SARNIA
ONTARIO

Stormwater Management Design Guidelines 2024

City of Sarnia

September 2024

Table of Contents

This document was prepared by MIG Engineering (2011) Ltd. on behalf of the City of Sarnia.

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1. Introduction

The City of Sarnia Stormwater Management (SWM) Design Guidelines (Guidelines) were developed for use by practitioners when preparing designs for stormwater management infrastructure within the City of Sarnia. It is intended that these Guidelines be used, in conjunction with other relevant engineering design standards and City of Sarnia documents, to prepare complete and compliant engineering designs and planning application packages for all developments within the City of Sarnia.

2. Guidelines

2.1. Design Guidelines

2.1.1. General

Licensed engineering practitioners (practitioners) shall evaluate the effects of all applicable storms based on the rainfall-intensity-duration-frequency (IDF) curves provided in this report and shall recommend the most appropriate stormwater design solutions on a site specific/case-by-case basis.

For each stormwater analysis considered (flood control, quality control, quantity control, and erosion control), practitioners shall identify and use the most critical storm and return period to select and size their proposed stormwater management solution.

These Guidelines shall be considered in conjunction with the provisions of the Ministry of the Environment, Conservation and Parks' (MOECP) "Stormwater Management Planning and Design Manual, 2003" (MOECP Design Manual) and the Ministry of Natural Resources and Forestry's (MNRF) "Natural Hazard Technical Guide, 2002" (MNRF Technical Guide). Practitioners shall look to the MOECP Design Manual and/or the MNRF Technical Guide for any and all stormwater management related design topics/issues not addressed by these Guidelines.

The MOECP Design Manual may be found via the link https://www.ontario.ca/document/stormwater-management-planning-and-design-manual-0.

2.1.2. Third-Party Reviews & Approvals

St. Clair Region Conservation Authority (SCRCA) consultation, review, and approval will be required for projects with stormwater management systems that outlet to a water course, water body, or wetland within the jurisdiction of SCRCA. Please refer to the SCRCA's online mapping tool via the link https://scrca.giscloud.com/ to determine the relative project location to the SCRCA boundary, water courses/bodies, and/or wetlands.

Projects within the 'Shoreline Hazard Areas' and/or 'Areas Affected by Ontario Regulation 171/06" (O. Reg. 171/06 – St. Clair Region Conservation Authority: Regulation of Development, Interference with Wetland and Alterations to Shorelines and Watercourses) delineated on the SCRCA online mapping tool are subject to further special restrictions that may affect the

stormwater management design criteria to be used by practitioners, above and beyond those specified herein.

MOECP review and approval of stormwater management designs will be required for projects located on industrial lands not exempt by their proposed use according to Ontario Regulation 525/98: Approval Exemptions (O. Reg. 525/98). Please refer to O. Reg. 525/98 via link https://www.ontario.ca/laws/regulation/980525 for specific exemption criteria.

Ontario Ministry of Transportation (MTO) review and approval will be required for projects abutting MTO lands and/or projects with stormwater management systems that outlet to lands within the MTO jurisdiction as per MTO corridor control regulations.

2.1.3. Low Impact Development Strategies

Low impact development (LID) strategies for stormwater management encompass a set of site design strategies specifically selected in order to minimize site runoff and/or mimic natural or pre-development site hydrology. Through the use of infiltration, evapotranspiration, harvesting, filtration, and/or detention of stormwater, LID strategies can effectively remove unwanted nutrients, pathogens, and metals from runoff, whilst also reducing the volume and intensity of stormwater flows.

The City of Sarnia supports the use of LID strategies for stormwater management and encourages practitioners to consider the latest version of the publication entitled "Low Impact Development (LID) Stormwater Management Planning and Design Guide, 2010" (LID Guide) published by the Toronto and Region Conservation Authority (TRCA) and the Credit Valley Conservation Authority via the link https://files.cvc.ca/cvc/uploads/2014/04/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf.

The following is a list of examples of LID strategies discussed in the LID Guide that should be considered by practitioners when designing stormwater management systems for new site developments or redevelopments as well infills, additions, and retrofits:

- Installation of rooftop storage for rainwater.
- Harvesting of rainwater from rooftops using rain barrels or cisterns for non-potable uses such as irrigation and toilet flushing.
- Installation of green roofs.
- Directing rooftop runoff to pervious or depression storage areas.

- Integrating of soak-away features such as infiltration trenches or chambers below landscaped areas, parking areas, parks, fields, etc.
- Incorporating of bio-retention areas, rain gardens, biofilters or constructed wetlands into the landscape/greenspace design.
- Installing permeable pavement in low to medium pedestrian and/or vehicular traffic areas.
- Using bio-retention areas, vegetated filter strips and/or swales to intercept and treat parking lot and/or road runoff.
- Incorporating woodlands or woodland restoration in upstream areas to reduce runoff rates.
- Construction of detention ponds or wetlands as aesthetic and recreational features.
- Incorporate rainwater planters or fountains in the landscape/greenspace design.
- Enhanced urban tree planting.

For more traditional SWM strategies such as wet ponds and wetlands, practitioners are encouraged to refer to the MOCEP Design Manual for more information.

Please note that the references made to the LID Guide and the MOECP Design Manual in this report are not intended to limit innovation or restrict the use of creative solutions for stormwater management. Indeed, the City supports and encourages the development of innovative designs and technologies for stormwater management.

2.1.4. Minor & Major System Requirements

Practitioners shall consider both minor and major stormwater management systems in land development projects.

Minor systems consist of storm drainage works (typically storm sewers) that convey surface flows from *minor* storm events to sufficient outlet in a quick and efficient manner in order to limit the inconvenience of stormwater ponding in urban areas.

Major systems consist of stormwater drainage features that safely convey surface flows from *major* storm events to sufficient outlet via overland flow paths.

For reconstruction projects and/or infill developments connecting to existing municipal stormwater collection or retention infrastructure, the City of Sarnia requires that all minor systems (collector storm sewers) be designed to accommodate flows from 1 in 2-year storm events.

For new right-of-way construction projects and/or new developments connecting to new retention infrastructure (new stormwater management facility) or directly to sufficient outlet (natural body of water or watercourse), the City of Sarnia requires that all minor systems (collector storm sewers) be designed to accommodate flows from 1 in-5-year storm events.

Please note that the City of Sarnia reserves the right to impose more stringent requirements on any and all types of projects/developments based on the available capacity of downstream infrastructure and/or other site-specific factors.

More stringent requirements shall apply to Development Area 1 and flood fringe areas as detailed in subsequent sections of this report.

As surcharging of storm sewers is expected during major rainfall events (equal to or greater than 1 in 5-year return periods), major systems (overland flow paths) must be provided in order to accommodate the safe conveyance of flows from up to 1 in 100-year storm events.

2.1.5. Rainfall Intensity-Duration-Frequency (IDF)

The City of Sarnia's 2024 IDF curves were developed using Version 6.5 of the University of Western Ontario's (UWO) "Computerized Tool for the Development of Intensity-Duration-Frequency Curves under a Changing Climate" and Version 3.30 of the Environment and Climate Change Canada IDF data set released in October of 2022 for Station/Climate ID. 6127519 (Sarnia).

For a given return period (T), the rainfall intensity (I) for a specific storm event duration (t) may be determined using the IDF curves and/or Table A2 provided in Appendix A. The IDF curves/tables shall be used for all developments in flood fringe area and for developments with catchment areas greater than 2 hectares (~5 acres).

For catchment areas less than 2 hectares, rainfall intensity (I) may be calculated using the following 'best-fit' equation and the IDF curve fitting parameters (A, B, C) provided in Table 1 below:

$$I\ (mm/hr) = A\ (t + C)^B$$

where: $I\ (mm/hr) = average\ rainfall\ intensity$

$t\ (hours) = storm\ event\ duration$

$A, B, C = IDF\ curve\ fitting\ parameters$

Table 1: IDF Curve Fitting Parameters.

Parameters	Return Period, T (Years)						
	1	2	5	10	25	50	100
A	27.0	30.7	41.8	49.3	58.5	65.1	71.4
B	-0.780	-0.798	-0.814	-0.820	-0.823	-0.824	-0.824
C	0.080	0.085	0.090	0.091	0.092	0.092	0.091

Please note the rainfall data and corresponding IDF curves have been modified since the 2017 Guideline publication to account for the impacts of climate change. To ensure that the Sarnia specific data included in these Guidelines remains relevant, the City of Sarnia may periodically revise and update the values, tables, graphs, and parameters provided herein accordingly.

2.1.6. Quantity Control

Post-development peak stormwater discharge rates from all new, non-infill development sites (residential, commercial, industrial and/or institutional) shall be limited to the pre-development rate generated by a 1 in 2-year storm event (2-year return period) on an equivalent greenfield area. As such, all development sites shall be designed with sufficient capacity to manage the quantity of stormwater generated by storm events with up to a 1 in 100-year return period.

Re-development, infill, addition, or extension of existing commercial, industrial and/or institutional sites will be considered an opportunity to 'retrofit' existing onsite stormwater management systems to meet the current requirements included in these Guidelines. In such cases, the City of Sarnia will require a licensed engineering practitioner to complete an evaluation of existing onsite stormwater management systems and discharge rates for comparison with existing Guideline requirements. Based on the evaluation, the City may require new stormwater management quantity controls to be constructed/installed on the site as part of the proposed development work.

For residential infill or additions, new quantity controls may only be required for the new/increased runoff from the site (i.e., pre-development discharge rate to consider existing, non-greenfield conditions).

Please note that more stringent discharge rate requirements may be imposed by the City of Sarnia on individual infill developments (residential, commercial, industrial, and institutional) based on site specific and/or existing municipal infrastructure capacity constraints. In particular, if infill development is being proposed within the City's combined sewer area (generally speaking, the area south of the Highway 402 corridor, north of Campbell Street and west of East Street) practitioners are encouraged to

arrange a pre-consultation meeting with the City of Sarnia to discuss discharge rate restrictions in advance of detailed design and/or application.

The post-development discharge rate shall be restricted to the prescribed pre-development rate by an appropriately sized orifice control (dip pipe, orifice plate or outlet pipe).

Every effort shall be made by the designer in setting temporary storage elevations during design to ensure that the calculated orifice size is not less than 75mm in diameter and that onsite ponding of stormwater runoff in paved areas does not exceed 300mm in depth.

In cases where the calculated orifice diameter is less than 150mm and the nominal diameter of the discharge pipe is 250mm or greater, a restrictive outlet pipe may be required by the City. Restrictive outlet pipes shall be a minimum of 100mm in diameter and minimum of 1.0m long and shall not extend more than 1.0m into the municipal right-of-way. Where outlet controls are required in addition to treatment through an oil and grit interceptor (OGI), the required controls shall be provided in a separate outlet structure preceding the inlet pipe into the OGI. Refer to City of Sarnia Standard Drawing 151-G (Division 5): Outlet Control Device / Restrictive Outlet Pipe via the link https://www.sarnia.ca/engineering/standard-specifications/.

Overland flow/bypass routes shall be provided to safely convey excess stormwater runoff (above and beyond that generated by 1 in 100-year storm) offsite and to sufficient outlet.

2.1.7. Time of Concentration

Time of concentration (t_c) may be calculated using either the NRCS Velocity Method or the NRCS Lag Method (watersheds under 2,000 acres). The method used by the practitioner shall be clearly documented in the submission calculations.

In residential areas, a maximum time of concentration (t_c) of ten minutes (10 min) shall be used to determine post-development runoff.

2.1.8. Land Use Considerations

The "worst-case" forecasted land use as specified in Sarnia's Official Plan shall be used when evaluating stormwater catchment areas and times of concentration (t_c) for the design of storm sewers in new development areas. Sarnia's Official Plan and associated maps and schedules can be found via the link https://www.sarnia.ca/official-plan-document/.

2.1.9. Quality Control

All development sites shall be designed with sufficient stormwater controls/ features to effectively manage the quality of stormwater generated by storm events with up to a 100-year return period.

Re-development, infill, addition, or extension of existing commercial, industrial and/or institutional sites will be considered an opportunity to 'retrofit' existing onsite stormwater management systems to meet the current quality control requirements included in these Guidelines. In such cases, the City of Sarnia will require a practitioner to complete an evaluation of existing onsite stormwater management systems and discharge quality for comparison with existing Guideline requirements. Based on the evaluation, the City may require new stormwater management quality controls to be constructed/ installed on the site as part of the proposed development work.

For residential infill or additions, new quality controls may only be required for the new/increased runoff from the site (i.e., pre-development discharge rate to consider existing, non-greenfield conditions).

All stormwater management systems discharging into the City's municipal storm sewer systems shall have a minimum suspended solids removal rate of seventy percent (70%) – normal protection level.

A minimum suspended solid removal rate of eighty percent (80%) will be required by the City where stormwater management systems discharge into or in close proximity to environmentally sensitive areas, water courses or bodies, aquifers, wetlands and/or wildlife habitat.

Please note that more stringent quality requirements may be imposed by the SCRCA.

An OGI shall be provided on the outlet of stormwater management systems from all developments involving any of the following:

- Gas stations.
- Significant parking lot areas (over 100 parking spaces or over 3,000 m^2).
- Loading/unloading zones for commercial or industrial use.
- Potential for oil or fuel spills.

OGIs for the above noted applications are to be designed based on a 25mm design storm and must provide the appropriate level of quality control to achieve the equivalent of enhanced removal of suspended solids (80% long-term average removal of suspended solids) at peak design flow levels leaving the site and shall hold Environmental Technology Verification Canada (ETV) verification status. The EVT Canada verification directory can be found via the

link https://etvcanada.ca/home/verify-your-technology/current-verified-technologies/.

For developments with parking lot areas accommodating between 15 to 100 parking spaces directly connected to the City's stormwater collection or retention infrastructure, stormwater quality control shall be provided through the inclusion of inverted tees/downturned elbows (sometimes referred to as dip pipes) installed on the outlet pipe inside site catchbasins and/or site stormwater manholes in advance of the site's discharge outlet(s) into the municipal system.

Total precipitation amounts (A) for a specific storm event duration (t) may be determined using Table A1 provided in Appendix A.

2.1.10. Rational Method

The City of Sarnia approves the use of the Rational Method for the design of minor stormwater management flow conveyance features, such as storm sewers and overland flow paths, for developments with catchment areas under 5 hectares (12 acres).

The storm event flows for a given return period (Q) shall be calculated using the following equation:

$$Q\ (m^3/s) = K\ x\ C\ x\ I\ x\ A$$

$where$: $Q\ (m^3/s) = return\ period\ storm\ event\ flow$

$K = convesion\ factor = 0.00278$

$C = runoff\ coefficient$

$I\ (mm/hr) = rainfall\ intensity$

$A\ (ha) = contributing\ catchbment\ area$

In the absence of site-specific parameters related to sub-soil conditions, topography, and material coverage, the minimum runoff coefficient (C) values included in Tables 2 and 3 may use used when calculating return period storm event flow (Q) using the Rational Method.

If impervious/pervious areas across the proposed site have been directly measured, practitioners may use the specific runoff coefficient (C) values provided in Table 2 below:

OGI

Table 2: Runoff Coefficient – Specific.

Land Use	C-Value
Asphalt, Concrete & Roof	0.95
Permeable Pavement	0.80[1]
Gravel	0.70
Agricultural	0.50
Grass – Clay Soil	0.35
Grass – Sandy Soil	0.25
Meadow / Forest	0.10

[1] *Subject to City approval.*

If impervious/pervious areas across the proposed site have *not* been directly measured, practitioners must use the general coefficient (C) values provided in Table 3 below:

Table 3: Runoff Coefficient - General.

Area Type	C-Value
Grassed Areas / Greenfield	0.30
Suburban	0.40
Single Family Residential	0.45
Semi-Detached Residential	0.60
Row Housing / Townhouses	0.65
Residential Apartments	0.70
Institutional (School / Church)	0.70
Commercial	0.80
Light Industrial	0.85
Heavy Industrial	0.90

2.1.11. Stormwater Modeling

For the design of stormwater management facilities and/or stormwater management systems for development sites over 5 hectares (12 acres), the City of Sarnia encourages the use of industry standard software/computer modeling for sizing, rainfall runoff analyses, and flow routing. If modeling software is used, the practitioner is expected to independently verify the accuracy of the results.

2.1.12. Special Areas

Practitioners shall note that specific and more stringent stormwater management policies apply to the following special areas:

- Flood plain areas designated as 'Flood Fringe' in Sarnia's Official Plan as detailed in Section 4.3: Natural Heritage.

- Development Area 1 as detailed in the Sarnia Official Plan, Section 8.1: Secondary Plan – Development Area 1.

Please refer to Schedule A – Secondary Plan Area 1 in the Official Plan – Maps and Schedules via link https://www.sarnia.ca/official-plan-document/ for Development Area 1 location map.

The permitted post-development peak discharge from a development site in a 'Flood Fringe' area or Development Area 1 shall be controlled to a pre-determined level (more stringent than that detailed in the preceding sections) based on the available capacity of downstream stormwater management facility designed for future development within the designated area. The specific pre-determined level shall be determined on a case-by-case basis with consultation with the City of Sarnia's Engineering Department.

When analyzing storm events with return periods greater than 1 in 10-years in Flood Fringe areas and/or areas within Development Area 1, the runoff coefficient values (C) listed in Section 3.1.9 of this report shall be increased as per below, up to a maximum value of 0.95:

- For a 1 in 25-year storm event – Increase by 10%
- For a 1 in 50-year storm event – Increase by 20%
- For a 1 in 100-year storm event – Increase by 25%

2.1.13. Maintenance Requirements

Practitioners shall ensure that minimum maintenance requirements of all stormwater management systems and/or controls proposed, including the parties responsible for the maintenance works, are clearly outlined in their report submission to the City. See Section 3.1.4 Maintenance Guidelines & Manuals.

2.1.14. Other Considerations

Practitioners shall ensure that winter provisions (winter runoff controls accounting for frozen ground conditions) and erosion control measures (slope and outlet protection, vegetation, etc.) are considered in their proposed stormwater management system designs.

2.2. Construction Guidelines

2.2.1. General

Material and construction specifications for all stormwater management systems and features shall meet or exceed the requirements of the City of Sarnia's Standard Specifications and Drawings accessible via https://www.sarnia.ca/engineering/standard-specifications/, in addition to all other applicable engineering design and construction standards.

Practitioners are encouraged to refer to the Ontario Provincial Standards for Road and Public Works (OPS) Specifications (OPSS) and Drawings (OPSD) accessible via https://www.roadauthority.com/Standards/ as appropriate.

2.2.2. Temporary Erosion & Sediment Control

Per the City of Sarnia's Consolidated Linear Infrastructure (CLI) Environmental Compliance Agreement (ECA) with the MOECP, owners and practitioners shall ensure that appropriate temporary erosion and sediment (E&S) control measures are employed on all construction projects that connect to or discharge stormwater, including overland flows, to any of the following:

- Stormwater infrastructure or features owned and/or maintained by the City of Sarnia.
- A natural water course or waterbody.
- A manmade watercourse (swale, ditch, etc.) or waterbody (pond, reservoir, etc.) beyond the limits of the owner's property.

The practitioner shall prepare a detailed Erosion and Sediment Control (ESC) Plan based on the ESC Plan Design and Submission Requirements specified in the "Erosion and Sediment Control Guide For Urban Construction" (ESC Guide) prepared by the TRCA accessible via https://sustainabletechnologies.ca/home/erosion-and-sediment-control/esc-guide/.

All appropriate temporary E&S control measures, as specified in the ESC Plan, must be installed in advance of the start of any construction works. The E&S control measures employed shall be inspected and maintained throughout the duration of construction or until they are deemed to no longer be required by the practitioner per the ESC Plan.

The installation, inspection and maintenance of temporary E&S control measures shall consider the best management practices detailed in the most recent publication of at least one (1) of the following:

- The ESC Guide prepared by the TRCA as noted above.
- The "W202 Erosion and Sediment Control Inspection and Monitoring Standard" published by the Canadian Standards Association's (CSA).
- The "W208 Erosion and Sediment Control Installation and Maintenance Guide" published by the Canadian Standards Association's (CSA).

The inspection of the E&S control measures in-place shall be conducted at the frequency specified in the ESC Plan for each of the following during both active and inactive construction phases:

- Dry weather periods.
- After significant storm and/or snowmelt events.
- After extreme weather events (≥25mm of rain in a 24-hour period).

Inspection records must, at a minimum, include the name of the inspector, date of the inspection, visual observations made, and any remedial measures undertaken to repair and/or maintain the temporary E&S control measures. Inspection records shall be retained by the owner and submitted to the City of Sarnia upon completion of the construction works (in advance of final conformance approval) and/or upon request.

Any deficiencies or maintenance requirements identified during inspections shall be addressed as soon as practicable and/or as directed by the practitioner or the City of Sarnia.

Please note that the City of Sarnia reserves the right to request that additional E&S control measures be installed, above and beyond those specified in the ESC Plan, if existing measures are deemed to be inadequate upon review or inspection by a City of Sarnia representative.

3. Submission Requirements

3.1. Reporting

3.1.1. Report Types

A detailed Stormwater Management Report shall be prepared by practitioners to support development applications for new subdivisions within the City of Sarnia.

For individual site plan applications, practitioners may include a dedicated 'stormwater management' section within their Functional Servicing Report (FSR).

The breadth of the Stormwater Management Report and/or stormwater management section within the FSR shall reflect the size of the site and/or the complexity of the stormwater management system/controls proposed.

3.1.2. Report Content

At a minimum, practitioners shall generally include the information described in the following sections in the preparation of stormwater management reports:

A. Existing Site Information

- Project address, legal description, parcel size, zoning, and land use.
- Current and potential future land uses on adjacent properties.
- Description of existing physical features on the property.
- All details pertaining to registered easements, agreements, and/or other licenses that may affect the proposed development and/or stormwater management design.
- Location map with aerial overlay identifying the following existing key site features:
  - *Municipal address.*
  - *Access routes.*
  - *Connecting municipal roadways.*
  - *Buildings.*
  - *Surface materials.*
  - *Treed areas.*
  - *Underlying soil conditions (geotechnical report preferred).*
  - *SWM features (swales/ditches, ponds, outlets, etc.).*
  - *Topography and drainage patterns.*

- Map(s) without aerial overlay identifying the following environmental features in the nearby area:
  - *Watershed information.*
  - *Receiving water courses and/or bodies.*
  - *Flood plain boundaries.*
  - *Shoreline hazard areas, if applicable.*
  - *Intake protection zones, significant groundwater recharge areas, vulnerable aquifers, etc.*
  - *Species at risk critical habitat in or surrounding receiving water course or body.*
  - *Wetlands or natural areas in or surrounding the site and/or receiving water course or body.*
- Describe the beneficial uses of surface water and groundwater in the surrounding area.
- Description of the sensitivity of receiving water course/body, nearby natural areas/wetlands, and/or groundwater recharge areas/aquifers.
- Description of local species at risk (aquatic, terrestrial, and avian) and existing soil erosion potential.

B. New Site Information

- Proposed zoning and/or land use.
- Description of proposed physical development features (buildings, parking lots, other solid surfaces, greenspace, landscaping, garbage enclosure, storage areas, etc.).
- Building size, building class, building use, finished floor elevation, and occupant level, if applicable.
- Adjacent land uses and occupancies (residential, commercial, warehouse, etc.).
- All details pertaining to registered easements, agreements, and/or other licenses that may be required for the proposed development and/or stormwater management design.
- Describe the stormwater management system to be installed on the site, including any and all the low impact design (LID) measures proposed.
- Describe the connecting municipal storm sewer location, size, and downstream pumping station location and/or City asset identification number, if applicable.
- Describe the outlet location, receiving water course or body, if applicable.
- Describe the effects of post-project runoff on site hydrology, the catchment area, drainage patterns, outfalls, and/or storm connections.

- Provide details pertaining to runoff water quantity control measures such as orifice controls, proposed ponding depths and areas, and overland flow/bypass routes.
- Provide details pertaining to runoff water quality control measures (natural features, site design features, physical structures, and/or best management practices proposed, etc.).
- Provide details pertaining to onsite and downstream erosion control measures (natural features, site design features, physical structures, and/or best management practices proposed, etc.).
- Describe the effects of the development on the existing beneficial uses of surface water and groundwater in the surrounding area, if any.
- Detail any and all potential stormwater quality pollutants of concern.
- Describe the effects of the development on the receiving water course/body, nearby natural areas/wetlands, and/or groundwater recharge areas/aquifers.
- Describe the effects of the development on local species at risk (aquatic, terrestrial, and avian) and existing soil erosion potential.
- Describe the effects of the development on the connecting municipal infrastructure downstream of the site, including discussion on the available capacity and/or updates that may be required, if applicable.

Please note that the information noted above may be shown on other development application documents and/or drawings. In such case, the practitioner shall detail in their report where the required information can otherwise be found.

3.1.3. Drawings & Calculations

Detailed design drawings and calculations are to be included as appendices to all SWM Reports or FSRs submitted to the City of Sarnia.

3.1.4. Maintenance Guidelines & Manuals

Maintenance Guidelines (MG) for the site's specific stormwater management systems shall be prepared by the designer and included as appendices to all SWM Reports or FSRs submitted to the City of Sarnia.

The MG shall specify the maintenance requirements (method and frequency for cleaning out accumulated solids, oils, and floatable materials) for any and all quality control devices and/or features selected by the designer. Design manuals for proprietary equipment or structures shall be included in the MG or referenced via a hyperlink within the MG text.

3.2. Engineer's Seal

As the contents of the SWM Report or FSR are of a technical/engineering nature, the report and associated drawings and design calculations shall be signed and sealed by a professional engineer licensed in the province of Ontario.

3.3. Online Mapping Resources

The following is a list of available online mapping tools that may assist practitioners in preparing their SWM Report or FSR:

- Ontario Ministry of Agriculture and Rural Affairs – AgMaps: https://www.lioapplications.lrc.gov.on.ca/AgMaps/Index.html?viewer=AgMaps.AgMaps&locale=en-CA
- Lambton County GIS Online: https://www.lambtongis.ca/sites/?viewer=lcgis
- St. Clair Region Conservation Authority Online Mapping Tool: https://scrca.giscloud.com/
- Ministry of the Environment Conservation and Parks – Source Water Protection Online Mapping Tool: https://www.lioapplications.lrc.gov.on.ca/SourceWaterProtection/index.html?viewer=SourceWaterProtection.SWPViewer&locale=en-CA

Appendices

Appendix A – IDF Tables & Curves

Table A1: Total Precipitation Amounts (mm) for the City of Sarnia.

Duration, t (Minutes)	Return Period, T (Years)						
	1	2	5	10	25	50	100
5 min	9.25	10.60	14.51	17.21	20.43	22.77	25.10
10 min	13.41	15.39	21.08	24.98	29.67	33.06	36.38
15 min	16.03	18.37	25.15	29.78	35.37	39.40	43.32
30 min	20.65	23.55	32.11	37.94	45.03	50.14	55.07
1 h	25.43	28.77	38.97	45.90	54.41	60.55	66.46
2 h	30.50	34.16	45.88	53.85	63.73	70.87	77.76
6 h	39.63	43.60	57.63	67.23	79.33	88.12	96.66
12 h	46.40	50.43	65.96	76.63	90.25	100.18	109.88
24 h	54.19	58.17	75.26	87.08	102.35	113.53	124.53

Table A2: Precipitation Intensity Rates (mm/hour) for the City of Sarnia.

Duration, t (Minutes)	Return Period, T (Years)						
	1	2	5	10	25	50	100
5 min	110.96	127.25	174.07	206.50	245.16	273.30	301.16
10 min	80.45	92.32	126.46	149.89	178.02	198.37	218.27
15 min	64.11	73.48	100.59	119.12	141.47	157.60	173.26
30 min	41.29	47.09	64.22	75.88	90.06	100.27	110.13
1 h	25.43	28.77	38.97	45.90	54.41	60.55	66.46
2 h	15.25	17.08	22.94	26.93	31.87	35.44	38.88
6 h	6.61	7.27	9.61	11.20	13.22	14.69	16.11
12 h	3.87	4.20	5.50	6.39	7.52	8.35	9.16
24 h	2.26	2.42	3.14	3.63	4.26	4.73	5.19

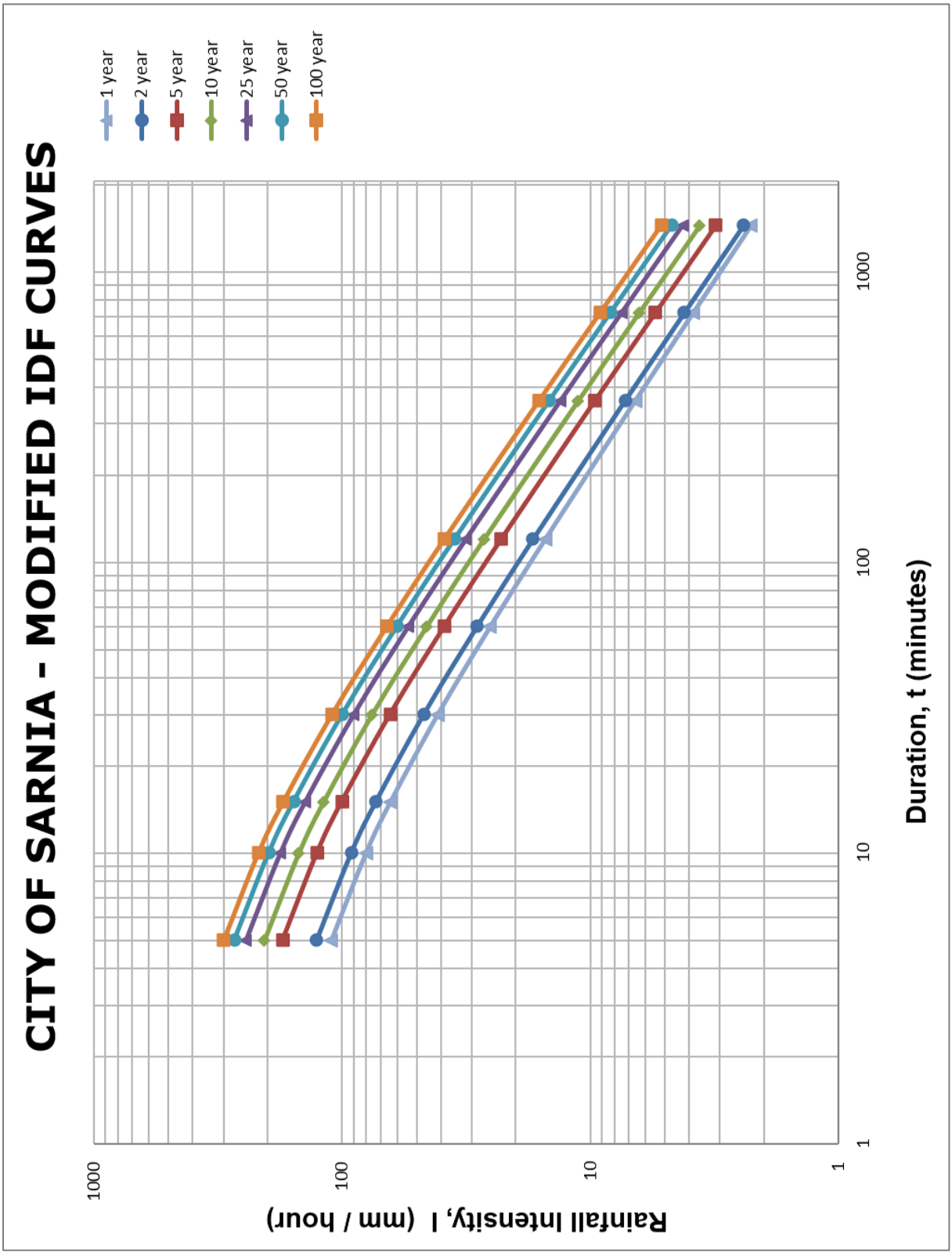

Figure A1: Sarnia IDF Curves –2024.

Appendix B – References

The following is a list of references to articles, websites and data sets used and/or referred to in the development of these Guidelines:

- **Credit Valley Conservation Authority and Toronto and Region Conservation Authority (2010)** "Low Impact Development – Stormwater Management Planning and Design Guide", *Credit Valley Conservation Authority website,* https://files.cvc.ca/cvc/uploads/2014/04/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf
- **Department of Energy Lawrence Livermore National Laboratory (2021a)** CMIP6 - Coupled Model Intercomparison Project Phase 6, https://pcmdi.llnl.gov/CMIP6/, last accessed July 2021.
- **Department of Energy Lawrence Livermore National Laboratory (2021b)** Earth System Grid Federation, https://esgf-node.llnl.gov/projects/esgf-llnl/, last accessed July 2021.
- **Environment and Climate Change Canada (2023)** Engineering Climate Datasets, available at http://climate.weather.gc.ca/prods_servs/engineering_e.html, last accessed July 2021.
- **Environment Canada (2020)** Engineering Climate Datasets, available at http://climate.weather.gc.ca/prods_servs/engineering_e.html, last accessed July 2017.
- **Gaur, A., Schardong, A., Simonovic, S.P. (2020)** "Gridded extreme precipitation Intensity—Duration-Frequency Estimates for the Canadian Landmass". J. Hydrol. Eng. 2020, 25.
- **Ministry of the Environment, Conservation and Parks (2023)** "Stormwater Management Planning and Design Manual", ontario.ca website, https://www.ontario.ca/document/stormwater-management-planning-and-design-manual-0.
- **Pacific Climate Impacts Consortium (2021)** Statistically Downscaled Climate Scenarios, https://pacificclimate.org/data/statistically-downscaled-climate-scenarios last accessed July 2021.
- **Sandink, D., S.P. Simonovic, A. Schardong, and R. Srivastav, (2016)** "A Decision Support System for Updating and Incorporating Climate Change Impacts into Rainfall Intensity-Duration-Frequency Curves: Review of the Stakeholder Involvement Process", *Environmental Modelling & Software Journal*, 84:193-209.

- **Schardong, A., S. P. Simonovic, A. Gaur, and D. Sandink (2020)** Web-based Tool for the Development of Intensity Duration Frequency Curves under Changing Climate at Gauged and Ungauged Locations, Water, Special Issue Extreme Value Analysis of Short-Duration Rainfall and Intensity–Duration–Frequency Models, 12, 1243; doi:10.3390/w12051243, open access, https://www.mdpi.com/2073-4441/12/5/1243/pdf.
- **Simonovic, S.P., A. Schardong, D. Sandink, and R. Srivastav, (2016)** "A Web-based Tool for the Development of Intensity Duration Frequency Curves under Changing Climate", *Environmental Modelling & Software Journal*, 81:136-153.
- **Srivastav, R.K., A. Schardong and S.P. Simonovic, (2014)** "Equidistance Quantile Matching Method for Updating IDF Curves Under Climate Change", *Water Resources Management: An International Journal*, 28(9): 2539-2562.