Systems

ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

10/07/2024

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33

Project Name:	Willoughby
Project Number:	221377
Designer Name:	Greg Rapp
Designer Company:	Husson Limited
Designer Email:	greg.rapp@husson.ca
Designer Phone:	416-788-1414
EOR Name:	
EOR Company:	
EOR Email:	
EOR Phone:	

Site Name:	104

Drainage Area (ha):	0.65
% Imperviousness:	65.00

Runoff Coefficient 'c': 0.69

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.00
Estimated Water Quality Flow Rate (L/s):	13.95
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	
Influent TSS Concentration (mg/L):	200
Estimated Average Annual Sediment Load (kg/yr):	361
Estimated Average Annual Sediment Volume (L/yr):	294

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	56
EFO6	63
EFO8	66
EFO10	68
EFO12	69

Recommended Stormceptor EFO Model: EFO6

Estimated Net Annual Sediment (TSS) Load Reduction (%): 63

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.

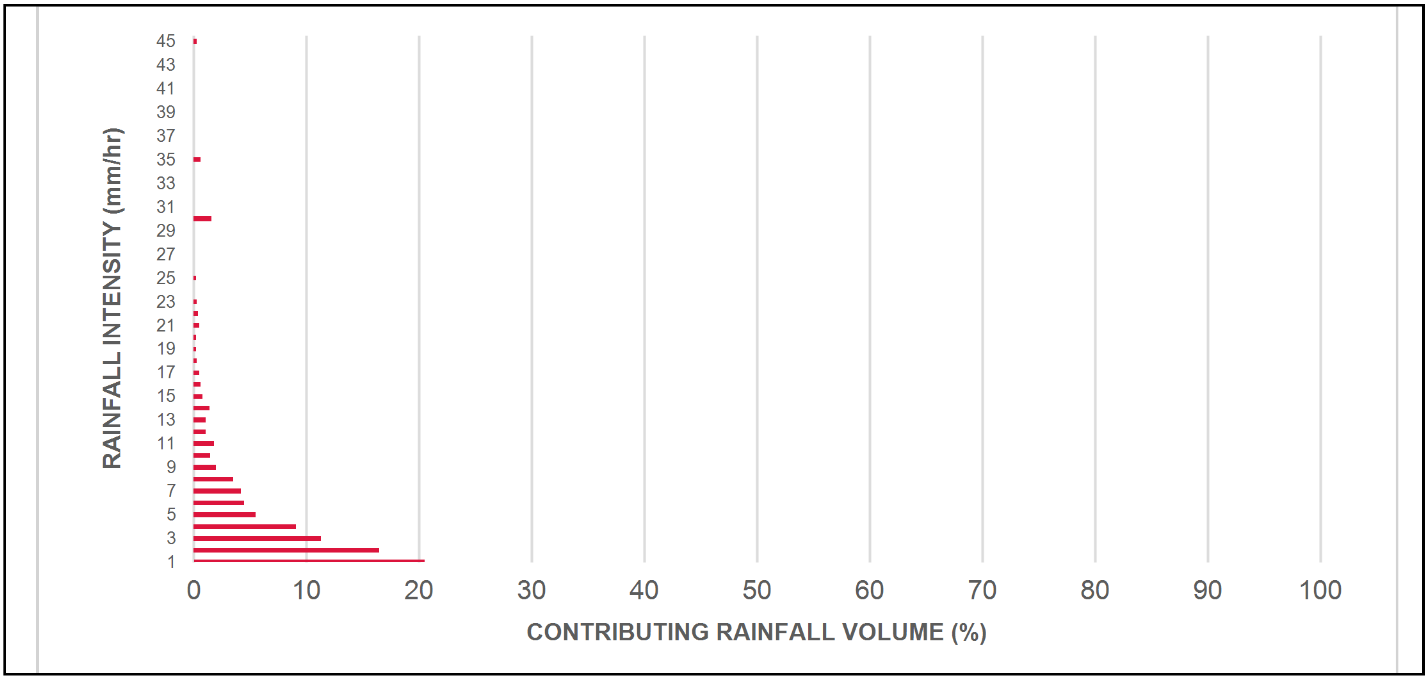
Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Stormceptor® EF Sizing Report

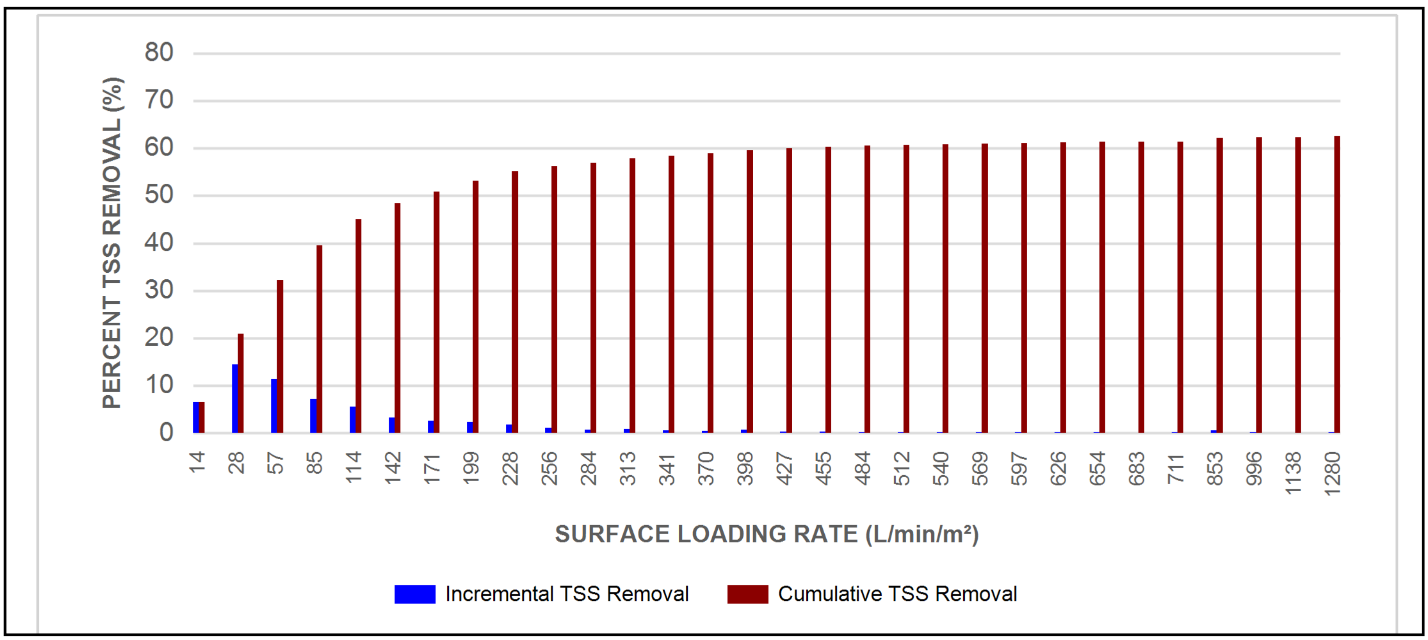
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.50	9.2	9.2	0.62	37.0	14.0	70	6.5	6.5
1.00	20.5	29.7	1.25	75.0	28.0	70	14.4	20.9
2.00	16.5	46.2	2.49	150.0	57.0	69	11.4	32.3
3.00	11.3	57.5	3.74	224.0	85.0	64	7.3	39.5
4.00	9.1	66.7	4.99	299.0	114.0	62	5.6	45.1
5.00	5.5	72.2	6.23	374.0	142.0	59	3.3	48.4
6.00	4.5	76.7	7.48	449.0	171.0	57	2.6	50.9
7.00	4.2	80.9	8.73	524.0	199.0	54	2.3	53.2
8.00	3.5	84.4	9.97	598.0	228.0	53	1.9	55.1
9.00	2.0	86.5	11.22	673.0	256.0	53	1.1	56.2
10.00	1.5	88.0	12.47	748.0	284.0	52	0.8	56.9
11.00	1.8	89.8	13.72	823.0	313.0	51	0.9	57.9
12.00	1.1	90.9	14.96	898.0	341.0	50	0.5	58.4
13.00	1.1	92.0	16.21	973.0	370.0	49	0.5	58.9
14.00	1.4	93.4	17.46	1047.0	398.0	48	0.7	59.6
15.00	0.8	94.2	18.70	1122.0	427.0	47	0.4	60.0
16.00	0.6	94.8	19.95	1197.0	455.0	47	0.3	60.3
17.00	0.5	95.3	21.20	1272.0	484.0	46	0.2	60.5
18.00	0.3	95.6	22.44	1347.0	512.0	45	0.1	60.7
19.00	0.2	95.9	23.69	1421.0	540.0	44	0.1	60.8
20.00	0.2	96.1	24.94	1496.0	569.0	43	0.1	60.9
21.00	0.5	96.6	26.18	1571.0	597.0	42	0.2	61.1
22.00	0.4	97.0	27.43	1646.0	626.0	42	0.2	61.2
23.00	0.3	97.3	28.68	1721.0	654.0	42	0.1	61.4
24.00	0.0	97.3	29.92	1795.0	683.0	42	0.0	61.4
25.00	0.2	97.4	31.17	1870.0	711.0	41	0.1	61.4
30.00	1.6	99.1	37.40	2244.0	853.0	41	0.7	62.1
35.00	0.6	99.7	43.64	2618.0	996.0	40	0.3	62.3
40.00	0.0	99.7	49.87	2992.0	1138.0	38	0.0	62.3
45.00	0.3	100.0	56.11	3366.0	1280.0	36	0.1	62.5
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

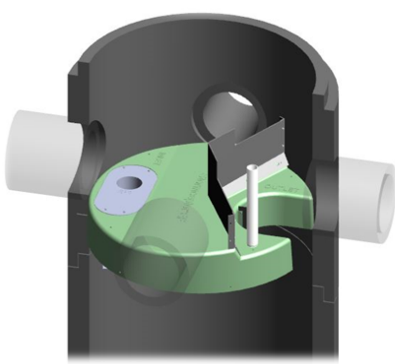
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test 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.

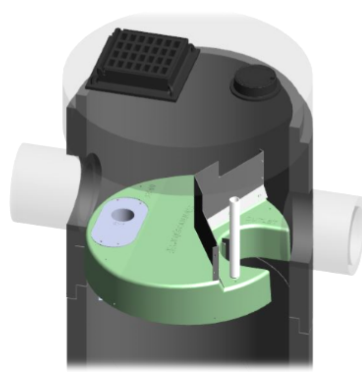
DESIGN FLEXIBILITY

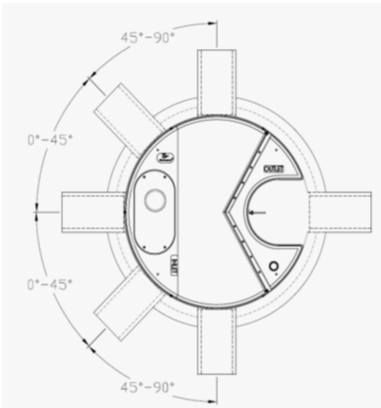
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend 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
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	2600	26

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 <u>SIZING METHODOLOGY</u>

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 <u>CANADIAN ETV or ISO 14034 ETV VERIFICATION OF SCOUR TESTING</u>

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 <u>LIGHT LIQUID RE-ENTRAINMENT SIMULATION TESTING</u>

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

Imbrium® Systems
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

10/07/2024

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33
Site Name:	105
Drainage Area (ha):	0.27
% Imperviousness:	65.00

Runoff Coefficient 'c': 0.69

Project Name:	Willoughby
Project Number:	221377
Designer Name:	Greg Rapp
Designer Company:	Husson Limited
Designer Email:	greg.rapp@husson.ca
Designer Phone:	416-788-1414
EOR Name:	
EOR Company:	
EOR Email:	
EOR Phone:	

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0
Required Water Quality Runoff Volume Capture (%):	90.00
Estimated Water Quality Flow Rate (L/s):	5.79
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	
Influent TSS Concentration (mg/L):	200
Estimated Average Annual Sediment Load (kg/yr):	150
Estimated Average Annual Sediment Volume (L/yr):	122

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	63
EFO6	67
EFO8	69
EFO10	70
EFO12	70

Recommended Stormceptor EFO Model: EFO4

Estimated Net Annual Sediment (TSS) Load Reduction (%): 63

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.

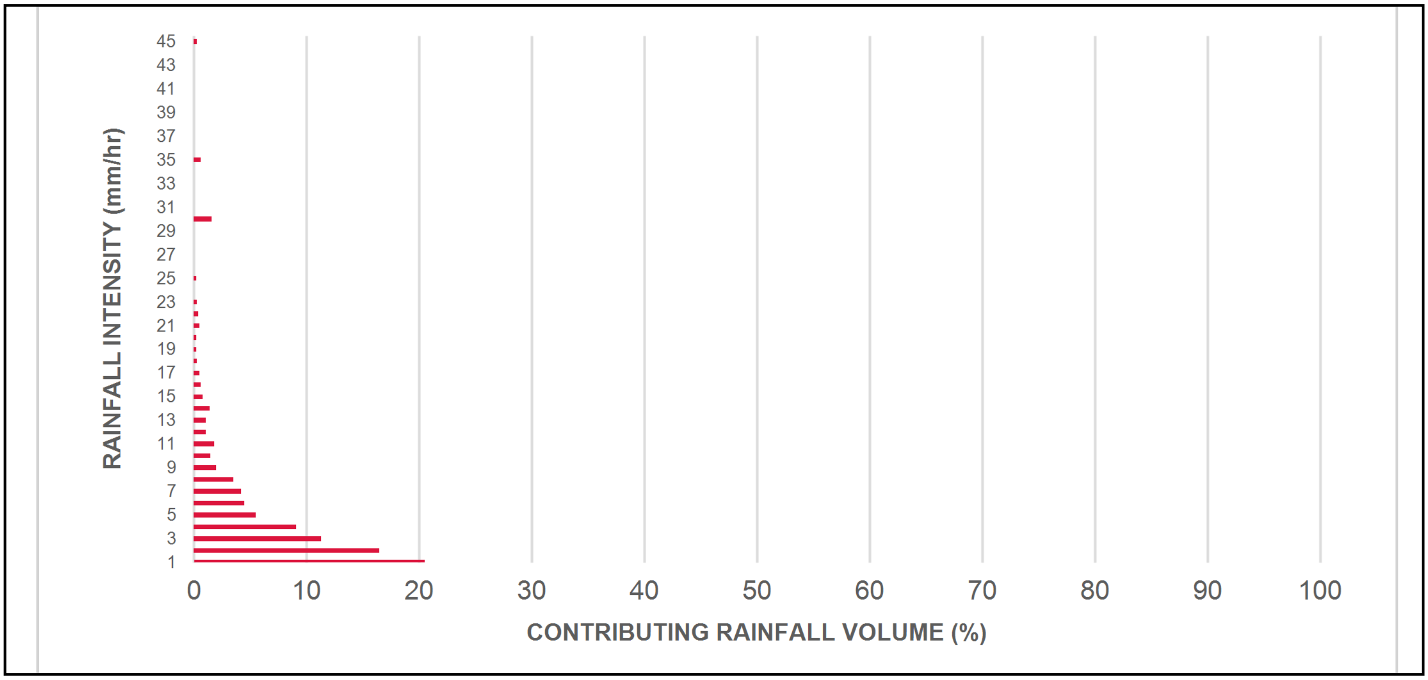
Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Stormceptor® EF Sizing Report

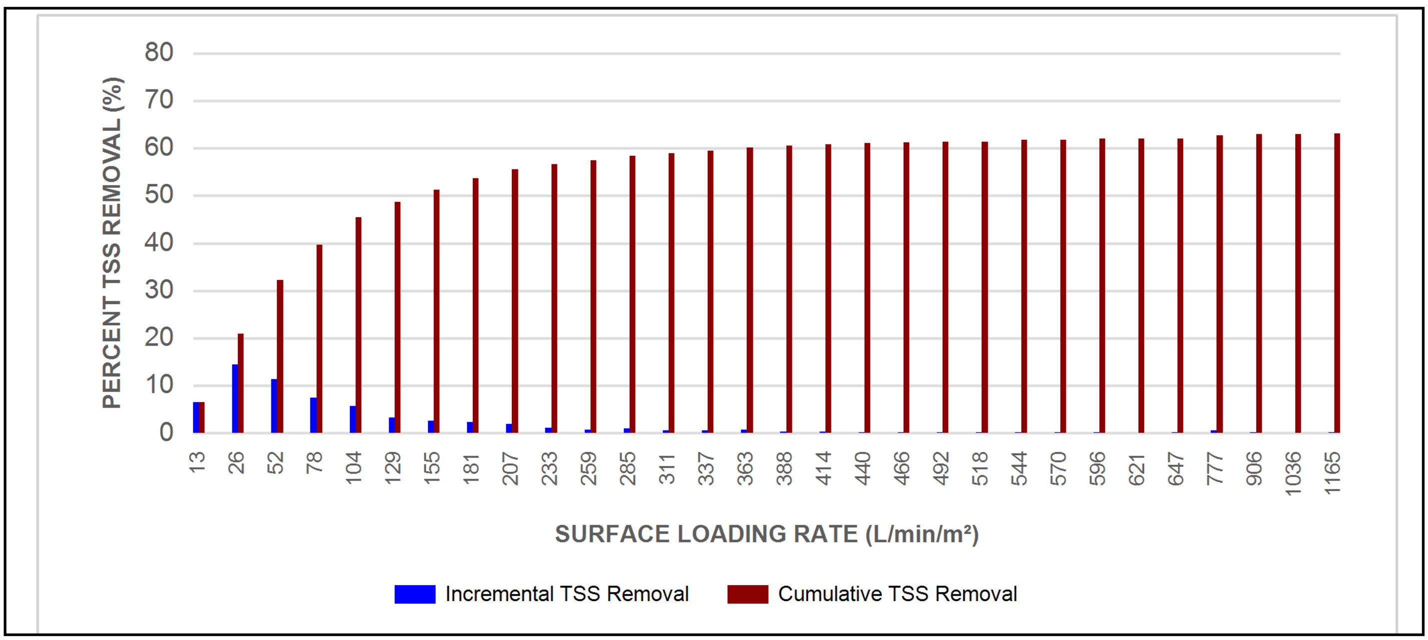
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.50	9.2	9.2	0.26	16.0	13.0	70	6.5	6.5
1.00	20.5	29.7	0.52	31.0	26.0	70	14.4	20.9
2.00	16.5	46.2	1.04	62.0	52.0	69	11.4	32.3
3.00	11.3	57.5	1.55	93.0	78.0	66	7.4	39.7
4.00	9.1	66.7	2.07	124.0	104.0	62	5.7	45.4
5.00	5.5	72.2	2.59	155.0	129.0	60	3.3	48.7
6.00	4.5	76.7	3.11	186.0	155.0	58	2.6	51.3
7.00	4.2	80.9	3.63	218.0	181.0	56	2.4	53.7
8.00	3.5	84.4	4.14	249.0	207.0	54	1.9	55.6
9.00	2.0	86.5	4.66	280.0	233.0	53	1.1	56.7
10.00	1.5	88.0	5.18	311.0	259.0	53	0.8	57.4
11.00	1.8	89.8	5.70	342.0	285.0	52	1.0	58.4
12.00	1.1	90.9	6.21	373.0	311.0	51	0.5	58.9
13.00	1.1	92.0	6.73	404.0	337.0	50	0.5	59.5
14.00	1.4	93.4	7.25	435.0	363.0	49	0.7	60.2
15.00	0.8	94.2	7.77	466.0	388.0	49	0.4	60.6
16.00	0.6	94.8	8.29	497.0	414.0	48	0.3	60.8
17.00	0.5	95.3	8.80	528.0	440.0	47	0.2	61.1
18.00	0.3	95.6	9.32	559.0	466.0	46	0.2	61.2
19.00	0.2	95.9	9.84	590.0	492.0	45	0.1	61.3
20.00	0.2	96.1	10.36	621.0	518.0	45	0.1	61.4
21.00	0.5	96.6	10.88	653.0	544.0	44	0.2	61.7
22.00	0.4	97.0	11.39	684.0	570.0	43	0.2	61.8
23.00	0.3	97.3	11.91	715.0	596.0	42	0.1	62.0
24.00	0.0	97.3	12.43	746.0	621.0	42	0.0	62.0
25.00	0.2	97.4	12.95	777.0	647.0	42	0.1	62.0
30.00	1.6	99.1	15.54	932.0	777.0	41	0.7	62.7
35.00	0.6	99.7	18.13	1088.0	906.0	41	0.3	63.0
40.00	0.0	99.7	20.72	1243.0	1036.0	40	0.0	63.0
45.00	0.3	100.0	23.31	1398.0	1165.0	38	0.1	63.1
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		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

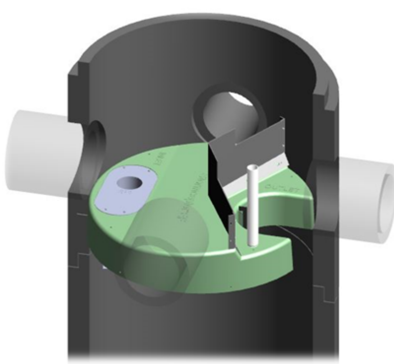
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test 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.

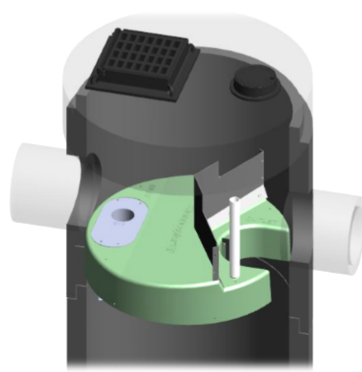
DESIGN FLEXIBILITY

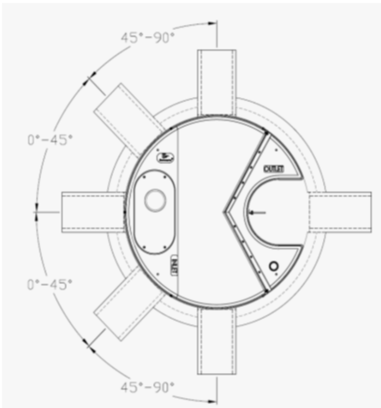
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend 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/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

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	2600	26

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
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3.1 GENERAL

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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.

Imbrium® Systems
ESTIMATED NET ANNUAL SEDIMENT (TSS) LOAD REDUCTION

10/07/2024

Province:	Ontario
City:	Niagara Falls
Nearest Rainfall Station:	ST CATHARINES AP
Climate Station Id:	6137287
Years of Rainfall Data:	33

Site Name:	106

Drainage Area (ha):	0.53
% Imperviousness:	65.00

Runoff Coefficient 'c': 0.69

Project Name:	Willoughby
Project Number:	221377
Designer Name:	Greg Rapp
Designer Company:	Husson Limited
Designer Email:	greg.rapp@husson.ca
Designer Phone:	416-788-1414
EOR Name:	
EOR Company:	
EOR Email:	
EOR Phone:	

Particle Size Distribution:	CA ETV
Target TSS Removal (%):	60.0

Required Water Quality Runoff Volume Capture (%):	90.00
Estimated Water Quality Flow Rate (L/s):	11.37
Oil / Fuel Spill Risk Site?	Yes
Upstream Flow Control?	No
Peak Conveyance (maximum) Flow Rate (L/s):	
Influent TSS Concentration (mg/L):	200
Estimated Average Annual Sediment Load (kg/yr):	299
Estimated Average Annual Sediment Volume (L/yr):	243

Net Annual Sediment (TSS) Load Reduction Sizing Summary

Stormceptor Model	TSS Removal Provided (%)
EFO4	58
EFO6	64
EFO8	67
EFO10	69
EFO12	69

Recommended Stormceptor EFO Model:	**EFO6**
Estimated Net Annual Sediment (TSS) Load Reduction (%):	**64**
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.

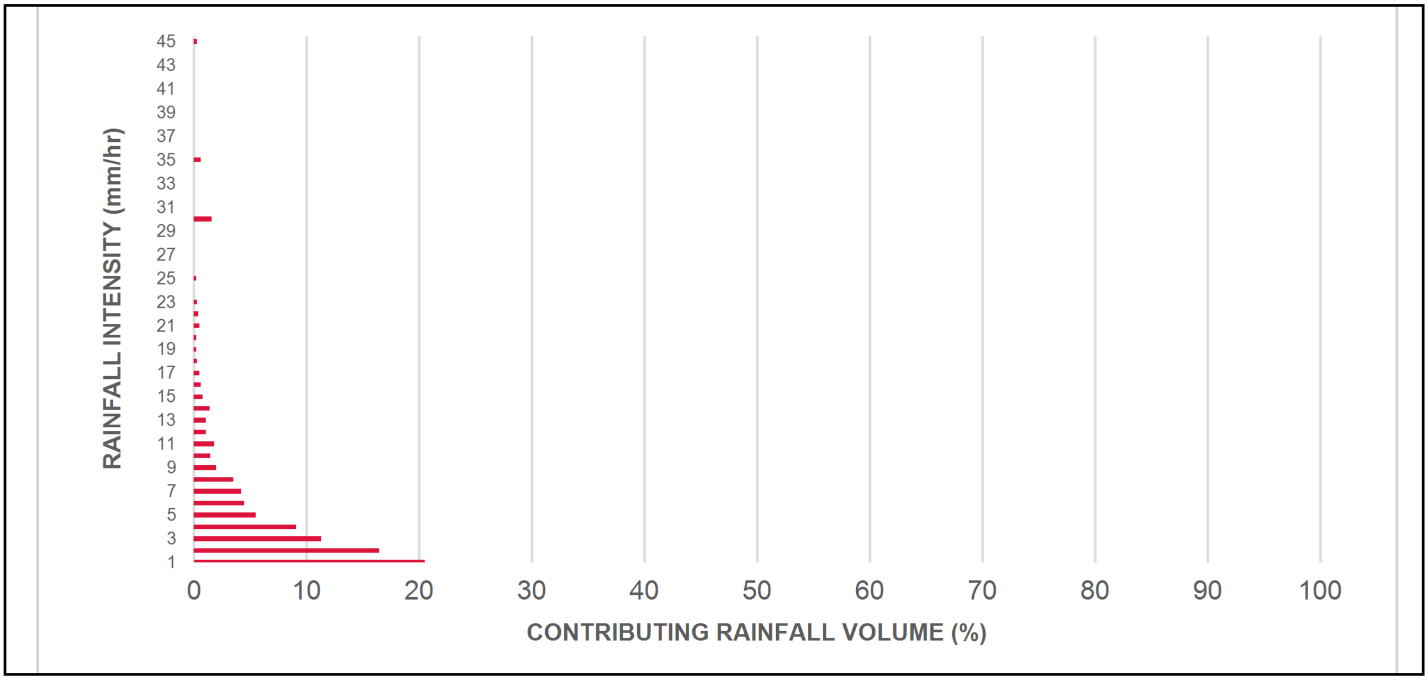
Particle Size (µm)	Percent Less Than	Particle Size Fraction (µm)	Percent
1000	100	500-1000	5
500	95	250-500	5
250	90	150-250	15
150	75	100-150	15
100	60	75-100	10
75	50	50-75	5
50	45	20-50	10
20	35	8-20	15
8	20	5-8	10
5	10	2-5	5
2	5	<2	5

Stormceptor® EF Sizing Report

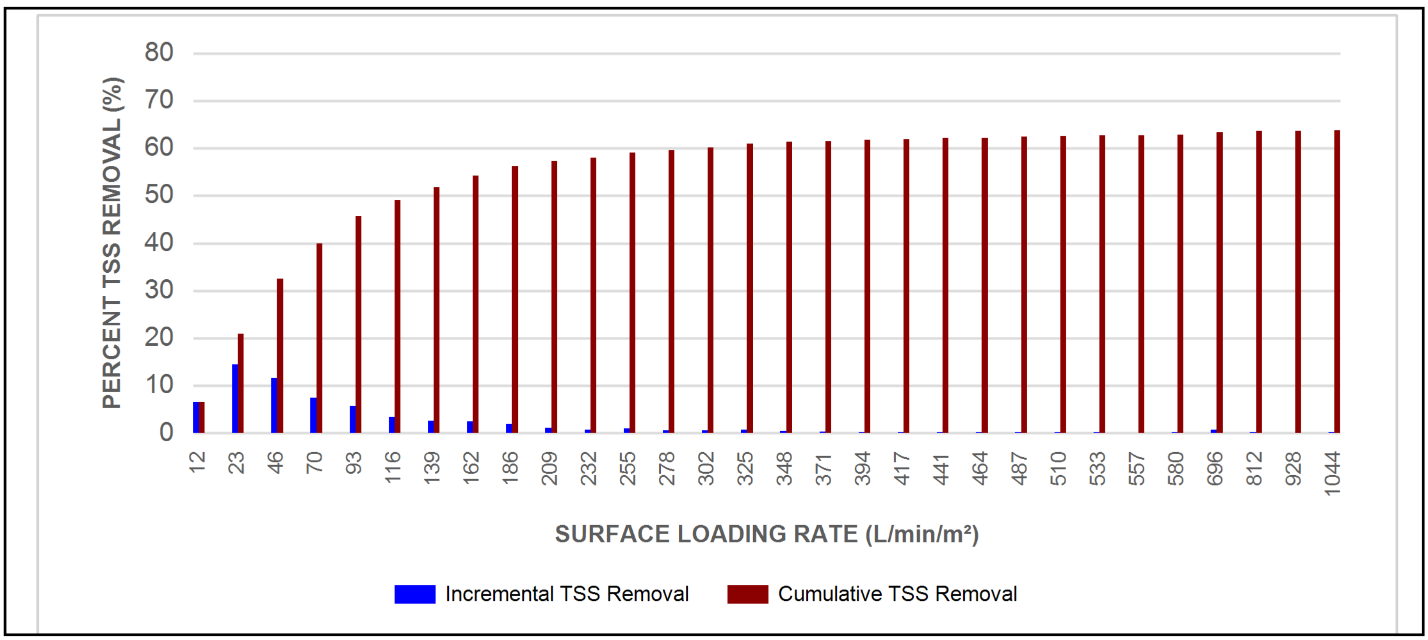
Rainfall Intensity (mm / hr)	Percent Rainfall Volume (%)	Cumulative Rainfall Volume (%)	Flow Rate (L/s)	Flow Rate (L/min)	Surface Loading Rate (L/min/m²)	Removal Efficiency (%)	Incremental Removal (%)	Cumulative Removal (%)
0.50	9.2	9.2	0.51	30.0	12.0	70	6.5	6.5
1.00	20.5	29.7	1.02	61.0	23.0	70	14.4	20.9
2.00	16.5	46.2	2.03	122.0	46.0	70	11.6	32.5
3.00	11.3	57.5	3.05	183.0	70.0	66	7.4	40.0
4.00	9.1	66.7	4.07	244.0	93.0	63	5.8	45.7
5.00	5.5	72.2	5.08	305.0	116.0	62	3.4	49.1
6.00	4.5	76.7	6.10	366.0	139.0	59	2.7	51.8
7.00	4.2	80.9	7.12	427.0	162.0	57	2.4	54.2
8.00	3.5	84.4	8.13	488.0	186.0	56	2.0	56.2
9.00	2.0	86.5	9.15	549.0	209.0	54	1.1	57.3
10.00	1.5	88.0	10.17	610.0	232.0	53	0.8	58.0
11.00	1.8	89.8	11.18	671.0	255.0	53	1.0	59.0
12.00	1.1	90.9	12.20	732.0	278.0	52	0.6	59.6
13.00	1.1	92.0	13.22	793.0	302.0	51	0.6	60.1
14.00	1.4	93.4	14.23	854.0	325.0	50	0.7	60.9
15.00	0.8	94.2	15.25	915.0	348.0	50	0.4	61.3
16.00	0.6	94.8	16.27	976.0	371.0	49	0.3	61.5
17.00	0.5	95.3	17.28	1037.0	394.0	48	0.2	61.8
18.00	0.3	95.6	18.30	1098.0	417.0	48	0.2	61.9
19.00	0.2	95.9	19.32	1159.0	441.0	47	0.1	62.1
20.00	0.2	96.1	20.33	1220.0	464.0	46	0.1	62.2
21.00	0.5	96.6	21.35	1281.0	487.0	46	0.2	62.4
22.00	0.4	97.0	22.37	1342.0	510.0	45	0.2	62.6
23.00	0.3	97.3	23.38	1403.0	533.0	44	0.1	62.7
24.00	0.0	97.3	24.40	1464.0	557.0	44	0.0	62.7
25.00	0.2	97.4	25.42	1525.0	580.0	43	0.1	62.8
30.00	1.6	99.1	30.50	1830.0	696.0	42	0.7	63.4
35.00	0.6	99.7	35.58	2135.0	812.0	41	0.3	63.7
40.00	0.0	99.7	40.67	2440.0	928.0	40	0.0	63.7
45.00	0.3	100.0	45.75	2745.0	1044.0	39	0.1	63.8
Estimated Net Annual Sediment (TSS) Load Reduction =								**64 %**

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

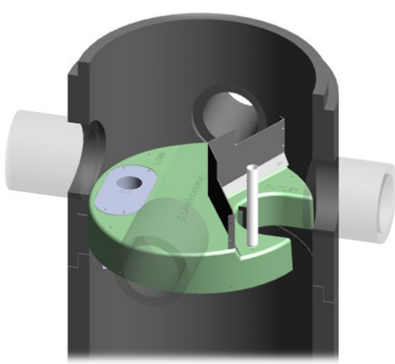
►**Stormceptor® EF and EFO** feature an internal bypass and superior scour prevention technology that have been demonstrated in third-party testing according to the scour testing provisions of the Canadian ETV **Procedure for Laboratory Testing of Oil-Grit Separators**, and the exceptional scour test 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.

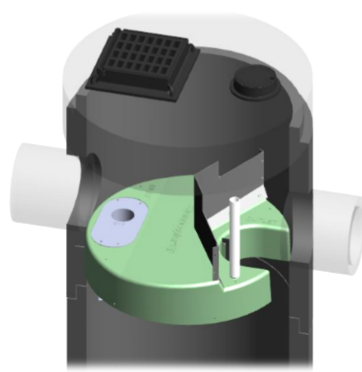
DESIGN FLEXIBILITY

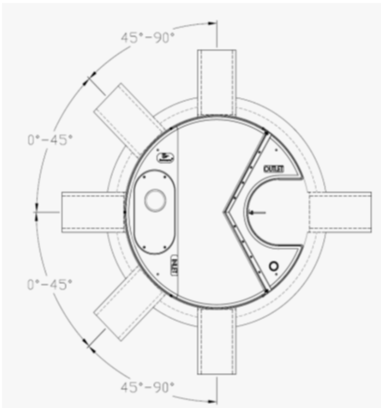
►**Stormceptor® EF** and **EFO** offers design flexibility in one simplified platform, accepting stormwater flow from a single inlet pipe or multiple inlet pipes, and/or surface runoff through an inlet grate. The device can also serve as a junction structure, accommodate a 90-degree inlet-to-outlet bend 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	2600	26

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.

HUSSON

APPENDIX C

STORMWATER MANAGEMENT CALCULATIONS

OSD Storage-Dicharge

HUSSON

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	103 & 108

Orifice Plate

Invert	173.37	m	@ MH116
Size	120	mm	
Co-efficient	0.62		
Area	0.0113	m^2	

Elevation	Area (m^2)	Incremental Storage (m^3)	Total Storage (m^3)	Head on Orifice (m)	Orifice Flow (m^3/s)
173.370		0.00	0.0	0.00	0.000
173.371		229.75	229.8	0.00	0.000
173.940	1046	297.70	238.0	0.51	0.022
174.950	1046	1056.86	1294.8	1.52	0.038
174.951		0.52	1295.3	1.52	0.038
175.860		0.00	1295.3	2.43	0.048

Pipe/Structure Storage Volumes

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	103 & 108

Pipe Storage

Diameter	Length	Storage Volume
150	0	0.00
200	0	0.00
250	0	0.00
300	12.47	0.88
375	0	0.00
450	0	0.00
525	87.66	18.98
600	104.34	29.50
675	0	0.00
750	154.84	68.41
825	124.81	66.72
900	0	0.00
975	0	0.00
1050	0	0.00
1200	0	0.00
1350	0	0.00
1500	0	0.00
1800	0	0.00

Total 184.48 m^3

Manhole Storage

Description	MH Inside Diam. (mm)	Invert (m)	Top Elev. (m)	Storage Depth (m)	Storage Volume (m^3)
MH116	1800	173.37	175.86	2.49	6.34
MH105	1800	173.45	176.20	2.75	7.00
MH106	1800	173.52	176.23	2.71	6.90
MH107	1800	173.64	176.25	2.61	6.64
MH108	1500	173.79	176.30	2.51	4.44
MH109	1500	173.91	176.27	2.36	4.17
MH110	1500	174.08	176.23	2.15	3.80
MH111	1500	174.24	176.23	1.99	3.52
MH112	1500	174.44	175.84	1.40	2.47

Total 45.27 m^3

Total Storage 229.8 m^3

OSD Storage-Dicharge

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	104

Orifice Plate

Invert	173.43	m	@ MH137
Size	204	mm	
Co-efficient	0.62		
Area	0.0327	m^2	

Elevation	Area (m^2)	Incremental Storage (m^3)	Total Storage (m^3)	Head on Orifice (m)	Orifice Flow (m^3/s)
173.430	221	0.00	0.0	0.00	0.000
174.440	221	223.01	223.0	0.91	0.086

Pipe/Structure Storage Volumes

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	104

Pipe Storage

Diameter	Length	Storage Volume
150	0	0.00
200	0	0.00
250	0	0.00
300	0	0.00
375	46.73	5.16
450	84.34	13.41
525	0	0.00
600	13.27	3.75
675	0	0.00
750	71.52	31.60
825	0	0.00
900	0	0.00
975	0	0.00
1050	0	0.00
1200	0	0.00
1350	0	0.00
1500	0	0.00
1800	0	0.00

Total 53.92 m^3

Manhole Storage

Description	MH Inside Diam. (mm)	Invert (m)	Top Elev. (m)	Storage Depth (m)	Storage Volume (m^3)
MH137	1500	173.43	175.83	2.40	4.24
MH119	1500	173.51	175.98	2.47	4.36
MH120	1500	173.65	176.03	2.38	4.21
MH121	1500	173.72	175.97	2.25	3.98
MH127	1500	174.20	176.03	1.83	3.23
MH128	1500	174.38	176.10	1.72	3.04

Total 23.06 m^3

Total Storage 77.0 m^3

OSD Storage-Dicharge

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	105

Orifice Plate

Invert	174.09	m	@ MH115	
Size	74	mm		*Use ICD
Co-efficient	0.62			
Area	0.0043	m^2		

Elevation	Area (m^2)	Incremental Storage (m^3)	Total Storage (m^3)	Head on Orifice (m)	Orifice Flow (m^3/s)
174.09	175	0.00	0.0	0.00	0.000
174.75	175	121.48	121.5	0.62	0.009

Pipe/Structure Storage Volumes

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	105

Pipe Storage

Diameter	Length	Storage Volume
150	0	0.00
200	0	0.00
250	0	0.00
300	0	0.00
375	0	0.00
450	0	0.00
525	0	0.00
600	0	0.00
675	0	0.00
750	0	0.00
825	0	0.00
900	0	0.00
975	0	0.00
1050	0	0.00
1200	0	0.00
1350	0	0.00
1500	0	0.00
1800	0	0.00

Total 0.00 m^3

Manhole Storage

Description	MH Inside Diam. (mm)	Invert (m)	Top Elev. (m)	Storage Depth (m)	Storage Volume (m^3)
MH115	1500	174.09	175.78	1.69	2.99
MH117	1500	174.33	176.13	1.80	3.18

Total 6.17 m^3

Total Storage 6.2 m^3

OSD Storage-Dicharge

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	106

Orifice Plate

Invert	173.4	m	@ MH118
Size	152	mm	
Co-efficient	0.62		
Area	0.0181	m^2	

Elevation	Area (m^2)	Incremental Storage (m^3)	Total Storage (m^3)	Head on Orifice (m)	Orifice Flow (m^3/s)
173.40	186	0.00	0.0	0.00	0.000
174.41	186	193.80	193.8	0.93	0.048

Pipe/Structure Storage Volumes

Project:	Willoughby Drive
Project No.:	221377
Municipality:	City of Niagara Falls
Catchment:	106

Pipe Storage

Diameter	Length	Storage Volume
150	0	0.00
200	0	0.00
250	0	0.00
300	19.16	1.35
375	0	0.00
450	0	0.00
525	0	0.00
600	0	0.00
675	0	0.00
750	0	0.00
825	0	0.00
900	0	0.00
975	0	0.00
1050	0	0.00
1200	0	0.00
1350	0	0.00
1500	0	0.00
1800	0	0.00

Total 1.35 m^3

Manhole Storage

Description	MH Inside Diam. (mm)	Invert (m)	Top Elev. (m)	Storage Depth (m)	Storage Volume (m^3)
MH118	1500	173.40	175.86	2.46	4.35

Total 4.35 m^3

Total Storage 5.7 m^3

APPENDIX D

HYDROLOGY MODEL OUTPUT

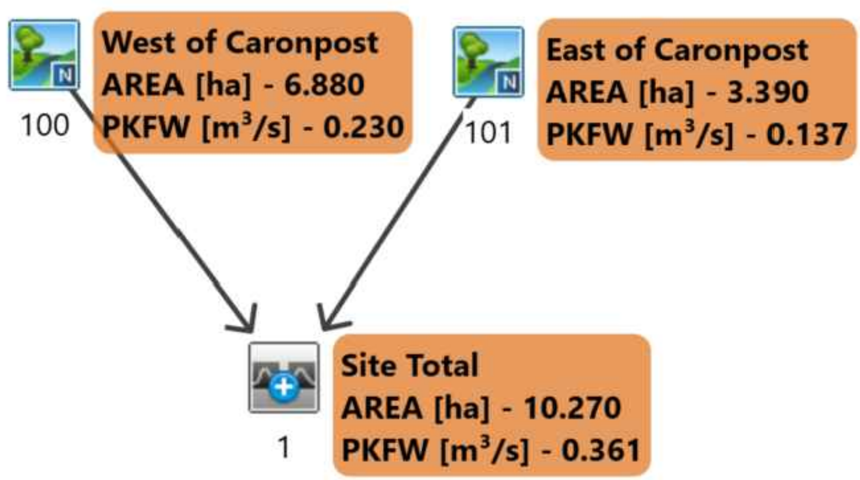


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FIGURE D1
WILLOUGHBY DRIVE
VO PRE DEVELOPMENT

DATE: OCTOBER 2024 SCALE: N.T.S. PROJECT: 221377

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

       V    V   I    SSSSS  U   U    A    L             (v 6.2.2015)
       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 *****


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DATE: 10-03-2024                          TIME: 05:26:57

USER:



COMMENTS: ____________________________________________________________

------------------------------------------------------------------------------------------------------
-----
  ************************************************
  ** SIMULATION : CHI4hr - 005yr                **
  ************************************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A= 719.500
| Ptotal= 41.74 mm |                          B=   6.340
--------------------                          C=   0.769
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  4.00 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
                 0.00    2.99 |  1.00   22.26 |  2.00    6.94 |  3.00    3.54
                 0.17    3.41 |  1.17   84.02 |  2.17    5.92 |  3.17    3.30
                 0.33    4.01 |  1.33   28.87 |  2.33    5.19 |  3.33    3.08
                 0.50    4.90 |  1.50   15.67 |  2.50    4.63 |  3.50    2.90
                 0.67    6.42 |  1.67   10.90 |  2.67    4.19 |  3.67    2.74
                 0.83    9.66 |  1.83    8.44 |  2.83    3.84 |  3.83    2.60


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0101)|   Area    (ha)=   3.39   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.65

         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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
                0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
```

```
               0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
               0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
               0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
               1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Unit Hyd Qpeak  (cms)=   0.199

     PEAK FLOW       (cms)=   0.055 (i)
     TIME TO PEAK    (hrs)=   2.167
     RUNOFF VOLUME    (mm)=  11.987
     TOTAL RAINFALL   (mm)=  41.741
     RUNOFF COEFFICIENT   =   0.287

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

-------------------------------------------------------------------------------
--------------------
| CALIB              |
| NASHYD   (  0100)|   Area    (ha)=   6.88   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.86

         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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
               0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
               0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
               0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
               0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
               0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
               0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
               0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
               0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
               0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
               0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
               1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Unit Hyd Qpeak  (cms)=   0.306

     PEAK FLOW       (cms)=   0.092 (i)
     TIME TO PEAK    (hrs)=   2.500
     RUNOFF VOLUME    (mm)=  11.987
     TOTAL RAINFALL   (mm)=  41.741
     RUNOFF COEFFICIENT   =   0.287

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

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0100):     6.88   0.092     2.50    11.99
      + ID2= 2 (  0101):     3.39   0.055     2.17    11.99
        ==================================================
        ID = 3 (  0001):    10.27   0.144     2.33    11.99

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

 FINISH
======================================================================================================
=====

======================================================================================================
=====

       V    V   I    SSSSS  U   U    A    L              (v 6.2.2015)
       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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```

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DATE: 10-03-2024                           TIME: 05:26:56

USER:


COMMENTS: ____________________________________________________________


-----------------------------------------------------------------------------------------------------
-----
  ************************************************
  ** SIMULATION : CHI4hr - 100yr                **
  ************************************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1264.570
| Ptotal= 68.11 mm |                          B=   7.720
--------------------                          C=   0.781
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm   =  4.00 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
                 0.00    4.74 |  1.00   37.64 |  2.00   11.39 |  3.00    5.65
                 0.17    5.44 |  1.17  133.78 |  2.17    9.65 |  3.17    5.25
                 0.33    6.43 |  1.33   48.90 |  2.33    8.41 |  3.33    4.90
                 0.50    7.93 |  1.50   26.44 |  2.50    7.47 |  3.50    4.60
                 0.67   10.51 |  1.67   18.20 |  2.67    6.73 |  3.67    4.34
                 0.83   16.06 |  1.83   13.96 |  2.83    6.14 |  3.83    4.10


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0101)|   Area    (ha)=    3.39   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia      (mm)=    5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=    0.65

         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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Unit Hyd Qpeak  (cms)=   0.199

     PEAK FLOW       (cms)=   0.137 (i)
     TIME TO PEAK    (hrs)=   2.167
     RUNOFF VOLUME    (mm)=  28.656
     TOTAL RAINFALL   (mm)=  68.109
     RUNOFF COEFFICIENT   =   0.421

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

```
--------------------------------------------------------------------------------
--------------------
| CALIB            |
| NASHYD   (  0100)|   Area     (ha)=   6.88   Curve Number   (CN)= 77.0
|ID= 1 DT= 5.0 min |   Ia       (mm)=   5.00   # of Linear Res.(N)= 3.00
--------------------   U.H. Tp(hrs)=   0.86

         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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                 0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                 0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                 0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                 0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                 0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                 0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                 0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                 0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                 0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                 0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                 1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Unit Hyd Qpeak  (cms)=   0.306

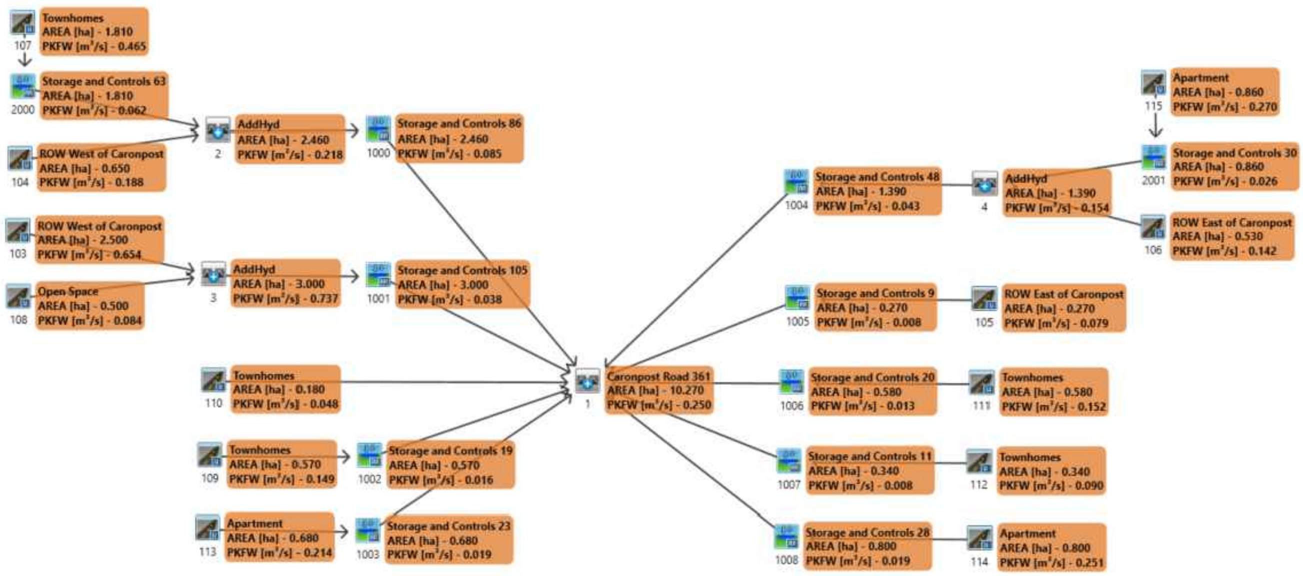
     PEAK FLOW       (cms)=   0.230 (i)
     TIME TO PEAK    (hrs)=   2.417
     RUNOFF VOLUME    (mm)=  28.657
     TOTAL RAINFALL   (mm)=  68.109
     RUNOFF COEFFICIENT   =   0.421

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

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0100):      6.88   0.230     2.42    28.66
      + ID2= 2 (  0101):      3.39   0.137     2.17    28.66
        ==================================================
        ID = 3 (  0001):     10.27   0.361     2.33    28.66

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



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MARKHAM, ON L6C 0Z8
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FIGURE D2
WILLOUGHBY DRIVE
VO POST DEVELOPMENT

DATE: OCTOBER 2024 SCALE: N.T.S. PROJECT: 221377

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

       V    V   I    SSSSS  U   U    A    L             (v 6.2.2015)
       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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```



```
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  Input   filename: C:\Program Files (x86)\Visual OTTHYMO 6.2\VO2\voin.dat
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\4ded57e8-a7e4-49c8-978f-553d056c4008\


DATE: 10-08-2024                          TIME: 06:28:21

USER:



COMMENTS: ____________________________________________________________

----------------------------------------------------------------------------------------------------
-----
  ************************************************
  ** SIMULATION : CHI4hr - 005yr               **
  ************************************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A= 719.500
| Ptotal= 41.74 mm |                          B=   6.340
--------------------                          C=   0.769
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  4.00 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
                 0.00    2.99 |  1.00   22.26 |  2.00    6.94 |  3.00    3.54
                 0.17    3.41 |  1.17   84.02 |  2.17    5.92 |  3.17    3.30
                 0.33    4.01 |  1.33   28.87 |  2.33    5.19 |  3.33    3.08
                 0.50    4.90 |  1.50   15.67 |  2.50    4.63 |  3.50    2.90
                 0.67    6.42 |  1.67   10.90 |  2.67    4.19 |  3.67    2.74
                 0.83    9.66 |  1.83    8.44 |  2.83    3.84 |  3.83    2.60


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0110)|   Area    (ha)=   0.18
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.12         0.06
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      34.64        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
```

```
              0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
              0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
              0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
              0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
              0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
              0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
              0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
              0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
              0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
              1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        63.55
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.45 (ii)    9.91 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.33         0.11
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.02         0.01          0.027 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      40.74        22.97          31.82
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.55           0.76

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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            |
| STANDHYD (  0103)|   Area    (ha)=   2.50
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  55.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.62         0.88
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     129.10        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
              0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
              0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
              0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
              0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
              0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
              0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
              0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
              0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
              0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
              0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
              1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        53.67
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       3.19 (ii)   12.25 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.27         0.09
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.31         0.07          0.351 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=      40.74        21.82          32.22
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.52           0.77

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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              |
| STANDHYD (  0108)|   Area    (ha)=   0.50
|ID= 1 DT= 5.0 min |   Total Imp(%)=  20.00   Dir. Conn.(%)=  20.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.10         0.40
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      57.74        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
                0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
                0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
                0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
                0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
                1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        28.90
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       1.97 (ii)   13.57 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.31         0.08
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.02         0.02          0.034 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04          23.36
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.46           0.56

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!
***** WARNING:FOR AREAS WITH IMPERVIOUS RATIOS BELOW 20%
              YOU SHOULD CONSIDER SPLITTING THE AREA.

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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  (  0003)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0103):     2.50   0.351     1.33    32.22
      + ID2= 2 (  0108):     0.50   0.034     1.33    23.36
        ===============================================
        ID = 3 (  0003):     3.00   0.385     1.33    30.75

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1001)|     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   |   0.0380     0.1290
                          0.0000     0.0230   |   0.0480     0.1290
                          0.0220     0.0460   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0003)      3.000      0.385      1.33      30.75
   OUTFLOW: ID= 1 (  1001)      3.000      0.026      3.25      22.99

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  6.83
                   TIME SHIFT OF PEAK FLOW         (min)=115.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0683
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--------------------
| CALIB             |
| STANDHYD (  0105)|   Area    (ha)=   0.27
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  65.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.18         0.09
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      42.43        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
                0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
                0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
                0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
                0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
                1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        28.90
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       1.64 (ii)   13.23 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.32         0.08
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.04         0.01           0.044 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04          33.11
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.46           0.79

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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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--------------------
| RESERVOIR( 1005)|     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   |   0.0090     0.0120

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0105)      0.270     0.044      1.33      33.11
   OUTFLOW: ID= 1 (  1005)      0.270     0.004      2.33      31.89

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.87
                   TIME SHIFT OF PEAK FLOW         (min)= 60.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0057

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--------------------
| CALIB             |
| STANDHYD (  0107)|   Area    (ha)=   1.81
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.18         0.63
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     109.85        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    RAIN |  TIME    RAIN |'  TIME    RAIN |  TIME    RAIN
               hrs   mm/hr |   hrs   mm/hr |'   hrs   mm/hr |   hrs   mm/hr
             0.083    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
             0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
             0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
             0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
             0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
             0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
             0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
             0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
             0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
             0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
             0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
             1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        63.55
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.90 (ii)   11.36 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.28         0.09
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.21         0.07          0.243 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=      40.74        22.97          31.85
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.55           0.76

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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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--------------------
| RESERVOIR( 2000)|     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    |   0.0630     0.0620

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0107)      1.810      0.243      1.33      31.85
   OUTFLOW: ID= 1 (  2000)      1.810      0.035      2.25      31.72

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 14.25
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0341

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--------------------
| CALIB            |
| STANDHYD (  0104)|   Area    (ha)=   0.65
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  65.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.42         0.23
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      65.83        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
             0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
             0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
             0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
             0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
             0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
             0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
             0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
             0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
             0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
             0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
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             1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        28.90
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.13 (ii)   13.73 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.31         0.08
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.10         0.01         0.104 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50          1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04         33.13
     TOTAL RAINFALL   (mm)=      41.74        41.74         41.74
     RUNOFF COEFFICIENT   =       0.98         0.46          0.79

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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  (  0002)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0104):     0.65   0.104     1.33    33.13
      + ID2= 2 (  2000):     1.81   0.035     2.25    31.72
        ==================================================
        ID = 3 (  0002):     2.46   0.120     1.33    32.09

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1000)|     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   |   0.0860     0.0220

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0002)      2.460      0.120      1.33      32.09
   OUTFLOW: ID= 1 (  1000)      2.460      0.047      2.17      32.07

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 39.37
                   TIME SHIFT OF PEAK FLOW         (min)= 50.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0121

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0112)|   Area    (ha)=   0.34
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.22         0.12
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      47.61        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
             0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
             0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
             0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
             0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
             0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
             0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
             0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
             0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
             0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
             0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
             1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        63.55
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              over (min)        5.00        15.00
     Storage Coeff.  (min)=      1.75 (ii)   10.22 (ii)
     Unit Hyd. Tpeak (min)=      5.00        15.00
     Unit Hyd. peak  (cms)=      0.32         0.09
                                                      *TOTALS*
     PEAK FLOW       (cms)=      0.04         0.01          0.047 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=     40.74        22.97          31.84
     TOTAL RAINFALL   (mm)=     41.74        41.74          41.74
     RUNOFF COEFFICIENT  =       0.98         0.55           0.76

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1007)|     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   |   0.0110     0.0130
                          0.0080     0.0130   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK      R.V.
                                (ha)     (cms)     (hrs)      (mm)
   INFLOW : ID= 2 (  0112)      0.340     0.047      1.33      31.84
   OUTFLOW: ID= 1 (  1007)      0.340     0.004      2.58      30.66

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.52
                   TIME SHIFT OF PEAK FLOW         (min)= 75.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0072

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD ( 0109)|   Area    (ha)=   0.57
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=      0.37         0.20
     Dep. Storage     (mm)=      1.00         1.50
     Average Slope     (%)=      1.00         2.00
     Length            (m)=     61.64        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
               0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
               0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
               0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
               0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
               0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
               0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
               0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
               0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
               0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
               0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
               1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=     84.02        63.55
              over (min)        5.00        15.00
     Storage Coeff.  (min)=      2.05 (ii)   10.51 (ii)
     Unit Hyd. Tpeak (min)=      5.00        15.00
     Unit Hyd. peak  (cms)=      0.31         0.09
                                                      *TOTALS*
     PEAK FLOW       (cms)=      0.07         0.02          0.078 (iii)
     TIME TO PEAK    (hrs)=      1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=     40.74        22.97          31.85
     TOTAL RAINFALL   (mm)=     41.74        41.74          41.74
     RUNOFF COEFFICIENT  =       0.98         0.55           0.76

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
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```
            CN*  =  85.0    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.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1002)|     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   |   0.0190     0.0220
                          0.0120     0.0220   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0109)      0.570      0.078      1.33      31.85
   OUTFLOW: ID= 1 (  1002)      0.570      0.007      2.67      31.04

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.71
                   TIME SHIFT OF PEAK FLOW         (min)= 80.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0125

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--------------------
| CALIB            |
| STANDHYD (  0115)|   Area    (ha)=   0.86
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.65         0.22
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      75.72        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
                0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
                0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
                0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
                0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
                1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        35.29
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.32 (ii)    7.19 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.30         0.14
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.15         0.02          0.162 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04          35.31
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.46           0.85

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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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--------------------
| RESERVOIR( 2001)|     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   |   0.0300     0.0350
                          0.0220     0.0350   |   0.0000     0.0000
```

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                              AREA     QPEAK     TPEAK       R.V.
                              (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0115)    0.860     0.162     1.33      35.31
   OUTFLOW: ID= 1 (  2001)    0.860     0.013     2.33      34.84

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=  7.95
                  TIME SHIFT OF PEAK FLOW         (min)= 60.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.0205

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--------------------
| CALIB            |
| STANDHYD (  0106)|   Area    (ha)=   0.53
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.34         0.19
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      59.44        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
                0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
                0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
                0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
                0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
                0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
                1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        53.67
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.00 (ii)   11.06 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.31         0.09
                                                         *TOTALS*
     PEAK FLOW       (cms)=       0.07         0.02          0.077 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50           1.33
     RUNOFF VOLUME    (mm)=      40.74        21.82          32.22
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.52           0.77

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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  (  0004)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0106):     0.53   0.077     1.33    32.22
      + ID2= 2 (  2001):     0.86   0.013     2.33    34.84
        ====================================================
        ID = 3 (  0004):     1.39   0.084     1.33    33.84

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1004)|     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   |   0.0480     0.0190

                              AREA     QPEAK     TPEAK       R.V.
                              (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0004)    1.390     0.084     1.33      33.84
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   OUTFLOW: ID= 1 (  1004)      1.390      0.024      2.08      33.78

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 29.20
                   TIME SHIFT OF PEAK FLOW         (min)= 45.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0097

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--------------------
| CALIB             |
| STANDHYD (  0114)|   Area    (ha)=    0.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.60         0.20
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      73.03        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
               0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
               0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
               0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
               0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
               0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
               0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
               0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
               0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
               0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
               0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
               1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        35.29
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.27 (ii)    7.14 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.30         0.14
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.14         0.01          0.151 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04          35.31
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.46           0.85

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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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--------------------
| RESERVOIR( 1008)|     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    |   0.0280     0.0340
                          0.0190     0.0340    |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0114)      0.800      0.151      1.33      35.31
   OUTFLOW: ID= 1 (  1008)      0.800      0.011      2.50      34.75

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  7.23
                   TIME SHIFT OF PEAK FLOW         (min)= 70.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0195

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--------------------
| CALIB             |
| STANDHYD (  0113)|   Area    (ha)=    0.68
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.51         0.17
```

```
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      67.33        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
               0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
               0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
               0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
               0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
               0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
               0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
               0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
               0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
               0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
               0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
               1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        35.29
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.16 (ii)    7.04 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.31         0.14
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.12         0.01          0.128 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      40.74        19.04          35.31
     TOTAL RAINFALL   (mm)=      41.74        41.74          41.74
     RUNOFF COEFFICIENT   =       0.98         0.46           0.85

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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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--------------------
| RESERVOIR( 1003)|     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   |   0.0230      0.0280
                          0.0190     0.0280   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0113)      0.680      0.128      1.33      35.31
   OUTFLOW: ID= 1 (  1003)      0.680      0.011      2.25      34.77

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.42
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0159

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--------------------
| CALIB             |
| STANDHYD (  0111)|   Area    (ha)=   0.58
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.38         0.20
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      62.18        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    2.99 | 1.083   22.26 | 2.083    6.94 |  3.08    3.54
               0.167    2.99 | 1.167   22.26 | 2.167    6.94 |  3.17    3.54
               0.250    3.41 | 1.250   84.02 | 2.250    5.92 |  3.25    3.30
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                0.333    3.41 | 1.333   84.02 | 2.333    5.92 |  3.33    3.30
                0.417    4.01 | 1.417   28.87 | 2.417    5.19 |  3.42    3.08
                0.500    4.01 | 1.500   28.87 | 2.500    5.19 |  3.50    3.08
                0.583    4.90 | 1.583   15.67 | 2.583    4.63 |  3.58    2.90
                0.667    4.90 | 1.667   15.67 | 2.667    4.63 |  3.67    2.90
                0.750    6.42 | 1.750   10.90 | 2.750    4.19 |  3.75    2.74
                0.833    6.42 | 1.833   10.90 | 2.833    4.19 |  3.83    2.74
                0.917    9.66 | 1.917    8.44 | 2.917    3.84 |  3.92    2.60
                1.000    9.66 | 2.000    8.44 | 3.000    3.84 |  4.00    2.60

     Max.Eff.Inten.(mm/hr)=      84.02        63.55
                over (min)        5.00        15.00
     Storage Coeff.  (min)=       2.06 (ii)   10.52 (ii)
     Unit Hyd. Tpeak (min)=       5.00        15.00
     Unit Hyd. peak  (cms)=       0.31         0.09
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.07         0.02           0.079 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.50            1.33
     RUNOFF VOLUME    (mm)=      40.74        22.97           31.85
     TOTAL RAINFALL   (mm)=      41.74        41.74           41.74
     RUNOFF COEFFICIENT   =       0.98         0.55            0.76

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1006)|     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   |   0.0200      0.0230
                          0.0130     0.0230   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0111)      0.580      0.079      1.33      31.85
   OUTFLOW: ID= 1 (  1006)      0.580      0.007      2.67      31.09

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.96
                   TIME SHIFT OF PEAK FLOW         (min)= 80.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0126

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1000):      2.46   0.047     2.17    32.07
      + ID2= 2 (  1001):      3.00   0.026     3.25    22.99
        ===================================================
        ID = 3 (  0001):      5.46   0.073     2.25    27.08

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):      5.46   0.073     2.25    27.08
      + ID2= 2 (  1002):      0.57   0.007     2.67    31.04
        ===================================================
        ID = 1 (  0001):      6.03   0.080     2.25    27.46

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):      6.03   0.080     2.25    27.46
      + ID2= 2 (  1003):      0.68   0.011     2.25    34.77
        ===================================================
        ID = 3 (  0001):      6.71   0.090     2.25    28.20

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

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     6.71   0.090     2.25    28.20
      + ID2= 2 (  1004):     1.39   0.024     2.08    33.78
        ===================================================
        ID = 1 (  0001):     8.10   0.115     2.25    29.16

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):     8.10   0.115     2.25    29.16
      + ID2= 2 (  1005):     0.27   0.004     2.33    31.89
        ===================================================
        ID = 3 (  0001):     8.37   0.119     2.25    29.24

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     8.37   0.119     2.25    29.24
      + ID2= 2 (  1006):     0.58   0.007     2.67    31.09
        ===================================================
        ID = 1 (  0001):     8.95   0.126     2.25    29.36

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):     8.95   0.126     2.25    29.36
      + ID2= 2 (  1007):     0.34   0.004     2.58    30.66
        ===================================================
        ID = 3 (  0001):     9.29   0.130     2.25    29.41

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     9.29   0.130     2.25    29.41
      + ID2= 2 (  1008):     0.80   0.011     2.50    34.75
        ===================================================
        ID = 1 (  0001):    10.09   0.141     2.25    29.83

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):    10.09   0.141     2.25    29.83
      + ID2= 2 (  0110):     0.18   0.027     1.33    31.82
        ===================================================
        ID = 3 (  0001):    10.27   0.144     2.17    29.87

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

 FINISH
=========================================================================================================
=====

=========================================================================================================
=====

       V    V   I    SSSSS  U   U    A    L              (v 6.2.2015)
       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\workstation\AppData\Local\Civica\VH5\ccf76975-8d50-4b70-aa0c-30fee69c1cca
\3e338b66-ac2e-404b-95c9-f18e0ced622b\
  Summary filename: C:\Users\workstation\AppData\Local\Civica\VH5\ccf76975-8d50-4b70-aa0c-30fee69c1cca
\3e338b66-ac2e-404b-95c9-f18e0ced622b\


DATE: 10-08-2024                          TIME: 06:28:20

USER:


COMMENTS: ____________________________________________________________

---------------------------------------------------------------------------------------------------------
-----
  ************************************************
  ** SIMULATION : CHI4hr - 100yr               **
  ************************************************

--------------------
| CHICAGO STORM    |    IDF curve parameters: A=1264.570
| Ptotal= 68.11 mm |                          B=   7.720
--------------------                          C=   0.781
                        used in:   INTENSITY =  A / (t + B)^C

                        Duration of storm  =  4.00 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
                 0.00    4.74 |  1.00   37.64 |  2.00   11.39 |  3.00    5.65
                 0.17    5.44 |  1.17  133.78 |  2.17    9.65 |  3.17    5.25
                 0.33    6.43 |  1.33   48.90 |  2.33    8.41 |  3.33    4.90
                 0.50    7.93 |  1.50   26.44 |  2.50    7.47 |  3.50    4.60
                 0.67   10.51 |  1.67   18.20 |  2.67    6.73 |  3.67    4.34
                 0.83   16.06 |  1.83   13.96 |  2.83    6.14 |  3.83    4.10


-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0110)|   Area    (ha)=   0.18
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.12         0.06
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      34.64        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
```

```
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       129.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.20 (ii)    7.57 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.33         0.13
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.03         0.02          0.048 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        45.68          56.38
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.67           0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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            |
| STANDHYD (  0103)|   Area    (ha)=   2.50
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  55.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.62         0.88
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     129.10        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       111.09
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.65 (ii)    9.42 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.29         0.12
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.50         0.18          0.654 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        44.02          56.72
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.65           0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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            |
| STANDHYD (  0108)|   Area    (ha)=   0.50
|ID= 1 DT= 5.0 min |   Total Imp(%)=  20.00   Dir. Conn.(%)=  20.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
```

```
     Surface Area     (ha)=       0.10         0.40
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      57.74        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.64 (ii)    9.50 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.12
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.04         0.06         0.084 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42          1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82         45.26
     TOTAL RAINFALL   (mm)=      68.11        68.11         68.11
     RUNOFF COEFFICIENT   =       0.99         0.58          0.66

***** WARNING: STORAGE COEFF. IS SMALLER THAN TIME STEP!
***** WARNING:FOR AREAS WITH IMPERVIOUS RATIOS BELOW 20%
              YOU SHOULD CONSIDER SPLITTING THE AREA.

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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  (  0003)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0103):     2.50   0.654     1.33    56.72
      + ID2= 2 (  0108):     0.50   0.084     1.33    45.26
        ===================================================
        ID = 3 (  0003):     3.00   0.737     1.33    54.81

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
-------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1001)|     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   |   0.0380      0.1290
                          0.0000     0.0230   |   0.0480      0.1290
                          0.0220     0.0460   |   0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0003)      3.000      0.737      1.33      54.81
   OUTFLOW: ID= 1 (  1001)      3.000      0.038      3.58      47.05

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=  5.14
                  TIME SHIFT OF PEAK FLOW         (min)=135.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.1285

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0105)|   Area    (ha)=   0.27
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  65.00
--------------------
```

```
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.18         0.09
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      42.43        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
               0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
               0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
               0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
               0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
               0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
               0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
               0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
               0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
               0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
               0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
               1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.36 (ii)    6.26 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.33         0.15
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.07         0.02          0.079 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82          57.54
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.58           0.84

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1005)|     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    |  0.0090      0.0120

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0105)      0.270     0.079      1.33      57.54
   OUTFLOW: ID= 1 (  1005)      0.270     0.008      2.25      56.32

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.64
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0101

-------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0107)|   Area    (ha)=   1.81
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       1.18         0.63
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=     109.85        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
               0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
```

```
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       129.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       2.41 (ii)    8.77 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.30         0.12
                                                             *TOTALS*
     PEAK FLOW       (cms)=       0.33         0.16           0.465 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42            1.33
     RUNOFF VOLUME    (mm)=      67.11        45.68           56.39
     TOTAL RAINFALL   (mm)=      68.11        68.11           68.11
     RUNOFF COEFFICIENT   =       0.99         0.67            0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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.

-------------------------------------------------------------------------------
--------------------
| RESERVOIR( 2000)|      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    |  0.0630      0.0620

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0107)      1.810      0.465      1.33      56.39
   OUTFLOW: ID= 1 (  2000)      1.810      0.062      2.08      56.26

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 13.42
                  TIME SHIFT OF PEAK FLOW         (min)= 45.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.0615

-------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD (  0104)|   Area     (ha)=   0.65
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  65.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.42         0.23
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      65.83        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.77 (ii)    6.67 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
```

```
     Unit Hyd. peak  (cms)=       0.32         0.14
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.16         0.04           0.188 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42            1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82           57.55
     TOTAL RAINFALL   (mm)=      68.11        68.11           68.11
     RUNOFF COEFFICIENT   =       0.99         0.58            0.84

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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  (  0002)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0104):     0.65   0.188     1.33    57.55
      + ID2= 2 (  2000):     1.81   0.062     2.08    56.26
        ==================================================
        ID = 3 (  0002):     2.46   0.218     1.33    56.60

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1000)|     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   |   0.0860     0.0220

                                AREA     QPEAK     TPEAK      R.V.
                                (ha)     (cms)     (hrs)      (mm)
   INFLOW : ID= 2 (  0002)      2.460     0.218      1.33      56.60
   OUTFLOW: ID= 1 (  1000)      2.460     0.085      2.08      56.58

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)= 38.93
                  TIME SHIFT OF PEAK FLOW         (min)= 45.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.0218

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD (  0112)|   Area    (ha)=   0.34
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.22         0.12
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      47.61        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
               0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
               0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
               0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
               0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
               0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
               0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
               0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
               0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
               0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
               0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
               1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       129.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.46 (ii)    7.83 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.33         0.13
                                                            *TOTALS*
     PEAK FLOW       (cms)=       0.06         0.03           0.090 (iii)
```

```
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        45.68          56.39
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.67           0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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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--------------------
| RESERVOIR( 1007)|     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    |  0.0110      0.0130
                          0.0080     0.0130    |  0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0112)      0.340     0.090      1.33      56.39
   OUTFLOW: ID= 1 (  1007)      0.340     0.008      2.50      55.19

                  PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.91
                  TIME SHIFT OF PEAK FLOW         (min)= 70.00
                  MAXIMUM  STORAGE   USED       (ha.m.)=  0.0130

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--------------------
| CALIB            |
| STANDHYD ( 0109)|   Area    (ha)=   0.57
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                               IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.37         0.20
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      61.64        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
               0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
               0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
               0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
               0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
               0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
               0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
               0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
               0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
               0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
               0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
               1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       129.26
                over (min)       5.00        10.00
     Storage Coeff.  (min)=       1.70 (ii)    8.07 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.13
                                                         *TOTALS*
     PEAK FLOW       (cms)=       0.11         0.05          0.149 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        45.68          56.39
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.67           0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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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--------------------
| RESERVOIR( 1002)|     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   |  0.0190      0.0220
                          0.0120     0.0220   |  0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0109)      0.570      0.149      1.33      56.39
   OUTFLOW: ID= 1 (  1002)      0.570      0.016      2.25      55.58

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)= 10.79
                   TIME SHIFT OF PEAK FLOW         (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0220

--------------------------------------------------------------------------------
--------------------
| CALIB             |
| STANDHYD ( 0115)|   Area    (ha)=   0.86
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                               IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.65         0.22
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      75.72        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
                0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
                0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
                0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
                0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
                0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
                0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
                0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
                0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
                0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
                0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
                1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.92 (ii)    5.97 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.31         0.15
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.24         0.04          0.270 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82          60.28
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.58           0.89

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 2001)|     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   |  0.0300      0.0350
                          0.0220     0.0350   |  0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0115)      0.860      0.270      1.33      60.28
   OUTFLOW: ID= 1 (  2001)      0.860      0.026      2.17      59.82

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  9.62
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                TIME SHIFT OF PEAK FLOW         (min)= 50.00
                MAXIMUM  STORAGE   USED       (ha.m.)=  0.0350

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD (  0106)|   Area    (ha)=   0.53
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  55.00
--------------------
                          IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.34         0.19
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      59.44        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
              0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
              0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
              0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
              0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
              0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
              0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
              0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
              0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
              0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
              0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
              1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       111.09
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.66 (ii)    8.43 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.12
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.11         0.04          0.142 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        44.02          56.71
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.65           0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0     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  (  0004)|
|   1 +  2 =  3    |          AREA    QPEAK    TPEAK     R.V.
--------------------          (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0106):      0.53   0.142     1.33    56.71
      + ID2= 2 (  2001):      0.86   0.026     2.17    59.82
        ==================================================
        ID = 3 (  0004):      1.39   0.154     1.33    58.63

     NOTE:  PEAK FLOWS DO NOT INCLUDE BASEFLOWS IF ANY.
--------------------------------------------------------------------------------
--------------------
| RESERVOIR(  1004)|     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   |   0.0480     0.0190

                                 AREA     QPEAK     TPEAK      R.V.
                                 (ha)     (cms)     (hrs)      (mm)
   INFLOW : ID= 2 (  0004)      1.390      0.154      1.33      58.63
   OUTFLOW: ID= 1 (  1004)      1.390      0.043      2.00      58.57

                PEAK   FLOW   REDUCTION [Qout/Qin](%)= 28.12
                TIME SHIFT OF PEAK FLOW         (min)= 40.00
                MAXIMUM  STORAGE   USED       (ha.m.)=  0.0172
```

```
--------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD (  0114)|   Area    (ha)=   0.80
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.60         0.20
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      73.03        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    4.74 | 1.083   37.64 | 2.083   11.39 |  3.08    5.65
               0.167    4.74 | 1.167   37.64 | 2.167   11.39 |  3.17    5.65
               0.250    5.44 | 1.250  133.78 | 2.250    9.65 |  3.25    5.25
               0.333    5.44 | 1.333  133.78 | 2.333    9.65 |  3.33    5.25
               0.417    6.43 | 1.417   48.90 | 2.417    8.41 |  3.42    4.90
               0.500    6.43 | 1.500   48.90 | 2.500    8.41 |  3.50    4.90
               0.583    7.93 | 1.583   26.44 | 2.583    7.47 |  3.58    4.60
               0.667    7.93 | 1.667   26.44 | 2.667    7.47 |  3.67    4.60
               0.750   10.51 | 1.750   18.20 | 2.750    6.73 |  3.75    4.34
               0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
               0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
               1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.88 (ii)    5.93 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.15
                                                          *TOTALS*
     PEAK FLOW       (cms)=       0.22         0.03          0.251 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82          60.28
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.58           0.89

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1008)|     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   |   0.0280     0.0340
                          0.0190     0.0340   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0114)      0.800      0.251      1.33      60.28
   OUTFLOW: ID= 1 (  1008)      0.800      0.019      2.42      59.72

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  7.45
                   TIME SHIFT OF PEAK FLOW         (min)= 65.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0335

--------------------------------------------------------------------------------
--------------------
| CALIB              |
| STANDHYD (  0113)|   Area    (ha)=   0.68
|ID= 1 DT= 5.0 min |   Total Imp(%)=  75.00   Dir. Conn.(%)=  75.00
--------------------
                             IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.51         0.17
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      67.33        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    4.74 | 1.083   37.64 | 2.083   11.39 | 3.08    5.65
             0.167    4.74 | 1.167   37.64 | 2.167   11.39 | 3.17    5.65
             0.250    5.44 | 1.250  133.78 | 2.250    9.65 | 3.25    5.25
             0.333    5.44 | 1.333  133.78 | 2.333    9.65 | 3.33    5.25
             0.417    6.43 | 1.417   48.90 | 2.417    8.41 | 3.42    4.90
             0.500    6.43 | 1.500   48.90 | 2.500    8.41 | 3.50    4.90
             0.583    7.93 | 1.583   26.44 | 2.583    7.47 | 3.58    4.60
             0.667    7.93 | 1.667   26.44 | 2.667    7.47 | 3.67    4.60
             0.750   10.51 | 1.750   18.20 | 2.750    6.73 | 3.75    4.34
             0.833   10.51 | 1.833   18.20 | 2.833    6.73 | 3.83    4.34
             0.917   16.06 | 1.917   13.96 | 2.917    6.14 | 3.92    4.10
             1.000   16.06 | 2.000   13.96 | 3.000    6.14 | 4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78        76.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.79 (ii)    5.84 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.15
                                                           *TOTALS*
     PEAK FLOW       (cms)=       0.19         0.03          0.214 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42           1.33
     RUNOFF VOLUME    (mm)=      67.11        39.82          60.28
     TOTAL RAINFALL   (mm)=      68.11        68.11          68.11
     RUNOFF COEFFICIENT   =       0.99         0.58           0.89

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN* =  85.0    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.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1003)|     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   |  0.0230      0.0280
                          0.0190     0.0280   |  0.0000      0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0113)      0.680     0.214      1.33      60.28
   OUTFLOW: ID= 1 (  1003)      0.680     0.019      2.25      59.74

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.68
                   TIME SHIFT OF PEAK FLOW          (min)= 55.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0274

--------------------------------------------------------------------------------
--------------------
| CALIB            |
| STANDHYD ( 0111)|   Area    (ha)=   0.58
|ID= 1 DT= 5.0 min |   Total Imp(%)=  65.00   Dir. Conn.(%)=  50.00
--------------------
                              IMPERVIOUS    PERVIOUS (i)
     Surface Area     (ha)=       0.38         0.20
     Dep. Storage     (mm)=       1.00         1.50
     Average Slope     (%)=       1.00         2.00
     Length            (m)=      62.18        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    4.74 | 1.083   37.64 | 2.083   11.39 | 3.08    5.65
             0.167    4.74 | 1.167   37.64 | 2.167   11.39 | 3.17    5.65
             0.250    5.44 | 1.250  133.78 | 2.250    9.65 | 3.25    5.25
             0.333    5.44 | 1.333  133.78 | 2.333    9.65 | 3.33    5.25
             0.417    6.43 | 1.417   48.90 | 2.417    8.41 | 3.42    4.90
             0.500    6.43 | 1.500   48.90 | 2.500    8.41 | 3.50    4.90
             0.583    7.93 | 1.583   26.44 | 2.583    7.47 | 3.58    4.60
             0.667    7.93 | 1.667   26.44 | 2.667    7.47 | 3.67    4.60
             0.750   10.51 | 1.750   18.20 | 2.750    6.73 | 3.75    4.34
```

```
           0.833   10.51 | 1.833   18.20 | 2.833    6.73 |  3.83    4.34
           0.917   16.06 | 1.917   13.96 | 2.917    6.14 |  3.92    4.10
           1.000   16.06 | 2.000   13.96 | 3.000    6.14 |  4.00    4.10

     Max.Eff.Inten.(mm/hr)=     133.78       129.26
                over (min)        5.00        10.00
     Storage Coeff.  (min)=       1.71 (ii)    8.08 (ii)
     Unit Hyd. Tpeak (min)=       5.00        10.00
     Unit Hyd. peak  (cms)=       0.32         0.13
                                                              *TOTALS*
     PEAK FLOW       (cms)=       0.11         0.05           0.152 (iii)
     TIME TO PEAK    (hrs)=       1.33         1.42            1.33
     RUNOFF VOLUME    (mm)=      67.11        45.68           56.39
     TOTAL RAINFALL   (mm)=      68.11        68.11           68.11
     RUNOFF COEFFICIENT   =       0.99         0.67            0.83

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

       (i) CN PROCEDURE SELECTED FOR PERVIOUS LOSSES:
            CN*  =  85.0    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.

--------------------------------------------------------------------------------
--------------------
| RESERVOIR( 1006)|     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   |   0.0200     0.0230
                          0.0130     0.0230   |   0.0000     0.0000

                                AREA     QPEAK     TPEAK       R.V.
                                (ha)     (cms)     (hrs)       (mm)
   INFLOW : ID= 2 (  0111)      0.580     0.152      1.33      56.39
   OUTFLOW: ID= 1 (  1006)      0.580     0.013      2.58      55.63

                   PEAK   FLOW   REDUCTION [Qout/Qin](%)=  8.38
                   TIME SHIFT OF PEAK FLOW         (min)= 75.00
                   MAXIMUM  STORAGE   USED       (ha.m.)=  0.0225

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  1000):     2.46   0.085     2.08    56.58
      + ID2= 2 (  1001):     3.00   0.038     3.58    47.05
        ==================================================
        ID = 3 (  0001):     5.46   0.121     2.17    51.34

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     5.46   0.121     2.17    51.34
      + ID2= 2 (  1002):     0.57   0.016     2.25    55.58
        ==================================================
        ID = 1 (  0001):     6.03   0.137     2.25    51.74

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):     6.03   0.137     2.25    51.74
      + ID2= 2 (  1003):     0.68   0.019     2.25    59.74
        ==================================================
        ID = 3 (  0001):     6.71   0.155     2.25    52.55

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
```

```
        ID1= 3 (  0001):     6.71   0.155     2.25    52.55
      + ID2= 2 (  1004):     1.39   0.043     2.00    58.57
        ====================================================
        ID = 1 (  0001):     8.10   0.198     2.25    53.59

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):     8.10   0.198     2.25    53.59
      + ID2= 2 (  1005):     0.27   0.008     2.25    56.32
        ====================================================
        ID = 3 (  0001):     8.37   0.206     2.25    53.67

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     8.37   0.206     2.25    53.67
      + ID2= 2 (  1006):     0.58   0.013     2.58    55.63
        ====================================================
        ID = 1 (  0001):     8.95   0.218     2.25    53.80

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):     8.95   0.218     2.25    53.80
      + ID2= 2 (  1007):     0.34   0.008     2.50    55.19
        ====================================================
        ID = 3 (  0001):     9.29   0.226     2.25    53.85

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

--------------------
| ADD HYD  (  0001)|
|   3 +  2 =  1    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 3 (  0001):     9.29   0.226     2.25    53.85
      + ID2= 2 (  1008):     0.80   0.019     2.42    59.72
        ====================================================
        ID = 1 (  0001):    10.09   0.245     2.25    54.32

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

--------------------
| ADD HYD  (  0001)|
|   1 +  2 =  3    |         AREA    QPEAK    TPEAK     R.V.
--------------------         (ha)    (cms)    (hrs)     (mm)
        ID1= 1 (  0001):    10.09   0.245     2.25    54.32
      + ID2= 2 (  0110):     0.18   0.048     1.33    56.38
        ====================================================
        ID = 3 (  0001):    10.27   0.250     2.25    54.35

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

HUSSON

APPENDIX E

SANITARY AND WATERMAIN MEMO

MEMO

February 10, 2023

File No. 221377

To: Mark Bristoll

From: Charles Groen

Re: **Willoughby Drive Development**
Preliminary Sanitary and Water Servicing Investigation
Updated to Address City Comments
Village of Chippawa, City of Niagara Falls

As requested, we have undertaken a preliminary sanitary and watermain servicing investigation for the proposed development located on the east side of Willoughby Drive in Niagara Falls, Ontario.

1.0 SITE DESCRIPTION

The 11.01ha development is located on the east side of Willoughby Drive between Cattell Drive and Weinbrenner Road which is currently undeveloped.

A preliminary concept plan, Development Concept 2, prepared by GSP Group has been provided for the site, refer to **Appendix A**. The concept plan includes the development of two 4-storey townhouse blocks, four 8 to 10-storey apartment blocks, one park block and two new municipal roads. The full buildout of the development includes 924 units.

2.0 SANITARY SERVICING

The following background information from the City of Niagara and Niagara Region was used to complete the assessment:

- Pre-construction meeting minutes.

ENGINEERING + MANAGEMENT
P 905.709.5825
200 CACHET WOODS COURT, SUITE 204
MARKHAM, ON L6C 0Z8
HUSSON.CA

- Plan and Profiles for: Banting Street, Bridgewater Street, Cattell Drive, Lyon's Creek Road, Main Street, Nassau Avenue, Sodom Street, Sophia Avenue, Southerland Court, Weinbrenner Road, and Welland Street.
- The latest City of Niagara Falls Sewer Design Criteria.
- Niagara Region 2016 Water and Wastewater Master Servicing Study.
- Niagara Region flow data from 2022 for the Low Lift Sewage Pumping Station

Based on the pre-consultation meeting minutes for the proposed development, a Functional Servicing Report would be required to review the impacts of the contribution from the proposed development on the existing sanitary sewer. Through correspondence with Josiah Jordan from the City, it was determined that a downstream sanitary sewer assessment would be required to confirm capacity for the proposed development. It was understood from the email on July 27, 2022 that the City did not have drainage modeling for the south side of Niagara Falls and that the drainage modeling would need to be completed through plan and profiles and design sheets based on City record information. Alternatively, GM BluePlan has a contract with the City to complete the downstream assessment at the cost of the developer (refer to the City standard fees for additional details).

Based on the depth of the existing sanitary sewers on Cattell Drive, Willoughby Drive and Weinbrenner Road and the estimated first floor elevations for the proposed buildings, we do not anticipate any concerns with providing gravity sewer connections for the proposed development.

2.1 Pre-development Downstream Sanitary Sewer Assessment

The area on the south side of Niagara Falls consists of a catchment area of approximately 520ha with a network of local City sanitary sewers that gravity drain to the Southside Low Lift Pumping Station; which is the Region pumping station for south Niagara Falls. The pumping station is located on the north side of the Welland River on the south side of Chippawa Parkway. Based on the Region Master Servicing Study there is capacity in the Southside Low Lift Pumping Station for forecasted growth up to 2041. The City requires an assessment to confirm capacity in the local sanitary sewers downstream of our development.

The pre-development downstream sanitary sewer drainage plan is provided in **Figure 1**. Based on our review of the existing sewers in south Niagara Falls, there are 5 separate gravity connections to the Region sewers connecting to the Southside Low Lift Pumping Station. The

Willoughby Drive development can either connect to the north-central (green boundary) or south-west (orange boundary) drainage areas which are included in the downstream sanitary sewer assessment/sanitary sewer design sheets. There are drainage areas in the centre of south Niagara Falls (blue boundary) and on the west side of Niagara Falls (red boundary) that have direct connections to a Region sewer and a drainage area on the north side of the Welland River (magenta boundary) that we have been advised by the City connects directly to the Southside Low Lift Pumping Station. These areas have not been included in the downstream sanitary sewer assessment.

The sanitary sewer analysis has been completed following the City's Sewer Design Criteria. The pre-development sanitary sewer design sheet is attached in **Appendix B**. Note that the Willoughby Drive development has been included in the north-central catchment area with a population density based on the current zoning. It was determined that there are sections of the existing sanitary sewer that are already over capacity.

In the north-central drainage area the existing sanitary sewer is over capacity (between 118 to 164% full) from the last downstream sewer on Willoughby Drive, on Gunning Drive from Willoughby Drive to the Chippawa Lions Park, in the easement through the park, and Sophia Avenue between the park and Bridgewater Street. This section of sewer is almost 1200m in length and is 375mm diameter sewer running at a slope of approximately 0.15%.

The south-west drainage area is only over capacity in the last length of the sanitary sewer on Lyon's Creek Road (approximately 150m in length) which is flowing at 240% full; a 375mm diameter sewer at a slope of 0.33%. The City provided comments which requested adding ~82ha with peaked flow of ~140L/s for other future developments in this drainage area; which accounts for the large increase to the flow since the first submission.

2.2 Post-development Downstream Sanitary Sewer Assessment

Two separate options were considered for the post-development scenarios:

- Option 1 – Proposed development to connect to the existing sanitary sewers adjacent to the development. The majority of the site would drain to the North-Central drainage area and a small area would drain to the South-West drainage area.
- Option 2 – The entire proposed development would connect to the South-West drainage area which has more capacity.

2.2.1 Post-Development Option 1

The post-development downstream sanitary sewer drainage plan – Option 1 (**Figure 2**) and corresponding sanitary sewer design sheet are attached in **Appendix C**. See **Table 1** below for a comparison of the sections of the existing sanitary sewer that were already over capacity prior to development in the pre- and post-development conditions. No additional sewers were over capacity as a result of the proposed development.

Table 1. Comparison of Sanitary Sewers Over Capacity – Option 1

Street	MH (From)	MH (TO)	Pre-Development (% Full)	Post-Development Option 1 (% Full)	Increase (% Full)
Willoughby Dr.	MH13A	MH12A	118%	146%	28%
Gunning Drive	MH12A	MH11A	122%	150%	28%
Gunning Drive	MH11A	MH10A	122%	150%	28%
Gunning Drive	MH10A	MH9A	126%	154%	28%
Gunning Drive	MH9A	MH8A	134%	162%	28%
Gunning Drive	MH8A	MH7A	135%	163%	28%
Gunning Drive	MH7A	MH6A	138%	166%	28%
Gunning Drive	MH6A	MH5A	139%	167%	28%
Easement	MH5A	MH4A	159%	185%	26%
Sophia Ave.	MH4A	MH3A	164%	191%	27%
Sophia Ave.	MH3A	MH50A	164%	191%	27%
Sophia Ave.	MH50A	MH49A	164%	191%	27%
Lyon's Creek	MH23A	MH22A	240%	242%	2%

In the north-central drainage area the existing sanitary sewer is over capacity (between 146 to 191% full) from the last downstream sewer on Willoughby Drive, on Gunning Drive from Willoughby Drive to the park, in the easement through the park, and Sophia Avenue between the park and Bridgewater Street. The increased density for the proposed development would result in an increase of 28% the capacity of the pipe; which is already over capacity.

The south-west drainage area has capacity except in the last length of the sanitary sewer on Lyon's Creek Road which is at 242% full. The increased density for the proposed development would result in an increase of 2% of the capacity of the pipe.

2.2.2 Post-development Option 2

The post-development downstream sanitary sewer drainage plan – Option 2 (**Figure 3**) and corresponding sanitary sewer design sheet is attached in **Appendix D**. See **Table 2** below for a comparison of the sections of the existing sanitary sewer that were already over capacity prior to development. No additional sewers were over capacity as a result of the proposed development.

Table 2. Comparison of Sanitary Sewers Over Capacity – Option 2

Street	MH (From)	MH (TO)	Pre-Development (% Full)	Post-Development Option 2 (% Full)	Increase (% Full)
Willoughby Dr.	MH13A	MH12A	118%	101%	-17%
Gunning Drive	MH12A	MH11A	122%	105%	-17%
Gunning Drive	MH11A	MH10A	122%	105%	-17%
Gunning Drive	MH10A	MH9A	126%	109%	-17%
Gunning Drive	MH9A	MH8A	134%	117%	-17%
Gunning Drive	MH8A	MH7A	135%	118%	-17%
Gunning Drive	MH7A	MH6A	138%	121%	-17%
Gunning Drive	MH6A	MH5A	139%	123%	-16%
Easement	MH5A	MH4A	159%	143%	-16%
Sophia Ave.	MH4A	MH3A	164%	147%	-17%
Sophia Ave.	MH3A	MH50A	164%	147%	-17%

Sophia Ave.	MH50A	MH49A	164%	147%	-17%
Lyon’s Creek	MH23A	MH22A	240%	270%	30%

In the north-central drainage area the existing sanitary sewer is over capacity (between 101% to 147%) from the last downstream sewer on Willoughby Drive, on Gunning Drive from Willoughby Drive to the park, in the easement through the park, and Sophia Avenue between the park and Bridgewater Street. The exceedance of the pipe capacity is reduced as the majority of the proposed development had been included in the north-central drainage area in the pre-development condition based on the zoning of the undeveloped property and this area is now transferred over to the south-west drainage area which has more capacity.

The south-west drainage area has capacity for the proposed development except in the last length of the sanitary sewer on Lyon’s Creek Road which is at 270% full. Adding the proposed development to the south-west drainage area would result in an increase of 30% the capacity of the one downstream pipe; which is already over capacity. There is capacity in the rest of the sewers for the proposed development.

If should be noted that in order for the proposed development to connect to the south-west drainage boundary about 265m of sanitary sewer on Willoughby Drive would need to be reconstructed to flow south instead of north; alternatively, a municipal sewer could be routed through the site in an easement as well as upsizing approximately 220m of sewer on Weinbrenner Road on the east side of Willoughby Drive to 300mm diameter. The easement option is show on **Figure 3** for reference. The details for the sanitary sewer upgrades can be confirmed during the detailed design stage.

2.3 Considerations for Overcapacity Sanitary Sewers

Based on our review of the downstream assessments for both the north-central and south-west drainage areas there are existing sewers over capacity prior to development. In order to support the proposed development, there are a number of ways to confirm or improve capacity in the existing sewers, as noted below.

a) Based on a review of the 2016 Niagara Region Master Servicing Study for the Southside Low Lift Pumping Station, the total equivalent population in 2016 was 11,684 for the 520ha on the south side of Niagara Falls with an existing design peak wet weather flow of 233.3L/s (refer to Part F Niagara Falls Wastewater System, page 22 for reference). Based on the north-central and south-west drainage areas that have been assessed in the sanitary sewer design for the pre-development condition, the equivalent population was calculated to be 17,902 for the area of 245ha (about 50% of the contributing area to the pumping station and already 153% of the total population) with an existing average peak wet weather flow of 295.8L/s (already 127% more than the calculated flow to the pumping station). The analysis appears to be extremely conservative. It is understood that the Region Master Servicing Study is in the process of being updated which will not be available until next year at the earliest.

In addition, Niagara Region provided flow monitoring data for the Low Lift Sewage Pumping Station for 2022, refer to Appendix F.

b) It should be confirmed if the City has completed any flow monitoring on the existing sanitary sewer system to confirm the peak wet weather flows. If the monitoring data is available, it can be reviewed to confirm if the assessment is reasonable or whether the calculated flows are conservative. Alternatively, we have contacted the Region to confirm if any flow monitoring has been completed on the Region sewers upstream of the Southside Low Lift Pumping Station.

The City has confirmed that they do not have any flow monitoring. The Region provided flow monitoring data for the Low Lift Sewage Pumping Station for 2022, refer to Appendix F. The data shows the average monthly dry weather flows for the Low Lift catchment area were 20.41L/s to 57.60L/s with the maximum daily average flow of 259.33L/s. See attached Figure 5 in Appendix F showing the Low Lift Catchment Drainage Boundary for reference. No reduction was considered in the analysis in this memorandum; which should be very conservative.

c) Complete flow monitoring in key locations on the south side of Niagara Falls to confirm the existing peak wet weather flow in the City sewers.

Based on the email comments from Brian Kostuk on January 30, 2023 flow monitoring is not required by the City.

d) Complete a hydraulic gradeline analysis on the existing sanitary sewers to confirm what the impact is on the existing system due to the system being over capacity. If it can be determined that the hydraulic gradeline is sufficiently below existing basements, the sewer may be acceptable in its surcharged condition.

Refer to Section 2.4 for the hydraulic gradeline analysis based on Option 2; where the development flows are directed to the south-west drainage boundary.

e) Consider upgrades to the existing sanitary sewers. For the north-central drainage area the existing 1200m of 375mm diameter surcharged sanitary sewer would need to be replaced with a minimum of 525mm diameter sanitary sewer at an average slope of 0.15% (if proceeding with the Post-development Option 1). For the south-west drainage area, the final downstream 375mm diameter sanitary sewer would need to be replaced with a 450mm diameter sanitary sewer at 0.33%; although it might be better to replace with a 600mm diameter sanitary sewer to match the size of the existing pipe immediately upstream (if proceeding with the Post-development Option 2).

Based on the email comments from Brian Kostuk on January 30, 2023 upgrades to the final downstream sewers on Lyons Creek Road will not be required by the City as part of the proposed development.

2.4 Hydraulic Grade Line Analysis

Based on our discussions with the City, the surcharging of the downstream system may be acceptable if it does not adversely impact connected properties or the environment. Given the depths of the existing surcharged sewers, it is likely that the required level of protection is provided. A hydraulic grade line (HGL) analysis has been prepared using Autodesk Storm and Sanitary Analysis (SSA). SSA is a dynamic model which is better suited for assessing surcharged sewer systems compared to a static spreadsheet analysis.

The downstream sewer system was assessed to determine if the surcharging sewers would adversely impact connected properties or the environment. City Criteria was reviewed, and no specific level of protection is specified. To be conservative and to provide an added factor of safety, the minimum depth criteria for sanitary sewers will be used for the freeboard requirement. Based on City Criteria, this is 2.80m for residential areas and 2.15m for industrial areas.

The results of the analysis are summarized below on **Table 3**. Refer to **Appendix G** for the SSA modeling information.

Table 3. Results of the Hydraulic Gradeline Analysis

MH	Downstream Invert (m)	MH Top Elevation (m)	Maximum HGL (m)	Freeboard Provided (m)
MH18A	170.02	175.31	172.25	3.06
MH23A	167.53	174.57	170.86	3.71
MH24A	167.80	175.30	171.04	4.26
MH25A	167.92	175.61	171.18	4.43
MH26A	168.17	175.37	171.35	4.02
MH27A	168.29	175.16	171.45	3.71
MH28A	168.49	175.72	171.54	4.18
MH29A	168.59	175.27	171.63	3.64
MH30A	168.79	175.21	171.71	3.50
MH31A	168.92	175.59	171.78	3.81
MH32A	169.07	175.40	171.86	3.54
MH33A	169.20	175.41	171.94	3.47
MH34A	169.32	175.36	171.97	3.39
MH35A	169.51	175.16	172.04	3.12
MH36A	169.70	175.51	172.11	3.40
MH37A	169.86	175.18	172.18	3.00

As shown above, sufficient freeboard is provided and there is no risk of basement flooding. Therefore, the required level of protection is provided and no upgrades or improvements are required. The existing downstream sewer system can accommodate the proposed development.

The hydraulic gradeline analysis was only completed for the Post-Development Option 2 scenario where the proposed development is directed to the south-west drainage area. Hydraulic gradeline analysis was not completed for the north-central drainage area which is also surcharged in the existing condition but we do not anticipate connecting to it with the proposed development.

3.0 WATERMAIN SERVICING

There is existing City watermain surrounding the proposed development. There is a 250mm diameter watermain on Cattell Drive, a 200mm diameter and 400mm diameter watermain on Willoughby Drive, and a 200mm diameter watermain on Weinbrenner Drive.

The existing watermain can be extended to and looped, if necessary, in order to service the proposed development. The details for the watermain extension can be confirmed during the detailed design stage.

A hydrant flow test was completed by L&D Waterworks on November 14, 2022 for the hydrant located in front of 8563 Willoughby Drive which is across the road from the proposed development, refer to **Appendix E** for information. The existing watermain had a residual static pressure of 90psi and theoretical minimum fire flow of 5,625GPM (21,300L/min). Based on the information in the hydrant flow test, there are no concerns regarding adequate water supply for the proposed development; however, a fire/booster pump may be required for the internal fire protection systems for the proposed townhouse and apartment blocks. This will need to be determined by the mechanical engineer at the detailed design stage.

4.0 CONCLUSION

Based on a review of the existing sanitary and watermain infrastructure available to service the proposed development, we provide the following:

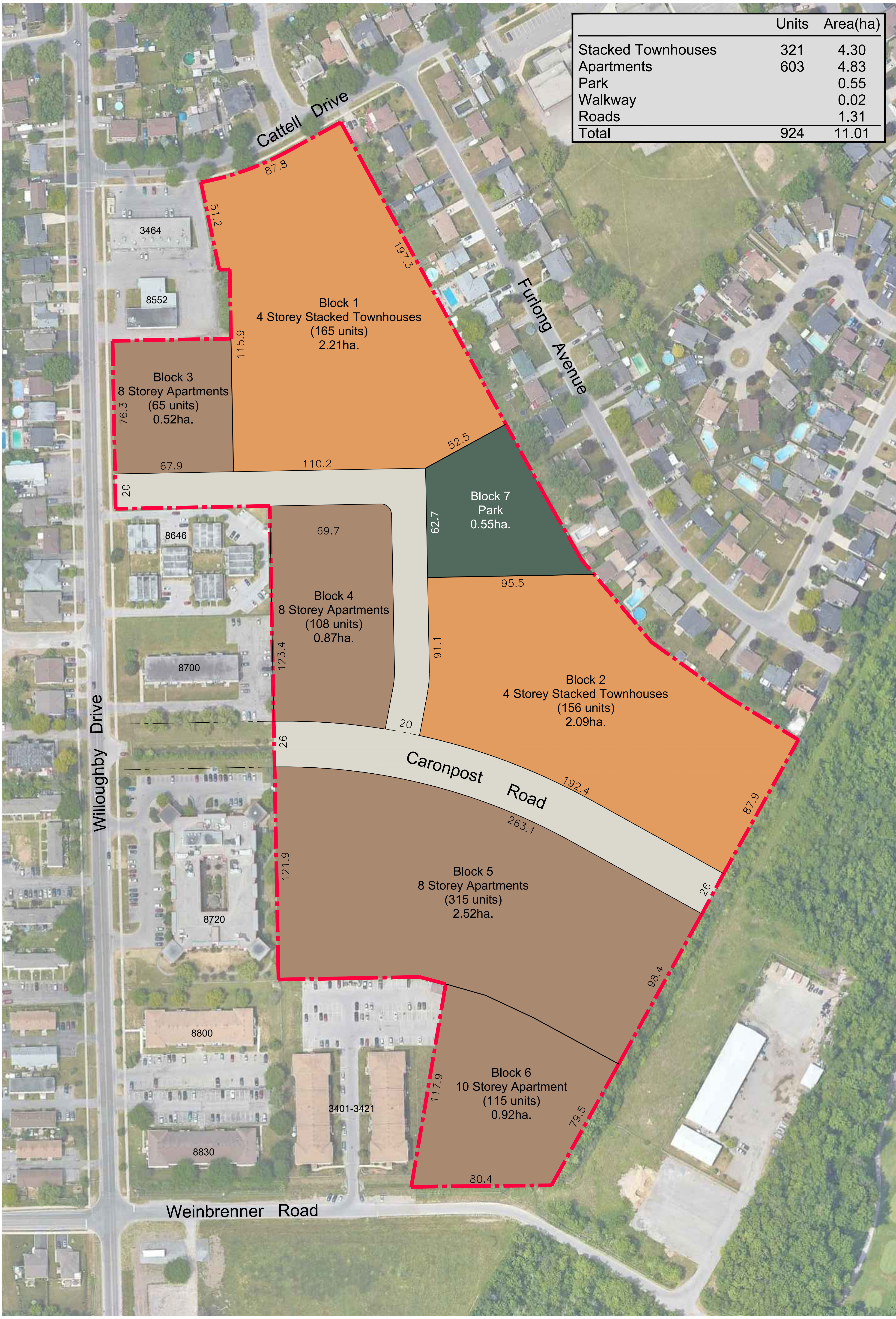
- The existing sanitary sewers downstream of the proposed development are already over capacity. There are options to consider in order for the development to proceed which will need to be confirmed with the City (eg. flow monitoring or hydraulic gradeline analysis to confirm if any upgrades are required). It is our recommendation to connect the proposed development to the south-west drainage area as there is more capacity available in the existing sewers and there is only one sewer at the downstream end that is over capacity. If upgrades to the existing sewer on Lyon's Creek Road is required, this may be partially, or completely funded through the City, as the sewer is already over capacity.

- **As required by the City, a hydraulic gradeline analysis was completed for Post-Development Option 2 for the south-west drainage area and it was determined that sufficient freeboard is provided and there is no risk of basement flooding. Based on this analysis there is capacity in the existing sanitary sewers in the south-west drainage area to service the entire proposed development.**
- Based on the hydrant flow test there appears to be sufficient pressure and fire flow in the municipal system to service the proposed development. This will need to be confirmed during the detailed design stage.

We trust this satisfies your requirements at this time. If you have any questions or require further information, please feel free to contact our office.

APPENDIX A

CONCEPT PLAN 2



	Units	Area(ha)
Stacked Townhouses	321	4.30
Apartments	603	4.83
Park		0.55
Walkway		0.02
Roads		1.31
Total	924	11.01

0 10 20 50 100
Meters

DEVELOPMENT CONCEPT 2

Willoughby Drive, Niagara Falls

NOTE: This concept should be considered as a preliminary demonstration model that illustrates an 'order of magnitude' development scenario for the site. The number of units, floor area and parking supply are approximate and subject to more detailed design as well as municipal planning approvals. Property boundary is approximate and subject to survey.

Scale 1:2,000 | December 3, 2020 | Project No.: 20282 | Drawn By: SL

GSP group

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APPENDIX B

PRE-DEVELOPMENT DOWNSTREAM SANITARY SEWER ASSESSMENT

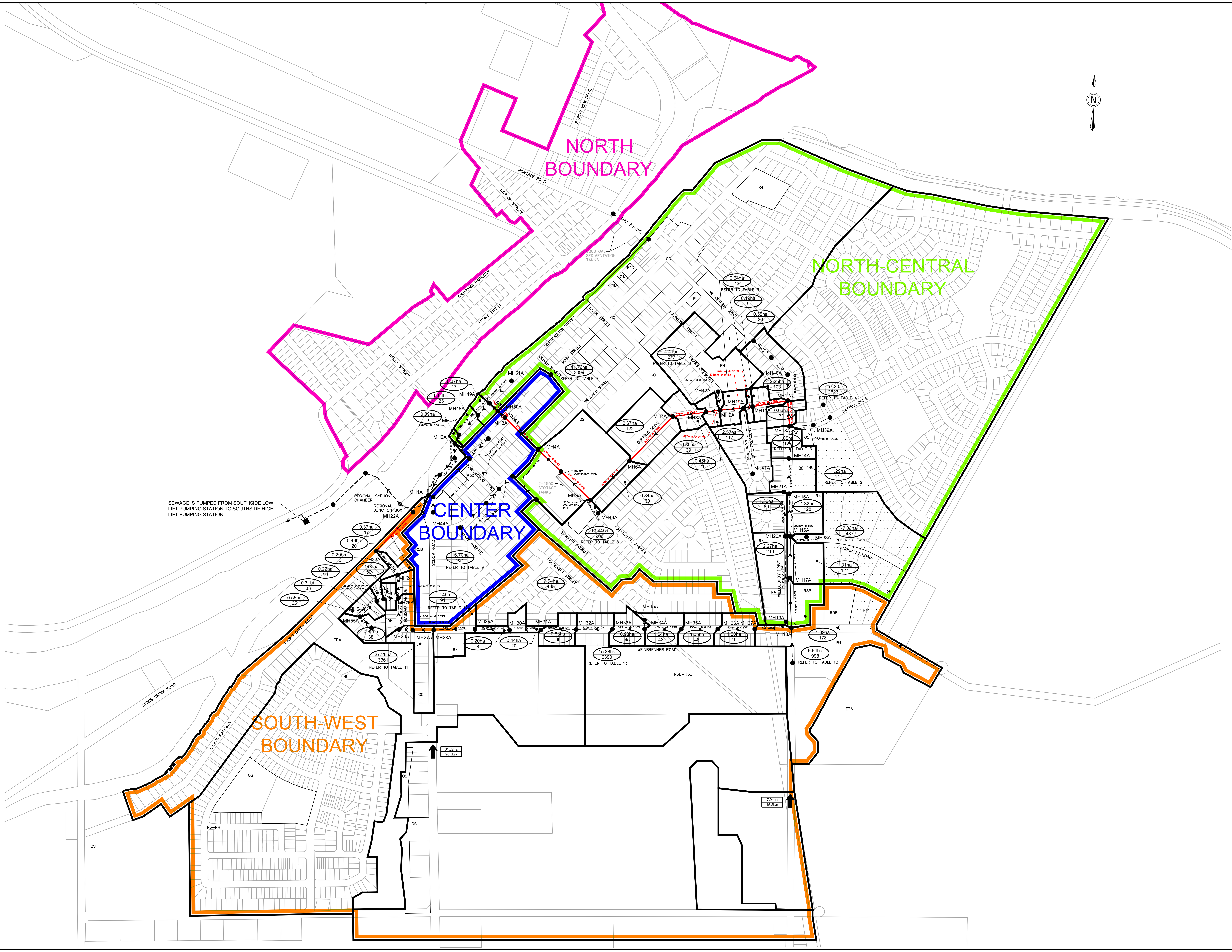

Table 1	AREA (ha)	DENSITY (P/ha)	POP (#)
R2	4.73	45.5	215.2
R4	2.30	96.4	221.7
TOTAL	7.03	62.1	436.9

Table 2	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.64	45.5	29.1
GC	0.65	180.4	117.3
TOTAL	1.29	113.5	146.4

Table 3	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.66	45.5	30.0
GC	0.39	180.4	70.4
TOTAL	1.05	95.6	100.4

Table 4	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-2	57.05	45.5	2595.8
GC	0.15	180.4	27.1
TOTAL	57.20	45.9	2622.9

Table 5	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.37	45.5	16.8
I	0.27	96.4	26.0
TOTAL	0.64	66.9	42.8

Table 6	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	2.93	45.5	133.3
R4	1.48	96.4	142.7
TOTAL	4.41	62.6	276.0

Table 7	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	31.06	45.5	1413.2
R3-R4	1.17	96.4	112.8
I	1.74	96.4	167.7
GC	7.79	180.4	1405.3
TOTAL	41.76	74.2	3099.0

Table 8	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	19.02	45.5	865.4
I	0.42	96.4	40.5
TOTAL	19.44	46.6	905.9

Table 9	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	15.06	45.5	685.2
R5D	1.29	163.1	210.4
I	0.35	96.4	33.7
TOTAL	16.70	55.7	929.3

Table 10	AREA (ha)	DENSITY (P/ha)	POP (#)
R1E	0.67	45.5	30.5
R4	7.92	96.4	763.5
R5B	1.25	163.1	203.9
TOTAL	9.84	101.4	997.9

Table 11	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	0.45	45.5	20.5
R3-R4	32.05	96.4	3089.6
GC	1.39	180.4	250.8
TOTAL	37.26	90.2	3360.9

Table 12	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	0.37	45.5	16.8
R4	0.77	96.4	74.2
TOTAL	1.14	79.8	91.0

Table 13	AREA (ha)	DENSITY (P/ha)	POP (#)
R1-R2	1.01	45.5	46.0
R5	14.37	163.1	2343.7
TOTAL	15.38	155.4	2389.7

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LEGEND

- 4.49ha / 203 — DRAINAGE AREA (ha) / POPULATION
- PROPOSED DEVELOPMENT
- 0.92ha — DRAINAGE AREA (ha); 115 | 311 — NUMBER OF UNITS / TOTAL POPULATION
- *POPULATION DENSITY ASSUMED TO BE 2.7 PEOPLE PER UNIT
- 61.22ha — DRAINAGE AREA (ha); 90.5L/s — EXTERNAL FLOW RATE (L/s)
- *ASSUMES PEAKING IS INCLUDED IN EXTERNAL FLOW RATE.
- SANITARY DRAINAGE AREA BOUNDARY
- EXISTING CITY SANITARY SEWERS
- EXISTING REGION SANITARY SEWERS
- SURCHARGED SANITARY SEWERS

LAND USE	POPULATION DENSITY (PPL/HA)
R1-R2 (RESIDENTIAL)	45.5
R3-R4 (RESIDENTIAL)	96.4
R5 (RESIDENTIAL)	163.1
I (INSTITUTIONAL)	96.4
GC (GENERAL COMMERCIAL)	180.4

*ZONING IS R1 OR R2; UNLESS OTHERWISE NOTED

FIGURE#1
Willoughby Drive
Pre-Development Sanitary Drainage Plan

DATE: FEBRUARY 6, 2023 SCALE: 1:5000 PROJECT: 221377

Minimum Dia. = 200 mm
Mannings "n"= 0.013
Minimum Velocity = 0.6 m/s
Minimum Grade = 0.5 %
Avg. Proposed Domestic Flow = 380 l/c/d
Avg. Existing Domestic Flow = 380 l/c/d

Infiltration = 0.28 l/s/ha
Peaking Factors calculated as per City Criteria
Harmon equation: PF=1 + (14/(4+(P/1000)½)) 2.0 min; 4.0 max

Chippawa Region, City of Niagara Falls
Sanitary Sewer Design Sheet
Post-Development Option 1

Project No: 221377
Date: 10-Feb-23
Designed by: CHG

			RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					
STREET	FROM	TO	AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	% FULL
Willoughby Drive	MH18A	MH17A	1.09	1.09	163.1	178	178			0.31	178	4.00	3.13		3.44	375	0.20	78.4	0.71	0.35	4%
Willoughby Drive	MH17A	MH16A	1.31	2.40	96.4	127	305			0.67	305	4.00	5.37		6.04	375	0.20	78.4	0.71	0.41	8%
Canonpost Road	MH38A	MH16A	9.68	9.68	207.6	2010	2010			2.71	2010	3.58	31.68		34.39	375	0.15	67.9	0.61	0.61	51%
Willoughby Drive	MH21A	MH20A	1.30	1.30	45.5	60	60			0.36	60	4.00	1.06		1.42	200	0.50	23.2	0.74	0.40	6%
Willoughby Drive	MH19A	MH20A	2.27	2.27	96.4	219	219			0.64	219	4.00	3.85		4.49	200	0.50	23.2	0.74	0.56	19%
Willoughby Drive	MH20A	MH16A		3.57			279			1.00	279	4.00	4.91		5.91	200	0.50	23.2	0.74	0.61	25%
Canonpost Road	MH16A	MH15A	1.32	16.97	96.4	128	2722			4.75	2722	3.48	41.64		46.39	375	0.20	78.4	0.71	0.74	59%
Willoughby Drive	MH15A	MH14A	1.29	18.26	163.2	211	2933			5.11	2933	3.45	44.51		49.63	375	0.20	78.4	0.71	0.75	63%
Willoughby Drive	MH14A	MH13A	1.05	19.31	95.6	101	3034			5.41	3034	3.44	45.88		51.29	375	0.20	78.4	0.71	0.75	65%
Cattrill Drive	MH39A	MH13A	54.56	54.56	45.9	2505	2505			15.28	2505	3.51	38.65		53.92	375	0.15	67.9	0.61	0.68	79%
Willoughby Drive	MH13A	MH12A	0.66	74.53	45.5	31	5570	0.00	0.00	20.87	5570	3.20	78.42	0.00	99.29	375	0.15	67.9	0.61	0.70	146%
Willoughby Drive	MH40A	MH12A	2.25	2.25	45.5	103	103			0.63	103	4.00	1.81		2.44	200	0.60	25.4	0.81	0.50	10%
Gunning Drive	MH12A	MH11A	0.55	77.33	45.5	26	5699	0.00	0.00	21.65	5699	3.19	80.00	0.00	101.66	375	0.15	67.9	0.61	0.70	150%
Gunning Drive	MH11A	MH10A	0.19	77.52	45.5	9	5708	0.00	0.00	21.71	5708	3.19	80.11	0.00	101.82	375	0.15	67.9	0.61	0.70	150%
Bell Crescent	MH41A	MH10A	2.57	2.57	45.5	117	117			0.72	117	4.00	2.06		2.78	200	0.50	23.2	0.74	0.49	12%
Gunning Drive	MH10A	MH9A	0.64	80.73	66.9	43	5868	0.00	0.00	22.60	5868	3.18	82.07	0.00	104.67	375	0.15	67.9	0.61	0.70	154%

STREET	FROM	TO	RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					% FULL
			AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	
Mears Crescent	MH42A	MH9A	4.41	4.41	62.6	277	277			1.23	277	4.00	4.87		6.11	250	0.50	42.0	0.86	0.60	15%
Gunning Drive	MH9A	MH8A	0.45	85.59	45.5	21	6166	0.00	0.00	23.97	6166	3.16	85.68	0.00	109.65	375	0.15	67.9	0.61	0.70	162%
Gunning Drive	MH8A	MH7A	0.85	86.44	45.5	39	6205	0.00	0.00	24.20	6205	3.16	86.15	0.00	110.35	375	0.15	67.9	0.61	0.70	163%
Gunning Drive	MH7A	MH6A	2.67	89.11	45.5	122	6327	0.00	0.00	24.95	6327	3.15	87.62	0.00	112.57	375	0.15	67.9	0.61	0.70	166%
Gunning Drive	MH6A	MH5A	0.84	89.95	45.5	39	6366	0.00	0.00	25.19	6366	3.15	88.09	0.00	113.28	375	0.15	67.9	0.61	0.70	167%
Parliament Avenue	MH43A	MH5A	19.44	19.44	46.6	906	906			5.44	906	3.83	15.25		20.69	300	0.30	52.9	0.75	0.70	39%
Easement	MH5A	MH4A		109.39	0.0	0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.16	70.1	0.63	0.72	185%
Sophie Avenue	MH4A	MH3A		109.39		0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH3A	MH50A		109.39		0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH50A	MH49A	0.00	109.39	0.0	0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH51A	MH49A	41.76	41.76	74.2	3099	3099			11.69	3099	3.43	46.76		58.45	450	0.15	110.4	0.69	0.70	53%
Sophie Avenue	MH49A	MH48A	0.37	151.52	45.5	17	10388			42.43	10388	2.94	134.24		176.67	525	0.35	254.3	1.17	1.27	69%
Sophie Avenue	MH48A	MH47A	0.54	152.06	45.5	25	10413			42.58	10413	2.94	134.52		177.09	525	0.30	235.4	1.09	1.19	75%
Sophie Avenue	MH47A	MH2A	0.09	152.15	45.5	5	10418			42.60	10418	2.94	134.57		177.17	525	0.30	235.4	1.09	1.19	75%
Weinbrenner Road	MH18A	MH37A	9.84	9.84	124.0	1221	1221	15.20	15.20	2.76	1221	3.74	20.10	15.20	38.05	450	0.13	102.7	0.65	0.60	37%
Weinbrenner Road	MH37A	MH36A	1.08	10.92	45.5	50	1271		15.20	3.06	1271	3.73	20.85	15.20	39.11	450	0.13	102.7	0.65	0.60	38%

			RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					
STREET	FROM	TO	AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	% FULL
Weinbrenner Road	MH36A	MH35A	1.05	11.97	45.5	48	1319		15.20	3.35	1319	3.72	21.58	15.20	40.13	450	0.13	102.7	0.65	0.60	39%
Weinbrenner Road	MH35A	MH34A	1.04	13.01	45.5	48	1367		15.20	3.64	1367	3.71	22.30	15.20	41.14	450	0.13	102.7	0.65	0.61	40%
Roosevelt Street	MH45A	MH34A	9.54	9.54	45.5	435	435			2.67	435	4.00	7.65		10.32	450	0.13	102.7	0.65	0.41	10%
Weinbrenner Road	MH34A	MH33A	0.98	23.53	45.5	45	1847		15.20	6.59	1847	3.61	29.34	15.20	51.13	525	0.10	135.9	0.63	0.58	38%
Weinbrenner Road	MH33A	MH32A	15.38	38.91	155.4	2391	4238		15.20	10.89	4238	3.31	61.71	15.20	87.81	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH32A	MH31A	0.83	39.74	45.5	38	4276		15.20	11.13	4276	3.31	62.20	15.20	88.52	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH31A	MH30A	0.44	40.18	45.5	21	4297		15.20	11.25	4297	3.31	62.47	15.20	88.92	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH30A	MH29A	0.20	40.38	45.5	10	4307		15.20	11.31	4307	3.30	62.59	15.20	89.10	525	0.10	135.9	0.63	0.67	66%
Weinbrenner Road	MH29A	MH28A	1.14	41.52	79.8	91	4398		15.20	11.63	4398	3.30	63.76	15.20	90.58	525	0.10	135.9	0.63	0.67	67%
Weinbrenner Road	MH28A	MH27A		41.52	45.5		4398	90.50	105.70	11.63	4398	3.30	63.76	105.70	181.08	600	0.20	274.5	0.97	1.04	66%
Weinbrenner Road	MH27A	MH26A	37.26	78.78	90.2	3361	7759		105.70	22.06	7759	3.06	104.53	105.70	232.29	600	0.21	281.2	0.99	1.11	83%
Nassau Avenue	MH26A	MH25A	0.71	79.49	45.5	33	7792		105.70	22.26	7792	3.06	104.92	105.70	232.87	600	0.21	281.2	0.99	1.11	83%
Southerland Court	MH55A	MH54A	0.82	0.82	45.5	38	38			0.23	38	4.00	0.67		0.90	250	1.00	59.4	1.21	0.42	2%
Southerland Court	MH54A	MH53A	0.55	1.37	45.5	26	64			0.38	64	4.00	1.13		1.51	250	0.40	37.6	0.77	0.36	4%
Southerland Court	MH53A	MH52A	0.22	1.59	45.5	11	75			0.45	75	4.00	1.32		1.76	250	0.40	37.6	0.77	0.38	5%
Southerland Court	MH52A	MH25A	0.29	1.88	45.5	14	89			0.53	89	4.00	1.57		2.09	250	0.40	37.6	0.77	0.41	6%
Nassau Avenue	MH25A	MH24A	0.43	81.80	45.5	20	7901		105.70	22.90	7901	3.06	106.18	105.70	234.78	600	0.21	281.2	0.99	1.11	83%
Nassau Avenue	MH24A	MH23A	0.37	82.17	45.5	17	7918		105.70	23.01	7918	3.05	106.38	105.70	235.08	600	0.21	281.2	0.99	1.11	84%
Lyon's Creek Road	MH23A	MH22A	11.00	93.17	45.5	501	8419	0.00	105.70	26.09	8419	3.03	112.14	105.70	243.93	375	0.33	100.7	0.91	1.04	242%

APPENDIX C

POST-DEVELOPMENT DOWNSTREAM SANITARY SEWER ASSESSMENT OPTION 1

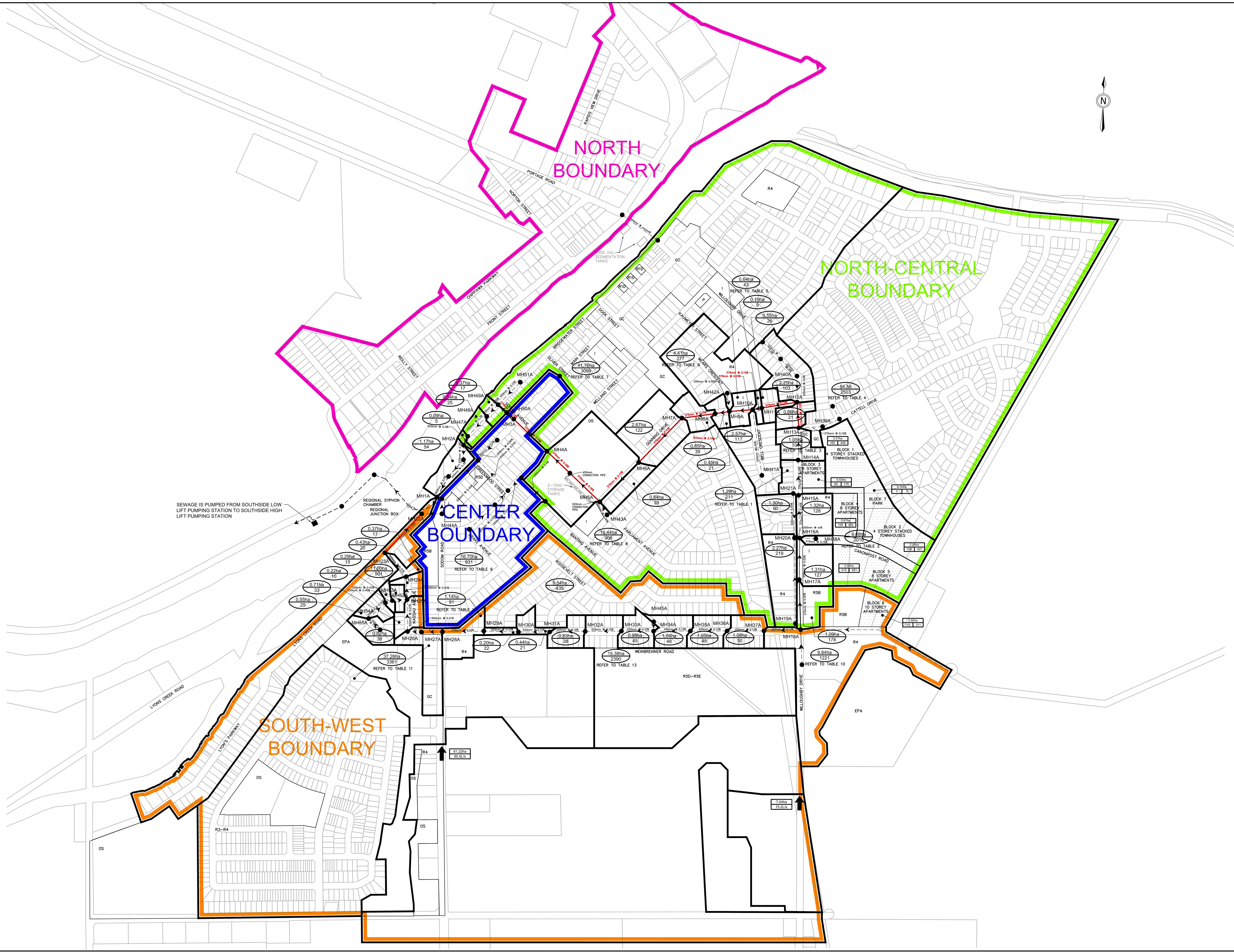

Table 1	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.77	45.5	35.0
BLOCK 3	0.52		175.5
TOTAL	1.29	163.2	210.5

Table 2	AREA (ha)	DENSITY (P/ha)	POP (#)
BLOCK 1	2.21		446.0
BLOCK 2	2.09		421.0
BLOCK 4	0.87		292.0
BLOCK 5	2.52		851.0
PARKS/ROADS	1.99		
TOTAL	9.68	207.6	2010.0

Table 3	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.66	45.5	30.0
GC	0.39	180.4	70.4
TOTAL	1.05	95.6	100.4

Table 4	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–2	54.41	45.5	2475.7
GC	0.15	180.4	27.1
TOTAL	54.56	45.9	2502.8

Table 5	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.37	45.5	16.8
I	0.27	96.4	26.0
TOTAL	0.64	66.9	42.8

Table 6	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	2.93	45.5	133.3
R4	1.48	96.4	142.7
TOTAL	4.41	62.6	276.0

Table 7	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	31.06	45.5	1413.2
R3–R4	1.17	96.4	112.8
I	1.74	96.4	167.7
GC	7.79	180.4	1405.3
TOTAL	41.76	74.2	3099.0

Table 8	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	19.02	45.5	865.4
I	0.42	96.4	40.5
TOTAL	19.44	46.6	905.9

Table 9	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	15.06	45.5	685.2
R5D	1.29	163.1	210.4
I	0.35	96.4	33.7
TOTAL	16.70	55.7	929.3

Table 10	AREA (ha)	DENSITY (P/ha)	POP (#)
R1E	0.67	45.5	30.5
R4	7.92	96.4	674.8
R5D	1.25	163.1	203.9
BLOCK 6	0.92	337.5	311.0
TOTAL	9.84	124.0	1220.2

Table 11	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.45	45.5	20.5
R3–R4	32.05	96.4	3089.6
GC	1.39	180.4	250.8
TOTAL	37.26	90.2	3360.9

Table 12	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.37	45.5	16.8
R4	0.77	96.4	74.2
TOTAL	1.14	79.8	91.0

Table 13	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	1.01	45.5	46.0
R5	14.37	163.1	2343.7
TOTAL	15.38	155.4	2389.7

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LEGEND

- 4.49ha / 203 — DRAINAGE AREA (ha) / POPULATION
- PROPOSED DEVELOPMENT
- 0.92ha / 115 / 311 — DRAINAGE AREA (ha) / TOTAL POPULATION / NUMBER OF UNITS
- *POPULATION DENSITY ASSUMED TO BE 2.7 PEOPLE PER UNIT
- 61.22ha / 90.5L/s — DRAINAGE AREA (ha) / EXTERNAL FLOW RATE (L/s)
- *ASSUMES PEAKING IS INCLUDED IN EXTERNAL FLOW RATE.
- SANITARY DRAINAGE AREA BOUNDARY
- EXISTING CITY SANITARY SEWERS
- EXISTING REGION SANITARY SEWERS
- SURCHARGED SANITARY SEWERS

LAND USE	POPULATION DENSITY (PPL/HA)
R1–R2 (RESIDENTIAL)	45.5
R3–R4 (RESIDENTIAL)	96.4
R5 (RESIDENTIAL)	163.1
I (INSTITUTIONAL)	96.4
GC (GENERAL COMMERCIAL)	180.4

*ZONING IS R1 OR R2; UNLESS OTHERWISE NOTED

FIGURE#2
Willoughby Drive
Post-Development Option 1

DATE: FEBRUARY 10, 2023 SCALE: 1:5000 PROJECT: 221377

Minimum Dia. = 200 mm
Mannings "n"= 0.013
Minimum Velocity = 0.6 m/s
Minimum Grade = 0.5 %
Avg. Proposed Domestic Flow = 380 l/c/d
Avg. Existing Domestic Flow = 380 l/c/d

Infiltration = 0.28 l/s/ha
Peaking Factors calculated as per City Criteria
Harmon equation: PF=1 + (14/(4+(P/1000)½)) 2.0 min; 4.0 max

Chippawa Region, City of Niagara Falls
Sanitary Sewer Design Sheet
Post-Development Option 1

Project No: 221377
Date: 10-Feb-23
Designed by: CHG

STREET	FROM	TO	RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					% FULL
			AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	
Willoughby Drive	MH18A	MH17A	1.09	1.09	163.1	178	178			0.31	178	4.00	3.13		3.44	375	0.20	78.4	0.71	0.35	4%
Willoughby Drive	MH17A	MH16A	1.31	2.40	96.4	127	305			0.67	305	4.00	5.37		6.04	375	0.20	78.4	0.71	0.41	8%
Canonpost Road	MH38A	MH16A	9.68	9.68	207.6	2010	2010			2.71	2010	3.58	31.68		34.39	375	0.15	67.9	0.61	0.61	51%
Willoughby Drive	MH21A	MH20A	1.30	1.30	45.5	60	60			0.36	60	4.00	1.06		1.42	200	0.50	23.2	0.74	0.40	6%
Willoughby Drive	MH19A	MH20A	2.27	2.27	96.4	219	219			0.64	219	4.00	3.85		4.49	200	0.50	23.2	0.74	0.56	19%
Willoughby Drive	MH20A	MH16A		3.57			279			1.00	279	4.00	4.91		5.91	200	0.50	23.2	0.74	0.61	25%
Canonpost Road	MH16A	MH15A	1.32	16.97	96.4	128	2722			4.75	2722	3.48	41.64		46.39	375	0.20	78.4	0.71	0.74	59%
Willoughby Drive	MH15A	MH14A	1.29	18.26	163.2	211	2933			5.11	2933	3.45	44.51		49.63	375	0.20	78.4	0.71	0.75	63%
Willoughby Drive	MH14A	MH13A	1.05	19.31	95.6	101	3034			5.41	3034	3.44	45.88		51.29	375	0.20	78.4	0.71	0.75	65%
Cattrill Drive	MH39A	MH13A	54.56	54.56	45.9	2505	2505			15.28	2505	3.51	38.65		53.92	375	0.15	67.9	0.61	0.68	79%
Willoughby Drive	MH13A	MH12A	0.66	74.53	45.5	31	5570	0.00	0.00	20.87	5570	3.20	78.42	0.00	99.29	375	0.15	67.9	0.61	0.70	146%
Willoughby Drive	MH40A	MH12A	2.25	2.25	45.5	103	103			0.63	103	4.00	1.81		2.44	200	0.60	25.4	0.81	0.50	10%
Gunning Drive	MH12A	MH11A	0.55	77.33	45.5	26	5699	0.00	0.00	21.65	5699	3.19	80.00	0.00	101.66	375	0.15	67.9	0.61	0.70	150%
Gunning Drive	MH11A	MH10A	0.19	77.52	45.5	9	5708	0.00	0.00	21.71	5708	3.19	80.11	0.00	101.82	375	0.15	67.9	0.61	0.70	150%
Bell Crescent	MH41A	MH10A	2.57	2.57	45.5	117	117			0.72	117	4.00	2.06		2.78	200	0.50	23.2	0.74	0.49	12%
Gunning Drive	MH10A	MH9A	0.64	80.73	66.9	43	5868	0.00	0.00	22.60	5868	3.18	82.07	0.00	104.67	375	0.15	67.9	0.61	0.70	154%

STREET	FROM	TO	RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					% FULL
			AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	
Mears Crescent	MH42A	MH9A	4.41	4.41	62.6	277	277			1.23	277	4.00	4.87		6.11	250	0.50	42.0	0.86	0.60	15%
Gunning Drive	MH9A	MH8A	0.45	85.59	45.5	21	6166	0.00	0.00	23.97	6166	3.16	85.68	0.00	109.65	375	0.15	67.9	0.61	0.70	162%
Gunning Drive	MH8A	MH7A	0.85	86.44	45.5	39	6205	0.00	0.00	24.20	6205	3.16	86.15	0.00	110.35	375	0.15	67.9	0.61	0.70	163%
Gunning Drive	MH7A	MH6A	2.67	89.11	45.5	122	6327	0.00	0.00	24.95	6327	3.15	87.62	0.00	112.57	375	0.15	67.9	0.61	0.70	166%
Gunning Drive	MH6A	MH5A	0.84	89.95	45.5	39	6366	0.00	0.00	25.19	6366	3.15	88.09	0.00	113.28	375	0.15	67.9	0.61	0.70	167%
Parliament Avenue	MH43A	MH5A	19.44	19.44	46.6	906	906			5.44	906	3.83	15.25		20.69	300	0.30	52.9	0.75	0.70	39%
Easement	MH5A	MH4A		109.39	0.0	0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.16	70.1	0.63	0.72	185%
Sophie Avenue	MH4A	MH3A		109.39		0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH3A	MH50A		109.39		0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH50A	MH49A	0.00	109.39	0.0	0	7272	0.00	0.00	30.63	7272	3.09	98.85	0.00	129.48	375	0.15	67.9	0.61	0.70	191%
Sophie Avenue	MH51A	MH49A	41.76	41.76	74.2	3099	3099			11.69	3099	3.43	46.76		58.45	450	0.15	110.4	0.69	0.70	53%
Sophie Avenue	MH49A	MH48A	0.37	151.52	45.5	17	10388			42.43	10388	2.94	134.24		176.67	525	0.35	254.3	1.17	1.27	69%
Sophie Avenue	MH48A	MH47A	0.54	152.06	45.5	25	10413			42.58	10413	2.94	134.52		177.09	525	0.30	235.4	1.09	1.19	75%
Sophie Avenue	MH47A	MH2A	0.09	152.15	45.5	5	10418			42.60	10418	2.94	134.57		177.17	525	0.30	235.4	1.09	1.19	75%
Weinbrenner Road	MH18A	MH37A	9.84	9.84	124.0	1221	1221	15.20	15.20	2.76	1221	3.74	20.10	15.20	38.05	450	0.13	102.7	0.65	0.60	37%
Weinbrenner Road	MH37A	MH36A	1.08	10.92	45.5	50	1271		15.20	3.06	1271	3.73	20.85	15.20	39.11	450	0.13	102.7	0.65	0.60	38%

			RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					
STREET	FROM	TO	AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	% FULL
Weinbrenner Road	MH36A	MH35A	1.05	11.97	45.5	48	1319		15.20	3.35	1319	3.72	21.58	15.20	40.13	450	0.13	102.7	0.65	0.60	39%
Weinbrenner Road	MH35A	MH34A	1.04	13.01	45.5	48	1367		15.20	3.64	1367	3.71	22.30	15.20	41.14	450	0.13	102.7	0.65	0.61	40%
Roosevelt Street	MH45A	MH34A	9.54	9.54	45.5	435	435			2.67	435	4.00	7.65		10.32	450	0.13	102.7	0.65	0.41	10%
Weinbrenner Road	MH34A	MH33A	0.98	23.53	45.5	45	1847		15.20	6.59	1847	3.61	29.34	15.20	51.13	525	0.10	135.9	0.63	0.58	38%
Weinbrenner Road	MH33A	MH32A	15.38	38.91	155.4	2391	4238		15.20	10.89	4238	3.31	61.71	15.20	87.81	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH32A	MH31A	0.83	39.74	45.5	38	4276		15.20	11.13	4276	3.31	62.20	15.20	88.52	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH31A	MH30A	0.44	40.18	45.5	21	4297		15.20	11.25	4297	3.31	62.47	15.20	88.92	525	0.10	135.9	0.63	0.67	65%
Weinbrenner Road	MH30A	MH29A	0.20	40.38	45.5	10	4307		15.20	11.31	4307	3.30	62.59	15.20	89.10	525	0.10	135.9	0.63	0.67	66%
Weinbrenner Road	MH29A	MH28A	1.14	41.52	79.8	91	4398		15.20	11.63	4398	3.30	63.76	15.20	90.58	525	0.10	135.9	0.63	0.67	67%
Weinbrenner Road	MH28A	MH27A		41.52	45.5		4398	90.50	105.70	11.63	4398	3.30	63.76	105.70	181.08	600	0.20	274.5	0.97	1.04	66%
Weinbrenner Road	MH27A	MH26A	37.26	78.78	90.2	3361	7759		105.70	22.06	7759	3.06	104.53	105.70	232.29	600	0.21	281.2	0.99	1.11	83%
Nassau Avenue	MH26A	MH25A	0.71	79.49	45.5	33	7792		105.70	22.26	7792	3.06	104.92	105.70	232.87	600	0.21	281.2	0.99	1.11	83%
Southerland Court	MH55A	MH54A	0.82	0.82	45.5	38	38			0.23	38	4.00	0.67		0.90	250	1.00	59.4	1.21	0.42	2%
Southerland Court	MH54A	MH53A	0.55	1.37	45.5	26	64			0.38	64	4.00	1.13		1.51	250	0.40	37.6	0.77	0.36	4%
Southerland Court	MH53A	MH52A	0.22	1.59	45.5	11	75			0.45	75	4.00	1.32		1.76	250	0.40	37.6	0.77	0.38	5%
Southerland Court	MH52A	MH25A	0.29	1.88	45.5	14	89			0.53	89	4.00	1.57		2.09	250	0.40	37.6	0.77	0.41	6%
Nassau Avenue	MH25A	MH24A	0.43	81.80	45.5	20	7901		105.70	22.90	7901	3.06	106.18	105.70	234.78	600	0.21	281.2	0.99	1.11	83%
Nassau Avenue	MH24A	MH23A	0.37	82.17	45.5	17	7918		105.70	23.01	7918	3.05	106.38	105.70	235.08	600	0.21	281.2	0.99	1.11	84%
Lyon's Creek Road	MH23A	MH22A	11.00	93.17	45.5	501	8419	0.00	105.70	26.09	8419	3.03	112.14	105.70	243.93	375	0.33	100.7	0.91	1.04	242%

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APPENDIX D

POST-DEVELOPMENT DOWNSTREAM SANITARY SEWER ASSESSMENT OPTION 2

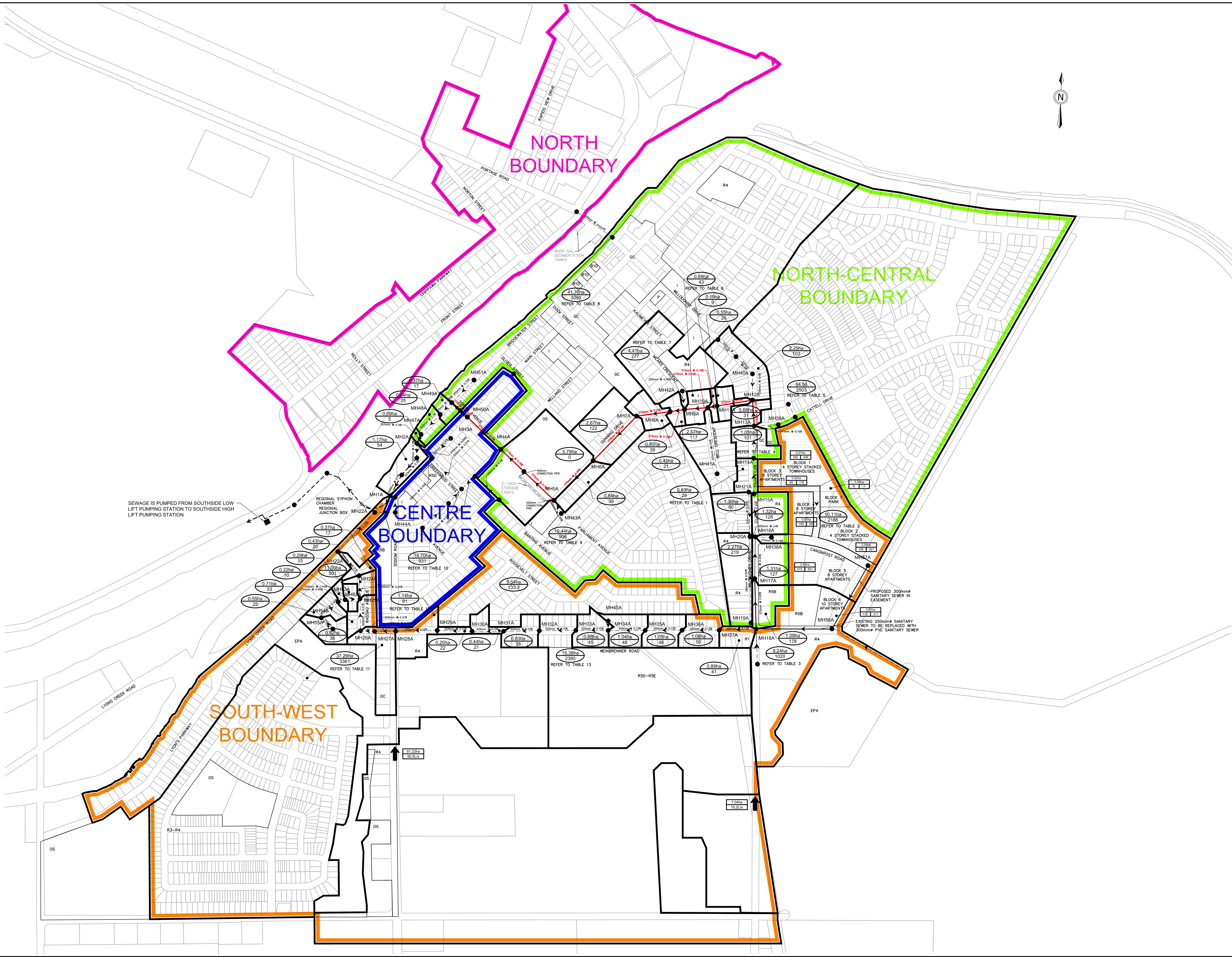

Table 1	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.77	45.5	35.0
TOTAL	1.29	163.2	210.5

Table 2	AREA (ha)	DENSITY (P/ha)	POP (#)
BLOCK 1	2.21		446.0
BLOCK 2	2.09		421.0
BLOCK 3	0.52		176.0
BLOCK 4	0.87		292.0
BLOCK 5	2.52		851.0
PARKS/ROADS	1.90		
TOTAL	10.11	216.2	2186.0

Table 3	AREA (ha)	DENSITY (P/ha)	POP (#)
R4	7.01	96.4	675.8
R5B	1.25	163.1	203.9
BLOCK 6	0.92		311.0
TOTAL	9.18	129.7	1190.2

Table 4	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.66	45.5	30.0
GC	0.39	180.4	70.4
TOTAL	1.05	95.6	100.4

Table 5	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–2	54.41	45.5	2475.7
GC	0.15	180.4	27.1
TOTAL	54.56	45.9	2502.8

Table 6	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	0.37	45.5	16.8
I	0.27	96.4	26.0
TOTAL	0.64	66.9	42.8

Table 7	AREA (ha)	DENSITY (P/ha)	POP (#)
R1C	2.93	45.5	133.3
R4	1.48	96.4	142.7
TOTAL	4.41	62.6	276.0

Table 8	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	31.06	45.5	1413.2
R3–R4	1.17	96.4	112.8
I	1.74	96.4	167.7
GC	7.79	180.4	1405.3
TOTAL	41.76	74.2	3099.0

Table 9	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	19.02	45.5	865.4
I	0.42	96.4	40.5
TOTAL	19.44	46.6	905.9

Table 10	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	15.06	45.5	685.2
R5D	1.29	163.1	210.4
I	0.35	96.4	33.7
TOTAL	16.70	55.7	929.3

Table 11	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.45	45.5	20.5
R3–R4	32.05	96.4	3089.6
GC	1.39	180.4	250.8
TOTAL	37.26	90.2	3360.9

Table 12	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	0.37	45.5	16.8
R4	0.77	96.4	74.2
TOTAL	1.14	79.8	91.0

Table 13	AREA (ha)	DENSITY (P/ha)	POP (#)
R1–R2	1.01	45.5	46.0
R5	14.37	163.1	2343.7
TOTAL	15.38	155.4	2389.7

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LEGEND

- 4.49ha — DRAINAGE AREA (ha); 203 — POPULATION
- PROPOSED DEVELOPMENT
- 0.92ha — DRAINAGE AREA (ha); 311 — TOTAL POPULATION; 115 — NUMBER OF UNITS
- *POPULATION DENSITY ASSUMED TO BE 2.7 PEOPLE PER UNIT
- 61.22ha — DRAINAGE AREA (ha); 90.5L/s — EXTERNAL FLOW RATE (L/s)
- *ASSUMES PEAKING IS INCLUDED IN EXTERNAL FLOW RATE.
- SANITARY DRAINAGE AREA BOUNDARY
- EXISTING CITY SANITARY SEWERS
- EXISTING REGION SANITARY SEWERS
- SURCHARGED SANITARY SEWERS

LAND USE	POPULATION DENSITY (PPL/HA)
R1–R2 (RESIDENTIAL)	45.5
R3–R4 (RESIDENTIAL)	96.4
R5 (RESIDENTIAL)	163.1
I (INSTITUTIONAL)	96.4
GC (GENERAL COMMERCIAL)	180.4

*ZONING IS R1 OR R2; UNLESS OTHERWISE NOTED

FIGURE#3

Willoughby Drive

Post-Development Option 2

DATE: FEBRUARY 10, 2023 SCALE: 1:5000 PROJECT: 221377

Minimum Dia. = 200 mm
Mannings "n"= 0.013
Minimum Velocity = 0.6 m/s
Minimum Grade = 0.5 %
Avg. Proposed Domestic Flow = 380 l/c/d
Avg. Existing Domestic Flow = 380 l/c/d

Infiltration = 0.28 l/s/ha
Peaking Factors calculated as per City Criteria
Harmon equation: PF=1 + (14/(4+(P/1000)½)) 2.0 min; 4.0 max

City of Niagara Falls
Sanitary Sewer Design Sheet
Post-Development Option 2

Project No: 221377
Date: 10-Feb-23
Designed by: CHG

			RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					
STREET	FROM	TO	AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	% FULL
Willoughby Drive	MH18A-N	MH17A	1.09	1.09	163.1	178	178			0.31	178	4.00	3.13		3.44	375	0.20	78.4	0.71	0.35	4%
Willoughby Drive	MH17A	MH16A	1.31	2.40	96.4	127	305			0.67	305	4.00	5.37		6.04	375	0.20	78.4	0.71	0.41	8%
Canonpost Road	MH38A	MH16A										1.00				375	0.15	67.9	0.61		
Willoughby Drive	MH21A	MH20A	1.30	1.30	45.5	60	60			0.36	60	4.00	1.06		1.42	200	0.50	23.2	0.74	0.40	6%
Willoughby Drive	MH19A	MH20A	2.27	2.27	96.4	219	219			0.64	219	4.00	3.85		4.49	200	0.50	23.2	0.74	0.56	19%
Willoughby Drive	MH20A	MH16A		3.57			279			1.00	279	4.00	4.91		5.91	200	0.50	23.2	0.74	0.61	25%
Canonpost Road	MH16A	MH15A	1.32	7.29	96.4	128	712			2.04	712	3.89	12.18		14.22	375	0.20	78.4	0.71	0.53	18%
Willoughby Drive	MH15A	MH14A	0.63	7.92	45.5	29	741			2.22	741	3.88	12.65		14.86	375	0.20	78.4	0.71	0.54	19%
Willoughby Drive	MH14A	MH13A	1.05	8.97	95.6	101	842			2.51	842	3.85	14.25		16.76	375	0.20	78.4	0.71	0.56	21%
Catrill Drive	MH39A	MH13A	54.56	54.56	45.9	2505	2505			15.28	2505	3.51	38.65		53.92	375	0.15	67.9	0.61	0.68	79%
Willoughby Drive	MH13A	MH12A	0.66	64.19	45.5	31	3378	0.00	0.00	17.97	3378	3.40	50.49	0.00	68.46	375	0.15	67.9	0.61	0.70	101%
Willoughby Drive	MH40A	MH12A	2.25	2.25	45.5	103	103			0.63	103	4.00	1.81		2.44	200	0.60	25.4	0.81	0.50	10%
Gunning Drive	MH12A	MH11A	0.55	66.99	45.5	26	3507	0.00	0.00	18.76	3507	3.38	52.19	0.00	70.95	375	0.15	67.9	0.61	0.70	105%
Gunning Drive	MH11A	MH10A	0.19	67.18	45.5	9	3516	0.00	0.00	18.81	3516	3.38	52.31	0.00	71.12	375	0.15	67.9	0.61	0.70	105%
Bell Crescent	MH41A	MH10A	2.57	2.57	45.5	117	117			0.72	117	4.00	2.06		2.78	200	0.50	23.2	0.74	0.49	12%
Gunning Drive	MH10A	MH9A	0.64	70.39	66.9	43	3676	0.00	0.00	19.71	3676	3.37	54.42	0.00	74.13	375	0.15	67.9	0.61	0.70	109%

STREET	FROM	TO	RESIDENTIAL AREA (ha)	RESIDENTIAL ACC. AREA (ha)	RESIDENTIAL DENSITY (P/ha)	RESIDENTIAL POP	RESIDENTIAL ACC. POP.	EXTERNAL EXT. FLOW (l/s)	EXTERNAL ACC. EXT. FLOW (l/s)	FLOW CALCULATIONS INFILTRATION ALLOWANCE (l/s)	FLOW CALCULATIONS TOTAL ACC. POP.	FLOW CALCULATIONS PEAKING FACTOR	FLOW CALCULATIONS RES. FLOW (l/s)	FLOW CALCULATIONS EXT. FLOW (l/s)	FLOW CALCULATIONS TOTAL FLOW (l/s)	PIPE DATA DIA. (mm)	PIPE DATA SLOPE (%)	PIPE DATA Q FULL (L/s)	PIPE DATA V FULL (m/s)	PIPE DATA V ACT (m/s)	% FULL
Mears Crescent	MH42A	MH9A	4.41	4.41	62.6	277	277			1.23	277	4.00	4.87		6.11	250	0.50	42.0	0.86	0.60	15%
Gunning Drive	MH9A	MH8A	0.45	75.25	45.5	21	3974	0.00	0.00	21.07	3974	3.34	58.31	0.00	79.38	375	0.15	67.9	0.61	0.70	117%
Gunning Drive	MH8A	MH7A	0.85	76.10	45.5	39	4013	0.00	0.00	21.31	4013	3.33	58.81	0.00	80.12	375	0.15	67.9	0.61	0.70	118%
Gunning Drive	MH7A	MH6A	2.67	78.77	45.5	122	4135	0.00	0.00	22.06	4135	3.32	60.39	0.00	82.44	375	0.15	67.9	0.61	0.70	121%
Gunning Drive	MH6A	MH5A	0.84	79.61	45.5	39	4174	0.00	0.00	22.29	4174	3.32	60.89	0.00	83.18	375	0.15	67.9	0.61	0.70	123%
Parliament Avenue	MH43A	MH5A	19.44	19.44	46.6	906	906			5.44	906	3.83	15.25		20.69	300	0.30	52.9	0.75	0.70	39%
Easement	MH5A	MH4A		99.05	0.0	0	5080	0.00	0.00	27.73	5080	3.24	72.36	0.00	100.09	375	0.16	70.1	0.63	0.72	143%
Sophie Avenue	MH4A	MH3A		99.05		0	5080	0.00	0.00	27.73	5080	3.24	72.36	0.00	100.09	375	0.15	67.9	0.61	0.70	147%
Sophie Avenue	MH3A	MH50A		99.05		0	5080	0.00	0.00	27.73	5080	3.24	72.36	0.00	100.09	375	0.15	67.9	0.61	0.70	147%
Sophie Avenue	MH50A	MH49A	0.00	99.05	0.0	0	5080	0.00	0.00	27.73	5080	3.24	72.36	0.00	100.09	375	0.15	67.9	0.61	0.70	147%
Sophie Avenue	MH51A	MH49A	41.76	41.76	74.2	3099	3099			11.69	3099	3.43	46.76		58.45	450	0.15	110.4	0.69	0.70	53%
Sophie Avenue	MH49A	MH48A	0.37	141.18	45.5	17	8196			39.53	8196	3.04	109.58		149.11	525	0.35	254.3	1.17	1.22	59%
Sophie Avenue	MH48A	MH47A	0.54	141.72	45.5	25	8221			39.68	8221	3.04	109.87		149.55	525	0.30	235.4	1.09	1.15	64%
Sophie Avenue	MH47A	MH2A	0.09	141.81	45.5	5	8226			39.71	8226	3.04	109.93		149.63	525	0.30	235.4	1.09	1.15	64%
Easement	MH57A	MH56A	10.11	10.11	216.2	2186	2186			2.83	2186	3.56	34.18		37.01	300	0.50	68.3	0.97	0.98	54%
Weinbrenner Road	MH56A	MH18A	9.18	19.29	129.7	1191	3377			5.40	3377	3.40	50.47		55.87	300	0.50	68.3	0.97	1.08	82%
Weinbrenner Road	MH18A	MH37A	0.89	20.18	45.5	41	3418	15.20	15.20	5.65	3418	3.39	51.02	15.20	71.87	450	0.13	102.7	0.65	0.70	70%
Weinbrenner Road	MH37A	MH36A	1.08	21.26	45.5	50	3468		15.20	5.95	3468	3.39	51.68	15.20	72.83	450	0.13	102.7	0.65	0.70	71%

STREET	FROM	TO	RESIDENTIAL					EXTERNAL		FLOW CALCULATIONS						PIPE DATA					% FULL
			AREA (ha)	ACC. AREA (ha)	DENSITY (P/ha)	POP	ACC. POP.	EXT. FLOW (l/s)	ACC. EXT. FLOW (l/s)	INFILTRATION ALLOWANCE (l/s)	TOTAL ACC. POP.	PEAKING FACTOR	RES. FLOW (l/s)	EXT. FLOW (l/s)	TOTAL FLOW (l/s)	DIA. (mm)	SLOPE (%)	Q FULL (L/s)	V FULL (m/s)	V ACT (m/s)	
Weinbrenner Road	MH36A	MH35A	1.05	22.31	45.5	48	3516		15.20	6.25	3516	3.38	52.31	15.20	73.76	450	0.13	102.7	0.65	0.70	72%
Weinbrenner Road	MH35A	MH34A	1.04	23.35	45.5	48	3564		15.20	6.54	3564	3.38	52.95	15.20	74.68	450	0.13	102.7	0.65	0.70	73%
Roosevelt Street	MH45A	MH34A	9.54	9.54	45.5	435	435			2.67	435	4.00	7.65		10.32	450	0.13	102.7	0.65	0.41	10%
Weinbrenner Road	MH34A	MH33A	0.98	33.87	45.5	45	4044		15.20	9.48	4044	3.33	59.21	15.20	83.89	525	0.10	135.9	0.63	0.66	62%
Weinbrenner Road	MH33A	MH32A	15.38	49.25	155.4	2391	6435		15.20	13.79	6435	3.14	88.92	15.20	117.91	525	0.10	135.9	0.63	0.71	87%
Weinbrenner Road	MH32A	MH31A	0.83	50.08	45.5	38	6473		15.20	14.02	6473	3.14	89.37	15.20	118.60	525	0.10	135.9	0.63	0.71	87%
Weinbrenner Road	MH31A	MH30A	0.44	50.52	45.5	21	6494		15.20	14.15	6494	3.14	89.62	15.20	118.97	525	0.10	135.9	0.63	0.71	88%
Weinbrenner Road	MH30A	MH29A	0.20	50.72	45.5	10	6504		15.20	14.20	6504	3.14	89.74	15.20	119.15	525	0.10	135.9	0.63	0.71	88%
Weinbrenner Road	MH29A	MH28A	1.14	51.86	79.8	91	6595		15.20	14.52	6595	3.13	90.83	15.20	120.55	525	0.10	135.9	0.63	0.71	89%
Weinbrenner Road	MH28A	MH27A		51.86	45.5		6595	90.50	105.70	14.52	6595	3.13	90.83	105.70	211.05	600	0.20	274.5	0.97	1.07	77%
Weinbrenner Road	MH27A	MH26A	37.26	89.12	90.2	3361	9956		105.70	24.95	9956	2.96	129.46	105.70	260.12	600	0.21	281.2	0.99	1.13	92%
Nassau Avenue	MH26A	MH25A	0.71	89.83	45.5	33	9989		105.70	25.15	9989	2.96	129.83	105.70	260.68	600	0.21	281.2	0.99	1.13	93%
Southerland Court	MH55A	MH54A	0.82	0.82	45.5	38	38			0.23	38	4.00	0.67		0.90	250	1.00	59.4	1.21	0.42	2%
Southerland Court	MH54A	MH53A	0.55	1.37	45.5	26	64			0.38	64	4.00	1.13		1.51	250	0.40	37.6	0.77	0.36	4%
Southerland Court	MH53A	MH52A	0.22	1.59	45.5	11	75			0.45	75	4.00	1.32		1.76	250	0.40	37.6	0.77	0.38	5%
Southerland Court	MH52A	MH25A	0.29	1.88	45.5	14	89			0.53	89	4.00	1.57		2.09	250	0.40	37.6	0.77	0.41	6%
Nassau Avenue	MH25A	MH24A	0.43	92.14	45.5	20	10098		105.70	25.80	10098	2.95	131.04	105.70	262.54	600	0.21	281.2	0.99	1.13	93%
Nassau Avenue	MH24A	MH23A	0.37	92.51	45.5	17	10115		105.70	25.90	10115	2.95	131.23	105.70	262.83	600	0.21	281.2	0.99	1.13	93%
Lyon's Parkway	MH23A	MH22A	11.00	103.51	45.5	501	10616	0.00	105.70	28.98	10616	2.93	136.75	105.70	271.43	375	0.33	100.7	0.91	1.04	270%

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APPENDIX E

HYDRANT FLOW TEST

Hydrant Flow Test Report

SITE NAME:

SITE ADDRESS / MUNICIPALITY: **Willoughby Drive Niagara Falls, On**

TEST HYDRANT LOCATION : **Front of # 8563 Willoughby Drive (Hydrant ID # 02029)**

BASE HYDRANT LOCATION: **By # 8729 Willoughby Drive (Hydrant ID # 02032)**

TEST BY: Luzia Wood

TEST DATE: Nov 14,2022

TEST TIME: 9:58AM

TEST DATA

FLOW HYDRANT — Pipe Diam. (in / mm): 8inch

	PITOT 1	**PITOT 2**
SIZE OPENING (inches):	2.5	2.5
COEFFICIENT (**note 1**):	0.90	0.90
PITOT READING (psi):	65	42 / 42
FLOW (usgpm):	**1353**	**2175**

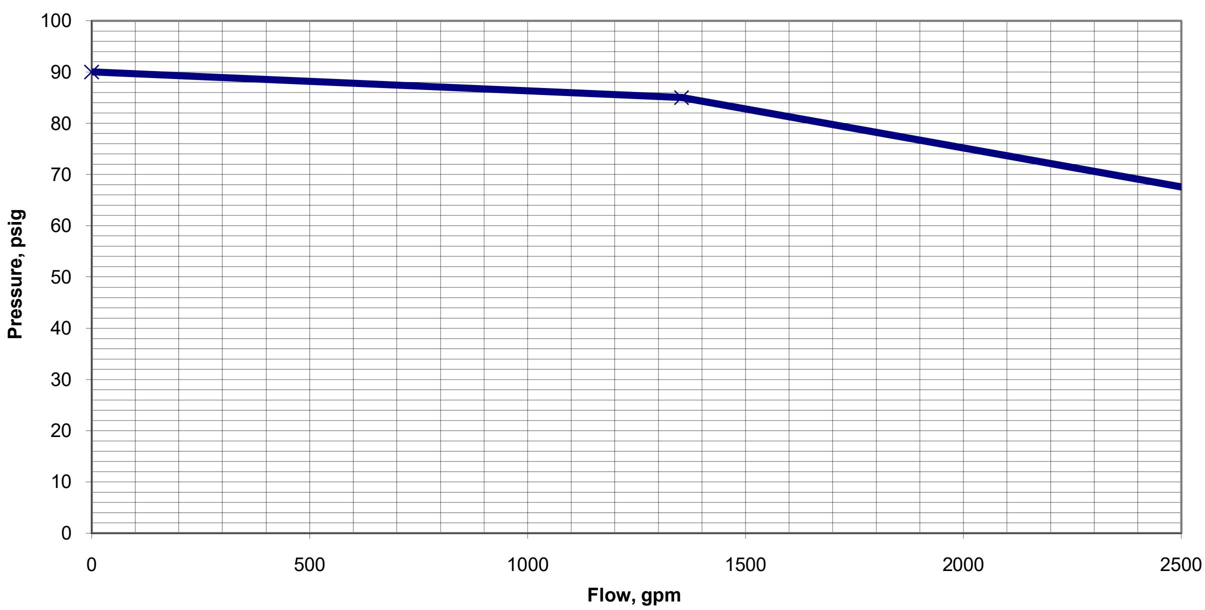
THEORETICAL FLOW @ 20 PSI 5625

BASE HYDRANT — Pipe Diam. (in / mm): 8inch

STATIC READING (psi): 90 RESIDUAL 1 (psi): 85 RESIDUAL 2 (psi): 80

REMARKS:

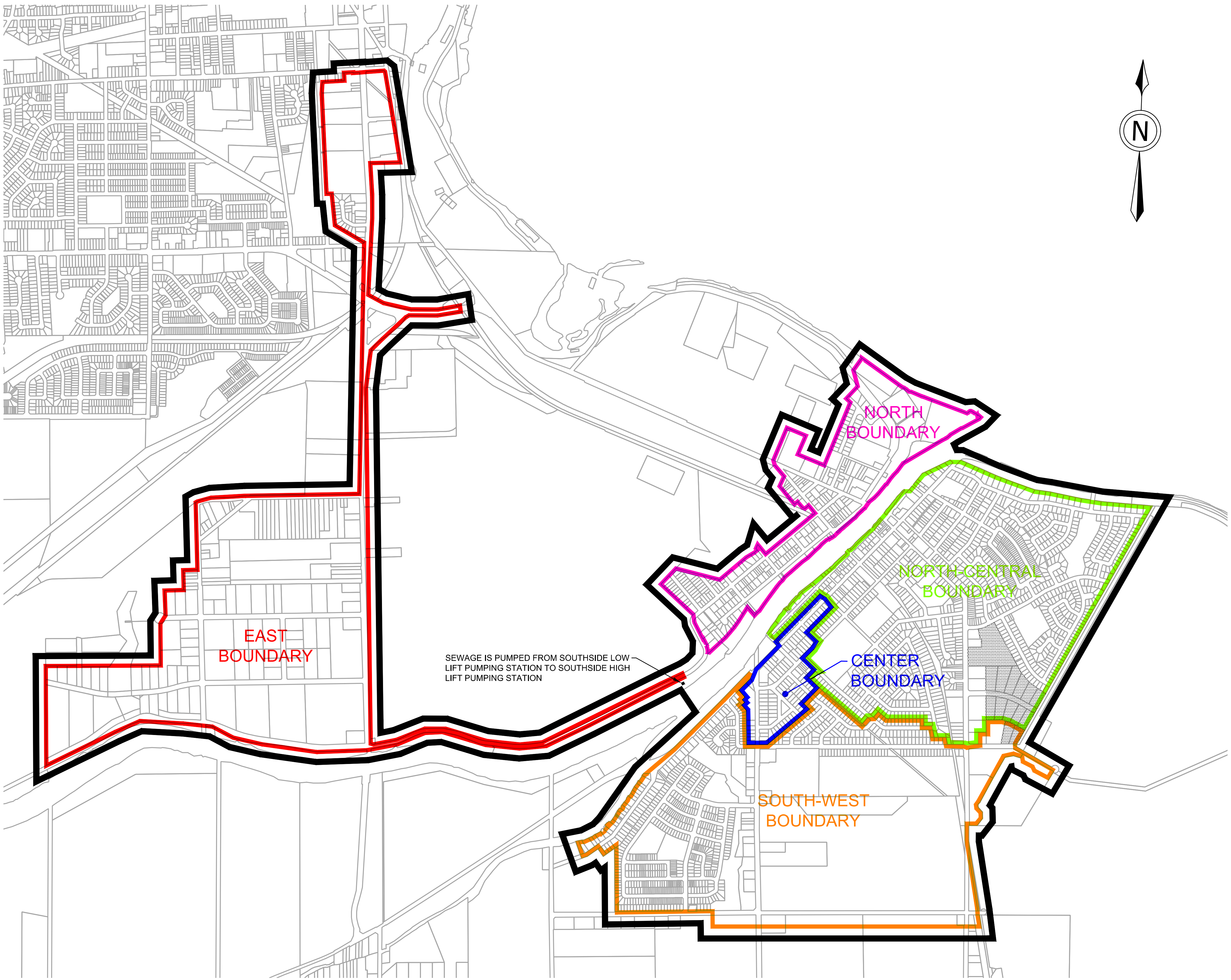
NOTE 1 : Conversion factor of .90 used for flow calculation based on rounded and flush internal nozzle configuration. No appreciable difference in pipe invert between flow and base hydrants.



L & D Waterworks Inc.
491 Port Maitland Rd
Dunnville, ON N1A 2W6
Ph: 289.684.6747

APPENDIX F

NIAGARA REGION LOW LIFT SEWAGE PUMPING STATION – 2022 FLOW MONITORING DATA



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FIGURE#4
WILLOUGHBY DRIVE
LOW LIFT PS DRAINAGE AREA

DATE: FEB. 2023 SCALE: 1:20,000 PROJECT: 221377

	Year: 2022									
	DWF Statistics			Monthly Average/Totals			Instant	Storm Factor	4	4
	Daily	Peak	Peak Factor	Max Daily Average Flow	% DWF to Max	Monthly Total	Peak		Daily Average High	Peak Flow High
Jan	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	0.00	Jan		
Feb	38.55	53.08	1.377	259.33	673%	Missing Data	528.70	Feb	yes	yes
Mar	44.65	57.60	1.290	157.26	352%	176499.87	277.30	Mar		
Apr	32.07	44.45	1.386	86.70	270%	118642.75	233.80	Apr		
May	25.41	33.00	1.299	93.89	370%	94885.62	169.80	May		
Jun	23.69	31.86	1.345	64.46	272%	Missing Data	119.80	Jun		
Jul	22.59	28.99	1.283	116.97	518%	75495.54	612.50	Jul	yes	yes
Aug	22.58	31.38	1.390	90.57	401%	87339.72	410.30	Aug	yes	
Sep	21.43	31.94	1.491	55.47	259%	Missing Data	132.00	Sep		
Oct	20.41	29.01	1.422	157.50	772%	Missing Data	267.20	Oct	yes	yes
Nov	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	0.00	Nov		
Dec	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	Missing Data	0.00	Dec		

Year to Date	**27.92993162**	**37.92407407**	**1.364721506**	**259.3296992**	**929%**	**552863.502**

Instant. Peak is the highest instantaneous flow showing a big impact of the wet weather flows to the catchment/station.

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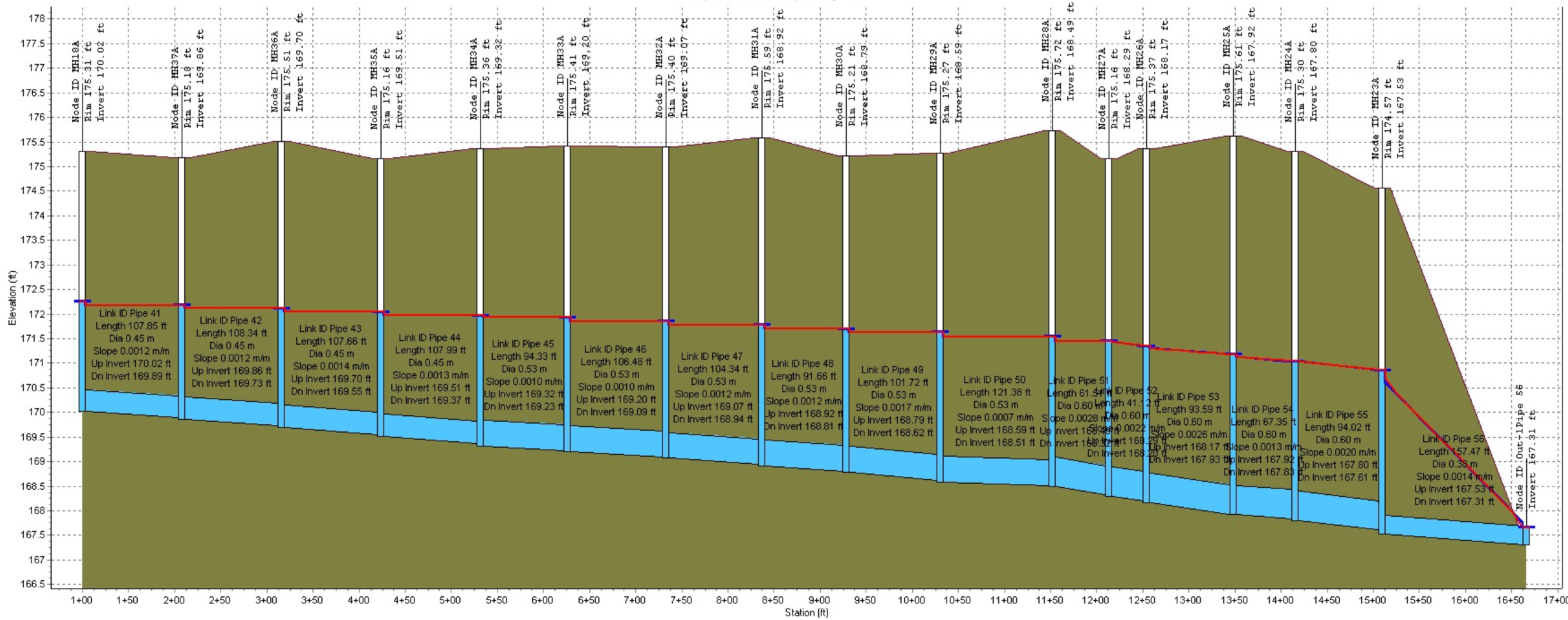
APPENDIX G

SSA MODELING
HGL ANALYSIS

Willoughby Drive Sanitary Sewer Analysis

Option 2 - Post Development Dry Weather



Node ID:	MH18A	MH37A	MH36A	MH35A	MH34A	MH33A	MH32A	MH31A	MH30A	MH29A	MH28A	MH27A	MH26A	MH25A	MH24A	MH23A	Out-1Pipe 56
Rim (ft):	175.31	175.18	175.51	175.16	175.36	175.41	175.40	175.59	175.21	175.27	175.72	175.16	175.37	175.61	175.30	174.57	
Invert (ft):	170.02	169.86	169.70	169.51	169.32	169.20	169.07	168.92	168.79	168.59	168.49	168.29	168.17	167.92	167.80	167.53	167.31
Min Pipe Cover (m):	4.84	4.84	5.33	5.16	5.52	5.65	5.78	6.13	5.88	6.13	6.63	6.24	6.57	7.08	6.87	6.36	
Max HGL (ft):	172.25	172.18	172.11	172.04	171.97	171.94	171.86	171.78	171.71	171.63	171.54	171.45	171.35	171.18	171.04	170.86	167.66

Link ID:	Pipe 41	Pipe 42	Pipe 43	Pipe 44	Pipe 45	Pipe 46	Pipe 47	Pipe 48	Pipe 49	Pipe 50	Pipe 51	Pipe 52	Pipe 53	Pipe 54	Pipe 55	Pipe 56
Length (ft):	107.85	108.34	107.66	107.99	94.33	106.48	104.34	91.66	101.72	121.38	61.51	41.12	93.59	67.35	94.02	157.47
Dia (m):	0.45	0.45	0.45	0.45	0.53	0.53	0.53	0.53	0.53	0.53	0.60	0.60	0.60	0.60	0.60	0.38
Slope (m/m):	0.0012	0.0012	0.0014	0.0013	0.0010	0.0010	0.0012	0.0012	0.0017	0.0007	0.0028	0.0022	0.0026	0.0013	0.0020	0.0014
Up Invert (ft):	170.02	169.86	169.70	169.51	169.32	169.20	169.07	168.92	168.79	168.59	168.49	168.29	168.17	167.92	167.80	167.53
Dn Invert (ft):	169.89	169.73	169.55	169.37	169.23	169.09	168.94	168.81	168.62	168.51	168.32	168.20	167.93	167.83	167.61	167.31
Max Q (cms):	0.07	0.07	0.07	0.07	0.08	0.12	0.12	0.12	0.12	0.12	0.21	0.25	0.25	0.26	0.26	0.26
Max Vel (ft/s):	0.76	0.76	0.78	0.74	0.59	0.76	0.77	0.82	0.76	0.62	0.91	1.10	1.04	1.01	0.90	2.40
Max Depth (m):	0.45	0.45	0.45	0.45	0.52	0.52	0.52	0.52	0.52	0.52	0.60	0.60	0.60	0.60	0.60	0.36

Autodesk Storm and Sanitary Analysis

Autodesk® Storm and Sanitary Analysis 2016 - Version 13.5.195 (Build 0)

****
Project Description
****

File Name .... 23-02-06 SSA-post.SPF

****
Analysis Options
****

Flow Units .... cms
Link Routing Method .... Hydrodynamic
Storage Node Exfiltration.. None
Starting Date MAY-31-2019 00:00:00
Ending Date JUN-02-2019 00:00:00
Report Time Step 00:05:00

****
Element Count
****

Number of subbasins 0
Number of nodes 17
Number of links 16

****
Node Summary
****

Node ID	Element Type	Invert Elevation m	Maximum Elev. m	Ponded Area m²	External Inflow
MH18A	JUNCTION	170.02	175.31	0.000	Yes
MH23A	JUNCTION	167.53	174.57	0.000	Yes
MH24A	JUNCTION	167.80	175.30	0.000	Yes
MH25A	JUNCTION	167.92	175.61	0.000	Yes
MH26A	JUNCTION	168.17	175.37	0.000	Yes
MH27A	JUNCTION	168.29	175.16	0.000	Yes
MH28A	JUNCTION	168.49	175.72	0.000	Yes
MH29A	JUNCTION	168.59	175.27	0.000	Yes
MH30A	JUNCTION	168.79	175.21	0.000	Yes
MH31A	JUNCTION	168.92	175.59	0.000	Yes
MH32A	JUNCTION	169.07	175.40	0.000	Yes
MH33A	JUNCTION	169.20	175.41	0.000	Yes
MH34A	JUNCTION	169.32	175.36	0.000	Yes
MH35A	JUNCTION	169.51	175.16	0.000	Yes
MH36A	JUNCTION	169.70	175.51	0.000	Yes
MH37A	JUNCTION	169.86	175.18	0.000	Yes
Out-1Pipe 56	OUTFALL	167.31	167.69	0.000	

****
Link Summary
****

Link ID	From Node	To Node	Element Type	Length m	Slope %	Manning's Roughness
Pipe 41	MH18A	MH37A	CONDUIT	107.9	0.2000	0.0120
Pipe 42	MH37A	MH36A	CONDUIT	108.3	0.2000	0.0120
Pipe 43	MH36A	MH35A	CONDUIT	107.7	0.2000	0.0120
Pipe 44	MH35A	MH34A	CONDUIT	108.0	0.2000	0.0120
Pipe 45	MH34A	MH33A	CONDUIT	94.3	0.2000	0.0120
Pipe 46	MH33A	MH32A	CONDUIT	106.5	0.2000	0.0120

Pipe 47	MH32A	MH31A	CONDUIT	104.3	0.2000	0.0120
Pipe 48	MH31A	MH30A	CONDUIT	91.7	0.2000	0.0120
Pipe 49	MH30A	MH29A	CONDUIT	101.7	0.2000	0.0120
Pipe 50	MH29A	MH28A	CONDUIT	121.4	0.2000	0.0120
Pipe 51	MH28A	MH27A	CONDUIT	61.5	0.2764	0.0120
Pipe 52	MH27A	MH26A	CONDUIT	41.1	0.2189	0.0120
Pipe 53	MH26A	MH25A	CONDUIT	93.6	0.2564	0.0120
Pipe 54	MH25A	MH24A	CONDUIT	67.4	0.2000	0.0120
Pipe 55	MH24A	MH23A	CONDUIT	94.0	0.2021	0.0120
Pipe 56	MH23A	Out-1Pipe 56	CONDUIT	157.5	0.2000	0.0120

****
Cross Section Summary
****

Link ID	Shape	Depth/ Diameter (m)	Width (m)	No. of Barrels	Cross Sectional Area (m²)	Full Flow Hydraulic Radius (m)	Design Flow Capacity (cms)
Pipe 41	CIRCULAR	0.45	0.45	1	0.16	0.11	0.14
Pipe 42	CIRCULAR	0.45	0.45	1	0.16	0.11	0.14
Pipe 43	CIRCULAR	0.45	0.45	1	0.16	0.11	0.14
Pipe 44	CIRCULAR	0.45	0.45	1	0.16	0.11	0.14
Pipe 45	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 46	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 47	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 48	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 49	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 50	CIRCULAR	0.53	0.53	1	0.22	0.13	0.21
Pipe 51	CIRCULAR	0.60	0.60	1	0.28	0.15	0.35
Pipe 52	CIRCULAR	0.60	0.60	1	0.28	0.15	0.31
Pipe 53	CIRCULAR	0.60	0.60	1	0.28	0.15	0.34
Pipe 54	CIRCULAR	0.60	0.60	1	0.28	0.15	0.30
Pipe 55	CIRCULAR	0.60	0.60	1	0.28	0.15	0.30
Pipe 56	CIRCULAR	0.38	0.38	1	0.11	0.09	0.08

************************** Flow Routing Continuity **************************	Volume hectare-m	Volume Mliters
External Inflow	0.501	5.008
External Outflow	2.838	28.376
Initial Stored Volume	0.000	0.000
Final Stored Volume	0.020	0.201

Continuity Error (%) ..... -0.003

****
Node Depth Summary
****

Node ID	Average Depth Attained m	Maximum Depth Attained m	Maximum HGL Attained m	Time of Max Occurrence days	Time of Max Occurrence hh:mm	Total Flooded Volume ha-mm	Total Time Flooded minutes	Retention Time hh:mm:ss
MH18A	0.40	2.23	172.25	1	18:59	0	0	0:00:00
MH23A	1.28	3.33	170.86	1	19:00	0	0	0:00:00
MH24A	1.09	3.24	171.04	1	19:00	0	0	0:00:00
MH25A	1.04	3.26	171.18	1	19:00	0	0	0:00:00
MH26A	0.88	3.18	171.35	1	18:59	0	0	0:00:00
MH27A	0.84	3.16	171.45	1	18:59	0	0	0:00:00
MH28A	0.71	3.05	171.54	1	18:59	0	0	0:00:00
MH29A	0.71	3.04	171.63	1	19:00	0	0	0:00:00
MH30A	0.61	2.92	171.71	1	19:00	0	0	0:00:00
MH31A	0.61	2.86	171.78	1	19:00	0	0	0:00:00
MH32A	0.58	2.79	171.86	1	19:00	0	0	0:00:00
MH33A	0.57	2.74	171.94	1	19:00	0	0	0:00:00
MH34A	0.52	2.65	171.97	1	18:59	0	0	0:00:00
MH35A	0.47	2.53	172.04	1	19:00	0	0	0:00:00
MH36A	0.44	2.41	172.11	1	18:59	0	0	0:00:00
MH37A	0.42	2.32	172.18	1	18:59	0	0	0:00:00
Out-1Pipe 56	0.28	0.35	167.66	1	19:00	0	0	0:00:00

****
Node Flow Summary
****

Node ID	Element Type	Maximum Lateral Inflow cms	Peak Inflow cms	Time of Peak Inflow Occurrence days	Time of Peak Inflow Occurrence hh:mm	Maximum Flooding Overflow cms	Time of Peak Flooding Occurrence days	Time of Peak Flooding Occurrence hh:mm
MH18A	JUNCTION	0.072	0.072	0	18:00	0.00		
MH23A	JUNCTION	0.009	0.263	1	19:00	0.00		
MH24A	JUNCTION	0.000	0.255	1	19:00	0.00		
MH25A	JUNCTION	0.002	0.255	1	18:59	0.00		
MH26A	JUNCTION	0.001	0.254	1	18:59	0.00		
MH27A	JUNCTION	0.049	0.255	1	18:59	0.00		
MH28A	JUNCTION	0.090	0.206	1	18:59	0.00		
MH29A	JUNCTION	0.001	0.120	1	20:00	0.00		
MH30A	JUNCTION	0.000	0.117	1	19:00	0.00		
MH31A	JUNCTION	0.000	0.116	1	18:59	0.00		
MH32A	JUNCTION	0.001	0.116	1	18:59	0.00		
MH33A	JUNCTION	0.034	0.116	1	18:59	0.00		
MH34A	JUNCTION	0.009	0.082	1	18:59	0.00		
MH35A	JUNCTION	0.001	0.075	0	17:21	0.00		
MH36A	JUNCTION	0.001	0.073	0	17:24	0.00		
MH37A	JUNCTION	0.001	0.073	1	18:59	0.00		
Out-1Pipe 56	OUTFALL	0.000	0.263	1	19:00	0.00		

****
Outfall Loading Summary
****

Outfall Node ID	Flow	Average	Peak

	Frequency (%)	Flow cms	Inflow cms
Out-1Pipe 56	99.99	0.152	0.263
System	99.99	0.152	0.263

****
Link Flow Summary
****

Link ID	Element Type	Time of Peak Flow Occurrence days hh:mm	Maximum Velocity Attained m/sec	Length Factor	Peak Flow during Analysis cms	Design Flow Capacity cms	Ratio of Maximum /Design Flow	Ratio of Maximum Flow Depth	Total Time Surcharged minutes	Reported Condition
Pipe 41	CONDUIT	1 18:59	0.76	1.00	0.072	0.138	0.52	1.00	738	SURCHARGED
Pipe 42	CONDUIT	0 17:24	0.76	1.00	0.072	0.138	0.52	1.00	785	SURCHARGED
Pipe 43	CONDUIT	0 17:21	0.78	1.00	0.074	0.138	0.53	1.00	866	SURCHARGED
Pipe 44	CONDUIT	1 19:00	0.74	1.00	0.073	0.138	0.53	1.00	937	SURCHARGED
Pipe 45	CONDUIT	1 19:00	0.59	1.00	0.082	0.208	0.40	1.00	970	SURCHARGED
Pipe 46	CONDUIT	1 18:59	0.76	1.00	0.115	0.208	0.55	1.00	1024	SURCHARGED
Pipe 47	CONDUIT	1 19:00	0.77	1.00	0.116	0.208	0.55	1.00	1086	SURCHARGED
Pipe 48	CONDUIT	1 19:00	0.82	1.00	0.116	0.208	0.56	1.00	1149	SURCHARGED
Pipe 49	CONDUIT	1 20:00	0.76	1.00	0.119	0.208	0.57	1.00	1190	SURCHARGED
Pipe 50	CONDUIT	1 20:00	0.62	1.00	0.123	0.208	0.59	1.00	1275	SURCHARGED
Pipe 51	CONDUIT	1 18:59	0.91	1.00	0.206	0.350	0.59	1.00	1269	SURCHARGED
Pipe 52	CONDUIT	1 18:59	1.10	1.00	0.254	0.311	0.82	1.00	1422	SURCHARGED
Pipe 53	CONDUIT	1 19:00	1.04	1.00	0.253	0.337	0.75	1.00	1582	SURCHARGED
Pipe 54	CONDUIT	1 19:00	1.01	1.00	0.255	0.298	0.86	1.00	2029	SURCHARGED
Pipe 55	CONDUIT	1 19:00	0.90	1.00	0.255	0.299	0.85	1.00	2317	SURCHARGED
Pipe 56	CONDUIT	1 19:00	2.40	1.00	0.263	0.085	3.09	0.97	0	> CAPACITY

****
Highest Flow Instability Indexes
****
Link Pipe 52 (4)
Link Pipe 54 (4)
Link Pipe 53 (4)
Link Pipe 51 (4)

Link Pipe 50 (3)

WARNING 108 : Surcharge elevation defined for Junction MH18A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH23A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH24A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH25A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH26A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH27A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH28A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH29A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH30A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH31A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH32A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH33A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH34A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH35A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH36A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 108 : Surcharge elevation defined for Junction MH37A is below junction maximum elevation. Assumed surcharge elevation equal to maximum elevation.
WARNING 005 : Minimum slope used for Conduit Pipe 41.
WARNING 005 : Minimum slope used for Conduit Pipe 42.
WARNING 005 : Minimum slope used for Conduit Pipe 43.
WARNING 005 : Minimum slope used for Conduit Pipe 44.
WARNING 005 : Minimum slope used for Conduit Pipe 45.
WARNING 005 : Minimum slope used for Conduit Pipe 46.
WARNING 005 : Minimum slope used for Conduit Pipe 47.
WARNING 005 : Minimum slope used for Conduit Pipe 48.
WARNING 005 : Minimum slope used for Conduit Pipe 49.
WARNING 005 : Minimum slope used for Conduit Pipe 50.
WARNING 005 : Minimum slope used for Conduit Pipe 54.
WARNING 005 : Minimum slope used for Conduit Pipe 56.

Analysis began on: Wed Feb 8 14:07:37 2023
Analysis ended on: Wed Feb 8 14:07:38 2023
Total elapsed time: 00:00:01

Hydrant Flow Test Report

SITE NAME:		TEST DATE:	
SITE ADDRESS / MUNICIPALITY:	**Willoughby Drive Niagara Falls, On**		Nov 14,2022
TEST HYDRANT LOCATION :	**Front of # 8563 Willoughby Drive (Hydrant ID # 02029)**		
BASE HYDRANT LOCATION:	**By # 8729 Willoughby Drive (Hydrant ID # 02032)**	TEST TIME:	9:58AM
TEST BY:	Luzia Wood		

TEST DATA

FLOW HYDRANT — Pipe Diam. (in / mm): 8inch

	PITOT 1	PITOT 2
SIZE OPENING (inches):	2.5	2.5
COEFFICIENT (**note 1**):	0.90	0.90
PITOT READING (psi):	65	42 / 42
FLOW (usgpm):	**1353**	**2175**

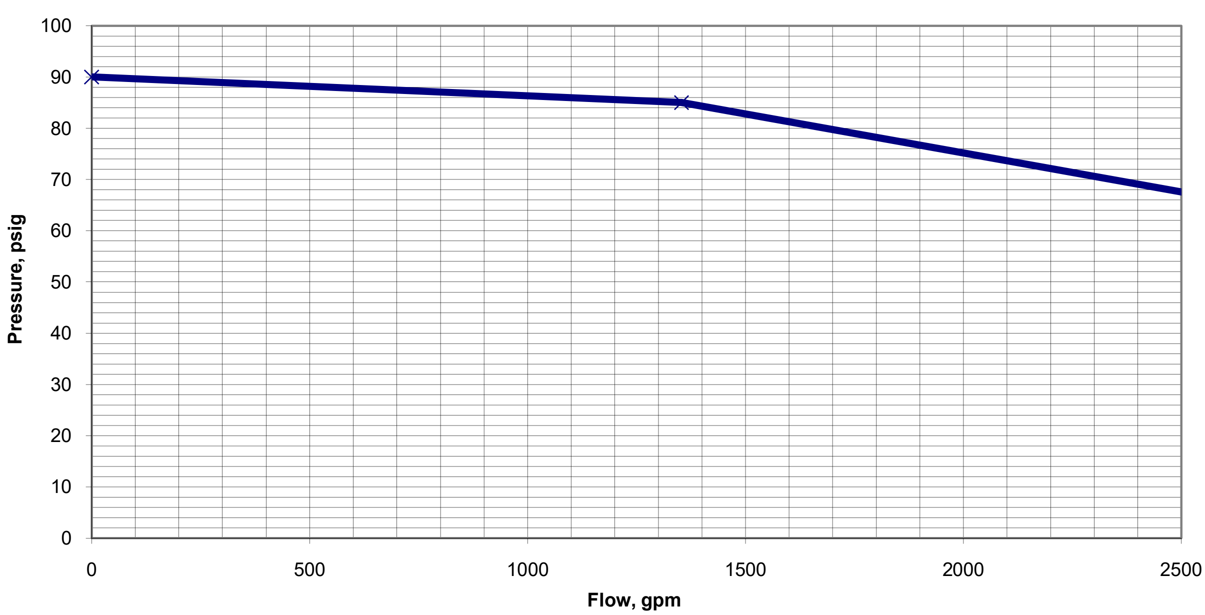
THEORETICAL FLOW @ 20 PSI 5625

BASE HYDRANT — Pipe Diam. (in / mm): 8inch

STATIC READING (psi): 90 RESIDUAL 1 (psi): 85 RESIDUAL 2 (psi): 80

REMARKS:

NOTE 1 : Conversion factor of .90 used for flow calculation based on rounded and flush internal nozzle configuration. No appreciable difference in pipe invert between flow and base hydrants.



L & D Waterworks Inc.

491 Port Maitland Rd
Dunnville, ON N1A 2W6
Ph: 289.684.6747

Fire Flow Calculation

Project:	Willoughby Drive Development
Project No.:	221377
Municipality:	City of Niagara Falls

GUIDE FOR CALCULATING CAPACITY AT 20psi FOR FIRE FLOW
(as per the NFPA 291: Recommended Practice for Fire Flow Testing and Marking of Hydrants. (2010). (Section 4.10.1.2.))

The Formula for Calculating Rated Capacity at 20psi

$$\mathbf{Q_R = Q_F \times (H_R / H_F)^{0.54}}$$

Where:

Based on hydrant flow test by Aquazition, November 14, 2022

Q_R = Rated Capacity at 20psi (in GPM)

Q_F = Total test flow (in GPM)

H_R = Static Pressure minus 20 psi

H_F = Static Pressure minus Residual Pressure

Flow Test Parameters:	1 Port	
Static Pressure	90.0	
Residual Pressure	85.0	
Test Flow Rate	1353	
Q_R =	**5626**	**GPM**
	21,297	**L/min**

HUSSON

Fire Flow Calculation at 30psi

Project:	Willoughby Drive Development
Project No.:	221377
Municipality:	City of Niagara Falls

GUIDE FOR CALCULATING CAPACITY AT 20psi FOR FIRE FLOW
(as per the NFPA 291: Recommended Practice for Fire Flow Testing and Marking of Hydrants. (2010). (Section 4.10.1.2.))

The Formula for Calculating Rated Capacity at 20psi

$$\mathbf{Q_R = Q_F \times (H_R / H_F)^{0.54}}$$

Where:

Based on hydrant flow test by Aquazition, November 14, 2022

Q_R = Rated Capacity at 20psi (in GPM)

Q_F = Total test flow (in GPM)

H_R = Static Pressure minus 20 psi

H_F = Static Pressure minus Residual Pressure

Flow Test Parameters:	1 Port
Static Pressure	90.0
Residual Pressure	85.0
Test Flow Rate	1353

Q_R = **5177 GPM**
19,596 L/min