Disclaimer: Please refer to CLI ECA 009-S701 SWM Criteria for latest stormwater management criteria from the MECP. This criteria is mandatory. If there is a conflict with the 2003 Stormwater Management Planning and Design Guidance Manual or the 2019 Region of Peel Public Works Stormwater Design Criteria and Procedural Manual, the CLI ECA 009-S701 SWM Criteria shall take precedence

REGION OF PEEL

PUBLIC WORKS STORMWATER DESIGN CRITERIA AND PROCEDURAL MANUAL

June 2019 (version 2.1)

This document ahs been prepared by Aquafor Beech Limited for the Region of Peel. The document contents reflect the outcomes of staff consultation and review processes.

Version 2.0 of the Public Works Stormwater Design Criteria and Procedural Manual has been prepared as a living document, with the intent that its content be revised and updated by the Region of Peel on an ongoing basis as part of an adaptive and iterative approach based on lessons learned and in-field implementation results.

Public Works Stormwater Design Criteria and Procedural Manual

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PREFACE

It is the Regional Municipality of Peel (Region of Peel) mandate in regards to stormwater management that impacts to the natural environment, by a proposed storm drainage system be identified with proposed solutions or mitigative measures, with a view to following policies set out in the *Provincial Policy Statement (PPS), 2014*. *The Provincial Policy Statement, 2014,* issued under Section 3 of the *Planning Act*, provides specific guidance for stormwater management, indicating that planning for stormwater management shall (under Section 1.6.6.7):

a) minimize, or, where possible, prevent increases in contaminant loads;

b) minimize changes in water balance and erosion;

c) not increase risks to human health and safety and property damage;

d) maximize the extent and function of vegetative and pervious surfaces; and

e) promote stormwater management best practices, including stormwater attenuation and re-use, and Low Impact Development (LID).

In addition, Section 2.2.1 states that planning authorities shall protect, improve or restore the quality and quantity of water by:

a) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development;

b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts;

c) identifying water resource systems consisting of ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas, which are necessary for the ecological and hydrological integrity of the watershed;

d) maintaining linkages and related functions among ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas;

e) implementing necessary restrictions on development and site alteration to:

1. *protect all municipal drinking water supplies and designated vulnerable areas; and*
2. *protect, improve or restore vulnerable surface and ground water, sensitive surface water features and sensitive ground water features, and their hydrologic functions;*

f) planning for efficient and sustainable use of water resources, through practices for water conservation and sustaining water quality;

g) ensuring consideration of environmental lake capacity, where applicable; and Provincial Policy Statement 24;

h) ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

In conformance with the aforementioned, the Region of Peel shall require the use of Low Impact Development (LID) approaches where no site specific soil, groundwater, infrastructure or policy constraints exist consistent with the Stormwater Management Planning and Design Manual (MOE 2003), the Draft MECP Low Impact Development Stormwater Guidance Manual (Pending), as well as the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC); as amended from time to time.

A **Resource Directory** accompanies this document in **Appendix A**. The Resource Directory includes links where these resources can be downloaded.

1.0 INTRODUCTION

Designs of municipal services in the Regional Municipality of Peel (Region of Peel) are to be based upon the most current Public Works Stormwater Design Criteria and Procedural Manual. All plans are to be reviewed and accepted by the Region prior to construction of services. Such Regional acceptance of plans and drawings shall not relieve the designer from primary responsibility of the design to meet all Federal, Provincial, Regional, local government, and Conservation Authority requirements and/or codes.

1.1 Document Purpose

The purpose of this document is to detail the expectation and requirements relating to the Region's stormwater services relating to:

- New developments
  - Site plans for Region of Peel properties;
  - Site plans for Private Property which abut and drain to Region of Peel stormwater infrastructure
- Regional capital works projects with the Right-of-Way (ROW)

The requirements within this document have been developed considering Conservation Authorities' watershed-wide criteria perspective consistent with the *Provincial Policy Statement (PPS), 2014*. This document provides clear and consistent direction with respect to stormwater management of the Region's existing and future road allowances, including direction as to the preferred methods for runoff management in regards to infrastructure located on Regional property and where applicable, the lands of adjacent and nearby landowners.

1.2 Intended User

The intended user of this document includes Region of Peel staff, practitioners and consultants, as well as agencies and stakeholders. It is intended that the following guidelines will be applied as part of:

- Pre-design phase of the Municipal Class Environmental Assessment Process;
- Detailed Design; and
- Approvals.

1.3 Document Outline

Provided below is a brief overview of the content of the following Implementation Document:

Section 1 – Provides the document introduction, document purpose and the report outline.

Section 2 – Describes the relevant key policies and jurisdictions as it relates to stormwater management within the Region of Peel.

Section 3 – Outlines the requires studies which may be required as part of the planning, design and approvals relating to stormwater management.

Section 4 – Describes the governing stormwater management requirements with the Region of Peel.

Section 5 – Describes the various design criteria related to the dual drainage system, storm sewers, ditches, and all related appurtenances. Design criteria for connections via storm laterals, crossing and Low Impact Development (LID) approaches are also detailed.

Section 6 – Outlines the approved methods for the determination of design flows from both a hydrologic and hydraulic perspective.

Section 7 – Defines climate change and the various associated terms, Provincial guidance for the assessments and mitigation of climate change impacts from a stormwater and water resources perspective, as well as the hydrologic and hydraulic modelling requirements in response to climate change.

Section 8 – Outlines the Region of Peel innovation and standards deviation process for proposed designs and approaches which are outside this document and its provisions.

Section 9 – Describes the requirements for the preparation of a stormwater management report.

Section 10 – Outlies the key approvals requirements.

2.0 RELEVANT POLICIES & JURISDICTIONS

Design Standards
All designs shall conform to Region of Peel standards, as amended from time to time, including the Public Works Design, Specification & Procedures Manual and the Approved Products List. If no Region standards are available, the design shall conform to current OPSD, OPSS, CSA, or ASTM standards, as applicable.

Watershed Level Studies
Stormwater, drainage and Low Impact Development (LID) approaches shall meet the requirements of available Master Environmental Servicing Plans (MESP's) and/or watershed/subwatershed studies for the watershed in which the undertaking is located and any related approved stormwater management report(s). Watershed and sub watershed studies and Master Drainage Plans should be referenced for specific stormwater management requirements.

Key Policies and Jurisdiction Considerations
The Region of Peel is subject to all Federal, Provincial and local legislation related to stormwater management, runoff control and flood control. Of most significance to the day-to-day undertaking of the Region of Peel in regards to stormwater management are the policies of the:

A complete list of all Federal, Provincial and local agencies policies and guidelines relating to the planning, design and approvals of stormwater management infrastructure has been prepared and is included in **Appendix B.**

- Department of Fisheries and Oceans (DFO)
- Ministry of the Environment, Conservation and Parks (MECP)
- Ministry of Natural Resources and Forestry (MNRF)
- Local Conservation Authorities (TRCA, CVC, LSRCA, HC, and NVCA) under the *Conservation Authority Act*
- Niagara Escarpment Commission (NEC)

Department of Fisheries and Oceans (DFO)
At the Federal level in Canada, the DFO is responsible for managing fisheries and safeguarding waters. The DFO has produced Land Development and Urban Stormwater Guidelines and best management practices for the protection of fish and habitat. It is up to the proponent to ensure that their projects meet the DFO requirements under the Self-Assessment Process. Further information regarding this process can be found at the following link http://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html. The Self-Assessment Process applies to any on-going projects where permits have not yet been issued and any future permit applications under the *Fisheries Act*.

Ministry of the Environment, Conservation and Parks (MECP)
The Ministry of the Environment, Conservation and Parks (MECP) is responsible for protecting clean and safe air, and water to ensure healthy communities, ecological protection and sustainable development for present and future generations of Ontarians.

The Stormwater Management Planning and Design Manual 2003 was developed to provide technical and procedural guidance for planning and designing SWM practices. Currently, Ontario does not have a regulation specifically for SWM, the Ontario *Water Resources Act* only requires an Environmental Compliance Approval (ECA) for works.

In 2015, the MECP produced an Interpretation Bulletin entitled Expectations Re: Stormwater Management. This Bulletin clarifies that the ministry's existing guidance emphasizes an approach to stormwater management that mimics a site's natural hydrology by controlling precipitation as close as possible to where it falls so water quality remains satisfactory for aquatic life

and recreation and water quantity is managed to ensure a fair sharing among users, water conservation, and sustainability of the resource.

The MECP has prepared a Draft Low Impact Development Stormwater Management Guidance Manual (Pending) includes:

- Stormwater volume control requirements for Ontario;
- Criteria to select the appropriate water budget and water quality modelling tools for use in Ontario;
- Criteria and processes for groundwater protection; and
- A process for which to reflect future Climate scenarios and assess Climate Change risks and vulnerabilities.

The development of the MECP Low Impact Development Stormwater Management Guidance Manual is not intended to replace the 2003 MOE Stormwater Planning and Design Manual, but rather to compliment the 2003 Manual as a companion document, coordinated with other newer LID Planning and Design Guides developed in collaboration with Ontario Conservation Authorities since 2003. Note: At time of release of this **Draft Public Works Stormwater Design Criteria and Procedural Manual (Version 2.0)**, the MECP Low Impact Development Stormwater Management Guidance Manual has not been formally released by the MECP, as such all targets, criteria and approaches detailed within have been included within this Region of Peel document as 'recommended' unless otherwise noted.

The Endangered Species Act (2007), as amended from time to time, is also under the jurisdiction of the MECP, and provides for broader protection for species at risk and their habitats. In general, the purpose of the act includes the preservation and rehabilitation of habitat and the enhancement of other areas so that they can become habitat. Under the act habitat may be described by specific boundaries, features or "in any other manner" and may prescribe areas where species live, used to live or is believed to be capable of living and beyond.

The applicable provisions for SWM per Section 10 state that a person shall not damage or destroy the habitat of a species that is listed as an endangered or threatened species. Policies under this legislation have relevance to urban development and stormwater management, including within the Region of Peel. As an example, the impacts to habitat can be as a result of:

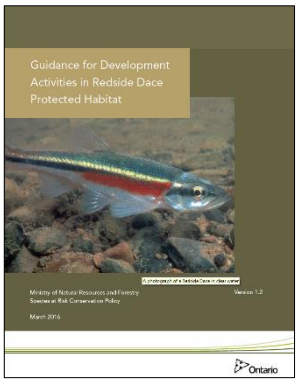
- Alteration to hydrologic regimes (increased runoff, flow regime change, and decreased infiltration) and increased water temperature (through increasing impervious surfaces and end-of-pipe discharges);
- Increased sedimentation and erosion through site grading and excavation;
- Releases of untreated stormwater which carry pollutants; and
- General habitat losses through the loss of riparian vegetation, in-stream habitat features, wetland and groundwater sources.

Species of significant for SWM practitioners within the Region Peel relating to the Endangered Species Act and SWM include, but are not limited to:

1) Redside Dace; and
2) Jefferson Salamander

At present, no specific SWM criteria is mandated for Jefferson Salamander habitat, but the Ministry of Natural Resources and Forestry (MNRF), who formerly had jurisdiction over the Endangered Species Act, has released guidance for Redside Dace habitats. It should be noted that, although not formalized within specific guidelines, within Jefferson Salamander habitat, provision for enhanced water quality control and thermal mitigation of stormwater runoff has typically been required. The following section describes the relevant SWM criteria for Redside Dace habitats.

SWM Criteria for Redside Dace Habitats



Per the MNRF Guidance for Development Activities in Redside Dace Protected Habitat (March 2016, Version 1.2) "Untreated runoff of urban landscapes may impact Redside Dace habitat by altering hydrologic regimes, increasing water temperatures, and conveyance of chemicals and pollutants to watercourses. Stormwater management facilities should target outflows consistent with Redside Dace habitat requirements, including water temperatures less than 24°C, dissolved oxygen levels above 7 mg/L and having total suspended sediment levels less than 25 mg/L above background conditions. Stormwater management should mimic pre-development hydrologic regimes by incorporating a 'treatment-train' approach and low-impact development designs."

In addition, it is a requirement to set targets for water balance, stormwater management, fish community, and natural heritage features (e.g., targets for water infiltration and stormwater management for the selected storm ranges, maximum percentage of impervious/impenetrable cover, maximum temperature increases based on needs of the fish, maximum total suspended solids, preservation and/or increase of wetlands to support Redside Dace, realignment of streams, etc.).

Specific to **Road Crossings**, it is required to develop a plan for managing the stormwater runoff from road crossings and where possible preventing it from entering the stream. It provides an example of retaining rural road cross-sections adjacent to the crossings, which do not have curbs or drains, such that stormwater will not be discharged directly into the stream.

It is important to note that a permit or registration may be required for an activity occurring outside of endangered species habitat where the activity will adversely affect endangered species or its protected habitat (e.g. construction, repair or redirection of storm water drains outside of endangered species habitat resulting in stormwater effluent flowing into protected habitat).

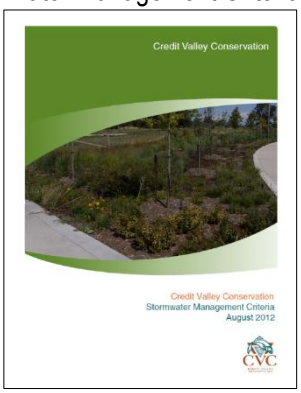
Local Conservation Authorities

At the local level, the Region of Peel boundaries fall within the jurisdiction of five (5) conservation authorities (CAs). The Toronto and Regional Conservation Authority (TRCA) and the Credit Valley Conservation Authority (CVC) jurisdiction comprise the vast majority of the Region of Peel. The Lake Simcoe Region Conservation Authority (LSRCA) and the Nottawasaga Valley Conservation Authority (NVCA) encompass small portions of land in the north-east corner of the Region, while the jurisdiction of Halton Conservation (HC) encompass a small sliver of land along the south-west boundary of the Region. **Figure 2.0** illustrates the areas of the Region of Peel which fall under the jurisdiction of five (5) Conservation Authorities.

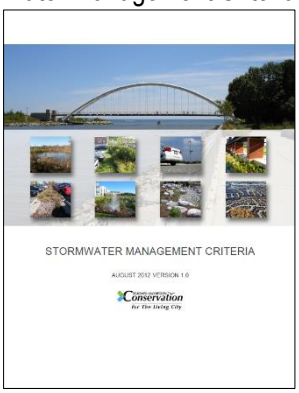
As watershed management agencies, several of the Conservation Authorities have developed watershed specific stormwater criteria for projects which fall within their respective watershed, including table lands and valley lands Regulated under the provisions of the *Conservation Authority Act.* The relevant watershed specific stormwater criteria documents are listed below.

The criteria within his document has been developed to generally comply with and satisfy the various watershed specific stormwater criteria, however the practitioner shall be required to consult the various documents for verification. Consultation with the various CAs may be required and is recommended.

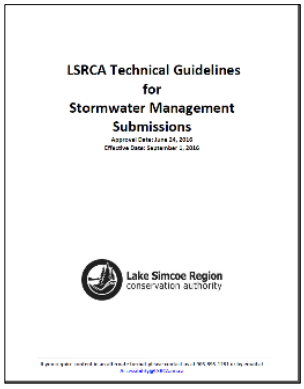
Credit Valley Conservation (CVC)
Stormwater Management Criteria - (Aug. 2012)



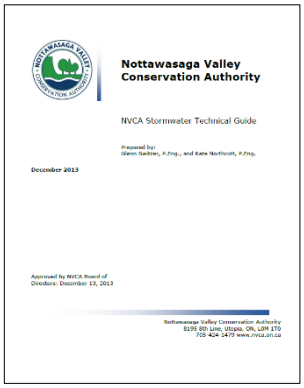
Toronto and Regional Conservation Authority (TRCA)
Stormwater Management Criteria - (Aug.2012)



Lake Simcoe Region Conservation Authority (LSRCA)
LSRCA Technical Guidelines for Stormwater
Management Submissions - (Sept. 1, 2016)



Nottawasaga Valley Conservation Authority (NVCA)
NVCA Stormwater Technical Guide (Dec. 2013)



Niagara Escarpment Commission (NEC)

The Niagara Escarpment Plan (NEP) protects the Escarpment's unique ecological, historic and scenic qualities. To ensure that the Escarpment's natural resources, ecosystem health and scenic landscape are protected, Niagara Escarpment landowners are required to obtain a Development Permit for certain types of development.

The boundaries of the Niagara Escarpment Plan (NEP) within the Region of Peel are detailed within Map 4 of the NEP and are generally located within the north-west corner of the Region, within the Town od Caledon. **Figure 2.1** illustrates the NEP boundaries within the Region of Peel.

To ensure that the Escarpment landscape and ecosystem remain protected, development permits from the NEC are required for certain types of development. A Niagara Escarpment Development Permit considers the impact of a development proposal on the Escarpment landscape and environment. The objective is to design and situate development in an environmentally compatible way. (Municipal building approvals and other permits may also be required, but may only be issued after the Development Permit.) Applications for Development Permits can include proposals for new single dwellings, road construction, quarries, sand and gravel pits, establishment of wineries, irrigation or recreational ponds, altering the grade of land, and changes in the use of any land, building or structure.

Ontario Regulation 826/90 under the *Niagara Escarpment Planning and Development Act* (NEPDA) describes lands within the Niagara Escarpment Planning Area which are designated as an area of development control. Lands located within the

area of development control could require a Development Permit from the Niagara Escarpment Commission (NEC) for certain types of development. (See: Ontario Regulation 826/90)

Exemptions

Ontario Regulation 828/90, under the NEPDA, lists the classes of development that are exempt from the requirement of obtaining a Development Permit from the NEC (see Ontario Regulation 828/90). Exemptions of most relevance to the Region of Peel relating to project within the Right-of-Way listed within Section 5, include:

> 4.3. The maintenance, repair or renewal of highways or municipal roads if the maintenance, repair or renewal does not,
>
> i. open an unopened road allowance,
> ii. expand the width of the road,
> iii. change the road from a seasonal to a year round road,
> iv. change the surface of the road from gravel to pavement, or
> v. require road cuts and contour changes.
>
> 4.4. The maintenance, repair or cleaning of drainage ditches and swales along highways and municipal roads, including the replacement of culverts associated with driveway lanes and entrances onto municipal roads and highways.
>
> 4.5. The maintenance or repair of slopes and retaining walls within the road allowance of highways and municipal roads.
>
> 4.6. The maintenance or repair of rock faces or cliffs associated with road cuts, including the mechanical scaling of rock cliffs within the road allowance required for safety purposes.
>
> 5. The construction, erection, installation, maintenance, repair or renewal of sidewalks, curbs, gutters, street signs and street lights on municipal roads and highways and the maintenance and renewal of driveway lanes and entrances onto municipal roads and highways.
>
> 6. The maintenance, repair or renewal of sewers, mains, pipes, cables, including fiber optic cables, wire or other apparatus connected with public utilities, including equipment shelters and lockers, and the breaking open of any municipal road or highway or other land for this purpose.
>
> 6.1. The construction or installation of sewers, mains, pipes, cables, including fiber optic cables, wire or other apparatus connected with public utilities, including equipment shelters and lockers, in an area designated as an Urban Area in the Niagara Escarpment Plan.

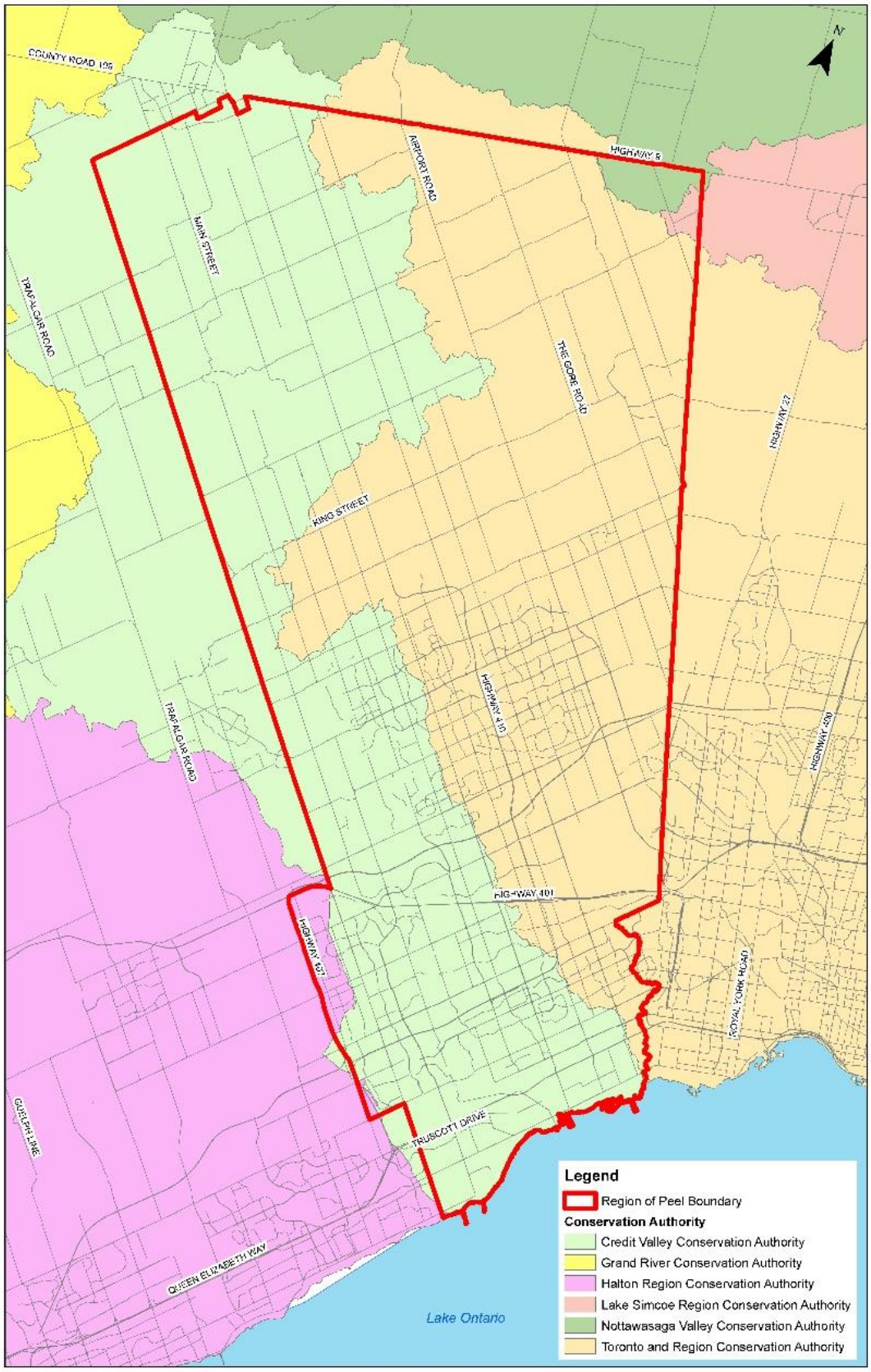


Figure 2.0 – Jurisdictions of the Five (5) Conservation Authorities within the Region of Peel

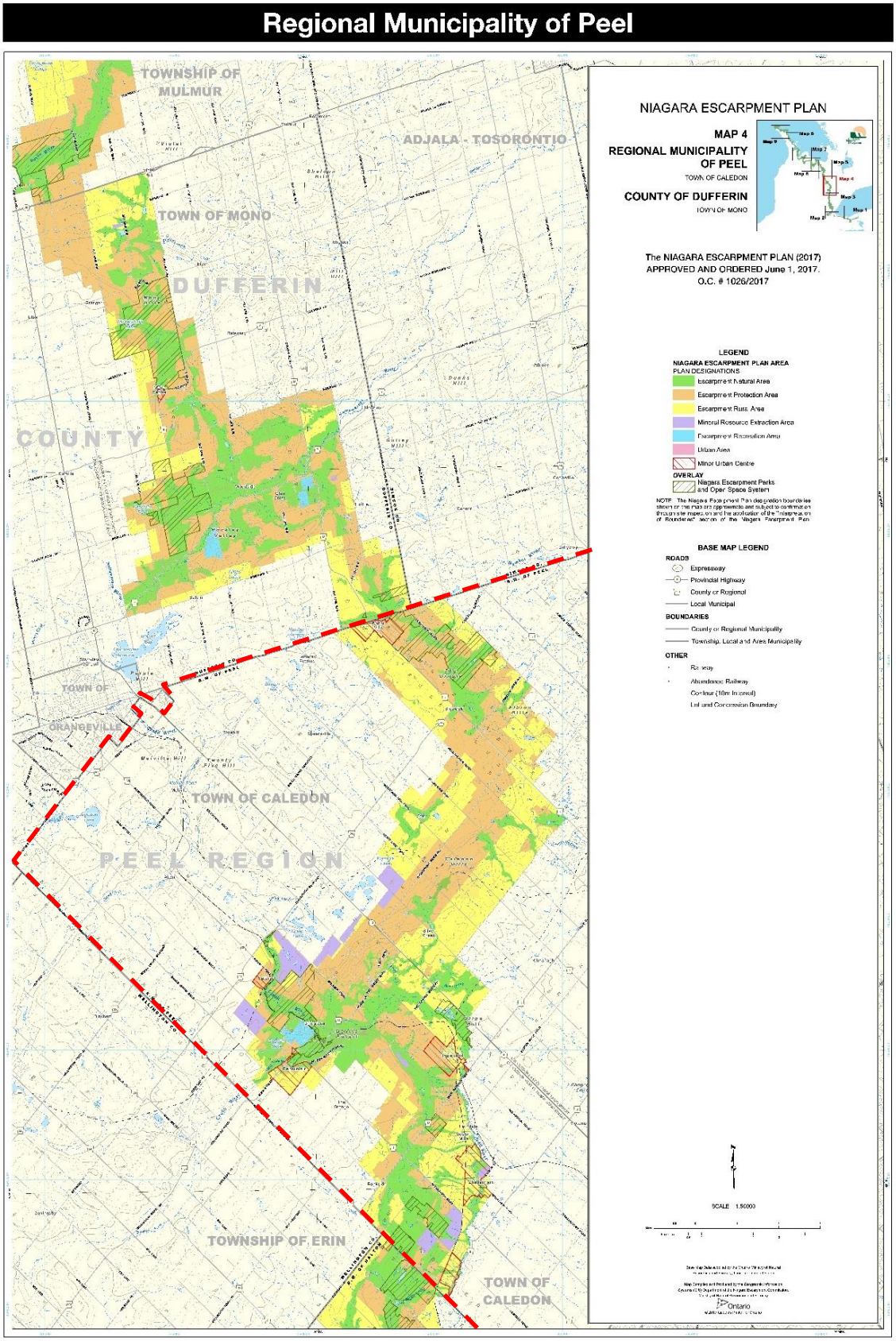


Figure 2.1 – Niagara Escarpment Plan (NEP) Boundaries within the Region of Peel

3.0 REQUIRED STUDIES

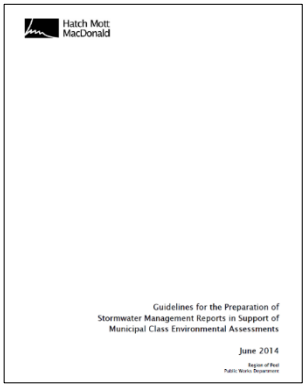
In the development of stormwater management plans for use within the Region of Peel, the following section details a series of studies that may be required. It is recommended that the proponent undertake consultations with Regional staff and local agencies, including but not limited to:

- Local conservation authorities (TRCA, CVC, LSRCA, NVCA and HC – see **Section 2.0** and **Figure 2.0**)
- The Niagara Escarpment Commission (NEC) - see **Section 2.0** and **Figure 2.1**)
- The Ministry of Natural Resources and Forestry (MNRF)
- The Ministry of the Environment, Conservation and Parks (MECP)
- The Department of Fisheries and Oceans (DFO)

3.1 Environmental Assessments

The Environmental Assessment Act was legislated by the Province of Ontario in 1980 to ensure that an Environmental Assessment is conducted prior to the onset of development and development related (servicing) projects. Class Environmental Assessments (Class EA) are prepared for approval by the minister of the environment. A Class EA is an approved planning document that defines a project or groups of project and activities and the environmental assessment (EA) process which the proponent commits to for each project undertaking. Provided the process is followed, projects and activities included under the Class EA do not require formal review and approval under the EA Act. In this fashion the Class EA process expedites the environmental assessment of smaller recurring projects.

Guidelines for the Preparation of Stormwater Management Reports in Support of Municipal Class Environmental Assessments (June 2004).



The Region of Peel has developed this guideline with the purpose of providing information and guidance on the process and techniques available to prepare stormwater management studies under the jurisdiction of the Regional Municipality of Peel (Region of Peel) in support of:

1 Municipal Class Environmental Assessment (EA),
2 Preliminary design
3 Detailed design projects for roads

Aligning with the Provincial Policy Statement (PPS, 2014) and drawing the objectives and design criteria from the local municipality and/ or Conservation Authority where the project is located, this document recommends the use of Low Impact Development (LID) approaches where feasible to mitigate the impacts of increased runoff and stormwater pollution and promote the use of natural systems for infiltration, evapotranspiration and reuse of stormwater runoff.

Stormwater criteria and targets as specified within Guidelines for the Preparation of Stormwater Management Reports in Support of Municipal Class Environmental Assessments (June 2004) shall be superseded by those listed in **Section 4.0**. Nevertheless the 2004 guidelines provide direction and a succinct process for use in the preparation of Municipal Class EAs for Regional ROW projects.

3.2 Environmental Impact Statements

Preservation, protection, and enhancement of the Natural Heritage System (NHS) is an important planning objective reflected in Provincial, Regional, and local planning policy as well as the policies and regulations of conservation authorities.

The Region of Peel recognises that the transportation system interacts with, and impacts, the environment (Region of Peel, 2016). The abovementioned types of plans and policies generally dictate that no development or site alteration is permitted in certain natural heritage and hydrologic features. Development and site alteration may be permitted in other natural heritage areas, and on lands adjacent to natural heritage and hydrologic features, if it has been demonstrated that it will have no negative impacts on the feature or its functions. The avoidance of negative impacts ought to be the first priority. This may entail the optimization and re-use/upgrade of existing infrastructure. If negative impacts cannot be avoided, then measures to mitigate negative impacts shall be identified and assessed. Natural heritage (as well as natural hazards) should be evaluated so that the stable top of bank, floodplain, erosion hazard, limit of natural features and their associated buffers are identified to avoid negative impacts on the natural features or on their ecological functions.

An Environmental Impact Study (EIS) assesses potential impacts to the form and function of the NHS resulting from proposed development and site alteration (as defined in the Region of Peel's Official Plan), and is intended to serve as both a planning and decision-making tool. The type and extent of biophysical studies required as part of an EIS varies depending on the context of the project and the availability of background information; generally, the Terms of Reference for an EIS are negotiated with the relevant planning authorities prior to the development proponent undertaking the study.

In the Region of Peel, an EIS is required for development and site alteration proposed within and on adjacent lands to the Greenlands System. EISs are typically submitted to the relevant planning authority/authorities, conservation authority, and in some cases, the Ministry of Natural Resources and Forestry (MNRF).

Similar to an EIS, an Environmental Implementation Report (EIR) may sometimes be required. The EIR includes an impact assessment of the proposed land use change and proposes management and monitoring plans to mitigate the impacts from the land use change.

3.3 Geotechnical Investigations

The designer and/or Regional staff shall determine the need for geotechnical/hydrogeology investigations. The purpose of an investigation would be to determine:

- The soil composition,
- Bearing strength and soil type,
- Pipe bedding requirements,
- Groundwater elevations and seasonally high groundwater elevations including seasonal fluctuations;
- Soil permeability in support of:
    - Permits to Take Water (PTTW)/ Environmental Activity and Sector Registry (EASR) per Ontario Regulation (O. Reg.) 63/16; and
    - Low Impact Development approaches (See **Section 5.20**)
- Soil quality for off-site disposal options i.e. to determine if contamination is present under Part XV.1 of the Environmental Protection Act (EPA); and
- Pavement strength or design recommendations.

3.3.1 Geotechnical Investigations for LID

In addition to the above general requirements listed in **Section 3.3**, the table below provides a summary of the geotechnical/hydrogeology investigation activities which are necessary for the detailed design of the various LID measures, with a focus on LIDs with the regional ROW.

Geotechnical Investigation Activities for LID SWM Options

LID Practice	Geotechnical Investigation Activities			
	Boreholes	Piezometers/ Monitoring wells	Laboratory Soil Testing	In-situ Infiltration Testing
Bioretention	●	●	●	●
Bioswale	●	●	●	●
Enhanced Grass Swales	●	n/a	●	●
Perforated Pipe	●	●	●	●
Permeable Pavements sidewalks & MUTs	●	●	● (Resilient Modulus or Soaked CBR)	●
Prefabricated Modules	n/a		●	●
Infiltration Facilities	●	●	●	●
Stormsewer Daylighting	●	●	●	●

Boreholes - Boreholes are typically specified to extend a minimum of 3 meters or to bit refusal (boreholes are recommended to be advanced a minimum of 1.5m below the proposed invert of proposed LID practice). The resolution of the investigation (i.e. quantity and spacing between boreholes) will vary from site to site. Resolution of the borehole investigations shall be such that sufficient information is collected for detailed design purposes.

Groundwater Elevation Monitoring - Piezometers or monitoring wells typically consist of 50mm diameter casings installed to depths of 3.5 to 4.5 meters and encased within an above ground and/or flush mount, lockable, steel housing. Piezometers or monitoring wells shall be installed to determine the seasonal high-water table including seasonal fluctuations and where required the groundwater flow direction (gradient). Usually one year of monitoring, preferably continuous data logging, is required to determine the seasonal high-water table.

Geotechnical Laboratory Soil Testing - Soils samples collected as part of geotechnical investigations characterize the soil properties including natural moisture content, plasticity characteristics, particle size distribution, and analytical results for contaminates. It is beneficial if geotechnical investigations include recommendations regarding soil disposal alternatives. The information can be used in the interpretation of in-situ infiltration testing results and the selection of geotextile properties as part of subsequent detailed design.

Resilient Modulus Soaked California Bearing Ratio (CBR) - If permeable pavements are proposed, specifically permeable interlocking concrete pavers (PICP) etc, determination of the resilient modulus or soaked CBR of the native soils must be included to determine the base and sub-base requirements to ensure adequate structural strength for users.

In-situ Infiltration Testing - is required to characterize the hydraulic properties of the existing native material on-site. The designer of the LID shall ensure a qualified professional conducts in-situ saturated hydraulic conductivity testing within the area of the proposed LID. The measurements shall be taken in soils that are indicative of the proposed invert of the LID system. Approved field tests for estimating the infiltration rate of the native soil that include:

- Guelph permeameter test;
- Double-ring infiltrometer test;
- Borehole permeameter test; and
- Phillip-Dunn Infiltrometer

Other methods may be utilized upon approval by the Region of Peel based on professional judgement and experience of a qualified person. Testing shall be completed in compliance the *Low Impact Development Stormwater Management Planning and Design Guide - Appendix C Site Evaluation and Soil Testing Protocol for Stormwater Infiltration* for infiltration testing recommendations and ASTM D3385.

The resolution of the investigation (i.e. spacing between and quantity of test holes) should be such that sufficient information is collected for detailed design purposes. The table below describes recommended testing resolution.

Recommended Soil Boring and Test Pit

Surface area of the LID system (m^2)	Boreholes	Pits	Recommended In-Situ Infiltration Sites
< 100	1	1	1-2
100 to 500	2	2	3-5
500 to 1000	3	3	6-10
>1000	4	4	+11

Additional tests shall be conducted if local conditions indicate significant variability in soil type, geology, water table levels, bedrock or topography. Similarly, uniform site conditions may indicate that fewer tests are required. All testing shall be completed when native soils are not frozen or during frost conditions, with a minimum of 48 hours of no precipitation prior to testing.

3.4 Tree Inventories

Where a retrofit of an existing regional roadway or sites are proposed, a tree inventory shall be required. A tree inventory determines the trees that should be preserved and accommodated within the design or deemed eligible for removal. A certified arborist or botanist should conduct the tree inventory assessment. A comprehensive assessment will include the following information:

- Tree health
- Crown reserves
- Diameter at Breast Height (DBH) (minimum of 10 cm DBH for preservation)
- Record GPS coordinates or note approximate tree locations on available mapping.

4.0 STORMWATER MANAGEMENT REQUIREMENTS

Stormwater management techniques shall be implemented to the satisfaction of the Region of Peel, the local Conservation Authority and all concerned departments and agencies.

The following sections describe the stormwater management requirements for Quality Control; Runoff Volume Control; Quantity Control, Erosion Control and Water Balance (infiltration). The following criteria is for use in SWM planning and design and is intended to streamlines permitting and approvals with the relevant agencies involved in the construction and /or reconstruction of Regional Roads and site plans.

4.1 Stormwater Quality Control

Urban runoff carries surficial sediments and debris into receiving streams and watercourses which degrades water quality and impacts aquatic habitat conditions. In addition, metals and other pollutants adhere to particulate matter found in the stormwater runoff column which further degrades water quality. The importance of stormwater runoff quality in the Region of Peel is underscored by the fact that runoff can impact drinking water wells within the Region or it quickly finds its way to Lake Ontario which is a primary source of the Region's drinking water.

Requirements:

1. Ensuring stormwater management practices minimize stormwater contaminant loads and maintain or increase the extent of vegetative and pervious surfaces.

2. Where possible retain rural cross-section using low-impact development (LID).

3. Level 1 (80%) Level 1 Enhanced treatment through the long-term removal of 80% Total Suspended Solids (TSS)

Additional Water Quality Control Requirements within Endangered Species Habitat for Redside Dace and Jefferson Salamander:

4. Control of the runoff from the Regional specific 90th percentile rainfall volume using the control hierarchy. See **Section 4.2 - Volume Control** to limit discharges to 25mg/L above background stream level.

5. Thermal mitigation: To minimize thermal impacts, preventative measures (e.g. low-impact development practices) and mitigation measures should be applied to limit discharges to 24°C maximum

If implementing Recommended Volume Control Criteria:

If implementing Recommended Volume Control Criteria, the following shall satisfy the water quality requirements for the subject undertaking:

6. Control of the runoff from the Regional specific 90th percentile rainfall volume using the control hierarchy. See Recommended Volume Control Criteria
    - Reduction in pollutant load to the receiver by 80% or greater through the control of 90th percentile runoff event.

- 80% load reduction on an annual basis is equivalent to Level 1 Enhanced treatment through the long-term removal of 80% Total Suspended Solids (TSS).
- Stormwater shall not be discharged directly to the stream without treatment corresponding to the runoff generated from the 90th percentile event.

4.2 Recommended Stormwater Runoff Volume Control

Note: At time of release of this **Draft Public Works Stormwater Design Criteria and Procedural Manual (Version 2.0)**, the MECP Low Impact Development Stormwater Management Guidance Manual has not been formally released by the MECP, as such the following volume control targets are 'recommended'. Users are encouraged by the Region of Peel to apply the volume control criteria to realize synergistic benefits among other stormwater criteria, specifically water quality, erosion, water balance and quantity (flood) control).

Stormwater runoff from developed sites impacts streams and watercourses by introducing erosive forces during frequent storms. In addition, the alteration of the hydrologic regime from raw land reduces the amount of water that would naturally evaporate, transpire or infiltrate essentially generating more runoff volume. These impacts are the target of the requirement outlined within this section with the goal being to reduce stormwater runoff volume from developing sites. Practices implemented to address this criterion may assist in mitigating water quality impacts, erosion and water balance requirements, per the MECP and local Conservation Authority requirements.

Volume control to be recognized as providing a portion of the detention and/or peak flow requirement, as long as the volume control facilities are maintained for their function as designed. Practitioners shall be required to demonstrate through calculations or hydrologic modelling the storage quantity and/or the peak flow reductions associated with incorporating the required volume controls.

Volume controlled shall be recognized as providing benefits to water quantity (detention and/or peak flow requirement), water quality impacts, erosion and water balance requirements. It is not the intent of the Region of Peel to require redundant SWM infrastructure.

Requirement:

1. Control of the runoff from the Regional specific 90th percentile rainfall volume (27-28mm) per **Figure 4.2**) using the Control Hierarchy (see **Section 4.2.1**):

    a) Priority 1 –Volume Retention (infiltration, re-use and/or ET) using LIDs to satisfy the pre-development water balance requirements.
        - Minimum post development recharge of the first 5 mm for any precipitation event. See **Sections 4.4 and 4.6 - Erosion and Water Balance**.

    b) Priority 2 – LID Volume Capture and Release using LIDs filtration techniques.
        - Treat remainder of 90th percentile rainfall volume (27-28mm) not retained using Priority 1 measures to enhance water quality and reduce runoff volumes. See **Section 4.1 - Water Quality** and **Section 4.4 Erosion**.

    c) Priority 3 – Volume Capture and Release using OGS, dry-ponds, wet-ponds and/or wetlands.

- Treat remainder of 90th percentile rainfall volume (27-28mm) not retained or filtered using Priority 1 and Priority 2 measures respectively to enhance water quality and reduce runoff volumes. See **Section 4.1 - Water Quality** and **Section 4.4 Erosion**.

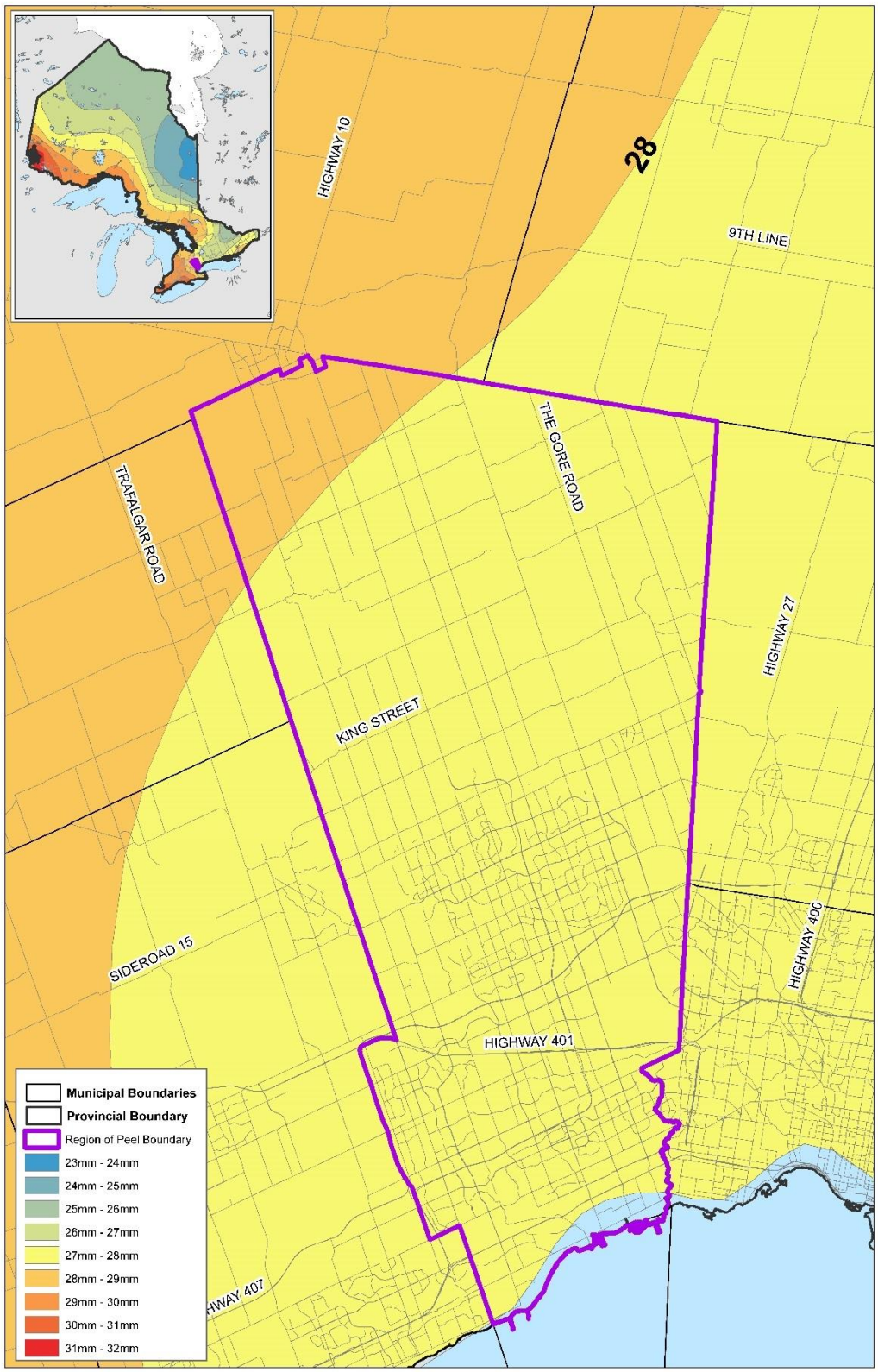


Figure 4.2 - 90th Percentile Rainfall Volume Target (27-28mm) for the Region of Peel per the Draft MECP Low Impact Development Stormwater Management Guidance Manual (Pending)

4.2.1 Control Hierarchy

A control hierarchy has been proposed whereby stormwater management practices are preferentially selected to control the 90th percentile rainfall volume (27-28mm) per **Figure 4.2**; which:

- Begin with better site design (see **Section 5.20.2**)
- Utilize natural systems and preserve existing natural systems;
- Create multifunctional landscapes that achieve goals and objectives beyond stormwater management to include broader community goals of livability and sustainably as well as environmental protection objectives;
- Contribute to water sustainability across the watershed to reduce the use of resources including potable water; and
- Provides climate change co-benefits. A co-benefit is an action or a technology that is designed to both reduce greenhouse gas (GHG) emissions and reduce vulnerability to climate impacts in the future. When something contributes to both climate change mitigation and adaptation, it is a climate co-benefit (see **Section 7.0**).

The control hierarchy for application includes the following priorities in keeping with the above noted rationale. While the control hierarchy provides inherent flexibility in the types of SWM BMPs which can be used, it shall be a requirement by the Region of Peel that the practitioner document the selection process of treatment approaches from priority 1 approaches to priority 3 approaches, explicitly describing the site restriction or constraints which prevented the implementation including all relevant supporting documentation as required.

1. **Control Hierarchy Priority 1 (Retention)** – LID retention technologies which utilize the mechanisms of infiltration, evapotranspiration and or re-use to recharge shallow and/or deep groundwater; return collected rainwater to the atmosphere and/or re-use collected rainwater for internal or external uses respectively. The target volume is controlled and not later discharged to the municipal sewer networks (with the exception of internal water re-use activities) or surface waters and does not therefore become runoff.

   Priority 1 BMPs shall be applied to meet local water balance requirements and are encouraged to be applied to the maximum level possible given the on-site conditions and the local environmental considerations. **Priority 1** BMPs:

   - Reduce runoff volumes
   - Provide less variable pollution control as pollutant loads to receivers are reduced through runoff volume reductions (infiltration, evapotranspiration and re-use) as compared to approaches which rely on removal efficiencies (i.e. % removal)
   - Prevent urban flood by increasing the sewer capacity by reduced volume and peak flows, as well as delayed time-to-peak;
   - Maintain the pre-development water balance;
   - Contribute to stream baseflow and mitigation of thermal impacts to urban streams; and
   - Preserve groundwater quantity and levels.

2. **Control Hierarchy Priority 2 (LID Volume Capture and Release)** – LID filtration technologies which utilize filtration to filter runoff using LIDs with appropriate filter media per the LID Stormwater Planning and Design Guide (wiki.sustainabletechnologies.ca as amended from time to time). The controlled volume is filtered and released to the municipal sewer networks or surface waters at a reduced rate and volume (a portion of LID Volume Capture and Release may be infiltrated or evapotranspirated).

   Priority 2 BMPs shall be applied to the maximum level possible given the on-site conditions and the local environmental considerations: **Priority 2** BMPs:

   - Reduce runoff volumes (LID filtration controls have been demonstrated to provide runoff volume reductions irrespective of the ability to infiltrate through absorption, material wetting and increased depression storage).
   - Provide less variable pollution control as pollutant loads to receivers are reduced through runoff volume reductions as compared to approaches which rely on removal efficiencies (i.e. % removal)
   - Provide additional water quality benefits result from treatment process of filtration which may also include pollution adsorption and sedimentation;

3. **Control Hierarchy Priority 3 (Other Volume Detention and Release)** – Other stormwater technologies which utilize filtration, hydrodynamic separation and or sedimentation (i.e. end-of-pipe facilities) to detain and treat runoff using an appropriate filter media per industry standard verification protocols; separate contaminates from runoff; and/or facilitate the sedimentation and removal of contaminants respectively. The controlled volume is treated and released to the municipal sewer networks or surface waters at a reduced rate.

   Priority 3 BMPs shall be applied such that the Regional specific 90th percentile rainfall volume (27-29mm) is satisfied and that other SWM criteria i.e. water quantity control, erosion control etc. are also satisfied. **Priority 3** BMPs:

   - Provide additional water quality benefits result from treatment process of filtration (which may also include pollution adsorption and sedimentation), separation of pollutants from runoff or sedimentation;

4.3 Stormwater Quantity (Flood) Control

Flooding that occurs through the storm drainage network, whether it be through a surcharged storm sewer or excess of flows backing up a creek, can cause impacts to large areas of public and private property as well Regional Infrastructure and the local watercourses. In order to help mitigate this and reduce the chance this may occur, the Region of Peel shall require stormwater quantity control, which echo the Conservation Authority flood control requirements in many cases, to reduce stormwater peak flow runoff from developing sites.

Requirements:

Post to Pre-control of peak flows of 2 to 100-year design storms to the appropriate Watershed Flood Control Criteria and/or local requirement. Where Watershed Flood Control Criteria does not exist, at a minimum, post-development flows must be equal to pre-development.

Post development flows shall not:

a) Adversely affect the performance of downstream Region of Peel infrastructure,
b) Negatively impact adjacent properties,
c) Exacerbate or increase the downstream flood or erosion risk.

Flood Control per CA's Jurisdiction: Consult agency's SWM criteria document or other as required.

- Credit Valley Conservation (CVC) Watershed
- Toronto and Regional Conservation Authority (TRCA) Watershed
- Lake Simcoe Region Conservation Authority (LSRCA) Watershed
- Nottawasaga Valley Conservation Authority (NVCA) Watershed
- Halton Conservation Authority (HC) Watershed

4.4 Erosion and Sediment Control

Erosion and sediment control measures should be implemented during construction projects to protect water quality. Adhering to CSA W202 (Erosion and Sediment Control, Inspection and Monitoring) is recommended, especially when there is the potential to impact the receiving watercourse.

4.5 Stormwater Erosion Control

Watercourse erosion is cause by Hydromodification. Hydromodification affects the elements of natural channel form that can lead to watercourse destabilization and destruction of aquatic habitat. Hydromodification is made up of three (3) key concepts as outlined in the table below.

Key Concepts in Watercourse Erosion

Hydromodification Component	Stromwater Relevance	Description, Rationale or Outcome
Magnitude	Peak flow rate	Excessive erosion occurs post-development, even with the inclusion of 'traditional' erosion controls because peak flow management often results in flows that are in excess of the watercourse erosion thresholds for prolonged periods of time when compared to pre-development.
Duration	Runoff volume	To mitigate the geomorphic impacts from development, runoff volumes must be prevented from increasing post development. Therefore, the pre-development water balance should be maintained.
Frequency	Number of Runoff Events	When dealing with watercourse erosion, the frequency of runoff events is important. It is during these frequent runoff events and corresponding watercourse flows (effective discharge) that the majority of the annual sediment load is conveyed. Stormwater techniques that are inherently designed to manage the smaller, more frequent rainfall events are highly effective at reducing runoff frequency, thereby reducing watercourse erosion.

Requirements:

1. Avoid increases in the amount of surface runoff during rain storms (i.e., stormwater) causing streams to become wider and more unstable as erosion of the banks occurs and increased sediment enters the streams as result of the erosion of the banks. Therefore:

a) At a minimum retain 5 mm on site where conditions do not warrant the detailed analyses.

b) If a site drains to a sensitive creek, or a subwatershed study, MESP or EIR is required, then the proponent must complete a geomorphologic assessment study to determine the erosion threshold. The proponent may need to consult the appropriate CA for direction on how to identify whether the creek is sensitive.

c) For sites with SWM ponds and sites which directly discharge to a watercourse, 25mm- 48hr detention may also be required, depending on the results of the erosion assessment.

4.6 Water Balance

Water balance is defined as the mass balance accounting for water entering, accumulating and exiting a system. It can include rainwater, potable drinking water, evapotranspiration and infiltration, wastewater and stormwater.

In many cases, even small incremental changes in watershed hydrology commensurate with an increase in impermeable surfaces of 4%, can result in changes to stream channel characteristics and aquatic communities. To offset these impacts, an increased emphasis on maintaining natural water balance and replicating the predevelopment hydrologic cycle is required. The maintenance of water balance can serve to protect groundwater recharge and discharge functions, including local groundwater infiltration volumes, patterns, and flows to wetlands and streams as well as preserve local water supply aquifers.

Requirements:

1. Stormwater management should mimic pre-development hydrologic regimes by incorporating a 'treatment-train' approach and low-impact development (LID) source and conveyance controls. To the greatest extent possible, the pre-development water balance should be maintained, returning precipitation volume to the natural pathways of runoff, evapotranspiration and infiltration in proportions which are in keeping with the watershed conditions prior to development. For the purpose of this manual, maintaining the pre-development water balance requires each development to match the infiltration volume on an annual basis based on a site-specific assessment, acknowledging that ET is variable pre vs. post development and that full runoff control may not always be possible.

2. Mandatory requirement to meet the pre-development water balance using LID Retention (Priority 1) for Significant, Ecologically Significant, High and Medium Volume Groundwater Recharge Areas (SGRA, EGRA, HGRA and MGRA) as well as endangered species habitat. Site specific water balance analyses is required.

3. For Low Volume Groundwater Recharge Areas (LGRA), provided the site does not impact a sensitive ecological feature, or require a subwatershed study, or EIS, the proponent has the option to:

    a) provide a minimum post development recharge of the first 5 mm for any precipitation event; or
    b) complete a site-specific water balance to identify pre-development groundwater recharge rates to be maintained post-development

4. For natural features (woodlands, wetlands, watercourses) maintain hydrologic regimes and hydroperiods. The proponent should determine with the appropriate conservation authority whether a feature-based water balance is required.

Additional Water Balance Requirements within Endangered Species Habitat for Redside Dace and Jefferson Salamander:

5. Post development water balance to match predevelopment water balance in order to protect the natural hydrological functions of streams.

6. Retention (no storm run-off from rainfall events in the range of 5 – 15 mm (depend on the recommendations set forth in the subwatershed plan and on the in-situ soil permeability).

4.7 SWM Requirements for Road Reconstructions

For all Linear Development, Volume Control requirements, are recommended by the Region of Peel. See **Section 4.2**). Linear Development projects are defined as "construction or reconstruction of roads, rail lines and transit infrastructure that are not part of a common plan of development or sale".

Recommended Requirements:

1. New linear projects without restrictions and subject to the approved Source Protection Plan, that results in the creation of impervious surface(s) and/or fully reconstructs the existing impervious surfaces, shall control per the mandatory control hierarchy the larger of the following:

    i. The runoff generated from the geographically specific 90th percentile rainfall event (**Figure 4.2)** from the new and/or fully reconstructed impervious surfaces on the site. The site shall be required to maintain the pre-development water balance.

    Or

    ii. The runoff generated from the geographically specific 90th percentile rainfall event (**Figure 4.2)** from the net increase in impervious area(s) on the site. The site shall be required to maintain the pre-development water balance.

Linear Development Volume Control Exemption

1. Roadway resurfacing (i.e. roadway projects which are primarily mill and overlay and other resurfacing activities) as well as trails and sidewalks, are not considered new linear projects and are exempt from but

are encouraged to undertake SWM retrofits to the activities Maximum extent possible (MEP). **Maximum Extent Possible (MEP)** shall be defined as the maximum achievable volume control, using all known, available and reasonable methods, given the site restriction. Excessive costs alone shall not be considered an acceptable constraint, instead practitioners are encouraged to explore and document alternative and innovative alternatives with a reduced implementation cost. Options considered and presented shall examine the merits of relocating project elements to address, varying soil conditions and other constraints across the site.

2. Minor roadway developments are exempt. Minor roadway developments are defined as changes to the roads that would result in minor changes to the impervious surfaces such as the following:

    a) Sliver widening (e.g. 3.66 m lanes being adjusted to 3.75 m width)
    b) Addition of turning lanes and interchange/intersection improvements
    c) Addition of entrance accesses
    d) Shoulder paving for short cycling network connections

4.8 Retrofits of Existing Sites and ROW

Stormwater retrofits, defined as: the voluntary construction of new and/or reconstruction of municipal stormwater infrastructure within an existing urban area, already serviced or inadequately serviced by stormwater infrastructure which provides a net environmental benefit. A stormwater retrofit cannot:

a) Be part of a common plan of development (i.e. subdivision, site plan, plan of condominium etc.)
b) Be described as new development, redevelopment, intensification and reurbanization; and
c) Require approval under the Planning Act.

Recommended Requirements:

For the voluntary construction of new and/or reconstruction municipal or non-municipal stormwater infrastructure within an existing urban area, including as part of road resurfacing project and / or trails and sidewalks construction, are encouraged to achieve volume control to the maximum extent possible (MEP) – See **Section 4.7** for the definition of MEP. A project can be considered a retrofit provided the following conditions are met:

a) The subject area is already serviced by or is inadequately serviced by stormwater infrastructure,
b) The stormwater retrofit can be demonstrated to provide a net environmental benefit,
c) The subject project can be implemented and is in compliance with the approved Source Protection Plan
d) The subject site or project is not part of a common plan of development as defined by the municipality (i.e. subdivision, site plan, plan of condominium etc.), cannot be described as new development, redevelopment, intensification and reurbanization and cannot require approval under the Planning Act.

Retrofit projects can include, but are not limited to, such projects as LID BMP implementation within parks, municipal buildings (community centres, arena, and administrative buildings), private building (commercial, institutional, or residential), private or public parking lots, road resurfacing projects, trails and sidewalk establishment or refurbishment.

5.0 DESIGN CRITERIA

5.1 General

For direction as to the process for the preparation of Preliminary and Detailed Stormwater Management Plans and Design, refer to the **Guidelines for the Preparation of Stormwater Management Reports in Support of Municipal Class Environmental Assessments (June 2004**). See **Section 3.1**.

The Region of Peel storm sewers are generally designed to convey runoff from the Right-of-Way (ROW) of a Regional Road (internal drainage areas) and external drainage areas which contribute to the ROW. Where possible, flows from outside the Regional road allowance are to be directed to the local municipality`s storm sewer system. No grading will be permitted within any Region of Peel ROW to support adjacent developments (Site Plans).

In the case of:

i. Rural Roads

   a. Low Impact Development approaches (dry swales aka bioswales, perforated pipe systems or other) in combination with ditches with corrugated steel culverts (or approved equivalents) shall be provided for the conveyance of storm water flow to the available outlet. For ditch design, follow MTO *Highway Drainage Design Standards (2008)* guidance based on road type. Ensure external flows are considered.

   b. The conversion of rural roads with a ditched cross-section to an urban road with an urban cross section (curb-and-gutter drainage) shall be avoided unless LID approaches are utilized to match or improve the overall environmental performance (water quality, quantity, erosion, runoff volume and water balance) or a site specific soil, groundwater, infrastructure or policy constraints exists which prevents the use of LIDs, consistent with the Stormwater Management Planning and Design Manual (MOE 2003), as well as the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC).

ii. Urban Roads

   a. Curb and gutters shall be used with catch basins and storm sewer in combination with LID approaches as part of a treatment train approach to stormwater management for the conveyance of storm water flow to the available outlet.

   b. Where a site specific soil, groundwater, infrastructure or policy constraints exists which prevents the use of LIDs, consistent with the Stormwater Management Planning and Design Manual (MOE 2003), as well as the LID Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the LID Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC); curb and gutters shall be used with catch basins and storm sewer in combination with other stormwater technologies which utilize filtration, hydrodynamic separation and or sedimentation (i.e. end-of-pipe facilities) to detain and treat runoff using an appropriate filter media per industry standard verification protocols; separate contaminates from runoff; and/or facilitate the sedimentation and removal of contaminants respectively for the conveyance of storm water flow to the available outlet.

5.2 External Drainage

All external lands that drain to a Region stormsewer must conform to the following:

c) Post- development flow must be equal to or less that than pre-development levels,
d) Drainage shall not adversely affect the performance of downstream Region of Peel infrastructure,
e) Drainage shall not exacerbate or increase the downstream flood or erosion risk.
f) Drainage from construction activities shall not increase sediment loadings to downstream Region of Peel infrastructure (LID or other) or local waterways.

5.3 Dual Drainage Considerations

The accepted best practice for the collection of urban storm drainage systems consist of two separate and distinct systems—the minor system and the major system. This two-system approach is called a "dual drainage system". **Section 5.4** describes the Minor System, while **Section 5.7** describes the major system.

5.4 Minor System Design

The minor system consists of ditches, underground storm sewer system and Low Impact Development (LID) approaches which provides the first response level of protection by conveying flows from the more frequent, lower intensity rainstorms, with minimal overland flow for traffic convenience.

Flow to the minor system is restricted to the capacity of the pipes, LID and associated appurtenances. The minor system shall be designed to accommodate a 10-year storm (see **Section 6.0**) with a 10-minute inlet time (Time of Concentration) for the roadway right-of-way only.

5.4.1 Minor System - Allowable Flow Spread on Regional Roads

The typical allowable flow spreads are as follows:

Type of Road	Minor System Design Storm Criteria	Criteria to Follow [3]
All	25mm	No surface ponding
Collector	10-year	No barrier curb overtopping.[1] Flow spread must leave at least one lane free of water.
Arterial	10-year	No barrier curb overtopping.[1] Flow spread must leave at least one lane free of water in each direction.
Highway	10-year	No encroachment is allowed on any traffic lanes.
Road underpass	10-year	No barrier curb overtopping.[1] Flow spread must leave at least one lane free of water in each direction.[2]

[1] When no barrier curb exists (i.e. ditches or LIDs), encroachment onto adjacent private property is not to occur (including under 100-year storm). Minimum freeboard of 300 mm under minor system design storm.

[2] For road underpasses of importance and or on a case-by-case basis alternate means such as pumping or an independent gravity flow system may be considered to increase the storm level of protection beyond the minor system capacity.

[3] Flow across road intersections shall not be permitted for minor storms (1:10 year).

5.5 Storm Sewers Requirements

For storm sewers, the length, slope, size of pipe, pipe material, class of pipe and inverts at all connections must be shown. Requirements for ditches can be found within **Section 5.6**.

5.5.1 Storm Sewers

A storm sewer system shall be defined as the upper part of a drainage system draining areas less than 100 ha of land. Storm sewer systems shall be designed to accommodate a 10-year return frequency storm and shall be designed to not surcharge during this storm event.

Sewer service connection shall be in accordance with Region of Peel standards and with OPSD 1006.02. Designers are to provide the Region with calculations and a certificate that an analysis has been completed, given:

a. The site conditions
b. Water table elevation
c. Trench width
d. Proposed bedding
e. Manufacturer H.D.B. rating identifying that pipe materials are stress rated

To ensure that all forms of flexible pipe failure have been addressed and that a factor of safety of 1.75 has been achieved. The typical types of pipe failure are as follows:

i. Wall thrust, i.e., buckling of walls at spring line
ii. Ring buckling - caused by hydrostatic pressures, normally identified as collapsing in the bottom quadrants of the pipe
iii. Joint failure
iv. Wall distress, i.e., strain cracking
v. Wall deformation
    a) Ring deflection, i.e., 5% elliptical deflection.
    b) Irregular distortion normally identified as inverse curvature within the top of the pipe.

5.5.2 Trunk Sewers

A trunk sewer system shall be defined as part of a drainage system that drains an area of 100 ha of land or greater. Trunk storm sewer systems shall be designed to accommodate a 25-year storm.

5.5.3 Pipe Capacities

Manning's formula shall be used in determining the capacity of all storm sewers. The capacity of the sewer shall be determined on the basis of the pipe flowing full.

The value of the roughness coefficient 'n' used in the Manning's formula shall be as follows:

Material	Roughness Coefficient
Concrete Pipe	0.013
Concrete box culverts	0.013
Corrugated Metal 68 x 13mm corrugations	0.024
Corrugated Metal 25% paved invert	0.021
PVC Pipe	0.013
High density polyethylene (HDPE)	0.013

5.5.4 Pipe Size

The minimum allowable size for a storm sewer will be 300 mm diameter. Where LIDs are proposed as the minor system in place of a storm sewer, the minimum subdrain or underdrain size shall be 200mm diameter.

5.5.5 Minimum & Maximum Velocity

The minimum full-bore velocity permitted in storm sewers will be 0.75metre/second. The maximum full-bore velocity permitted in storm sewers will be 4 metres/second. Where velocities in excess of 3 metres/second are proposed, additional design factors shall be taken to protect against pipe displacement, scouring, erosion, and hydraulic jumps. Supercritical flow should not occur.

5.5.6 Minimum Grades

The minimum grade on a 300 mm diameter storm sewer will be 0.5%. If conditions require a slope of less than 0.5%, then self-cleaning velocities must be maintained. For replacement of pipe sections of existing storm sewer systems, a minimum flow velocity of 0.8 metre/second shall be achieved.

5.5.7 Radius Pipes

Radius pipe shall be allowed for storm sewers 975mm in diameter and larger provided that a manhole is located at the beginning or at the end of the radial section. The minimum centre line radius allowable shall be in accordance with the minimum radii table as provided by the manufacturers.

5.5.8 Sewer Alignment

Storm sewers shall be laid in a straight line between manholes unless radius pipe has been designed. The maximum change in direction for pipe sizes 675 mm and larger is 45 degrees. For 675 mm and larger diameter pipes where the change in direction is greater than 45 degrees, additional maintenance holes 1200 mm in diameter will be required to reduce the angle.

5.5.9 Changes in Pipe Size

No decrease of pipe size from a larger upstream to a smaller size downstream will be allowed regardless of the increase in grade.

5.5.10 Frost Protection

Frost protection is required where cover is less than 1.2 metres from the pipe obvert to grade. The designer shall delineate extent of insulation on plan and provide a dimensioned detail. Frost protection may not be possible and/or required for perforated pipe systems, subdrains and underdrains. The designer shall evaluate the potential for frost penetration and provide recommendations based on the intended design and systems function.

5.6 Ditches

Simple grass channels or ditches have long been used for stormwater conveyance, particularly for roadway drainage. For ditch design, practitioners are to follow MTO *Highway Drainage Design Standards (2008)* guidance based on road type. Ensure external flows are considered.

Ditches and grass channels shall be designed per the following:

Ditches and Grass Channels	Minimum Velocity	Maximum Velocity
Grass lined – Natural	0.7 m^3/s	1.5 m^3/s †
Grass lined – maintained	0.7 m^3/s	1.5 m^3/s †
† if maximum velocity is exceeded, use of check-dams or baffles can be applied, however conveyance capacity must be maintained. See Enhanced Grass Swale LIDs		

5.7 Major System Design

The major system, which consists of specially engineered overland flow routes along the street network, swales, high capacity water courses and so on, is designed to convey runoff from the less frequent high intensity storm events that are in excess of the minor system design capacity to an engineered receiving point. Grading must be completed such that an overland flow route is maintained assuming all mechanical systems fail. This route must be clearly identified on the drawings including the ultimate outlet of the overland flow route (i.e. watercourse or roadway). The maximum ponding depths as outlined in section must not be exceeded

5.7.1 Major System - Allowable Flow Spread on Regional Roads

The typical allowable flow spreads are as follows:

Type of Road	Major System Design Criteria	Criteria to Follow
Collector	Greater than 10-year up to 100-year	Maximum depth of flow shall be the lesser of 10 cm above the crown of the road or the water level up to the right-of way.
Arterial	Greater than 10-year up to 100-year	No barrier curb overtopping.[1] Flow spread must leave at least one lane free of water in each direction. Preferred Criteria: no greater than 150 mm under 100-year storm event.
Road underpass	Greater than 10-year up to 100-year	Since there is no overland flow route possible, water can be expected to accumulate for the event.[2]

[1] When no barrier curb exists (i.e. ditches or LIDs), encroachment onto adjacent private property is not to occur (including under 100-year storm). Minimum freeboard of 300 mm under minor system design storm.

[2] For road underpasses of importance and or on a case-by-case basis alternate means such as pumping may be considered to increase the storm level of protection beyond the minor system capacity.

5.8 Pipe Specifications

Pipe material shall be as per the latest Region of Peel material specifications and standard drawings. All storm sewer pipes shall conform to the requirements of the Canadian Standards Association (CSA). Both rigid and flexible pipe are permitted in the construction of storm sewer systems including service connections and catch basin leads. These materials include:

- Reinforced concrete (RC),
- High density polyethylene (HDPE) – smooth interior dual wall pipe only
- Polyvinyl chloride.

The bedding design must be compatible with the type of pipe material used. Approved pipe material is detailed in the Approved Products List, available from www.peelregion.ca**.** Pipe class will be selected to suit the bedding class and height of fill. The minimum pipe class for reinforced concrete storm sewer will be 65-D.

Storm Sewer Preferred Materials Table

Diameter	Application	Preferred Material
Less than or equal to 375mm	Storm sewer	PVC, HDPE or RC
Equal or greater than 450 mm	Storm sewer	RC
Less than or equal to 375mm	Low Impact Development (perforated subdrain or underdrain)	PVC, HDPE
Equal or greater than 450 mm	Low Impact Development (perforated subdrain or underdrain)	HDPE

Pipe materials for storm sewer mainline, fittings, and leads will be CSA certified and according to the following:

Concrete Sewer Pipe and Fittings – Up to and including 900mm diameter

Circular concrete pipe and fittings will conform to OPSS 1820 and will be manufactured at a plant certified under the Ontario concrete plant prequalification program. All pipes will be marked with a "Prequalification Stamp" (triangular symbol) as detailed in the Approved Products List, available from www.peelregion.ca. Non-reinforced concrete pipe will be according to CSA A257.1. Reinforced concrete pipe will be according to CSA A257.2. Joints and gaskets will be according to CSA A257.3.

Concrete Sewer Pipe and Fittings – Larger than 900mm diameter

Circular concrete pipe and fittings will conform to OPSS 1820 and will be manufactured at a plant certified under the Ontario concrete plant prequalification program. All pipes will be marked with a "Prequalification Stamp" (triangular symbol) as detailed in the Approved Products List, available from www.peelregion.ca. Reinforced concrete pipe will be according to CSA A257.2. Joints and gaskets will be according to CSA A257.3.

Solid PVC Sewer Pipe and Fittings

Circular Solid Wall PVC pipe and fittings complete with bell and spigot joints, rubber gasket, lubricant and all other necessary appurtenances will be manufactured according to OPSS 1841 and certified to CSA B182.2 for PVC sewer pipe and fittings as described in the Approved Products List, available from www.peelregion.ca. PVC pipe will have a minimum pipe stiffness of 320 kilopascals (DR 35). When a PVC sewer is installed into a maintenance hole, one of the following methods is to be used:

i. Couplings providing an elastomeric gasket seal are to be grouted into the maintenance hole wall.
ii. A manufactured length of PVC pipe that has been softened with solvent and covered with sand for adherence to grout in the maintenance wall.

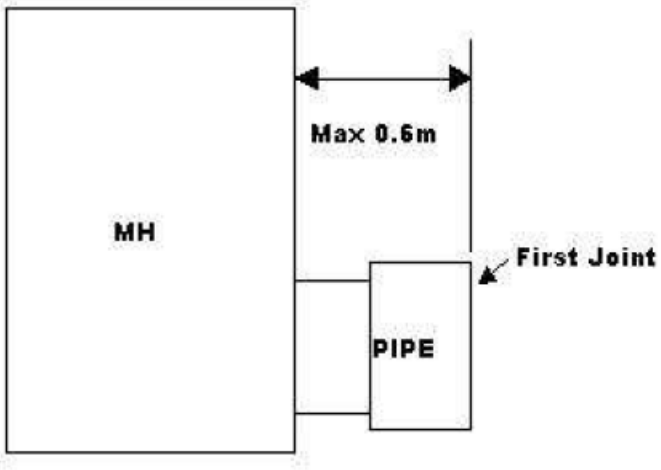
Solid Wall PVC pipe 450mm diameter and larger will meet ASTM F679 (T-11) in addition to the above-mentioned specifications.

Profile (Ribbed) Wall Sewer Pipe and Fittings

Circular Profile (Ribbed) Wall PVC pipe and fittings complete with bell and spigot joints, rubber gasket, lubricant and all other necessary appurtenances will be manufactured according to OPSS 1841 and certified to CSA B182.4 and ASTM F 794 for PVC sewer pipe and fittings as described in the Approved Products List, available from www.peelregion.ca. PVC pipe will have a minimum pipe stiffness of 320 kilopascals (DR 35). When a PVC sewer is installed into a maintenance hole, one of the following methods is to be used:

i. Couplings providing an elastomeric gasket seal are to be grouted into the maintenance hole wall.
ii. A manufactured length of PVC pipe that has been softened with solvent and covered with sand for adherence to grout in the maintenance wall.

The maximum distance to the first joint from the maintenance hole wall when using PVC pipe shall be 0.60 m (see diagram). Special care shall be taken in compacting the over-excavated area at the maintenance hole wall. As an alternative, concrete fill may be used to 100 mm below the sewer invert. Standard bedding is then used for the remainder.



HDPE Sewer Pipe and Fittings

Circular PE pipe and fittings complete with bell and spigot joints, rubber gasket, lubricant and all other necessary appurtenances will be manufactured according to OPSS 1840 using virgin resin and will be certified to CSA B182.8 for pipe to be installed through Manholes in a continuous fashion as per manufacturers recommendation. ASTM F894 certification will apply for corrugated outer wall and smooth interior walls (a.k.a closed profile pipe) as described in the Approved Products List, available from www.peelregion.ca, for polyethylene sewer pipe and fittings for non-pressure applications. Circular PE pipe and fittings will have a minimum pipe stiffness of 320 kilopascals and 100 kilopascals gasketed joints.

Perforated Pipes, Subdrains, Underdrains and Fittings

Subdrains and fittings fall within three main categories; Corrugated High Density Polyethylene, 150 mm HDPE and Polyethylene pipes as detailed in the Approved Products List, available from www.peelregion.ca.

i. Corrugated High-Density Polyethylene Circular pipes and fittings will be certified to ASTM F405, ASTM F667 and AASHTO M0294.
ii. HDPE subdrains and fittings with 150mm diameter will be certified to AASHTO M-252 standards.
iii. Polyethylene Pipes with 100mm to 600mm diameter will conform to ASTM F405 specifications.

Gaskets in Contaminated Soil Conditions

Prior to specifying the pipe material, the soils should be assessed for contamination. Upon determination that there is contamination, even in trace amounts, the longevity of ordinary gaskets becomes a concern. When locating sewer pipes, rubber gasket inserts, and service lines in areas of soils contaminated with hydrocarbons, nitrile gaskets will be specified in the area of contamination. Drawings must show locations of all nitrile gaskets.

5.9 Pipe Bedding

The type and classification of storm sewer pipe and the sewer bedding type shall be clearly indicated on all profile drawings for each sewer length. Storm sewers shall be installed with bedding as per Region Standards detailed in the Public Work Design, Specifications & Procedures Manual.

The class of pipe and the type of bedding shall be selected to suit loading and proposed construction conditions. In general, the Type "B" bedding (crushed stone base with granular over the sewer) shall be used for storm sewers, and the class of pipe will be selected to suit this bedding detail.

The bedding design must be compatible with the type of pipe material used.

- Rigid pipe bedding will be as per OPSD 802.030, 802.031, 802.032, 802.033 and 802.034.
- Flexible pipe bedding will be as per OPSD 802.010, 802.013 and 802.014.
- Perforated subdrain or underdrain will be per the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca)

The use of an HL8 stone or 6mm Washed Crushed Gravel (self compacting) sewer bedding is allowed on a per project basis. Approval in writing is required from the Region of Peel in advance before this material may be used. All clear stone must be completely wrapped in a suitable geotextile selected and installed in accordance with the manufacturer's requirement.

The width of trench at the top of the pipe must be carefully controlled to ensure that the maximum trench width is not exceeded unless additional bedding or higher strength pipe is used.

Appropriate measures should be followed to reduce the creation of preferential pathways through services installation.

5.10 Minimum Depth of Cover

The minimum depth of a storm sewer on roadways will be 1.5 metres measured from the centre line road elevation to obvert of the pipe. For storm sewers located in open space such as parks, the minimum depth of cover will be 1.2 metres from finished ground elevation to obvert of the pipe.

5.11 Maximum Depth of Cover

Maximum depth of cover for concrete pipe will be in accordance with OPSD 807.010, 807.030 and 807.040. For PVC gravity sewer pipe, the maximum cover will be in accordance with OPSD 806.040. For HDPE perforated or solid pipe, the maximum cover will be in accordance with the manufacturer.

5.12 Location and Alignment

The preferred location for storm sewers will be located 1.5 metres—as measured from the centre line of pipe—on either the south side or the west side of the road centre line in a separate trench unless a conflict with other utilities requires a revised location. Storm maintenance holes must be located within the asphalt area of the road for maintenance purposes. Alternative locations and alignments may be used upon approval from the Region of Peel.

Exceptions will occur on curved streets, as well as for roadways designed with LIDs where the location and alignment will be dependant on the selected LID and whether infiltration of runoff is proposed.

5.13 Separation

The minimum distance between new parallel sewers in separate trenches will be 3 metres as measured from centre line of pipe to centre line of pipe. Exceptions can be made for site specific design constraints and depths as in the case of dual maintenance holes installations.

It is preferred that a one metre minimum separation from outside wall to outside wall will be provided to permit installation of service connections and the future maintenance of the underground servicing.

5.14 Maintenance Holes

Maintenance holes will be located at each change in alignment, pipe size, grade, material and at all pipe junctions, at the beginning or end of radius pipe sections and at intervals along the pipe to permit entry for maintenance to the sewer. Maintenance holes may be either precast or poured in place and shall conform to Region of Peel standards in the Public Work Design, Specifications & Procedures Manual or to current OPSD standards if no Region standards are available.

Although these standards provide details for maintenance holes up to certain maximum depths and sizes, the Consulting Engineer shall analyze, individually, each application of the standards related to soil conditions, loading and other pertinent factors to determine structural suitability. In all cases where the standards are not applicable, the maintenance hole shall be individually designed and detailed. A reference shall be made on all profile drawings to the type and size of storm maintenance holes. All storm maintenance holes shall adhere to the following criteria as detailed in the subsequent sections.

The engineer shall adhere to the following guidelines in the design and specification of maintenance holes:

- Openings shall be located on the side of the manhole parallel to the flow for straight run manholes, or on the upstream side of the manhole at all junctions.
- Endeavour to keep entrance and exit velocities equal. In order to reduce the amount of drop required, the engineer will try to restrict the change in velocity from one pipe to another in a maintenance hole to less than 0.6 metre/second.
- No acute interior angles will be allowed. The change in direction of flow in any manhole shall not be less than 90 degrees.
- No decrease in pipe diameter from a larger size upstream to a smaller size downstream will be allowed regardless of an increase in grade.
- The obverts on the upstream side of manholes shall not be lower than the obvert of the outlet pipe.

- When an increase in pipe size occurs at the downstream side of the storm maintenance hole, match obvert elevations of the incoming and outgoing pipes or have incoming pipe obverts higher than outgoing pipe obverts.
- Manholes shall be located, wherever possible, a minimum of 1.5m away from the face of curb and/or any other service.
- If the lead or lateral connection diameter is less than or equal to half the diameter of the main storm sewer, then a maintenance hole may not be required.
- Tee manholes are permitted on straight runs only.

Further specifications regarding maintenance hole constructions are detailed in the standard drawings of the Public Work Design, Specifications & Procedures Manual. All storm maintenance holes shall adhere to the criteria as detailed in the Public Work Design, Specifications & Procedures Manual.

5.14.1 Spacing and Size of Maintenance Holes

Generally, the maximum allowable horizontal spacing between maintenance holes shall be as follows:

Pipe Diameter	Maintenance Hole Spacing
300 mm–975 mm	110 m
1050 mm–1350 mm	130 m
1500 mm–1650 mm	160 m
1800 mm and larger	305 m

All sizing of storm precast maintenance holes are based on incoming and outgoing pipe sizes, The minimum diameter for a maintenance hole is 1200 mm. The type and size of the maintenance hole will be specified on the profile drawing. When any dimension of a maintenance hole differs from the current standard, the maintenance hole will be individually designed and detailed by the design engineer.

5.14.2 Maintenance Hole Frame and Covers

Maintenance hole frame and covers are required for all maintenance holes and shall conform with the applicable Region standards detailed in the Public Work Design, Specifications & Procedures Manual and the Approved Products List available from www.peelregion.ca, and OPSD 401.01. Maintenance hole chamber openings must be located on the upstream side of the maintenance hole.

Further specifications regarding maintenance hole appurtenances are detailed in the standard drawings in the Public Work Design, Specifications & Procedures Manual. All storm maintenance hole frames and covers shall adhere to the criteria as detailed in the Public Work Design, Specifications & Procedures Manual. The word “STORM” to be cast into cover with 50mm letters.

5.14.3 Maintenance Hole Safety Landings

When the depth from invert to top of the maintenance hole exceeds 5 metres, a safety platform will be provided as per Regional Standards in the Public Work Design, Specifications & Procedures Manual. Safety grates will not be more than 5 metres apart. The platform will be located 2 metres below the maintenance hole cover and 2.6 metres above the maintenance hole benching. For details and additional design information, see OPSD 404.020.

5.14.4 Benching

As per Regional Standards storm sewer maintenance holes shall be benched to the obvert of the outlet pipe on a vertical projection from the spring line of the sewer. All required benching works shall conform to the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual . Benching height will extend from the pipe obvert to improve hydraulic performance. Catch basin maintenance holes will not be benched so that a 0.3 metre sump remains.

5.14.5 Hydraulic Losses at Maintenance Holes

Suitable drops will be provided across maintenance holes to compensate for the energy losses due to the change in flow velocity and to accommodate the difference in depth of flow in the upstream and downstream sewers. In order to reduce the amount of drop required, the designer shall, wherever possible, restrict the change in velocity between the inlet and outlet pipes to 0.6 m/s.

When the pipe size does not change through a maintenance hole and the upstream flow velocity does not exceed 1.5 metres/second, the following allowances will be made to compensate for hydraulic losses.

Allowable Hydraulic Loses

Alignment Change	Required Drop
Straight Run (no change)	grade of sewer or 0.03 m
15°–45°	0.030 m – MECP minimum 0.075 m – preferred
45°–90°	0.06 m – MECP minimum 0.15 m – preferred
junctions and transitions [a]	MECP calculations

[a] For all junctions and transition maintenance holes and when the upstream flow velocity exceeds 1.5 metres/second, the drop required will need to be calculated using the MECP guidelines; "*Hydraulic Calculations for Junction and Transition Maintenance Holes*". Calculations for hydraulic losses will be included in the design submission.

Drop Maintenance Holes - Maintenance Hole Drop Structures shall conform with the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual. Drop maintenance holes shall be provided where the difference in invert elevation is greater than 1.2m. The drop pipe shall be one size smaller than the sewer line (minimum 300mm diameter). The economic feasibility of providing a deeper storm sewer instead of a drop maintenance hole shall be explored. The use of 45° bends and Y's for drops is acceptable. Drops through storm maintenance holes shall be calculated using the following formula:

$$\text{Velocity Head} = \frac{V^2}{2g}$$

90^{o} bends = ½ Velocity Head

45^{o} bends = ¼ Velocity Head

Where: g = 9.8 m/sec^2

5.14.6 *Pipe Connections to Maintenance Holes*

Pipe Connections to Maintenance Holes shall conform with the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual. Match obvert elevations of the incoming and outgoing pipes or have incoming pipe obvert higher than outgoing pipe obverts. Invert to invert connections will not be allowed. The connection of the sewer pipe at the maintenance hole will utilize a flexible joint for either rigid or flexible pipe. A concrete cradle may be used for rigid pipe.

Orifice controls may be used to control flow. For orifice diameters of 100mm or greater, an orifice tube shall be used. For diameters less than 100mm, a combination shall be used of an orifice plate with a minimum diameter of 75mm that discharges into a 100mm orifice tube.

5.14.7 Maintenance Hole and Catch Basin Specifications

Adjustment Units - Pre-Cast Concrete and Rubber adjustment units shall be manufactured according to material specification OPSS 1853. Shims shall be composed of HDPE and Polyethylene adjustment units will be manufactured according to OPSD 704.011.

Precast adjustment units will be laid in a full bed of mortar with successive units being joined using sealant as recommended by the manufacturer. A minimum of one adjustment unit will be installed with a minimum height of 75 mm. A maximum of four adjustment units be installed to a height not in excess of 0.3 meters.

Precast Maintenance Holes and Components – Precast maintenance holes shall be as manufactured in according to material specification OPSS 1351 and will be certified according to the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual, or CSA A257.4 and ASTM C-478 if no Region standard available, along with precast drop structures.

Pre-Benched Maintenance Holes will conform to the same specifications as Concrete Precast Maintenance Holes and shall be utilized for 200mm and 250mm inlet and outlet pipes only as detailed in the Approved Products List**.**

Maintenance Hole Frames and Covers - Maintenance hole frames and covers are manufactured and certified under the three following classifications as detailed in the Approved Products List, available from www.peelregion.ca:

i. Standard: Maintenance Hole Frame and Covers in this class shall be manufactured and certified in accordance with the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual, or OPSD 401.01 – Type A without lugs if no Regional standard is available..

ii. Water Tight: Maintenance Hole Frames and Covers in this class shall be manufactured and certified according to the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual, or OPSD 401.03 without lugs if no Regional standard is available, with the frame to be attached to the precast section as per the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual.

iii. Water Tight-Hinged: Maintenance Hole Frames and Covers in this class will be within the easements, outside of the ROW only and certified in accordance with the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual.

Flexible Rubber Connectors - Flexible rubber connectors for connecting pipe to maintenance holes can be either cast-in-place during the manufacture of the precast product, or installed into a cored or preformed hole in the finished maintenance hole. Both types shall be according to CSA A.257.3 and ASTM C923M-07.

5.15 Catch Basins

Catch basins will be provided to collect drainage from both pervious and impervious areas. Catch basins may be either precast or poured in place and shall be designed and constructed in accordance with the most recent O.P.S.D. and O.P.S.S. requirements. Catch basins located within the travelled portion of a roadway, shall have the frame elevation flush with the surface of the base course asphalt. The adjustment and setting of the frame and cover shall be completed in accordance with the details provided in the OPSD Standards.

The engineer will limit the number of catch basins connected to each section of sewer so that the minor system is not overloaded. Any special catch basins and inlet structures proposed for use as part of LIDs or other must be fully designed and detailed by the Consulting Engineer for approval by the Region of Peel.

5.15.1 Location

Catch basins shall be selected, located and spaced in accordance with the conditions of design. Typical catch basins locations include:

- at intersections,

- immediately upstream of sidewalk or pedestrian crosswalks when the road grade falls towards the intersection.

Catch basins will not be located within one metre of a driveway or walkway curb depression. Catch basins and its lead connections will be designed to capture the expected maximum flow. Double catch basins will be required when drainage is received from more than one direction.

5.15.2 Minimum Lead Diameter

For a single catch basin, the minimum catch basin lead connection diameter will be 200 mm and the minimum grade will be 1.0% (with 2% preferred). For double catch basins, the minimum lead connection diameter will be 300 mm and the minimum grade will be 1.0 percent (with 2% preferred). See **Section 5.16** for maximum permissible connection sizes for commercial and industrial lands.

5.15.3 Spacing

Catch basins should be provided at adequate intervals to ensure that the road drainage is able to be intercepted up to the capacity of the storm sewer which will be the basis to determine the type, location, and spacing of the catch basins. The spacing will vary with the road width, grade, and cross fall. The spacing will also be affected by the location of pedestrian crossing points, intersections, major depression points, driveway depressions, and so on. The recommended maximum spacing is as follows:

Maximum Catch Basin Spacing

Pavement Width	Grade < 4%	Grade > 4%
7.3m -8.5m	90m	60m
8.5m -9.8m	82m	55m
9.8m -12.2m	73m	50m
12.2m -14.0m	60m	40m

The desired maximum distance between catch basins from a crest in a road to a catch basin is 90 metres, measured along the curb line for each side of the road.

The maximum area to be serviced by any catch basin shall be 0.2 hectare (2000m^2) of paved area or 0.5 hectare (5000m^2) of sodded area.

5.15.4 Catch Basin Types

Single Catch Basin - Single catch basins will be constructed on all streets and within LID facilities.

Double Catch Basin - Double catch basins will be constructed at sag points when the catchment area is greater than 100 square metres and received from more than one direction in the road way or in cul-de-sacs.

Catch Basin Maintenance Hole – are not preferred by the Region of Peel as they do not provide any opportunity for sediment capture or pre-treatment. Use of catch basin manholes shall be permitted only when drainage is directed to a downstream stormwater management facility designed in conformance with the 2003 MOE Stormwater Planning and Design Guide. Use of catch basin manholes requires written approval from the Region of Peel.

Ditch Inlet Maintenance Holes/Catch Basins - Ditch inlet maintenance holes/catch basin will be constructed along regional roads which have ditch drainage or are designed as LIDs. For details and additional design information, see OPSD 702.040 Type 'A', and OPSD 702.050 Type 'B' or OPSD 705.030 and OPSD 705.040.

Catch Basin Inserts and Pre-treatment Devices – Internal catch basin inserts and /or pre-treatment devices are acceptable for use within catch basins. Proprietary treatment devices such as hydrodynamic separators should be ETV certified, per the Approved Products List, available from www.peelregion.ca.

5.15.5 Depth of Cover

The minimum depth of cover over a catch basin lead is 1.5 metres within the traveled portion of the road and 1.2 metres within the boulevard.

The maximum catch basin height measured from the top of grate to pipe invert shall not exceed 2.4m. Otherwise manhole-catch basins with 300mm sumps shall be used.

5.15.6 Frame and Grates

Cast Iron Side Inlet (preferred) - on Regional roadways OPSD-400.081 (latest version), Cast Iron, Curb Inlet Frame with Two Piece Raised Cover for Catch Basins shall be used.

Cast Iron Square Frame with Square Flat Grate - When design will not permit a side inlet catch basin, OPSD-400.100 (latest revision), Cast Iron, Square Frame, with Square Flat Grate for Catch Basins, Perforated Openings shall be used.

Cast Iron Square Frame with Square Flat Grate - To be used on catch basin maintenance holes in laneways and single and double catch basins on private property. For details and additional design information, see OPSD 400.020.

Galvanized Steel, Honey Comb Grate - To be used with a ditch inlet catch basin. For details and additional design information, see OPSD 403.010.

Cast Iron Square Frame with Beehive Grate - To be used with LID approaches for internal overflows within vegetated facilities (i.e. bioswales, bioretention facilities etc.). Laperle Grate JW-105B (square base beehive grate for OPSD 705.010 catch basin) or equivalent shall be used.

5.15.7 Catch Basin Specifications

Adjustment Units - Pre-Cast Concrete and Rubber adjustment units shall be manufactured according to material specification OPSS 1853. Shims shall be composed of HDPE and Polyethylene adjustment units will be manufactured according to OPSD 704.011.

Precast adjustment units will be laid in a full bed of mortar with successive units being joined using sealant as recommended by the manufacturer. A minimum of one adjustment unit will be installed

with a minimum height of 75 mm. A maximum of four adjustment units be installed to a height not in excess of 0.3 meters.

Precast Catch Basins - Precast catch basin (typically 600m x 600mm) shall be as manufactured in according to material specification OPSS 1351 and OPSD 702.040 as detailed in the Approved Products List, available from www.peelregion.ca**.**

Maintenance Catch Basin Frames and Covers –Maintenance catch basin Frames and Covers with Curb Inlet shall be as manufactured in according to material specification OPSS 400.081. Maintenance Catch basin Frames and Covers with Perforated Openings shall be as manufactured in according to material specification OPSS 400.100.

5.16 Storm Laterals

5.16.1 Residential Laterals

All residential connections shall be in accordance with the methods, specification and requirements as detailed within this document. The minimum diameter within the road allowance shall be 125 mm for a single connection and 150 mm for a double connection. If necessary, risers shall be provided for connection with the main sewer as per the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual. These risers are to be shown on the profile portion of the drawings. Grades of 1% minimum shall be used for laterals (with 2% preferred) subject to the maximum and minimum velocity criteria listed in Section 5.5.5. Onsite storage may be required to limit the discharge subject to the maximum pipe size of 250mm. Connections directly into maintenance holes shall be minimized and reviewed on an individual basis.

5.16.2 Commercial Laterals

All commercial connections shall be in accordance with the methods, specification and requirements as detailed within this document. In commercial areas, the maximum connection size shall be 250mm in diameter, installed with a minimum grade of 1% (with 2% preferred) subject to the maximum and minimum velocity criteria listed in Section 5.5.5. Onsite storage may be required to limit the discharge subject to the maximum pipe size of 250mm. The drop across the property line manhole shall be between a minimum of 0.03 m and a maximum of 0.2 m. The maximum depth is as required by design.

For commercial connections, a maintenance hole will be required if the lateral diameter is equal to or greater than half the diameter on the main line sewer, except for the conditions as noted in the **Storm Lateral Connection Matrix in Section 5.16.3** below.

If necessary, risers shall be provided at the main sewer and shown on the profile drawings as per the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual. Connection numbers are to be established prior to construction of the lateral.

5.16.3 Industrial Laterals

The maximum connection size shall be 250 mm diameter, installed on a minimum grade of 1% (with 2% preferred) subject to the maximum and minimum velocity criteria listed in Section 5.5.5. Onsite

storage may be required to limit the discharge subject to the maximum pipe size of 250mm. The drop across the property line manhole shall be between a minimum of 0.03 m and a maximum of 0.2 m.

For industrial connections, a maintenance hole will be required if the lateral diameter is equal to or greater than half the diameter on the main line sewer, except for the conditions as noted in the **Storm Lateral Connection Matrix** below.

If necessary, risers shall be provided at the main sewer and shown on the profile drawings as per the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual. Connection numbers are to be established prior to construction of the lateral. Pipe materials shall be in accordance with the Approved Products List, available from www.peelregion.ca.

Industrial & Commercial Storm Lateral Connection Matrix

Mainline Storm Sewer Diameter	Storm Lateral Diameter		
	150mm Ø	200mm Ø	250mm Ø
250 mm Ø*	Y	Y	Y
300 mm Ø	N	Y	Y
375 mm Ø	N	Y	Y
450 mm Ø	N	N	Y
525 mm Ø	N	N	N
> 525 mm Ø	N	N	N
MH Required = Y, MH not Required = N			
* Applies to existing pipes only, as minimum pipe diameter for new construction is 300mm per Section 5.5.4			

Service Connections and Fittings- PCV Service Connections complete with bell and spigot joints, rubber gasket, lubricant and all other necessary appurtenances will be white in colour and certified to CSA B182.1, with manufactured fittings certified to ASTM D 3034 standards as described in the Approved Products List, available from www.peelregion.ca. For new development connections extending services beyond property lines shall be certified and will comply with the applicable Region standard detailed in the Public Work Design, Specifications & Procedures Manual.

5.17 Culverts and Crossings

Storm crossings under a Regional Road shall meet the following criteria:

Driveway Crossings

Minimum 375mm diameter (inside diameter). Headwalls are preferred on driveway culverts. All culverts must be of sufficient length to provide for a minimum 3:1 slope off the driving surface to the ditch invert. All driveway culverts require entrance approval.

Roadway Crossing/ Major Crossing

Major crossings are to be designed per the table below and a hydraulic analysis shall be required. The minimum diameter for roadway crossings shall be 600mm. The frequency and magnitude of flooding or

erosion should not be increased on upstream or downstream properties. Minimum road freeboard of 1 m above minor system storm depth at culvert.

Pipe Crossing Design Flood Frequency Requirements

Road Classification	Design Storm Criteria	Other Criteria
Arterial	1:100 Year to Regional	See **Section 5.7.1:** No barrier curb overtopping.[1] Flow spread must leave at least one lane free of water in each direction.
Collector	1:50 Year	See **Section 5.7.1:** Maximum depth of flow shall be the lesser of 10 cm above the crown of the road or the water level up to the right-of way.
Urban Local	1:50 Year	Flow spread must leave at least one lane free of water in each direction.
Rural Local	1:25 Year	See **Section 5.4.1:** Encroachment onto adjacent private property is not to occur.
Driveway	1:10 Year	n/a

[1] When no barrier curb exists (i.e. ditches or LIDs), encroachment onto adjacent private property is not to occur (including under 100-year storm). Minimum freeboard of 300 mm under minor system design storm.

Culverts

Bridges and other major drainage structures shall require special designs and attention. Most culverts which are intended to permit passage of a watercourse, and sometimes wildlife, beneath a roadway will fall within the jurisdictions of the local Conservation Authority (see **Section 2.0**) regulated area and will require review and the acquisition of a permit pursuant to the Conservation Authority Act. In addition, watercourse crossings may be subject to approvals from the Ministry of Natural Resources and Forestry (see **Section 2.0**) if a species at risk has been identified; and / or the Department of Fisheries and Oceans (DFO) if in-water works are proposed.

Pre-consultation with the local Conservation Authority and /or MECP is required to:

- Define the Regulated Area limits;
- Obtain existing hydraulic models. If no hydraulic models exist, the proponent should develop one using the applicable Conservation Authority guidelines;
- Determine mitigation and compensation requirements pursuant to the Endangered Species Act (2007); and
- Define design criteria. The proposed watercourse crossing shall not result in any increase in water surface elevation for events corresponding to the 2-year to the Regional storm.

Culvert Pipe Specifications

Culvert pipe will be made of High Density Polyethylene (HDPE) and be certified to ASTM F894 as detailed in the Approved Products List, available from www.peelregion.ca. HDPE Culvert pipe will have a minimum pipe stiffness of 320 kilopascals (DR 35) and conform to CSA B182.8 specification standard.

5.18 Pipe Clearances – Watermain and Sanitary

The minimum clearances required when storm sewers cross other services will be measured from outside wall to outside wall of pipe. Where utilities cross watermain and sanitary services, a minimum clearance of

300mm must be provided between the top elevation of the lower pipe and the bottom elevation of the upper pipe.

Watermain Crossing - Clearances with respect to watermains as per MOE procedure F-6-1 are as follows:

Crossing Type	Minimum Clearance
Over or under a sanitary sewer	300 mm
Under a watermain 450 mm diameter or less	300 mm
Over a watermain 450 mm diameter or less	500 mm
Over or under a watermain greater than 450 mm diameter	500 mm

The minimum horizontal separation between a sewer and watermain is 2.5 metres. In cases where it is not practical to maintain separate trenches or the recommended horizontal separation cannot be achieved a deviation may be allowed. Under normal conditions, watermains will cross above sewers with sufficient vertical separation to allow for proper bedding and structural support of the watermain and sewer main. Where it is not possible for the watermain to cross above the sewer (perforated or otherwise), the watermain passing under a sewer will be protected by providing:

- A vertical separation of at least half metre between the invert of the sewer and crown of the watermain.
- Adequate structural support for the sewers to prevent excessive deflection of joints and settling.
- That the length of water pipe be centred at the point of crossing so that the joints will be equidistant and as far as possible from the sewer.

Refer to MOE procedure F-6-1 “Procedures to Govern the Separation of Sewers and Watermains.”

A minimum clearance of 0.6 metre between the obvert of the sanitary sewer and the invert of the storm sewer must be provided if any sanitary service connections are required to go under the storm sewer.

5.19 Camera Inspections

All storm sewers and catch basins must be cleaned and camera inspected prior to end of underground construction and /or maintenance. The sewers must be clear of all debris and obstructions and any damaged or leaking sewers must be cleaned and repaired. DVD’s of the repaired/cleaned sewer’s must be submitted to the Region of Peel to the end of underground construction and /or maintenance for review and acceptance.

5.20 Low Impact Development (LID)

Low Impact Development (LID) approaches. LID is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution, and promotes the use of natural systems for infiltration, evapotranspiration, and reuse of stormwater. These practices can effectively remove nutrients, pathogens, and metals from stormwater and they reduce the volume and intensity of stormwater flows.

SWM submissions to the Region of Peel should show that effort has been made to follow Low Impact Development (LID) approaches consistent with the requirements detailed within **Section 4.0.**

The Region of Peel shall strongly encourage and support the use of Low Impact Development (LID) approaches where no site specific soil, groundwater, infrastructure or policy constraints exist consistent with the Stormwater Management Planning and Design Manual (MOE 2003), as well as the Low Impact

Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC), as amended from time to time.

The design and specifications of LID approaches within the Region of Peel, shall be consistent with the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC); as amended from time to time.

5.20.1 Types of LIDs

LID features can be divided into the following general categories. The Region of Peel supports the use of LID features within Regional roadways and as part of site plans, provided they have been planned, selected and designed in accordance with the consistent with the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Optimizing Your Infrastructure Assets through Low Impact Development (CVC) guidance manuals, as amended from time to time. See **Appendix A.**

- Rainwater harvesting;
- Green roofs;
- Roof downspout disconnection;
- Soakaways, infiltration trenches and chambers;
- Bioretention;
- Vegetated filter strips;
- Permeable pavement;
- Enhanced grass swales (i.e. modified ditches);
- Dry swales (aka bioswales); and
- Perforated pipe systems

5.20.2 Better Site Design

The implementation of LID features within any development context begins not with the planning, selection or design of the individual LID BMPs themselves, but with the application of the principles of better site design.

There are more than a dozen better site design techniques which can be applied early in the design process at development sites. While not all of the better site design techniques will apply to every development site, the goal is to apply as many of them as possible to maximize stormwater reduction benefits before the use of structural LID BMPs. The application of better site design techniques is the most cost-effective means of achieving stormwater management targets, as many of the techniques are no-cost approaches, and some may in fact represent a potential cost saving. Better site design techniques include:

- Preserving natural areas and natural area conservation;
- Site reforestation;
- Stream and shoreline buffers;
- Open space design;
- Disconnecting and distributing runoff;

- Disconnection of surface impervious cover;
- Rooftop disconnection;
- Stormwater/ absorbent landscaping;
- Reducing impervious cover in site design including:
    - Narrower streets
    - Slimmer sidewalks
    - Smaller cul-de-sacs
    - Shorter driveways
    - Smaller parking lots
    - Material substitutions (replacement of impervious materials with pervious materials)

5.20.3 LID Benefits

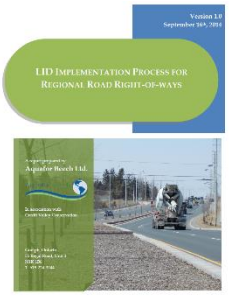
The Region of Peel recognizes the following functionality (control mechanisms) and stormwater management (SWM) and environmental benefits. The table below identifies the mechanisms and benefits of LIDs as compared to end-of-pipe stormwater management facilities.

SWM Control Mechanisms and Benefits of LIDs vs. End-of-Pipe Facilities.

SWM Approach		Potential SWM Control Mechanism				SWM and Environmental Benefit				
		Infiltration*	Retention	Filtration	Evaporation/ Transpiration	Water Quality	Flood Control*	Erosion Control *	Water Balance *	Water Reuse
Source Controls	Bioretention	✓	✓	✓	✓	✓	x	✓	✓	x
	Bioretention Planters	✓	✓	✓	✓	✓	x	✓	✓	x
	Permeable Pavement	✓	✓	✓	x	✓	✓	✓	✓	✓
	Soakaways and Infiltration Chambers	✓	✓	x	x	✓	✓	✓	✓	x
	Rainwater Harvesting	x	✓	x	x	x	x	✓	x	✓
	Green Roofs	x	✓	✓	✓	✓	x	✓	x	x
	Landscape Alternatives	✓	✓	✓	✓	✓	x	✓	✓	x
	Soil Amendments	✓	x	✓	✓	✓	x	✓	✓	x
	Downspout Disconnection	✓	x	✓	✓	✓	x	✓	✓	x
	Filter Strips	✓	x	✓	✓	✓	x	✓	✓	x
	Prefabricated Modules	✓	✓	✓	✓	✓	x	✓	✓	x
Conveyance Controls	Perforate Pipe System	✓	✓	x	x	✓	x	✓	✓	x
	Enhanced Grass Swale	✓	✓	✓	✓	✓	x	✓	✓	x
	Bioswales	✓	✓	✓	✓	✓	x	✓	✓	x
End-of-Pipe	Wet Ponds	x	✓	x	✓	✓	✓	✓	x	✓
	Engineered Wetlands	x	✓	x	✓	✓	✓	✓	x	x
	Hybrid Facilities	x	✓	x	✓	✓	✓	✓	x	✓

SWM Approach		Potential SWM Control Mechanism				SWM and Environmental Benefit				
		Infiltration*	Retention	Filtration	Evaporation/ Transpiration	Water Quality	Flood Control*	Erosion Control *	Water Balance *	Water Reuse
	Dry Ponds	X	✓	X	✓	X	✓	✓	X	X
	Subsurface Storage	✓	✓	X	✓	✓	✓	✓	X	X
* Extent of performance and environmental benefits will be subject to site testing results to identify site constraints related to predominant soil types and characteristics, including the ability of the native soils to infiltrate stormwater runoff. Testing will be required to determine the hydraulic conductivity "K" of the native soils										

5.20.4 Suitable LIDs for Roadway Applications



The Region of Peel has developed a ten (10) step generalized approach for practitioners to follow for the implementation of LID in the regional road right-of-ways (retrofit and/or new design) based on the Grey to Green Road Retrofits: Optimizing your infrastructure Assets Through Low Impact Development, Road Right-of-Way (2014). The report entitled **LID Implementation Process for Regional Road Right-of-Ways** (September 2014) is included in **Appendix E** and is an approved template process for LID projects in the Region of Peel right-of-way (ROW).

The table below provides general guidance with respect to the selection of candidate SWM and LID approaches for application within Regional ROWs based on the Grey to Green Road Retrofits: Optimizing your Infrastructure Assets Through Low Impact Development, Road Right-of-Way (2014). The selection process is based on four key factors:

- Type of Project
- Municipal Staff and Financial Considerations
- Design Considerations
- Environmental and Other Benefits

The table provides a series of qualitative indicators for each of the four factors to illustrate the relative applicability of different SWM and LID features. Each indicator is ranked from high applicability to low applicability. Rankings are representative of average conditions and may vary based on context. Selection of practices should always be based on site specific investigations. LID systems shall be designed as minor system (see **Section 5.4.1**).

SWM and LID Practice Selection and Evaluation

LEGEND: High ● Moderate ◒ Low ○		SWM Ponds	Bio-Retention Facilities	Enhanced Grass Swales	Bioswales	Perforated Pipe	Permeable Pavement	Proprietary SWM Devices [1]	Superpipe Storage	Infiltration Trenches
Type of Project	Facility Site Development	●	●	●	●	●	●	●	●	●
	Road Works (Urban)	○	●	●	●	◒	◒	●	●	●
	Road Works (Rural)	◒	●	●	●	○	◒	◒	○	◒
Municipal Staff and Financial Considerations	Community Engagement	●	●	○	●	○	◒	○	◒	◒
	Inter-department Coordination	●	●	○	●	○	○	○	◒	◒
	Design Team	●	●	○	●	○	◒	◒	◒	◒
	Capital Cost	●	●	○	◒	○	●	●	◒	◒
	Operation and Maintenance Cost	●	●	○	◒	○	◒	●	◒	◒
Design Considerations	Geotechnical Testing Complexity	◒	◒	◒	●	◒	●	○	◒	◒
	Infiltration Testing Complexity	◒	◒	◒	●	◒	●	○	◒	◒
	Planning Complexity	●	●	○	◒	◒	◒	◒	◒	◒
	Design Complexity	◒	◒	○	◒	◒	●	◒	◒	◒
Benefits	Flood Risk Reduction	●	◒	○	◒	◒	◒	○	●	○
	Pollutant Removal	●	●	◒	●	◒	◒	●	○	●
	Groundwater Recharge	○	◒	◒	◒	◒	●	○	○	●
	Stream Channel Erosion Control	●	●	◒	◒	●	●	○	○	◒
	Amenity and Aesthetic Value	●	●	◒	◒	○	○	○	◒	◒
	Traffic Calming	○	○	○	○	○	○	○	◒	◒
	Urban Tree Canopy	●	●	○	○	○	○	○	◒	◒
	High Profile with Community and Media	●	●	○	●	○	○	◒	◒	◒

[1] This refers specifically to proprietary oil/grit separator (OGS) devices, and may be used for spill control, or as a pre-treatment device. Where possible, they should be used with the incorporation of other quality control measures, such as naturalized buffers, grassed swales, etc.

● Practices that have high applicability based on the criteria

◒ Practices that have moderate applicability based on the criteria.

○ Practices that have low applicability based on the criteria

5.20.5 Sites with LID Restrictions

Constraints which may restrict the use of LID approaches or result in the use of alternatives to the prescribed volume targets described in **Section 4.0** include:

a) Shallow bedrock†;
b) High groundwater† or areas where increased infiltration will result in elevated groundwater levels which can be shown to impact critical utilities or private property;
c) Swelling clays or unstable sub-soils;
d) Contaminated soils (i.e. Brownfields);
e) High Risk Site Activities including spill prone areas. Infiltration-based LID practices should not accept runoff from catchment areas that are associated with high risk site activities (see **Appendix F**);
f) Prohibitions and or restrictions per the approved Source Protection Plans;
g) Flood risk prone areas where wastewater systems have been shown through technical studies to be sensitive to groundwater conditions that contribute to extraneous flow rates that cause property flooding / sewer back-ups and where LID BMPs have been found to be ineffective;
h) Surface water dominated or dependant features including but not limited to marshes and/or riparian forest wetlands which derive the all or a majority of their water from surface water, including streams, runoff, and overbank flooding. Surface water dominated or dependant features which are identified through approved site specific hydrologic or hydrogeologic studies, and/or Environmental Impact Statements (EIS) may be considered for a reduced volume control target. Pre-consultation with the MECP and local agencies is required;
i) Existing urban areas where risk to life, property or infrastructure has been identified through an appropriate area specific study;
j) Water reuse feasibility study has been completed to determine non-potable reuse of stormwater for onsite or shared use. Potable reuse may be considered on case specific basis.

† May limit infiltration capabilities if bedrock and groundwater is within 1m of the proposed facility invert per the LID Stormwater Planning and Design Guide (wiki.sustainabletechnologies.ca). Detailed assessment or studies are required to demonstrate infiltration effects and results may permit relaxation of the minimum 1m offset.

5.20.6 Underdrain Requirements

Where infiltration rates are less than 15 mm/hr (hydraulic conductivity less than $1x10^{-6}$ cm/s) an underdrain shall be required as part of the design. Native soil infiltration rate at the proposed facility location and depth shall be confirmed through measurement of hydraulic conductivity under field saturated conditions (see **Section 3.3.1**). Where LIDs are proposed as the minor system in place of a storm sewer, the minimum subdrain or underdrain size shall be 200mm diameter.

5.20.7 Inlet Types

Inlets to be used in LID approaches within the Region of Peel, shall be installed within standard barrier curb per OPSD standards or approved equivalent. Types of inlets for use with LID approaches, shall include the following, or as detailed in the Approved Products List available from www.peelregion.ca:

- Standard catch basins (see **Section 5.15**) or modified side-inlet catch basins;
- 45° concrete outlet for curb and gutter per OPSD 605.010
- Cast-iron curb-cut inserts; or

- Curb-cuts (i.e. removal of sections of barrier curb to permit flow to pass behind the curb). Curb-cuts shall not exceed 0.75m in width as measured along the gutter line and shall have a minimum width of 0.3m measured along the gutter line.

Additional inlet type options, may be considered by the Region of Peel subject to the Innovations and Standards Deviation Process (See **Section 8**).

5.20.8 Inlet Location

Inlets shall be selected, located and spaced in accordance with the conditions of design. Inlets shall not be located within one metre of a driveway or walkway curb depression. Inlets shall be designed to capture the expected maximum flow. Typical inlet locations include:

- at intersections,
- immediately upstream of sidewalk or pedestrian crosswalks when the road grade falls towards the intersection.
- Immediately upstream of existing or proposed catch basin locations. The inlets shall be designed to capture the flow prior to flow being received by the catch-basin. The catch-basin in his regard shall be used as an overflow device.

5.20.9 Inlet Spacing

Inlets should be provided at adequate intervals to ensure that the road drainage is able to be intercepted up to and including the capacity of the receiving LID which will be the basis to determine the type, location, and spacing of the inlets. The spacing will vary with the road width, grade, and cross fall and with the anticipated capacity of the feature (hydrologic and hydraulic). The spacing will also be affected by the location of pedestrian crossing points, intersections, major depression points, driveway depressions, and so on (see **Section 6.20.7**). The recommended spacing is as follows:

Maximum Spacing – inlets spacing for LID shall not exceed the Maximum Catch Basin Spacing detailed in **Section 5.15.3.**

Minimum Spacing – there shall be no minimum spacing for LID within regional roadways. Typical inlet spacing will range from 5 to 25m. The practitioner shall instead ensure that inlet spacing:

- maintains sheet flow with the LID to the maximum extent possible,
- minimizes erosion by avoiding concentrated flows,
- provides adequate water to the LID such that
    a) the recommended impervious to pervious ratios are maintained,
    b) that the performance of the LID is not compromised (hydraulics, infiltration rates or filtration capacity are not exceeded leading to reduced performance), and / or
    c) plant material(s) are vibrant and healthy and do not require long-term irrigation.
- operation and maintenance burdens are minimized.

5.20.10 Overflow Requirements

All LID facilities shall be designed with an emergency overflow. Overflow within LID features can be managed using the following methods:

External Management of Overflows (off-line LID systems) - Off-line LID systems do not accept major system flows. Flow splitters or diverted are included such that only the design storm or design flow enters the LID. As such overflow volumes may:

- be permitted to overflow from the LID measure through a downstream curb cut and discharge back onto the roadway (major system),
- discharge to an existing catch basin or storm sewer inlet,
- discharge to a downstream LID feature.

Internal Management of Overflows (on-line LID systems) – On-line LID systems accept major system flows or flows of significance as to possibly overwhelm the LID. As such, overflows located within the LID measure itself shall be constructed to directly connects to a proposed underdrain or existing storm sewer using the following, or as detailed in the Approved Products List available from www.peelregion.ca:

- a metal atrium grate connected to a storm sewer or other drainage feature with adequate capacity,
- an internal catch basin with a Beehive Grate (see **Section 5.15.6**) connected to a storm sewer or other drainage feature with adequate capacity,
- a ditch-inlet catch basin (see **Section 5.15.5**) connected to a storm sewer or other drainage feature with adequate capacity.

5.20.11 Pre-Treatment

Practitioners shall endeavor to provide pre-treatment to LID features where possible, subject to the following conditions and considerations:

- Permeable pavements shall not require pre-treatment. Accumulated surface sediments shall be removed as part of regular annual maintenance practices using a vacuum sweeper or regenerative air sweeper.
- LIDs which utilize a catch basin as the primary inlet shall include:
    a) A sump to collect larger sediments and particulate,
    b) Where possible, utilize an internal pre-treatment device such as a catch basin insert or other device to remove larger sediments and particulate prior to discharging to the LID (see **Section 5.15.4**)
- Inlets which direct regional roadway runoff to sub-surface LID infiltration systems such as soakaways, infiltration trenches and chambers and / or perforated pipe systems shall include internal catch basin inserts and /or pre-treatment devices such a hydrodynamic separator or membrane filtration unit (detailed in the Approved Products List available from www.peelregion.ca). As dictated by the intended function and LID type, the pre-treatment device shall be selected to:
    a) reduce sediment delivery to the subsurface LID and prolong operational life,
    b) capture floatables (including oils and grease or debris), or
    c) both a) and b)

- Where sheet flow enters an LID facility, gravel diaphragms, vegetated filter strips, and/or level spreaders can be used for pre-treatment.

5.20.12 Recommended LID Materials

Recommended LID materials shall be in compliance with the direction and guidance as presented within, the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and the Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC); as amended from time to time. Key materials have been described below:

Mulches – for vegetated LIDs planted with perennials, trees and / or shrubs, the preferred mulch shall be shredded hardwood or softwood mulches, aged a minimum of 12-months. A 75 - 100 mm layer on the surface of the filter bed shall be required.

Aggregates – for infiltration and filtration-based LIDs, aggregates shall be free-draining, clean/ washed, contain zero plasticity and contain zero No. 200 sieve materials (i.e. containing no fines). Typical materials include 6-9mmØ, 20mmØ, 40-50mmØ angular clear-stone, granular 'O', HL-8 aggregate, pea-gravel, rip-rap and round-stone. Crushed angular stone shall be 90% fractured face, LA Abrasion per ASTM 131 and have a minimum CBR of 805 per ASTM D 1883.

Aggregates for Permeable Pavements – shall be selected based on the structural and hydrologic design according to:

- Permeable Interlocking Concrete Pavers (PICP) - per the ASCE Design, Construction and Maintenance of Permeable Interlocking Concrete Pavement (Pending) and or design guidance from the Interlocking Concrete Pavement Institute (ICPI) or the manufacturer specifications as required.
- Permeable Concrete - per the manufacturer specifications.
- Porous Asphalt - per the manufacturer specifications.

Biorientation, Dry-swales (Bioswale) and Enhanced Swale Media – media for use in bioretention, dry-swales (bioswale) and enhanced swales shall comply with the Low Impact Development Stormwater Management Planning and Design Guide (wiki.sustainabletechnologies.ca) and / or the Bioretention Design Standard (CSA, 2018). Alternative media types may be considered by the Region of Peel to accommodate specific project requirements, however written approval is required.

5.20.13 Utility Avoidance & Separation

As a general rule, LID design should aim to avoid utilities as much as possible. In a conflict, LID practices can be adjusted to avoid utilities. Management strategies for utility conflicts shall adhere to the following hierarchy:

1. **Avoidance** - Locate LID feature clear of any utility conflicts where possible. To do this, selection of one particular LID design options might be better suited for the site condition

than others. Avoidance can also mean that a stormwater facility's dimensions are reduced in order to provide an adequate setback from utilities.

2. **Mitigation -** LID practices can generally coexist near utilities, but the original design or layout of a LID facility may require adjustment in order to mitigate any concerns about the proximity to the utility. A LID facility's design may need to be significantly altered to accommodate a utility line, or key features of the stormwater facility may need to be moved to avoid conflict. Mitigation strategies include, but are not limited to, use of impermeable liners, installation of root barriers, avoidance of infiltration, etc.

3. **Replacement -** Utility lines may need to be replaced and/or relocated so that a conflict no longer exists. This can be the most complex, cost-prohibitive, and difficult design option to implement. However, in some cases, the age of the utility line is a factor in selecting this solution. It might be more advantageous to plan on replacing an aging utility line during construction than to wait to replace it at a later date.

5.20.14 Groundwater Mounding Analysis

A groundwater mounding analysis shall not be required for infiltration-based LID where:

Criterion	Condition 1	Condition 2
Area of the infiltration practice bottom	≤ 10 m²	≤ 25 m²
Distance separating the infiltration practice bottom from the seasonal high-water table	≥ 2.0 m	≥ 2.0 m
Minimum saturated hydraulic conductivity of the subsoil within 2.0 m below infiltration practice bottom	≥ 15 mm/h (1)	≥ 40 mm/h (1)

(1) Before the safety factor being considered.

5.20.15 Setbacks from Buildings

To avoid saturation of the soil adjacent to the building and associated flooding risks, all LID systems shall be set back at least 4 metres from building foundations unless the following are relevant or implemented:

a) Impervious sidewalls and liners - LID which have vertical impervious sidewalls do not require a setback from building foundations provided they are also designed with an impermeable liner under the filter media or bed.

b) Waterproofing of Building Foundation - Membranes and liners that fully waterproof the foundation of a building may be used to eliminate the need for a setback.

c) LID with an Underdrain - LID systems with a perforated underdrain that conveys water away from the foundation may be situated within the 4 meter setback provided the following conditions are met.

   i. A hydrogeologic and/or geotechnical analysis establishes that zone of influence of the proposed bioretention system will not impact function of any structural or mechanical systems associated with the building.

ii. A groundwater mounding analysis is performed using the Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins by the USGS or equivalent (See **Appendix A**).

iii. Monitoring is incorporated into the design to determine immediate and long-term groundwater impacts.

5.21 End-of-Pipe SWM Controls

End-of-pipe controls will be installed as required by the Stormwater Management Planning and Design Manual (2003) manual, as amended from time to time, and accounting for other habitat considerations.

6. DESIGN FLOWS – HYDROLOGIC & HYDRAULIC MODELS

The hydrologic and hydraulic modelling to be used in the planning and design of SWM infrastructure is described in the following sections.

6.1 Rational Method

Storm sewers shall be designed to drain all lands based on the Rational Method. The Rational Method calculations must be checked using a model approved by the Region of Peel where the drainage area is greater than 10 hectares (see **Section 6.3**). The larger of the flows is to be used in the design of the sewer system.

Q = 0.0028 C I A

where: Q = Flow in cubic metres per second
A = Area in Hectares
C = Run-off coefficient (dimensionless)
I = Intensity in mm/hr

Storm sewers shall be designed to drain all lands for individual catchment areas based on the Rational Method. For drainage areas greater than 40 hectares, the Rational Method will not be accepted where storage, flooding, storm water quality and design of watercourses is involved. In those cases, only computer modeling methods will be acceptable.

Intensity of Rainfall

Each municipality within the Region of Peel stipulates the use of a unique Intensity-Duration-Frequency (IDF) curves for use on projects within its municipality. In order to standardize design approaches for Regional Project, a standard IDF has been adopted for use on Region of Peel projects regardless of the respective municipality. The Region of Peel IDF curve, has been selected such that it will generally meets or exceed the municipal requirements for all return frequencies from the 2-year the 100-year.

The intensity of rainfall is to be determined from the most recent Region of Peel INTENSITY - DURATION - FREQUENCY RAINFALL CURVES. These curves were originally derived from rainfall data taken from the Pearson International Airport (**Appendix C**). The equations for these curves are as follows:

2 Year Storm $$I = \frac{1070}{(TC+7.85)^{0.8759}}$$

5 Year Storm $$I = \frac{1593}{(TC+11)^{0.8789}}$$

10 Year Storm $$I = \frac{2221}{(TC+12)^{0.9080}}$$

25 Year Storm $$I = \frac{3158}{(TC+15)^{0.0.9335}}$$

50 Year Storm $$I = \frac{3886}{(TC+16)^{0.0.9495}}$$

100 Year Storm $$I = \frac{4688}{(TC+17)^{0.0.9624}}$$

Runoff Coefficient

Runoff coefficients are based on the amount of impervious area for a particular land use:

Land use	Runoff coefficient
forest and dense wooded areas	0.10–0.25
parks, open space and playgrounds	0.30
single family residential	0.65
semi-detached residential	0.70
townhouse or rowhouse	0.75
apartments or hi-rise residential	0.90
industrial	0.90
commercial	0.90
institutional	0.75
densely built, paved	0.90
asphalt, concrete, roof areas—without green roofs	0.90
Permeable pavements	0.15 to 0.25

The above runoff coefficients are provided in absence of actual runoff coefficients. When the development consists of a mix of land uses, a weighted average value of the runoff coefficient

Runoff Coefficient Adjustment Factor

In order to account for the increase in runoff due to saturation of the catchment surface that would occur for larger, less frequent storms, the adjustment factor below shall be used:

Design Storm Frequency	Adjustment Factor
10-year	1.0
25-year	1.1
50-year	1.2
100-year	1.25

$$\mathbf{Q = C_f\ C\ I\ A}$$

where: Q = Flow in cubic metres per second
A = Area in Hectares
C = Run-off coefficient (dimensionless)
I = Intensity in mm/hr
C_f = Runoff coefficient adjustment factor to account for reduction of infiltration and other losses during high intensity storms per table above.

Time of Concentration

The minimum initial time of concentration is to be 10 minutes.

Pre-Development Time of Concentration

To calculate the initial time of concentration (tc) for upstream, undeveloped lands, the following formulae may be used: Bransby Williams, HYMO/OTTHYMO, or SCS Upland Method. The most appropriate method will be determined at the discretion of the Region of Peel.

External Drainage – Time of Concentration

In the event that external drainage areas contribute to the minor system, the post development inlet time shall be calculated. To calculate the initial time of concentration (T) for external lands that are scheduled for future development, a straight line is to be drawn from the furthest point within the catchment to proposed inlet. The top 50m shall have an initial T of 10 minutes and the remainder shall have a T as if the velocity in the sewer is 2m/s. The summation of the two T values will give the future external time of concentration.

If the upstream area has adequate storm sewers, channels, or culverts, the velocity of the flow through these sewers, channels, or culverts shall supersede the 2m/s calculation.

Climate Change

Where storm sewers are being planned within existing areas which are subject to flooding during extreme events or where flow / capacity risks have been identified and /or are anticipated to be severe and likely to occur, the practitioner shall conduct unbiased assessments of future climate change, account for uncertainties in the predictions, and develop adaptive strategies that would be resilient to a wide range of climate change outcomes. See **Section 7.0.**

6.2 Design Storms

Each municipality within the Region of Peel stipulates the use of a unique Intensity-Duration-Frequency (IDF) curves for use on projects within its municipality. In order to standardize design approaches for Regional Project, a standard IDF has been adopted for use on Region of Peel projects regardless of the respective municipality. The Region of Peel IDF curve, has been selected such that it will generally meets or exceed the municipal requirements for all return frequencies from the 2-year the 100-year.

The intensity of rainfall is to be determined from the most recent Region of Peel INTENSITY - DURATION - FREQUENCY RAINFALL CURVES. These curves were originally derived from rainfall data taken from the Pearson International Airport (**Appendix C**). For the hydrologic analysis and modeling of within the Region of Peel, the following IDF parameters shall be used:

IDF Parameter	a	b	c
2-year	1070	0.8759	7.85
5-year	1593	0.8789	11
10-year	2221	0.9080	12
25-year	3158	0.9335	15
50-year	3886	0.9495	16
100-year	4688	0.9624	17

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

Where: a, b, c = above
I = intensity (mm/hr)
t = storm duration (min)

In general, the practitioner shall:

- Use the 2, 5, 10, 25, 50, 100-year return period storm events for water quantity (i.e., peak flow and volume control) estimates.
- Generate and select appropriate design storm hyetographs based on a design storm interval and a storm duration of synthetic storm distributions. Alternatives include:
    - 4-hour Chicago storm distribution – Recommended for peak runoff prediction from urban watersheds,
    - 24-hour Chicago storm distribution – Recommended for maximum volume storage from urban watersheds. The Chicago design storms should be used for determining hydrographs in urban areas and also for checking detention storage.
    - 24-hour SCS Type II – Developed by the US Soil Conservation Service (SCS) as the applicable storm distribution over most parts of Canada. In general, the SCS design storms should be used for determining the hydrographs for undeveloped watersheds and for checking detention storages required for quantity control.
        - Note: In many cases, the consultant will be required to run both the SCS and Chicago distributions to make sure that the more stringent is used for each individual element of the drainage system.
    - The time step for discretization of the design storm can vary according to the size of the sub-watershed, but must not exceed the estimated time of concentration. A minimum hydrograph computational time interval of 10 minutes is required (5 minutes is recommended).
- For quality control design of proposed features and volume control requirements, generate regional specific 90th percentile rainfall volume (27-29mm) using:
    - a 4-hr event storm event; or
    - From historic rainfall records of a local meteorological station which is representative of the subject area.
- Evaluate the impact of a real/actual extreme storm events on existing and proposed conditions, which could include the Regional storm (Hurricane Hazel) or extreme observed event (i.e., Toronto Pearson July 8, 2013 rain event).
- Evaluate the predicted impacts as a result of Climate Change.

6.3 Hydrologic Modelling

When required, hydrologic studies shall employ an appropriate modelling technique with defensible parameter values. The study report (design brief) shall describe the modelling parameters and the criteria for their selection as well as input and output data. The practitioner is to assume full responsibility for the proper application of the hydrologic models.

For total catchment areas < 10 ha, use the rational method (see **Section 6.1**) to estimate runoff peak flows and modified rational method to estimate runoff volumetric storage requirements. However, hydrologic simulation models based on design storm input with hydrograph analysis are preferred.

For total catchment areas > 10 ha, use hydrologic simulation models and:

- Provide hydrologic model indicating sub-catchment and routing (i.e., through channels, pipes etc) mechanism to outlets.
- Tabulate and clearly present applicable sub-catchment areas, and hydrologic catchment parameters (i.e., % imperviousness, hydraulic flow length, slope, calculated time of concentration).

- Ensure appropriate runoff loss methodology is used in model and documented as per established soil conditions (e.g., SCS Curve Number, Horton's Infiltration Loss, Green-Ampt Method).

To describe the existing and proposed runoff peak flows and volumes for the study area, select and apply the applicable modelling tool. Approved options for use in the Region of Peel include:

- HYMO-based models – e.g., OTTHYMO, SWMHYMO widely accepted for design situations.
- SWMM-based Models – e.g., EPA SWMM, PCSWMM, XPSWMM widely accepted for design situations.

For the design of Low Impact Development BMPs, modelling tools shall have a dedicated LID control module in the runoff model that streamlines the LID setup and incorporates LID into the overall design as well as runoff volume, flow rate, and load reduction. Model examples include, but are not limited to: EPA SWMM, PCSWMM, LID TTT Tool (http://www.sustainabletechnologies.ca/wp/low-impact-development-treatment-train-tool/) etc.

All model input and output files are to be provided in hard copy in report format and in digital format. All formulas and values used by the program must be clearly identified in the report. Any qualified person must be able to recognize and understand all methods, approaches, basic data and rationale used in design calculations. With the exception of proprietary models, equations and supporting calculations are required to be provided.

Climate Change

When conducting hydrologic analyses, as it relates to climate change, the overall objective is to conduct unbiased assessments of future climate change, account for uncertainties in the predictions, and develop adaptive strategies that would be resilient to a wide range of climate change outcomes. See **Section 7.0.**

6.4 Hydraulic Analysis

When required (see **Section 5.17**), hydraulic analysis shall employ an appropriate modelling technique with defensible parameter values. The study shall describe the modelling parameters and the criteria for their selection as well as input and output data. The practitioner is to assume full responsibility for the proper application of the hydraulic models and should consult with the appropriate conservation authority when selecting and applying a model for regulated watercourses. MTO Drainage Manual (2008, 1997) criteria and guidance should be followed for assessing standard and watercourse crossing hydraulics.

To describe the existing and proposed water surface elevations and associated outputs, select and apply the applicable modelling tool. Options include:

- Culvert/Ditch Capacity Modelling – e.g., FlowMaster, CulvertMaster, spreadsheet calculations.
- Culvert/Bridge Backwater Analysis – e.g., HEC-RAS, PCSWMM

In general, the practitioner shall:

Existing Conditions

- Clearly defining the existing number of drainage structures within the study area. This includes roadway culverts/bridges, entranceway culverts, and any storm sewer structures.
- Identifying the size and receiving drainage area for the existing drainage structure(s).

- Assessing the existing hydraulic capacity using appropriate models of existing culverts through computing the headwater elevations, head water depth to culvert dimension (H/D) ratio and freeboard based on modelled pre-development flows for culvert/ditch design storms.

Future Conditions

- For future proposed conditions, evaluate the hydraulic capacity of proposed culvert by computing the headwater elevations, head water depth to culvert dimension (H/D) ratio and freeboard based on modelled post-development flows for culvert/ditch design storms.
- Ensure new structure or crossing structures do not increase design floodline water surface elevations (WSELs) from existing conditions (see **Section 5.17**).
- For existing conditions where "free discharge" conditions are deemed not to exist (i.e., tailwater conditions are identified at the receiving outlet under the design storm conditions as flow limiting), conduct backwater analysis to establish maximum allowable flow from outlet.
- For future conditions, where use hydraulic model (e.g., HEC-RAS) for receiving watercourse is to assess the impact of post-development discharge and crossing changes on upstream watercourse WSEL.

Climate Change

When conducting hydraulic modelling for culvert, watercourse crossing, bridge design, or major system conveyancer capacity and risks have been identified and /or are anticipated to be severe and likely to occur, the practitioner shall conduct unbiased assessments of future climate change, account for uncertainties in the predictions, and develop adaptive strategies that would be resilient to a wide range of climate change outcomes. See **Section 7.0.**

7. CLIMATE CHANGE

Climate change is an additional factor that must be considered by stormwater practitioners for projects within the Region of Peel. For the geographic Region of Peel, this means warmer winters, hotter summers with more frequent and extreme weather events. This shift in climate conditions in Peel will have an effect the Region's economy, local communities, and natural and urban landscapes. In response, the Region is rising to this global challenge to combat climate change at the local level though the preparation of the Peel Climate Change Strategy (2011). The Peel Climate Change Strategy aims to address climate change through both mitigation (activities that reduce GHG emissions) and adaption (actions, initiatives and measures to reduce vulnerability of natural and human systems) with the overall objectives being to:

> **Build resilience in spite of climate change conditions, and to maintain a safe, healthy, prosperous, sustainable and inclusive community for residents and businesses in the geographic region of Peel.**

The six principles of Partnership, Leadership, Integration, Synergy, Accountability and Stewardship are intended to guide the implementation of the Peel Climate Change Strategy which has been developed with specific Goals and Actions, many of which relate to stormwater management.

Stormwater management is directly related to climate. Changes in precipitation patterns and seasonal temperatures can reduce the ability of our engineered stormwater systems to effectively provide an acceptable level of service. These changes may also affect the ability of natural systems such as streams, rivers, wetlands and lakes to support important ecological functions. As stormwater practitioners, adaptation and mitigation should be prioritized when planning and designing stormwater management systems.

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) concluded that "warming in the climate system is unequivocal, with many of the observed changes unprecedented over decades to millennia: warming of the atmosphere and the ocean, diminishing snow and ice, rising sea levels and increasing concentrations of greenhouse gases."

7.1 Definition of Climate Change

Climate change is defined as any significant change in long-term weather patterns. It can apply to any major variation in temperature, wind patterns or precipitation that occurs over time. Weather patterns are highly variable and therefore climate can appear to be changing depending on the time scale selected for averaging. Climate change, however, refers to a consistent, observable trend in the long-term average values.

It is important to define 1) mitigation, 2) adaptation and 3) co-benefits in the context of climate change.

Climate Change Mitigation - The use of measures or actions to avoid or reduce greenhouse gas emissions, to avoid or reduce effects on carbon sinks, or to protect, enhance, or create carbon sinks.

Climate Change Adaptation - The process of adjustment in the built and natural environments in response to actual or expected climate change and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.

Climate Change Co-Benefits - Many technologies achieve some level of both climate change mitigation and climate change adaptation. These are known as "climate co-benefits". Low Impact Development stormwater management practices can be applied to achieve some level of both climate change mitigation and climate change adaptation and are a key approach for stormwater management and water resource practitioners to address climate change impacts.

7.2 Designing for Climate Change

There exist a number of tools and process for increasing the resilience of stormwater management services to current climate variability or future climate impacts.

7.2.1 Climate Change Tools

The Climate change tools available to practitioners which are supported by the Region of Peel in the design of stormwater management systems include:

1. **PIEVC** - Engineers Canada created the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol to assess the vulnerabilities of infrastructure to extreme weather events and future changes in climate. The protocol is a risk screening tool specifically designed to address future climate uncertainty that can:
    - Evaluate infrastructure risks to public and private services that can have economic, environmental or societal negative impacts;
    - Support decision-making for capital investments in the acquisition of infrastructure
    - Help establish life-cycle operations, maintenance and reinvestment plans (asset management)
    - Inform policy-makers and supports sustainable and resilient objectives at the project, system, region or country level.

2. **BARC** - The International Council for Local Environmental Initiatives (ICLEI) Building Adaptive and Resilient Communities (BARC) tool has been designed to assist local governments with climate change adaptation planning. Methodology provides a structured approach to adaptation planning which moves participating local governments through a series of progressive steps. While each milestone builds off of the findings of the one before, the methodology as a whole creates an opportunity to re-evaluate and review findings and decisions.

In general, a science-based, documented, repeatable process should be used to incorporate climate change considerations into stormwater management planning.

7.2.2 Climate Change Assessment Process for SWM

The Region of Peel recommends a four (4) step process that stormwater practitioners are encouraged to use to incorporate climate change adaptation strategies into stormwater management projects. Through the application of this process, practitioners can establish bounding estimates for consideration during stormwater design or, if a defensible design estimate cannot be established, how at the early stages of infrastructure planning approaches can be taken to design infrastructure that is resilient to a wide range of possible future climates. The process can be applied to all stormwater projects.

The four (4) step process includes:

1. Identifying Climate Change Considerations
2. Evaluating Risk caused by Climate Change Parameters
3. Climate Change Impact Management Planning
4. Monitoring and Adaptive Management

STEP 1 - Identifying Climate Change Considerations

Potential climate change impacts will differ depending on location, type of project and other the site-specific factors.

Step 1a) - During the first step of this process, it is suggested that the stormwater practitioner evaluate whether each climate change parameter expected in Ontario will cause impacts for any specific project component. The key climate change parameters that have the potential to impact a stormwater or water resources which should be considered to determine if they are relevant to the specific Region of Peel stormwater projects are listed below. Additional parameters may be relevant on a project-specific basis. These parameters should be considered during the design process for all water resources projects within the Region of Peel to mitigate negative climate change impacts on the project level and within communities.

Key climate change parameters include:

- Increased Mean Temperature
- Increased Annual Rainfall
- Decreased Annual Snowfall
- Increased Frequency and Severity of Precipitation Extremes
- Changes in Lake Levels and stream flows
- Changes in Soil Moisture and Groundwater Recharge
- Increased Potential Evaporation Rate
- Other - Additional project-specific claimed change parameters

Step 1b) - Once the potential impact of climate change parameters on a project have been identified, the risks associated with failing to meet project goals, objectives and targets must be evaluated. Not all components of a project will be sensitive to climate change and not all potential impacts will mandate adaptation strategies. To assess significant risks while avoiding excessive analysis, climate change parameters should be evaluated using the following five (5) ***Climate Change Impact Screening Questions:***

1. Is there a potential for a climate change parameter to cause a failure to meet design objectives?
2. Is there a potential for a climate change parameter to result in the reduction of the level of service for stormwater to an unacceptable level?
3. Is there a potential for a climate change parameter to cause a public hazard or safety issues for the public within or around the project site?

4. Is there a potential for a climate change parameter to cause damage to property within the project site or on adjacent lands?
5. Is there potential for a climate change parameter to cause environmental degradation on the project site or resulting from the project site?

The practitioner shall answer and document the climate change parameter screening process by utilizing the template below and modify as required.

Climate Change Parameters for Stormwater Management	Apply the five (5) climate change screening question. (yes/ no)	List Anticipated Impact(s)
Increased Mean Temperature		
Increased Annual Rainfall		
Decreased Annual Snowfall		
Increased Frequency and Severity of Precipitation Extremes		
Increased Frequency and Severity of Ice Storms		
Changes in Lake Levels and Stream Flows		
Changes in Soil Moisture and Groundwater Recharge		
Increased Potential Evaporation Rate		
Prolonged Dry Periods / Drought		
Others		

If "Yes" to any of the above questions, proceed to STEP 2

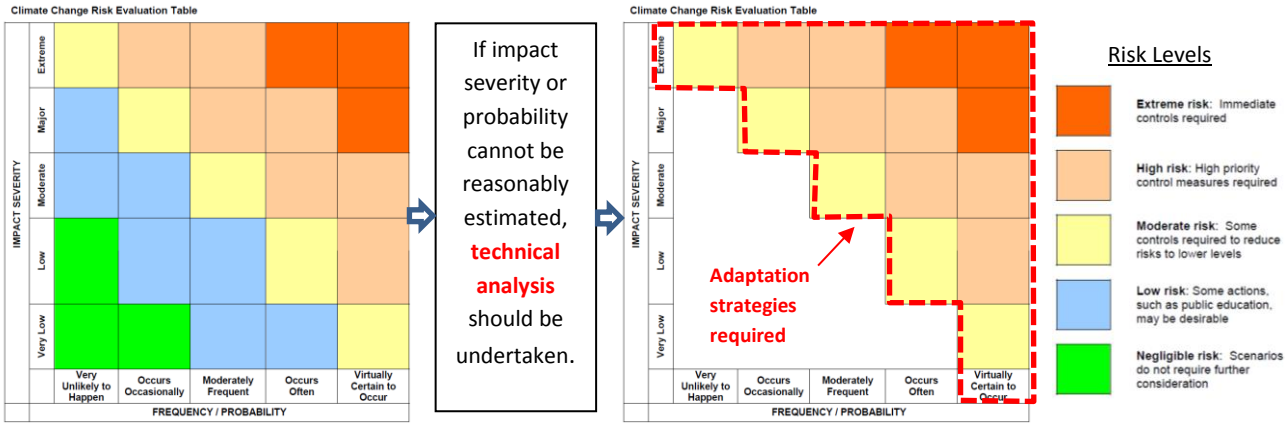
STEP 2 - Evaluating Risk caused by Climate Change Parameters

Climate change is a field that is characterized by uncertainty. There is uncertainty associated with climate projections and the impacts of these projections, especially on a local scale. Uncertainty is a common issue facing engineers and risk management offers a reliable approach for prioritizing complex risk issues and for selecting preferred risk reduction strategies. To use a risk assessment framework in a climate change context, the following climate change risks must be established:

a) Probability (certain to very unlikely to occur) and
b) Impact severity (severe to negligible impacts)

For climate change risks that meet a threshold level of probability and impact severity, adaptation strategies must be evaluated to avoid an unacceptable level of risk.

The **Climate Change Risk Evaluation Matrix** (below) can be applied to evaluate the risk. Impact severity is shown increasing along the y-axis, while probability or frequency is shown along the x-axis. Using this approach, addressing risks can be prioritized with extreme risks requiring immediate adaptation strategies and negligible risks requiring no action. This can be used to asses any climate change impact on a stormwater project.



Climate Change Risk Evaluation Matrix (Bruce et al., 2006b).

STEP 3: Climate Change Impact Management Planning

Involves the application of adaptation measures to reduce the project's vulnerability to changes in climate parameters. The following options of measures should be prioritized (in decreasing order of priority).

Option 1: Win-win options – cost-effective adaptation measures that minimise climate risks or exploit potential opportunities but also have other social, environmental or economic benefits. In this context, win-win options are often associated with those measures or activities that address climate impacts but which also contribute to climate change mitigation or meet other social and environmental objectives. For example, tree planting in urban settings shade impervious areas and intercept rainfall providing environmental, aesthetic, and social benefits;

Option 2: No-regrets Options – cost-effective adaptation measures that are worthwhile (i.e. they bring net socio-economic benefits) whatever the extent of future climate change. These types of measure include those which are justified (cost-effective) under current climate conditions (including those addressing its variability and extremes) and are also consistent with addressing risks associated with projected climate changes. For example, promoting good practice in street cleaning to limit the risks of diffuse pollution is a no-regrets option;

Option 3: Low-regrets (or limited-regrets) Options – adaptation measures where the associated costs are relatively low and where the benefits, although mainly met under projected future climate change, may be relatively large. For example, constructing drainage systems with a higher capacity than required by current climatic conditions can have limited additional (incremental) costs, but can help to cope with increased run-off as a result of expected climate change impacts;

Options 4: Flexible adaptation Options – measures which are designed with the capacity to be modified at a future date as climate changes. Influencing the design of a stormwater

management facility so that its capacity can be increased at a future date, if necessary, would be an example of flexible adaptation.

The following strategies may be considered, along with other project specific strategies, within each of the four (4) Options listed above:

1. Plan for more Low Impact Development (LID) and/ or Green Infrastructure.
2. Use low impact development facilities to reduce stormwater runoff volumes.
3. Minimize impervious surfaces such as parking lots, roads, and rooftops.
4. Use smart growth and sustainable growth strategies that decrease road building and include transportation choices other than automobiles.
5. Encourage riparian buffers along streams, rivers, and waterways and maintain flood plains.
6. Protect and re-establish wetlands to hold runoff and recharge groundwater.
7. Encourage tree planting, especially in urban settings.
8. Promote landscaping with native vegetation to further reduce runoff and the need for irrigation.
9. Removing or diverting flows from undersized storm sewers to mitigate the damages associated with more frequent intense storm events;
10. Increasing the flood storage volume of existing ponds in flood prone areas and/or increasing the sizing requirements of future ponds to avoid an increased frequency of urban flooding;
11. Expanding or rerouting major flow paths to avoid flooding associated with significant urban rainfall events;
12. Increasing forecasting and warning capabilities;
13. Modifying inspection and maintenance programs;
14. Reducing seasonal storage levels in dams; and
15. Replacing storm sewers with higher capacity systems.

Step 4 – Monitoring and Adaptive Management

The monitoring and adaptive management step is in place to incorporate lessons learned. The implementation of a monitoring and adaptive management plan reduces risks and allows for adaptation to future changes. This step involves collecting and evaluating data on key climate parameters over the lifetime of a project and modifying the project or introducing new adaptation measures in response to updated information. Vulnerabilities can be mitigated during this phase by incorporating remedial measures, new operations procedures and or management processes. Monitoring of climate change impacts is an important aspect of this phase and should be incorporated into standard stormwater monitoring programs.

All monitoring can generally fall into two (2) categories, these are:

- Environmental Monitoring - designed to assess the environmental health of a watershed or subwatershed (measured based on a range of environmental indicators), in response to land use or climate change. This includes climate data collection as well as project specific monitoring.

- Performance Monitoring - designed to evaluate whether a measure is implemented properly (compliance monitoring) and how well it performs, based on a range of performance indicators or targets (effectiveness monitoring). Typically, performance monitoring is completed for a Stormwater Master Plan and generally includes monitoring for compliance purposes and effectiveness monitoring.

Practitioners shall be required to develop environmental and performance monitoring plans for submission to the Region of Peel as part of stormwater management design and reporting requirements (see **Section 9**).

7.3 Hydrologic Modelling & Climate Change

When conducting hydrologic analyses, as it relates to climate change, the overall objective is to conduct unbiased assessments of future climate change, account for uncertainties in the predictions, and develop adaptive strategies that would be resilient to a wide range of climate change outcomes. To ensure that a duty and standard of care have been provided and to help minimize the legal risk associated with the impact of climate change on stormwater management infrastructure, the practitioner shall select and apply one or more of the following approaches to account for the range of possible climate change outcomes:

1. Data sets downscaled from a wide selection of Global Circulation Models (GCMs) results have been assembled by several Ontario agencies and made available to the public and can be used in hydrologic modelling activities. These include:

   a) Ontario Ministry of Natural Resources and Forestry has established a website (http://climate.aquamapper.com/) where future climate data sets can be downloaded for use in hydrologic models.

   b) Dynamically downscaled climate projections are available for the Province from the Ontario Climate Change Data Portal (www.ontarioccdp.ca or http://lamps.math.yorku.ca/OntarioClimate/).

   c) The Canadian Centre for Climate Services provides statistically downscaled climate scenarios (https://www.canada.ca/en/environment-climate-change/services/climate-change/canadian-centre-climate-services.html).

2. Where intensity- duration-frequency (IDF) curves for the 2, 5, 10, 25, 50, 100-year return period storm events for water quantity (i.e., peak flow and volume control) per **Section 6.1** and **Section 6.2**, the practitioner shall select and apply one or more of the following approaches to account for the range of possible climate change outcomes:

   a) Apply the results of Localized Climate Projections for the Region of Peel developed from statistical downscaling of global model from a full ensemble of the latest generation of climate models (Coupled Model Intercomparison Project version 5 - CMIP5) or most recent (if available).

   b) Apply Predicted IDF Curves under Climate Change:

i) For a local meteorological station from the IDF CC Tool for deriving rainfall Intensity-Duration-Frequency Curves for future climate scenarios (University of Western Ontario and the Canadian Water Institute) - http://www.idf-cc-uwo.ca/default.aspx

ii) Intensity Duration Frequency (IDF) curves have been developed for future climate conditions and are available for the Province from the Ontario Climate Change Data Portal (www.ontarioccdp.ca)

c) An adjustment to the design flows (i.e. % adjustment for IDF curves) - not a preferred approach by the Region of Peel

Best practices for applying these models include:

1. Using an appropriate climate baseline (minimum 30 years of data) for historical and for future climate trends.
2. Using an ensemble of climate models to account for a range of future conditions and uncertainty. If only one scenario is used, it should be the "business as usual" scenario (i.e. RCP 8.5), rather than a lower emissions scenario that is less likely to occur.
3. Assessing model and system sensitivity by applying multiple scenarios or outputs from climate models to examine a range of future conditions (i.e. one scenario representing 90th percentile conditions and one representing 10th percentile conditions).

7.4 Hydraulics Analysis & Climate Change

When conducting hydraulic modelling for stormwater infrastructure, culvert, watercourse crossing, bridge design, or major system conveyance capacity and risks have been identified and /or are anticipated to be severe and likely to occur, the practitioner shall select and apply one or more of the following approaches, and include a discussion of the uncertainty associated with the application:

a) Apply the results of Localized Climate Projections for the Region of Peel developed from statistical downscaling of global model from a full ensemble of the latest generation of climate models (Coupled Model Intercomparison Project version 5 - CMIP5) or most recent (if available).

b) Apply Predicted IDF Curves under Climate Change:
   i) For a local meteorological station from the IDF CC Tool for deriving rainfall Intensity-Duration-Frequency Curves for future climate scenarios (University of Western Ontario and the Canadian Water Institute) - http://www.idf-cc-uwo.ca/default.aspx

   ii) Intensity Duration Frequency (IDF) curves have been developed for future climate conditions and are available for the Province from the Ontario Climate Change Data Portal (www.ontarioccdp.ca).

c) An adjustment to the design flows (i.e. % adjustment for IDF curves) - not a preferred approach by the Region of Peel.

8. INNOVATION & STANDARDS DEVIATION PROCESS

The Region of Peel supports innovation in all areas of service, including within the treatment, conveyance, infiltration, filtration and general control of stormwater runoff.

The Region of Peel has a significant investment in the infrastructure that it owns, operates and maintains. In order to ensure new infrastructure will achieve life cycle cost expectations, the Region has developed a variety of guidelines and standards to communicate what the Region expects to receive. There is a constant stream of new materials, design methods and construction techniques being developed and these may be of interest to the Region. In order for the Region to evaluate these new materials and/or construction techniques the Region may undertake a pilot project.

This process is intended to ensure that sufficient information is obtained at the onset of a pilot project to be able to reach a recommendation at the conclusion of the pilot. The process is also intended to document the existence of the pilot for tracking purposes.

Process:

1. **Proposal for Innovative Approach / Deviation from Standard** - The designer shall present the proposed innovation / deviation from standard to the Region of Peel.

2. **Deviations from Existing Guidelines, Standards, Approved Products** - Most aspects of infrastructure design and construction are described in existing Design Guidelines, Construction Standards and Approved Product Lists. If the designer proposes methods which differ from these documents, then the designer should propose a deviation. The onus is on the designer to justify the deviation, to the satisfaction of the Region, in the form of a deviation report. The requirements of the deviation report which are summarized as follows:
    a) the report shall be signed, sealed, and submitted to the Region for review by a professional engineer;
    b) the report shall present the alternative method and shall make a justification in terms of policy considerations, implementation feasibility, economics, engineering, environmental, operational, reliability, risk, and / or maintenance issues etc.
    c) the report shall make a recommendation as to the suitability of deviation to be considered a pilot project.

3. **Project Tracking** – Once the Deviation report if accepted by the Region, the designer shall complete the Innovation, Deviation & Pilot Project Tracking Form (**Appendix D**) and submit to the Region of Peel for project tracking purposes. Upon approval of the terms of the pilot by the appropriate authority (if applicable/Project Manager/Program Manager) then the pilot may proceed.

4. **Pilot Monitoring and Final Reporting** – To evaluate the success of the product, design, new materials, design methods and construction techniques, the innovation, deviation or pilot project must be tracked or monitored. At the conclusion of the assessment period as described in the deviation report, a final report must be completed including all necessary information for the Region to determine any next steps. The reports will be used to periodically assess the existing standards and determine if the product, design, new materials, design methods and construction techniques is appropriate to be included in subsequent Region of Peel standards.

9. STORMWATER MANAGEMENT REPORT

A stormwater management report is required for all linear infrastructure projects and site plans subject to the Region of Peel jurisdiction. The report is to address the stormwater management techniques to be implemented to reduce the impact of stormwater runoff from the development activity, the minor and major drainage systems, the external drainage, and the erosion and sedimentation controls to be used. The report shall be developed such that it can be used to support the acquisition of permits and approvals.

The Stormwater Management report must state suggested methods of reducing volume and peak rates of runoff to prevent overloading of downstream facilities and the report must confirm that the plan will accommodate both the "minor" and "major" drainage systems.

The report must also implement the requirements as specified in the Watershed, Subwatershed Studies and/or in the Master Environmental Servicing Studies, Environmental Impact Statement and/or Functional Servicing Studies or Environmental Assessment.

The report itself should, at a minimum, document the following:

- Project background and objectives;
- Description and illustration of existing and proposed conditions including figures showing pre- and post-development drainage areas and runoff coefficients, existing storm drainage infrastructure and justification for the proposed runoff coefficient values being utilized;
- A storm drainage area plan showing the flooding extend and ponded areas (including the depth) as well as the overland routes;
- Summarize the Region's stormwater management requirements (See **Section 4.0**) and all agency requirements as determined through pre-consultation activities.
    - Provide a section outlining how each requirement has been met
    - For Stormwater Runoff Volume Reduction: describe the measure(s) being proposed to meet the requirement and include supporting calculations and documentation
    - For Stormwater Quantity Control: specify what criteria governs (e.g. storm sewer constraints or stormwater quantity control requirements), document the required stormwater storage and compare to the storage provided
- Provide a table summarizing the pre and post-development flows which are to be directed towards the Regional road and ROW (minor system and overland) for the 2-year to 100-year event with the supporting calculations;
- Describe how external flows will be accommodated, if applicable;
- Performance based modeling analysis, and calculations (hydraulic and hydrologic);
    - Hydraulic Grade Line and Overland Flow analyses if required;
- Design optimization process and performance;
- Landscape and plant selection considerations if required;
- Include or reference Issued for Approval (IFA) engineering plans that depict the proposed measures;
- Monitoring plan details;
- Reference Materials;
- Supplier Information (as required); and
- Operation and maintenance plan - should detail guidelines for landscaping maintenance and drainage system elements, complete with a maintenance checklist for each. Key elements typically include but are not limited to:
    - Maintenance requirements post installation
    - Regular/ routine maintenance activities and frequency
    - Annual maintenance activities

  - Long term maintenance activities & frequency (rehabilitation, restoration and disposal activities)
  - Typical costs associated for all of the aforementioned
  - Staff training and equipment requirements
- Report must be stamped, signed and dated by P. Eng.

10. APPROVALS

Per **Section 2.0**, the Region of Peel is subject to all Federal and Provincial legislation related to stormwater management, runoff control and flood control. Of most significance to the day-to-day undertaking of the Region of Peel in regards to stormwater management are the policies of the:

- Department of Fisheries and Oceans (DFO)
- Ministry of the Environment, Conservation and Parks (MECP)
- Ministry of Natural Resources and Forestry (MNRF)
- Local Conservation Authorities (TRCA, CVC, LSRCA, HC, and NVCA) and the *Conservation Authority Act*
- Niagara Escarpment Commission (NEC)

In many cases, an explicit approval from the relevant agency is required prior to the Region of Peel or its agents undertaking the proposed project. The following summarizes typical agencies and approval:

10.1 Conservation Authority Approvals

Approval under the Application for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Permit, under the provisions of the *Conservation Authority Act* for those projects which are*:*

- Within the conservation authority Regulated Area;
- Within 15m of the Lake Ontario shoreline, or 30m of a dynamic beach; or
- May interfere with wetland features, wetland top of bank, watercourses, meander belt, erosion hazards, and areas of contiguous vegetation.

10.2 MECP Environmental Compliance Approvals

Section 53 of the OWRA requires that an approval must be obtained in order to establish, alter, extend or replace any sewage works (sewage works are defined as works used for the collection, transmission treatment or disposal of wastewater, but not including plumbing to which the *Building Code Act,* 1992 applies). Under the OWRA, sewage includes drainage, storm water, commercial wastes and industrial wastes and such other matter or substance as is specified by the regulations.

Operations that require approvals from a stormwater perspective include:

- Stormwater management facilities; and
- Storm sewers

The rule is: Everything that discharges stormwater or drainage (i.e. sewage) require approval unless specifically exempted.

10.2.1 ECA Exemptions

In general, such, the need for, and nature of, an approval depends on the site and the activity. However, specific exemptions for certain types of sewage works equipment, system and application have been granted through legislation. The OWRA and Approval Exemption Regulation (O.Reg. 525/98) exempt minor sewage works from the approval requirements of the Act. Under the O. Reg 525/98 Approval Exemptions, the establishment, alteration, extension or replacement of or a change to stormwater management facility can be exempted from requiring an ECA if **all** of the following applicable conditions are met. A stormwater management facility is defined as a facility for the

treatment, retention, infiltration or control of storm water. More specifically, an ECA is not required if the stormwater management facility (i.e. the works) are:

1. designed to service one lot or parcel of land; AND
2. discharging into a storm sewer that is not a combined sewer; AND
3. not servicing industrial land or a structure located on industrial land; AND
4. not located on industrial land.

Industrial lands are defined as lands used for the production, process, repair, maintenance or storage or goods or materials, or the processing, storage, transfer or disposal of waste, but does not include lands used primarily for the purpose of buying or selling,

a) goods or materials other than fuel, or
b) services other than vehicle repair services

Other approval exemptions under Section 53 include:

5. drainage works under the Drainage Act or a sewage works where the main purpose of the work is to drain land for the purposes of agricultural activity;
6. drainage works under the Cemeteries Act, the Public Transportation and Highways Improvement Act or the Railway Act.

In all other circumstances beyond the aforementioned exemptions, an ECA from MECP is required. If unsure about the exemption of your stormwater works, a pre-consultation meeting with the ministry is recommended.

10.3 Endangered Species Act (ESA) & Species at Risk Act (SAR)

The Endangered Species Act, 2007 (ESA) prohibits the harming or harassing of an endangered and threatened species, or the destruction of their habitat. For SWM Design projects for ROWs which are adjacent or discharge to watercourses and or natural areas which are designated as habitat will require a permit under Section 17 of the Endangered Species Act (2007). Consultation with Ministry of Environment, Conservation and Parks (MECP) staff is recommended to determine the specific submission requirements. At time of publication of this manual, the ESA is undergoing review, which may change some of the requirements.

10.4 Department of Fisheries and Oceans (DFO)

At the Federal level in Canada, the DFO is responsible for managing fisheries and safeguarding waters. The Self-Assessment Process applies to any on-going projects where permits have not yet been issued and any future permit applications under the *Fisheries Act*.

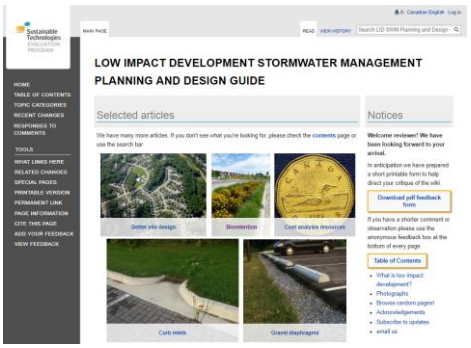
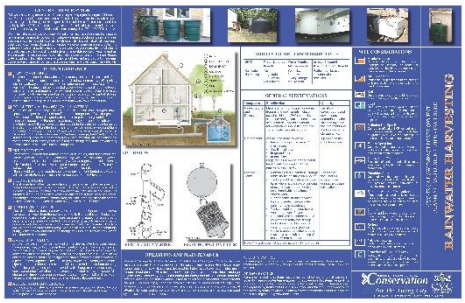
10.5 Niagara Escarpment Commission (NEC)

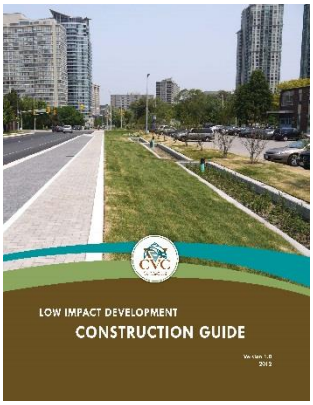
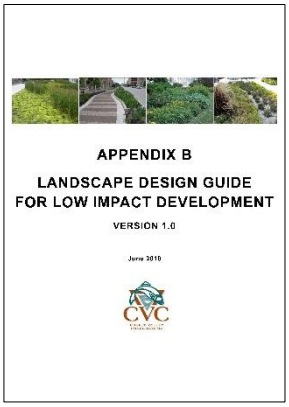
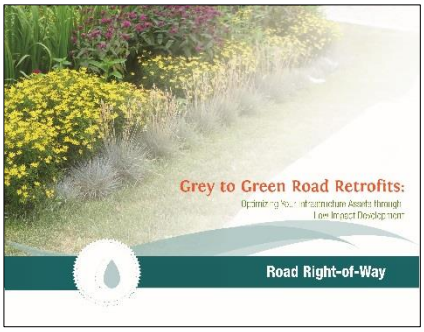
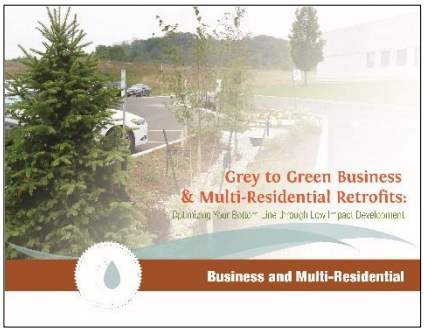
The Niagara Escarpment Plan (NEP) protects the Escarpment's unique ecological, historic and scenic qualities. To ensure that the Escarpment's natural resources, ecosystem health and scenic landscape are protected, Niagara Escarpment landowners are required to obtain a Development Permit for certain types of development.

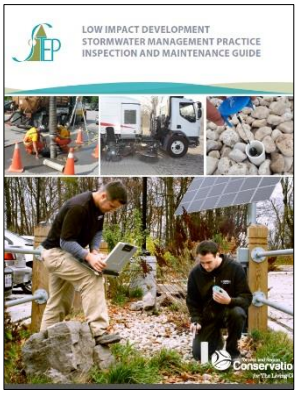
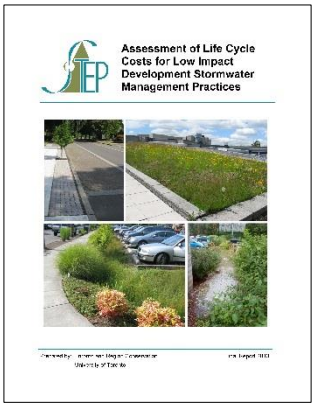
To ensure that the Escarpment landscape and ecosystem remain protected, development permits from the NEC are required for certain types of development. A Niagara Escarpment Development Permit is similar to a municipal building permit. The difference is that a Niagara Escarpment Development Permit considers the impact of a development proposal on the Escarpment landscape and environment. The objective is to design and situate development in an environmentally compatible way. (Municipal building approvals and other permits may also be required, but may only be issued after the Development Permit.) Applications for Development Permits can include proposals for new single dwellings, road construction, quarries, sand and gravel pits, establishment of wineries, irrigation or recreational ponds, altering the grade of land, and changes in the use of any land, building or structure.

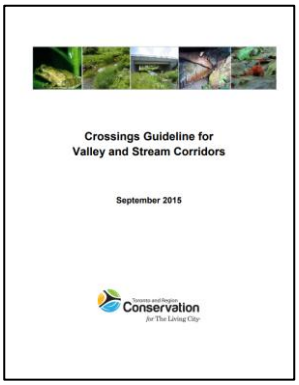
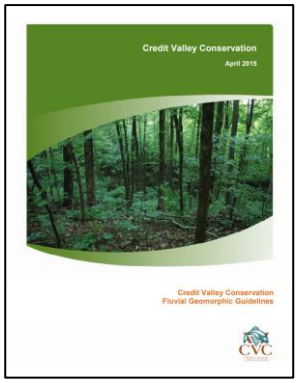
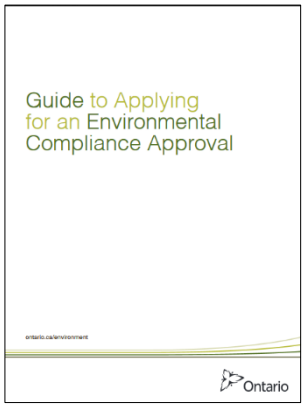
Ontario Regulation 826/90 under the *Niagara Escarpment Planning and Development Act* (NEPDA) describes lands within the Niagara Escarpment Planning Area which are designated as an area of development control. Lands located within the area of development control could require a Development Permit from the Niagara Escarpment Commission (NEC) for certain types of development. (See: Ontario Regulation 826/90)

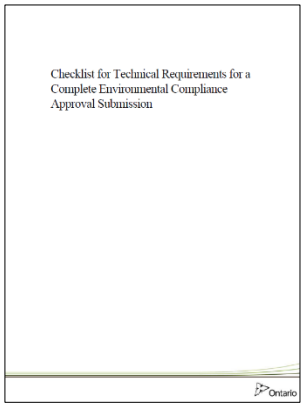
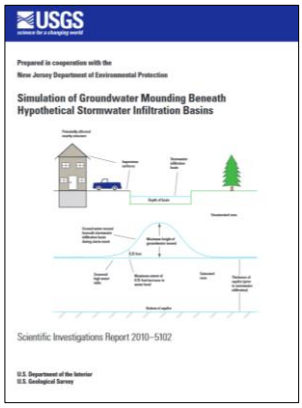
Appendix A – Resource Directory

Design Standards	**Region of Peel Public Works Design, Specification & Procedures Manual** https://www.peelregion.ca/pw/other/standards/ **Region of Peel Approved Products List** https://www.peelregion.ca/pw/other/standards/linear/mat-specs/pdfs/storm-sewer-roads-product-list.pdf	
Planning and Design Guide	**Low Impact Development Stormwater Management Planning and Design Guide (Sustainable Technologies Evaluation Program)** http://wiki.sustainabletechnologies.ca	
Planning Guide	**Grey to Green Enhanced Stormwater Management Master Planning: Guide to Optimizing Municipal Infrastructure Assets and Reducing Risk (CVC)** http://www.creditvalleyca.ca/wp-content/uploads/2016/01/ORGuide.pdf	
Planning & Design Fact Sheets	**Low Impact Development Stormwater Management Planning and Design Guide, including Fact Sheets:** http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/stormwater-management-lid-guidance-documents/low-impact-development-stormwater-management-planning-and-design-guide/	

Construction Guide	**Construction Guide for Low Impact Development (CVC, 2012, Version 1.0)** http://www.creditvalleyca.ca/wp-content/uploads/2013/03/CVC-LID-Construction-Guide-Book.pdf	
Landscape Design Guide	**Landscape Design Guide for Low Impact Development (CVC – Version 1.0)** http://www.creditvalleyca.ca/low-impact-development/low-impact-development-support/stormwater-management-lid-guidance-documents/andscape-design-guide-for-low-impact-development-version-1-0-june-2010/	
Roads Retrofit Design Guide	**Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC)** http://www.creditvalleyca.ca/wp-content/uploads/2014/08/Grey-to-Green-Road-ROW-Retrofits-Complete_1.pdf	
Business & Multi- Res. Retrofit Design Guide	**Grey to Green Business & Multi- Residential Retrofits: Optimizing Your Infrastructure through Low Impact Development (CVC)** http://www.creditvalleyca.ca/wp-content/uploads/2015/01/Grey-to-Green-Business-and-Multiresidential-Guide1.pdf	

Residential Retrofit Design Guide	**Low Impact Development Residential Retrofits: Engaging Residents to Adopt Low Impact Development in their Properties (CVC)** http://www.creditvalleyca.ca/wp-content/uploads/2015/01/Grey-to-Green-Residential-Guide1.pdf	
Public Lands Retrofit Design Guide	**Grey to Green Public Lands Retrofits: Optimizing Parks, Public Buildings, Schools and Places of Worship through Low Impact Development (CVC)** http://www.creditvalleyca.ca/wp-content/uploads/2015/01/Grey-to-Green-Pulic-Lands-Guide.pdf	
Inspection and Maintenance Guide	**Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide (TRCA/ STEP, 2016, Version 1.0)** http://www.sustainabletechnologies.ca/wp/home/urban-runoff-green-infrastructure/low-impact-development/low-impact-development-stormwater-practice-inspection-and-maintenance-guide/	
Life Cycle Costs Report	**Assessment of Life Cycle Costs for Low Impact Development Stormwater Management Practices (TRCA, UofT, 2013)** http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2013/06/LID-LCC-final-2013.pdf	

Costing Tool	**Low Impact Development Life Cycle Costing Tool (STEP)** http://www.sustainabletechnologies.ca/wp/home/urban-runoff-green-infrastructure/low-impact-development/low-impact-development-life-cycle-costs/	
Crossing Guidelines	**TRCA: Crossings Guidelines for Valley and Stream Corridors** http://www.trca.on.ca/dotAsset/214493.pdf **CVC:** Under development (2019).	
Fluvial Geomorphic Guidelines	**Credit Valley Conservation Fluvial Geomorphic Guidelines** https://cvc.ca/wp-content/uploads/2015/05/CVC-Fluvial-G-Guide_April-2015.pdf	
Approval Guide	**Guide to Applying for an Environmental Compliance Approval** https://www.ontario.ca/document/guide-applying-environmental-compliance-approval	

ECA Submission Checklist	**Checklist for Technical Requirements for Complete Environmental Compliance Approval Submission** https://www.ontario.ca/document/checklist-technical-requirements-complete-environmental-compliance-approval-submission	
Groundwater Mounding Analysis	**Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins** **USGS** https://pubs.usgs.gov/sir/2010/5102/ spreadsheet Hantush_USGS_SIR_2010-5102-1110.xlsm	
LID Performance Resources	**Sustainable Technologies Evaluation Program available** http://www.sustainabletechnologies.ca/wp/publications/ **LID BMP monitoring plans, technical reports and case studies** http://www.creditvalleyca.ca/low-impact-development/lid-maintenance-monitoring/ **International Stormwater BMP Database** http://www.bmpdatabase.org/index.htm.	
Other Resources and Reports		

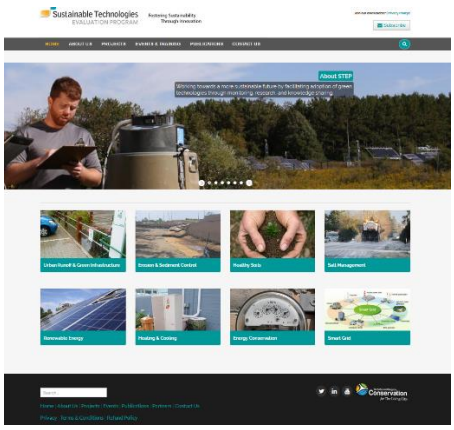
Sustainable Technologies Evaluation Program (STEP): www.sustainabletechnologies.ca/

Resources, Studies and Reports

1. Green Infrastructure Map
2. Stormwater Infiltration in Cold Climates Review (2009)
3. Stormwater Management and Watercourse Impacts: The Need for a Water Balance Approach
4. Preserving and Restoring Healthy Soil: Best Practices for Urban Construction
5. LID Discussion Paper
6. Urban Water Balance
7. LID "Barrier Buster" fact sheet series

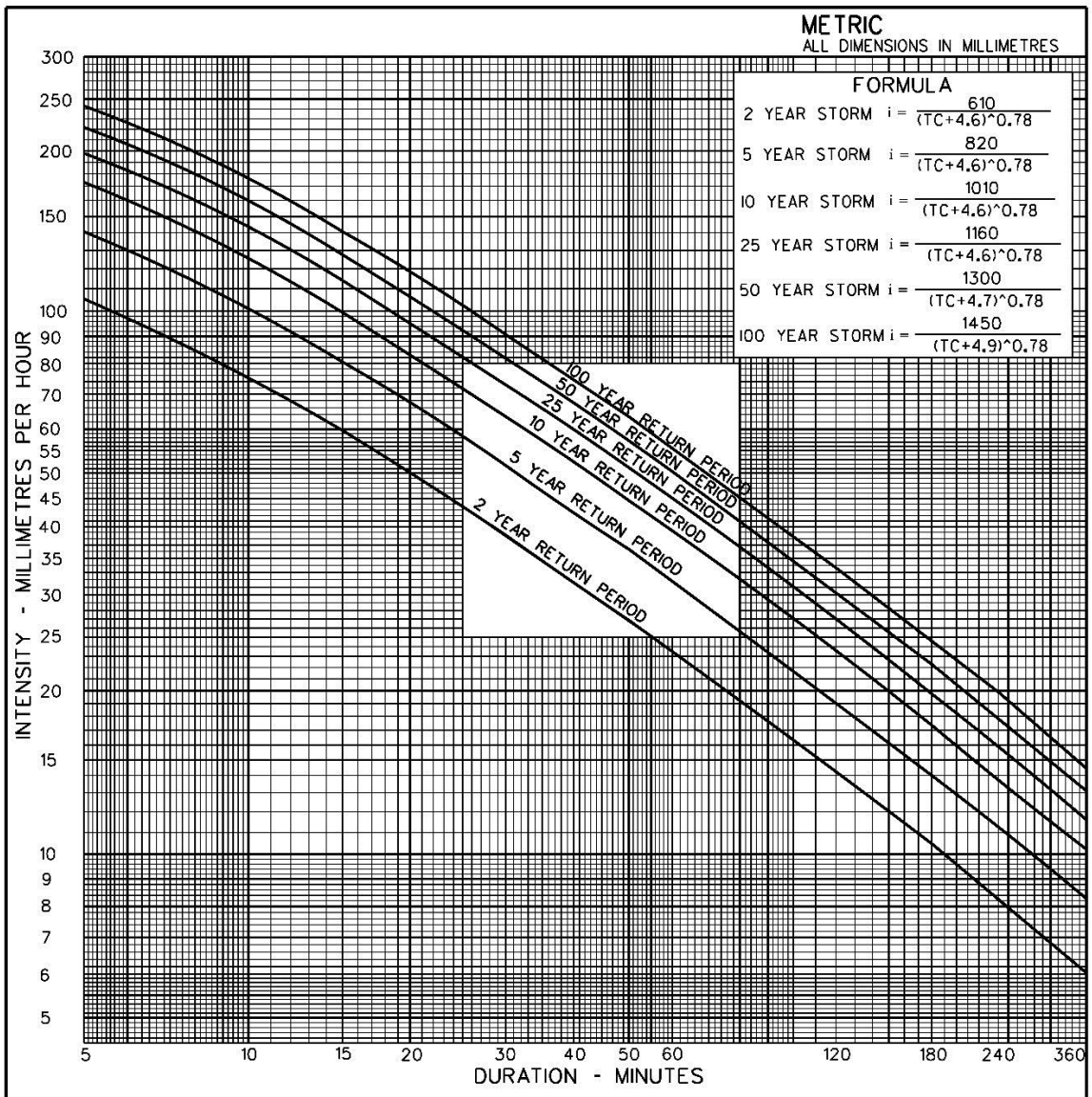
Features Studies and Resources:

8. Bioretention and Rain Gardens
9. Green Roofs
10. Soakaways, Infiltration Trenches and Chambers
11. Permeable Pavement
12. Swales and Roadside Ditches
13. Perforated Pipe Systems
14. Rainwater Harvesting
15. Residential Stormwater Landscaping
16. Water Balance for the Protection of Natural Features



Appendix B – Policy Review Report

Appendix C – Region of Peel Intensity-Duration-Frequency Curves



NOTES

1. ALL CALCULATIONS TO BE DONE ASSUMING FULL DEVELOPMENT

2. TO BE USED WITH RATIONAL FORMULA:
   $Q = \frac{CIA}{360}$
   Q=QUANTITY OF RUNOFF (M^3/S)
   C=RUNOFF COEFFICIENT
   A=AREA (ha)
   I=RAINFALL INTENSITY (mm/hr)

REGION OF PEEL

STANDARD
INTENSITY-DURATION-FREQUENCY
RAINFALL CURVES

EFF. DATE			SCALE N.T.S
REV.		-	STANDARD No.

Appendix D – Innovation, Deviation & Pilot Project Tracking Form

Region of Peel
Working for you

INNOVATION / DEVIATION & PILOT PROJECT TRACKING FORM

Pilot Project Tracking No.

Pilot Initiator:		**Date:**	
City Contact:		**Phone/ Email:**	
Project Title:			
Type of Pilot:	**Product:**	**Method**:	**Other:**

Pilot Description:

Pilot Location:

Pilot Start Date:

Estimated Pilot End Date:

Name and Section of Design Guidelines and/ or Standard which the pilot is applicable:

Title of the deviation report describing the proposed pilot:

Has the deviation report been included?

Name of Product(s):

Product Contact:

Phone Number and E-mail:

Pilot Monitoring Required (yes/no)? If yes specify:

Region of Peel
Working for you

INNOVATION / DEVIATION & PILOT PROJECT TRACKING FORM

Final Pilot Report (yes/no)? If yes specify:

Is a report required at the end of the pilot?:

Name of individual or consultant to write the report:

Phone Number and e-mail:

Document Change Authority Notified at end of pilot:

Other Information:

Appendix E – LID Implementation Process for Regional Road ROW

Appendix F – High Risk Site Activities

High Risk Site Activities

High Risk Site Activities which preclude the use infiltration-based LID practices within the contributing catchment area		
Acid and Alkali Manufacturing, Processing and Bulk Storage	Explosives and Firing Range	Petroleum-derived Gas Refining, Manufacturing, Processing and Bulk Storage
Adhesives and Resins Manufacturing, Processing and Bulk Storage	Fertilizer Manufacturing, Processing and Bulk Storage	Pharmaceutical Manufacturing and Processing
Airstrips and Hangars Operation	Fire Retardant Manufacturing, Processing and Bulk Storage	Plastics (including Fibreglass) Manufacturing and Processing
Antifreeze and De-icing Manufacturing and Bulk Storage	Fire Training	Port Activities, including Operation and Maintenance of Wharves and Docks
Asphalt and Bitumen Manufacturing	Flocculants Manufacturing, Processing and Bulk Storage	Pulp, Paper and Paperboard Manufacturing and Processing
Battery Manufacturing, Recycling and Bulk Storage	Foam and Expanded Foam Manufacturing and Processing	Rail Yards, Tracks and Spurs
Boat Manufacturing	Garages and Maintenance and Repair of Railcars, Marine Vehicles and Aviation Vehicles	Rubber Manufacturing and Processing
Chemical Manufacturing, Processing and Bulk Storage	Gasoline and Associated Products Storage in Fixed Tanks	Salt Manufacturing, Processing and Bulk Storage
Coal Gasification	Glass Manufacturing	Salvage Yard, including automobile wrecking
Commercial Autobody Shops	Importation of Fill Material of Unknown Quality	Soap and Detergent Manufacturing, Processing and Bulk Storage
Commercial Trucking and Container Terminals	Ink Manufacturing, Processing and Bulk Storage	Solvent Manufacturing, Processing and Bulk Storage
Concrete, Cement and Lime Manufacturing	Iron and Steel Manufacturing and Processing	Storage, maintenance, fuelling and repair of equipment, vehicles, and material used to maintain transportation systems
Cosmetics Manufacturing, Processing and Bulk Storage	Metal Treatment, Coating, Plating and Finishing	Tannery
Crude Oil Refining, Processing and Bulk Storage	Metal Fabrication	Textile Manufacturing and Processing
Discharge of Brine related to oil and gas production	Mining, Smelting and Refining; Ore Processing; Tailings Storage	Transformer Manufacturing, Processing and Use
Drum and Barrel and Tank Reconditioning and Recycling	Oil Production	Treatment of Sewage equal to or greater than 10,000 litres per day
Dye Manufacturing, Processing and Bulk Storage	Operation of Dry Cleaning Equipment (where chemicals are used)	Vehicles and Associated Parts Manufacturing
Electricity Generation, Transformation and Power Stations	Ordnance Use	Waste Disposal and Waste Management, including thermal treatment, landfilling and transfer of waste, other than use of biosoils as soil conditioners
Electronic and Computer Equipment Manufacturing	Paints Manufacturing, Processing and Bulk Storage	Wood Treating and Preservative Facility and Bulk Storage of Treated and Preserved Wood Products
Explosives and Ammunition Manufacturing, Production and Bulk Storage	Pesticides (including Herbicides, Fungicides and Anti-Fouling Agents) Manufacturing, Processing, Bulk Storage and Large-Scale Applications	

Source: O. Reg. 153/04: Records of Site Condition- Table 2 – Potentially Contaminating Activities