Lower Trent Region

Conservation Authority

Stormwater Management Technical Guidelines

December 2020

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NOTE:

Provincial Ministries have gone through a number of name modifications due to changes in political ideology or focus. In the following document references to the current version of the Ministry label have been made but in referencing certain publications by these ministries under previous names, the previous name or acronym associated with the publication at that time is used.

Ministry of Environment, Conservation and Parks (MECP) (2018 to present) was previously known as Ministry of the Environment (MOE), (1972 – 1993, 1998 -2014), Ministry of Environment and Energy (MOEE) (1993 – 1997) and the Ministry of Environment and Climate Change (MOECC) (2014 – 2018).

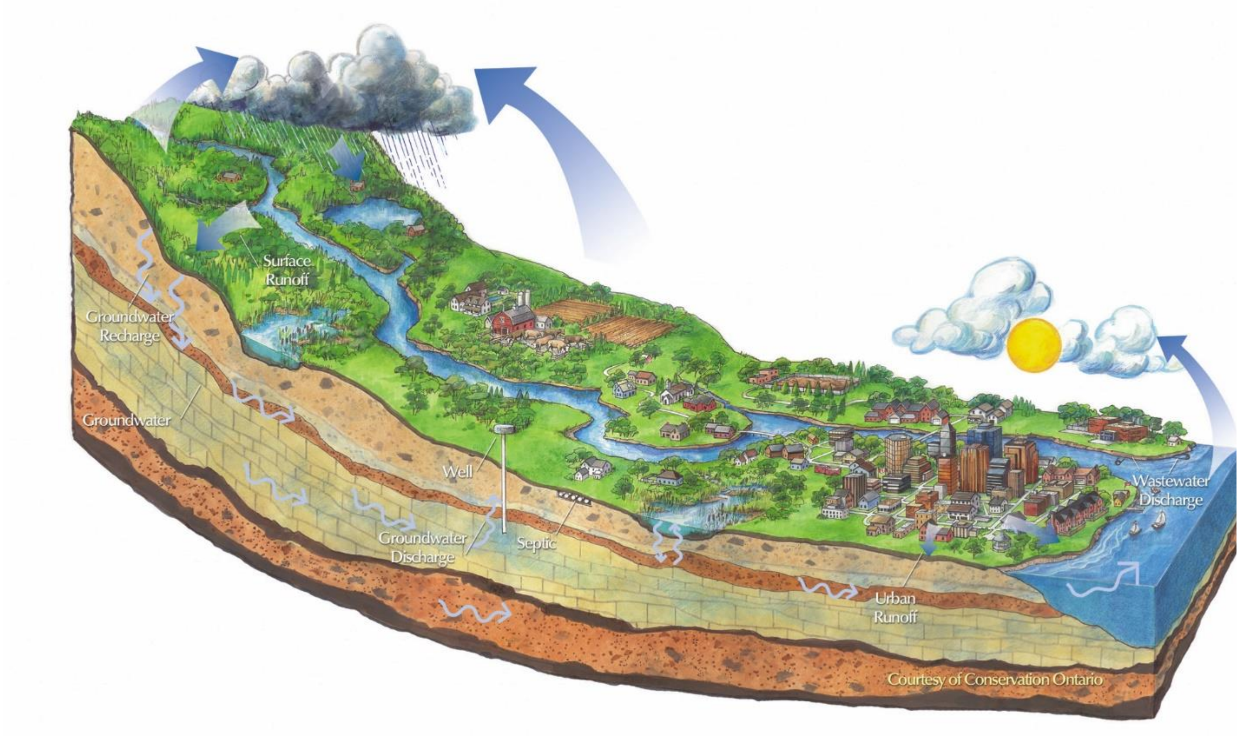
The Ministry of Natural Resources and Forestry (MNRF) (2014 –present) was previously known as the Ministry of Natural Resources (MNR) (1997 – 2014).

1 INTRODUCTION

1.1 The Need for Effective Stormwater Management

The Trent River, Bay of Quinte and Lake Ontario play essential roles in the health and well-being of residents of the Lower Trent Conservation watershed. The Trent River provides the Towns and Villages of Trenton, Batawa, Frankford, Campbellford and Hastings with a safe and abundant source of drinking water. The Bay of Quinte, Lake Ontario and all the tributary streams support a wide range of recreational opportunities that include swimming, boating, fishing and many other activities. Effective management of stormwater is critical to the continued health of our streams, rivers, lakes, fisheries and terrestrial habitats.

As can be seen in Figure 1 below, rain can take several paths once it falls on the ground. It can infiltrate into the soil, evaporate, be subject to evapotranspiration, or it can run overland as runoff. In natural settings, vegetation and the lack of hard surfaces ensures that little runoff occurs. In urban areas with hard surfaces and limited vegetation, the majority of the rainwater becomes runoff.



(Source: Conservation Ontario)

Figure 1: The Hydrologic Cycle

The water quality of the Bay of Quinte and Lake Ontario are directly dependent on the health of the rivers and creeks that feed into them. The Bay of Quinte was identified as an Area of Concern (AOC) and the Remedial Action Plan (BQRAP) has been put in place to address poor water quality in the Bay, among other issues. Stormwater contributions play a role in this concern. The BQRAP is currently in process of developing a Phosphorus Management Strategy that may require even further consideration of

Stormwater Quality criteria in the Lower Trent Conservation (LTC) watershed. Once the strategy has been developed the recommendations from the Strategy may be incorporated into an updated version of this document. Please see the website for more details. https://www.bqrap.ca/

Lake Ontario and its contributing watersheds can be severely impacted by human activity, particularly through the release of various pollutants into the natural environment. Human activity affects the quality and quantity of runoff. In urban areas, for example, buildings and paved streets increase the amount of hard surfaces and in turn reduce opportunities for natural infiltration. These hard surfaces decrease water quality by providing increased opportunity for pollutants to accumulate (e.g. oil, grease, and exhaust emissions from vehicles), which are washed off during rainfall events polluting ground and surface waters.

As well, hard surfaces generate increased levels of runoff, which causes downstream flooding and erosion. The increase in surface runoff may cause flooding, thus damaging property and municipal infrastructure. Water-borne pollutants can cause hydrological, water quality, and ecological impacts to natural heritage features. Natural flow patterns are disrupted since rainfall is redirected via storm sewers away from source areas to concentrated outfalls. As a result, urban areas change the natural hydrology cycle by altering the volume, frequency, duration, timing, and distribution of runoff.

1.2 Conservation Authority Role

"*The Provincial Policy Statement provides policy direction on matters of provincial interest related to land use planning and development. As a key part of Ontario's policy-led planning system, the Provincial Policy Statement sets the policy foundation for regulating the development and use of land. It also supports the provincial goal to enhance the quality of life for all Ontarians.*" Preamble from the Provincial Policy Statement (PPS 2020).

Lower Trent Conservation, along with the other 35 Conservation Authorities, has been delegated by the Province to provide input and review on Planning Act applications with respect to Natural Hazards under Section 3.1 of the PPS 2020. In this capacity flooding and erosion hazards and impacts from development on these natural hazards are assessed and reviewed by LTC on behalf of the Province. Development is to be kept out of lands that are deemed hazardous due to flooding, erosion or dynamic beaches along Great Lakes Shorelines, erosion and flood hazard lands along riverine or inland lake systems or hazardous sites, such as those with Karst bedrock hazards or peat soils sites. LTC does not provide comment on hazardous forest types for wildland fire.

Lower Trent Conservation has an agreement with all our municipal partners to also provide advice to the municipality under Sections 2.1 Natural Heritage and 2.2 Water (PPS 2020). In this capacity comments from LTC are provided to the municipal partners for consideration ensuring that a watershed based approach and solution is considered. Under the Water Section of the PPS, stormwater management review is undertaken by LTC to ensure "… *stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces*." (PPS 2020)

It is worth noting here that the municipality and/or the County is the planning authority that provides approval for municipal planning act applications. The Conservation Authority is a commenting agency, providing advice and recommendations to our municipal partners in regards to Section 2.1 and 2.2 and we provide input in Section 3.1 on behalf of the province.

1.3 Purpose of this Document

The purpose of this document is to provide guidance to the development community and their consultants regarding the stormwater management (SWM) requirements of the Lower Trent Region Conservation Authority (LTC). The guidance in this document is focused on what should be included in the SWM submissions. It should result in the following benefits:

- application of uniform SWM standards
- consistency of SWM requirements
- fairness to proponents
- reduced need for re-submissions due to inadequate information
- streamlined review process
- improved client service

It is not intended to be a comprehensive stormwater management planning and design manual like the *Stormwater Management Planning & Design Manual* (SWMPDM) published by the Ministry of the Environment (MOE, 2003) or similar documents. The former Ministry of Environment (MOE) is now referred to as the Ministry of Environment, Conservation and Parks (MECP). Detailed planning and design guidance can be found in those documents.

Referenced documents include:

- *Credit Valley Conservation & Toronto Region Conservation Authority Low Impact Development Stormwater Management Planning and Design Guide*, Version 1.0 (2010) – referred as CVC/TRCA LID Guide.
- *Toronto and Region Conservation Authority Erosion and Sediment Control Guideline for Urban Construction* (2019) – referred as TRCA ESC.
- *Bay of Quinte Remedial Action Plan – Stormwater Management Design Guidelines* (March 2006) – referred as BQRAP SWM Guidelines.
- *Ministry of the Environment Stormwater Management Planning and Design Manual* (2003) – referred as MOE SWMPDM.
- *Ministry of Natural Resources River and Stream Systems Flooding Hazard Limit Technical Guide* (2002)
- *Ministry of Transportation Drainage Management Manual* (1997) – referred as MTO Drainage Manual.

The Ministry of Environment and Climate Change (MOECC now MECP) issued an Interpretation Bulletin on February 4, 2015 outlining the expectations of the Ministry with respect to Stormwater Management. The main points of this Bulletin are listed below:

- The natural hydrologic cycle should be maintained to the greatest extent possible. The Ministry's existing acts, regulations, policies and guidelines emphasize the need for this approach to stormwater management.
- Too often, preservation of the natural hydrologic cycle is not sufficiently addressed in stormwater management plans submitted to the Ministry for an Environmental Compliance Approval (ECA).

- Low Impact Development (LID) stormwater management is relevant to all forms of development, including urban intensification and retrofit.
- LID can be less costly than conventional stormwater management practices.
- Going forward, the Ministry expects that stormwater management plans will reflect the findings of watershed, sub-watershed, and environmental management plans and will employ LID in order to maintain the natural hydrologic cycle to the greatest extent possible.

It is noted that the Ministry of Environment, Conservation and Parks (MECP) is currently working on Low Impact Design Guidance Manual. The *Draft Low Impact Design Stormwater Management Guidance Manual* was released for comment in April 2017. This document has not been finalized or endorsed by the MECP at this time of the writing of this LTC document but certain concepts are still applicable and may be referenced.

1.4 Stormwater Design Criteria

Stormwater criteria should be defined at the preliminary stages of a new planning development, and are defined to reflect the scale of studies. For example, at the watershed scale, flood control targets may consist of peak flow rates at the subwatershed outlet, while the focus at the site plan scale is on site release rates.

Design criteria are provided to:

- Prevent increased flooding
- Protect water quality
- Preserve baseflow characteristics
- Limit undesirable geomorphic changes in watercourses
- Maintain groundwater quality
- Maintain the existing pre-development water balance

2 STORMWATER MANAGEMENT DESIGN PROCESS

2.1 Environmental Planning and Stormwater Management

The MOE SWMPDM provides an environmental planning context and shows the relationship with the municipal land use planning process. The environmental planning process includes watershed and subwatershed studies, environmental management plan or master drainage plan, and the Stormwater Management Report or Brief (SWM). Urban development should be done in relationship with the environmental planning process. The SWM plan for urban development, i.e. plan of subdivision or site plan, would then follow the environmental criteria developed through the watershed/subwatershed plan to meet its objectives. In some cases, where the development is allowed to proceed without subwatershed planning having taken place e.g. where little future development is planned, the MOE SWMPDM provides some guidance on the environmental design criteria.

2.2 Project Scale and the Planning Process

All change in land use proposed by a development application should evaluate the hydraulic, hydrologic, geomorphic, and ecological conditions of a subject area. SWM designs should address water quantity, water quality, erosion controls and water balance. The scale and scope of land development ranges widely. The level of detail required to address SWM controls reflects the land use application under consideration, as described in the subsequent sections of this document.

Lower Trent Conservation will provide plan input for:

- Any proposed development greater than 1 ha; or
- Proposals that will result in a change of surface hardening greater than 0.5 ha.

It is very strongly recommended that a Pre-Consultation meeting with the proponent, municipal planning and public works departments and Lower Trent Conservation be arranged at the onset of the proposal before any technical studies are undertaken to ensure the requirements for moving forward are clear to all parties.

2.2.1 Official Plan Amendments, Secondary Plans, or "Block" Plans

These are normally supported by a functional servicing report, a component of which includes a detailed evaluation of the subject area and its catchment(s) to derive a preliminary SWM plan. Preliminary targets and criteria are established.

2.2.2 Zoning By-law Amendments

If the change in proposed land use is deemed by the municipality to be significant, a SWM plan may be created as part of a functional servicing report. Since the scale of project is more defined than at an official plan stage, a more detailed evaluation of site conditions is expected.

2.2.3 Plans of Subdivision

These require detailed infrastructure design. A conceptual SWM plan, usually based on an existing functional servicing report, is typically submitted to get draft plan approval and to provide the necessary space or block for SWM controls. Prior to construction, a detailed SWM plan is required.

2.2.4 Site Plans

Depending on the size and complexity of the site, either a functional servicing report, or detailed SWM plan or brief is required.

2.2.5 Consents (Severances) and Minor Variances

These may require technical analyses and SWM controls, depending on the size and complexity of the site. Some may only require lot grading and drainage considerations. The requirement for these studies will be identified by the municipality.

2.2.6 Single Lot Residential Development (<0.5 ha)

The municipality may require an outline brief of the best management practices (BMPs such as roof drain disconnection, rain garden, soakaway pit) to be incorporated for the site. Lot grading and drainage considerations are typically included. LTC does not need to be circulated on small residential development applications.

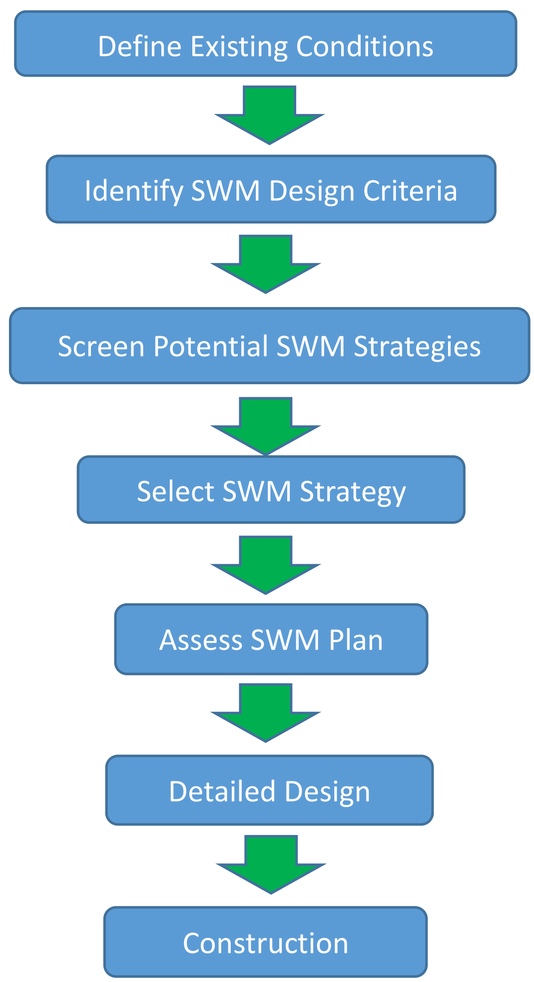
2.3 Design Steps

2.3.1 Define Existing Conditions

Pre-development conditions must be established – **this is a very critical step in the Stormwater Management Plan**. All analyses should include maps showing existing land use, external drainage areas, topography, relevant environmental features, and existing infrastructure. A soils analysis, outlining the native soil types, infiltration capacity, depth to water table and depth to bedrock should be included as well. In many cases a detailed hydrogeologic or geotechnical report may be required for the development and these reports will provide additional background information for the stormwater management report. Slope stability or karst hazard assessments may also be required.

Presence of natural heritage features will require development setback to be observed. Analysis of the existing conditions will provide the environmental constraints for the proposed development. This is an important first step for the SWM design process.

Stormwater Management Design Process



2.3.2 Establish SWM and/or Environmental Design Criteria

With the existing conditions established, individual SWM components must be assessed to define the project's SWM design criteria, which may be: water quality control, water quantity control (or flood protection), stream erosion control, water balance or a combination of these. A discussion of the physical site constraints based on the existing conditions and applicable SWM types should be included in the review for design criteria. Reference to Table 4.1 of the MOE SWMPDM 2003 should be included.

2.3.3 Screen and Select Potential SWM Strategies

It is strongly encouraged that more than one treatment system be used for a project by using a treatment train approach. A combination of source, conveyance, end-of-pipe facilities, and low impact development practices should be considered to meet the water quantity, water quality, water balance and erosion design criteria.

2.3.4 Assess the Effectiveness of the Stormwater Management Plan

With a SWM strategy selected, an analysis of its effectiveness should be carried out. Depending on the size of the project, calculations or computer models should be used to test the SWM concept. This is typically done with modelling software, such as an OTTHYMO based model that is the most widely locally accepted modelling tool. There are other acceptable modelling tools but the selection of model software should be discussed with LTC and the Municipality.

The use of the computational model will facilitate the design process to be able to assess various storms of different return periods, durations and distributions to help evaluate the effectiveness of the proposed design. Design modifications and sensitivity analyses can be undertaken easily to better support the proposed methodologies when using a computational model rather than simple hand calculations.

2.3.5 Detailed Design

Detailed stormwater management infrastructure design will be required at this stage and clearance from the Conservation Authority is typically required as part of the submission to MECP for and Environmental Compliance Approval (ECA) application. Any local municipal engineering standards should be referenced. Details on the design criteria for major and minor storm infrastructure as well as the design of SWM facilities will be included. Drawings will show section views of the SWM facility, details of the inlet and outlet control structure, stage-storage information and any other views necessary to explain the facility function and construction. Lot grading and erosion control will be reviewed at this time. An operation and maintenance manual is expected to be included as information to the ultimate owner/user of the system. Parking lot and rooftop storage facilities will show the extent of flooding for the 100-year event as well.

2.3.6 Construction

During construction, stormwater management is largely focused on erosion and sediment control (ESC). The Erosion and Sediment Control Guideline for Urban Construction (TRCA ESC, 2019) provides guidance on the approaches and criteria and is a good resource for reference while preparing sediment and erosion control plans. There may be additional considerations for construction of infiltration facilities to ensure that the subsoils do not get compacted beyond their capacity to infiltrate runoff. These considerations should also be included in the ESC plan.

2.4 LTC Local Studies

The stormwater management guidelines of the Lower Trent Region Conservation Authority (LTC) are to be read in conjunction with local municipal standards and/or watershed/sub-watershed studies in respect of stormwater quantity and quality control. The LTC's requirements for all stormwater management submissions are outlined in the following sections, which include a description of LTC guidelines, guidance on approved methods and techniques, a summary of key hydrologic parameters, and a summary of submission requirements.

The City of Quinte West has stormwater design standards that should be considered for a stormwater management submission in this municipality.
http://www.quintewest.ca/en/cityhall/EngineeringServices.asp

Approved Master Drainage Plans (MDP) have been developed for areas in Brighton and Frankford:

- Municipality of Brighton Stormwater Master Plan (EOR 2019)
- Master Drainage Study, Southwest Brighton (Totten Sims Hubicki - April 1991)
- Master Drainage Study, Northeast Brighton (Totten Sims Hubicki - January 1993)
- North-West Urban Area Master Drainage Study – Village of Frankford (GM Sernas – July 1997)

Other Master Drainage Plans (MDP) that have been undertaken but not approved or accepted:

- DRAFT Mayhew Creek Master Drainage Plan (WaterPlan & XCG – April 2009) – not adopted

Subwatershed Studies have been undertaken by LTC in the LTC Watershed in the City of Quinte West. Floodplain mapping and guidance on stormwater are included in these two studies, which include:

- South Sidney Watershed Plan (March 1995)
- Dead & York Creek Subwatershed Plan (July 1997)

The City of Quinte West has also developed other drainage strategies to address urban development in the former Murray Township (West End), Sidney Township (Monogram Place) and Trenton (North Murray Street) that should be followed as well.

- West End Infrastructure Design Brief (Greer Galloway Group – February 1999)
- Preliminary Assessment Report Stormwater Management North Murray Industrial Park (Ainley – February 2001)
- Stormwater Management Strategy Report – Monogram Place (Ainley – February & October 2008)

2.5 Summary of Stormwater Management Design Criteria

For quantity control, the minimum requirement is that post-development flow is restricted to pre-development peaks, unless identified otherwise. Further control may be required depending on the receiver for the stormwater runoff (i.e. municipal storm sewer system). There are some areas that have been identified with Allowable Release Rates (ARR) in an MDP or drainage strategy.

For erosion control, the minimum requirement is that the runoff from a 25mm storm is detained for 24 hours, unless identified otherwise.

For water quality control, outflow from SWM facilities should attempt to achieve enhanced level requirements (80% removal of total suspended solids), unless identified otherwise. For the City of Quinte West, the Bay of Quinte Remedial Action Plan Stormwater Design Guidelines require Enhanced level water quality control for new and retrofit stormwater facilities.

Many watercourses within the LTC jurisdiction are cold-water systems and/or have sensitive wetland systems. SWM facilities should therefore incorporate measures to provide enhanced water quality and reduce the temperature of water discharging to the sensitive receiving watercourses.

In some cases, it will be recommended that Water Balance assessments be made and attempts to achieve pre-development water balance should be undertaken through Low Impact Development design and treatment train approaches. This is consistent with MECP's Interpretation Bulletin (Feb 2015).

2.6 Climate Change Considerations

In the Spring of 2020, the provincial government released an update on the Provincial Policy Statement (PPS 2020). There is a strong focus on preparing for the impacts of climate change throughout the document. When reviewing stormwater management plans, the policies in the PPS are considered as per the Conservation Authorities delegated responsibilities from the province (Section 3.1) and the Agreements with municipal partners (Sections 2.1 and 2.2). Specific Sections referencing impacts to climate change in the PPS are listed below:

- 1.0 Building Strong Healthy Communities:
    - 1.6 Infrastructure and Public Service Facilities: 1.6.1 Infrastructure and public service facilities shall be provided in an efficient manner that prepares for the *impacts of a changing climate* while accommodating projected needs.
    - 1.6 Infrastructure and Public Service Facilities: 1.6.2 Planning authorities should *promote green infrastructure to complement infrastructure*.
    - 1.6 Infrastructure and Public Service Facilities: 1.6.6 Sewage, Water and Stormwater: 1.6.6.1 Planning for sewage and water services shall: b) ensure that these systems are provided in a manner that: 2. *prepares for the impacts of a changing climate*;
    - 1.6 Infrastructure and Public Service Facilities: 1.6.6 Sewage, Water and Stormwater: 1.6.6.7 Planning for stormwater management shall: c) minimize erosion and changes in water balance, and *prepare for the impacts of a changing climate through the effective management of stormwater, including the use of green infrastructure*;
    - 1.7 Long-Term Economic Prosperity: 1.7.1 Long-term economic prosperity should be supported by: k) *minimizing negative impacts from a changing climate and considering the ecological benefits provided by nature*;
    - 1.8 Energy Conservation, Air Quality and Climate Change: 1.8.1 Planning authorities shall support energy conservation and efficiency, improved air quality, reduced greenhouse gas emissions, and *preparing for the impacts of a changing climate* through land use and development patterns which: f) promote design and orientation which maximizes energy efficiency and conservation, and considers the mitigating effects of vegetation and *green infrastructure*;
- 2.0 Wise Use and Management of Resources:
    - 2.2 Water 2.2.1 Planning authorities shall protect, improve or restore the quality and quantity of water by: c) evaluating and *preparing for the impacts of a changing climate* to water resource systems at the watershed level;
- 3.0 Protecting Public Health and Safety:
    - 3.1 Natural Hazards 3.1.3 Planning authorities shall *prepare for the impacts of a changing climate* that may increase the risk associated with natural hazards.

These statements underline the importance of addressing climate change impacts in reviewing stormwater management submissions. Climate change considerations should be addressed by the applicant and the Conservation Authority will review and provide comments and recommendations in our comments to municipal partners as per our agreements and provincially delegated role. Recommendations of how to address climate change impacts with respect to stormwater management are provided in Section 3.9 of this document.

2.7 Fisheries Criteria

Level of Water Quality Protection, as defined by the MECP, is based on the protection of fisheries and fish habitat. A good discussion of Level of Protection required with regards to fisheries for proposed development can be found in the MOE SWMPD Manual 2003 in Section 3.3.1.1. This level of protection defines whether enhanced, normal or basic water quality protection is required.

Where stormwater management, erosion, or sedimentation control issues related to development proposals could impact fish habitat, a Department of Fisheries and Oceans (DFO) review to ensure protection of habitat is recommended. Please see the DFO Website for Projects Near Water for further information: https://www.dfo-mpo.gc.ca/pnw-ppe/index-eng.html

2.8 Erosion and Sediment Control during Construction

Proponents are encouraged to adhere to the recommendations outlined in the 2019 *Erosion and Sediment Control Guideline for Urban Construction* written by the Toronto and Region Conservation Authority (TRCA) as part of the Sustainable Technologies Evaluation Program (STEP) https://sustainabletechnologies.ca/home/erosion-and-sediment-control/esc-guide/.

Municipalities should have a clear understanding of the required erosion and sediment control (ESC) and how this will be monitored throughout the construction process and through various phases.

The Canadian Standards Association (CSA) Group has also come up with a new erosion and sediment control standard labelled CSA W202-18. This new standard sets measurable benchmarks for inspections and monitoring, clearly details inspector qualifications and encourages the use of the best available technologies. The STEP ESC Guideline should be read in conjunction with the CSA Standard.

2.9 Hydraulic Considerations

LTC requires a thorough hydraulic analysis for all developments proposing to alter land use and grades within the Regulatory floodplain. The proponent will be required, where available, to use existing LTC-approved analyses, maps, and/or computer models as the base model for computations.

The MNR's 2002 *River and Stream Systems Flooding Hazard Limit Technical Guide* should be followed when developing the hydraulic model and completing the analysis. The U.S Army Corps of Engineers' HEC-RAS is recommended to be used, unless an alternative is approved by the Authority. Both paper and digital copies of model input/output must be submitted. If hydrologic analyses have been undertaken by the consultant, calculation sheets, model outputs, and digital model files are requested to be appended to the report.

2.10 Channelization

Creek channelization or re-channelization should be avoided wherever possible. Depending on the watercourse, the Municipality and Authority must be consulted to determine conveyance requirements for any proposed channelization.

3 STORMWATER MANAGEMENT CONSIDERATIONS

Stormwater management technology is constantly being improved through research and implementation experience. It is not the intent of LTC to restrict innovative technology with these guidelines. Rather, LTC encourages the application of innovative green technologies in stormwater management and is willing to work with proponents wishing to explore green options with the concurrence of the Municipality. The Sustainable Technologies Evaluation Program (STEP) is an initiative between local conservation authorities, federal and provincial agencies, municipalities and universities to advance innovative technologies in stormwater management. Interested proponents are encouraged to visit the STEP website, https://sustainabletechnologies.ca/ for further information.

3.1 Stormwater Management Requirements

All SWM submissions for the site should identify and meet the requirements of the watershed or subwatershed study for the watershed (if applicable) in which it is located, and any related approved stormwater management report or previous report. Supporting information should be provided as necessary. The MOE's SWMPDM (March 2003) advocates the use of a hierarchy of SWM practices or "treatment train" approach that starts with lot level controls, followed by conveyance controls and then end-of-pipe SWM facilities. Examples (not an exhaustive list) of these controls are listed below:

Lot Level Controls:

- rooftop detention
- parking lot storage through catch basin restrictors or orifices in the storm sewer
- rear yard storage
- reduced lot grading
- disconnecting roof leaders and directing the flow to the backyard or soakaway pits
- Porous pavement

Conveyance Controls:

- Grassed swales
- Pervious pipe systems
- Pervious catch-basins

End-of-pipe (EOP) Stormwater Management:

- Filter strips
- Buffer strips
- Infiltration basins or trenches
- Oil/grit separators
- Sand filters
- Dry ponds
- Wet ponds
- Wetlands
- Hybrid Ponds
- Filtration Devices

A treatment train approach is required to meet the multiple SWM objectives of water quality, water balance, erosion and flood control. Lot level and conveyance controls are best for achieving water balance objectives. They can also reduce end-of-pipe storage requirements for erosion control. In many cases, end-of-pipe controls are required to meet water quality, and erosion and flood control objectives.

If stormwater runoff is discharged to a roadside ditch that is part of a provincial highway drainage system, approvals may be required from the Ministry of Transportation (MTO). Guidance can be found in the *MTO Drainage Management Manual* (MTO, 1997), and the *Stormwater Management Requirements for Land Development Proposals* (MTO, 1999).

Similarly, if stormwater runoff is discharged as part of an upper or lower tier municipal transportation system, municipalities may require municipal or regional standards to be followed. The impacts of urbanization on the hydrologic cycle and the ecosystem can be broadly categorized to include changes to water balance, stream flows e.g. floods, stream morphology, water quality, and aquatic habitat and ecology. In order to mitigate these changes, stormwater management criteria are designed to deal with flooding (peak flow control), stream erosion (peak, duration, frequency control), water quality (pollution loading control), and water balance (volume reduction).

3.2 Lot Level and Conveyance Controls or Low Impact Development (LID)

In recent years, more emphasis has been put on lot level controls and conveyance controls such as green roofs, bioretention, infiltration practices, permeable pavement, and rainwater harvesting. In the U.S., the term "Low Impact Development" has been used for these stormwater management practices and has been adopted here in Canada as well. The U.S. EPA has put out a document on LID and defines it as: "*Low impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution. LID comprises a set of site design approaches and small scale stormwater practices that promote 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*". Credit Valley Conservation (CVC) and the Toronto and Region Conservation Authority (TRCA) have jointly developed a *LID Stormwater Management Manual* (CVC & TRCA, 2010). More details about some of these SWM practices are provided in this 2010 manual. SWM submissions to LTC should show that effort has been made to follow the LID approach by incorporating lot level and conveyance controls as recommended in the MOE's SWMPDM (2003) or most current version.

In 2017 the Ontario government (MOECC) issued a DRAFT LID Guidance Manual for review but this document has not been finalized and released for use at this time. Although only a draft document, this document does provide good information and a great resource directory in the appendices.

3.3 Stormwater Quantity (Flood) Control

Every effort should be made to maintain existing watershed boundaries and drainage patterns. As a rule, significant changes in drainage boundaries are not allowed. Pre-consultation is mandatory for any proposed change in drainage boundaries.

Unless specified otherwise by a subwatershed study or fluvial geomorphic analysis, the post-development peak flow rates must not exceed the corresponding pre-development peak flow rates for the 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 25 year, 1 in 50 year and the 1 in 100 year design storm events. If noted in a subwatershed study, the Regional Storm (Timmins) may be required to be controlled to the pre-development peak flow rate level as well otherwise safe conveyance of the Timmins event must be proven.

Quantity control may not be required if the site is directly adjacent to Lake Ontario or the Trent River or other large riverine system where onsite peak flows do not need to be detained for flood control purposes. A safe outlet connected to a municipal system that is designed to accept uncontrolled flows from the site may not require quantity control either but this must be confirmed by the municipality. If there is a known deficiency in the downstream conveyance, additional quantity control may be required (i.e. private property, undersized pipes). Quantity control facilities are to be designed in accordance with recommendations set out in the MOE's *Stormwater Management Planning and Design Manual* (2003) or most current version. The reduction in peak flows can be accomplished through a combination of lot level controls, followed by conveyance and end-of-pipe controls.

Among the lot level controls are design requirements for downspouts, foundation drains, catch basins, parking lot and rooftop storage. Downspouts should discharge to a permeable surface where possible, and not connected to the storm sewer.

Further restriction for quantity control may be required if there are downstream constraints that must be included in the assessment, such as requirement to discharge all flows to a municipal storm sewer. In these cases, the 100-year post-development flow may have to be restricted to the pre-development 5-year peak flow (or other appropriate design storm) for storm sewer capacity. Discussions and pre-consultation with LTC and the municipality regarding these requirements should be undertaken at the very beginning of a project.

3.3.1 Parking Lot Storage and Rooftop Storage

Parking lots and rooftops can be used to provide storage to reduce the peak flows in storm sewer systems if approved through the municipality. It has generally been used in commercial and industrial development but not in residential areas due to the small parking areas and generally peaked roofs. It is also widely applied for infill developments in urban areas. Some municipalities do not support roof top storage so the developer is encouraged to discuss this option with the municipality.

Specific Design Requirements for Parking Lot Storage - Inlet control devices (ICDs) and/or orifices when placed in maintenance holes or catch basins restrict the flow going into the sewer system. Storage is created when the runoff is greater than the restricted capacity.

- The maximum allowable ponding depth within the parking lot is to be limited to 0.3 metres for safe access or in accordance with local Municipal standards.
- The maximum ponding extent, elevation and storage volume should be provided at each ponding location and must be shown on the design drawings.
- An emergency overflow system and overland flow route should be provided to allow all runoff exceeding the 100-year storage to be safely routed from the site to a suitable outlet. (i.e. municipal R.O.W.) This flow route should be shown on an engineering plan.
- Orifice / pipe restrictions, inverts and design flows must be shown on the design drawings. Only orifices which are not easy to remove are recommended. Some examples include tube orifices, plate orifices that are grouted in place or have the bolt heads rounded. Bolt-on controls which attach to catch basin lids are not recommended.

Specific Design Requirements for Rooftop Storage - Where rooftop controls are used, design submissions should indicate:

- the type of control to be installed (i.e., product name and manufacturer);
- the number and placement of proposed drains and weirs;
- product specifications showing design release rates for each structure;
- the maximum ponding depth, drawdown time and detained volume at each structure;
- detailed design calculations to determine the total release rate and detained volume for the roof;
- wherever possible, tamper-proof structures are to be selected;

An emergency weir overflow or scuppers should be provided at the maximum design water elevation. Splash pads or erosion protection should also be indicated.

3.3.2 Major-Minor System

The SWM report should include the design for the major and minor systems (MNR et al, 1987). The minor system conveys the frequent runoff events up to the design frequency of the system while the major system conveys the runoff from infrequent storm events that exceed the minor system capacity. Under pre-development conditions, the minor system is the stream or the watercourse conveying the low flows. For post-development conditions, the minor system includes the lot drainage components e.g. lot grades, ditches, swales, street gutters, catch basins and the storm sewer system. The catch basin is the interface between the minor and major drainage systems. They should be designed to capture all the flows up to the design frequency (typically 5-year). For higher intensity storms, the runoff will bypass the catch basins and flow down the street. The major system may include overland flow routes, roadways, artificial channels, streams, and valleys. The major system is designed to provide overland flow routes to a safe outlet that reduces the risk to life and property due to flooding. If it is not planned or designed, water will still find its way to the lowest level but it may be through buildings. Typically, major overland flow routes must be sized for the 1 in 100-year design storm from the site to the receiving watercourse or waterbody.

Other than flow routing within the site plan development, it is recommended that all major overland flow routes be secured by the municipality through ownership or easement (i.e. a road R.O.W. or easement between houses etc.). Note: Regulatory storm conveyance may be required where there are large external drainage areas flowing through a site.

3.3.3 Right of Way

It is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm (in the Lower Trent Watershed this is the Timmins event) through the development site to a sufficient outlet, such that no adverse impacts will be incurred upon downstream landowners. A sufficient outlet typically constitutes a permanently flowing watercourse or water body. A public right of way may also provide a sufficient outlet but must be confirmed by the Municipality. In the case of privately owned land, the proponent may be required to obtain a legal right of discharge registered on title.

3.4 Stormwater Quality Control

Stormwater management practices must be applied to all development in order to provide water quality protection as per the MOE's *Stormwater Management Planning and Design Manual* (March 2003 or subsequent versions). In order to meet the requirements of the federal Fisheries Act prohibiting the deposit of deleterious substances in water frequented by fish, the MOE SWM manual includes three levels of protection for water quality that were developed in consultation with the federal Department of Fisheries and Oceans (DFO). The minimum level of treatment required for any development within the LTC watershed is the Enhanced Protection Level (Level 1) unless otherwise specified. It corresponds to the long-term average removal of 80% of suspended solids. Currently there are no other removal requirements for other water quality parameters such as phosphorus in the Lower Trent watershed.

Please note that a Phosphorus Management Strategy is currently being developed as part of the Bay of Quinte Remedial Action Plan. Once this Strategy comes into effect, the recommendations will be incorporated into this document. There may be stormwater management systems located in sensitive areas that may require a nutrient balance to be incorporated into the stormwater management plan.

The MOE SWMPD manual (Table 3.2) provides water quality storage volume requirements for different SWM practices for the three protection levels. The storage volumes (m^3/ha) are given for different impervious levels. For the specified storage volumes for wet facilities, 40 m^3/ha is the minimum for extended detention, and the remainder is for the permanent pool volume. Dry ponds are normally used for erosion control and flood control. They are not as effective for water quality control as there is no inter-event settling time compared to ponds with a permanent pool. Dry ponds are not an acceptable means of quality control unless part of a treatment train which yields (in total) an Enhanced level of treatment.

3.4.1 Temperature

Temperature is of vital concern to fish and their habitat especially where the discharge is to a cold water stream. Various techniques to reduce thermal impacts are discussed in the MOE SWM manual. They include pond configuration, riparian planting strategy, bottom-draw outlet, subsurface trench outlet, night time release, and outlet channel design. In general, bottom draw outfalls are encouraged within the LTC watershed.

With ponds and wetlands, a suggested maintenance manual must be provided to highlight standard operating conditions and maintenance schedule and guide the site owner or municipal operator through recommended maintenance requirements for all aspects of the stormwater management system.

3.4.2 The Use of Oil/Grit Separators

Oil/Grit separators (OGS) are water quality control devices designed to allow grit to settle by gravity and allow the oil to float and be separated out. They may be used for spill control, or as a pre-treatment device as part of a multi-component system for water quality control. Where possible, such systems should be used with the incorporation of other quality control measures, such as naturalized buffers, grassed swales, etc. They are typically used for small sites or infill development (typically 5 ha or less) and on commercial and industrial properties where infiltration methods aren't recommended. They can be used alone or together with by-pass chambers to provide pre-treatment for other end-of-pipe technologies.

The MOE SWM Manual requires that for enhanced protection, oil/grit separators be sized to capture and treat at least 90 % of the runoff volume that occurs for a site on a long-term average basis and meet the 80 % suspended solids removal efficiency. Recently the Canadian Environmental Technology Verification Program (ETV) has developed upgraded testing protocols for Oil/Grit Separators in consultation with Toronto and Region Conservation Authority (TRCA) in 2014. A number of technologies have recently undergone testing and are now certified through the ETV process. If OGS units are proposed in the Stormwater Management Plan, LTC will request confirmation of the technology passing the Canadian ETV protocol. Please check the Canadian ETV website for more details. http://etvcanada.ca/

It is permissible to specify two (2) or three (3) alternate oil/grit separators on submitted drawings and reports as long as the proper accreditation has been provided. Sizing calculations and proof of Canadian ETV acceptance would need to be provided for each device.

Filtration Devices are water quality control devices that are used to remove fine particles (less than 20 microns). The proposed use of this type of device would require the same approach as outlined above for OGS including sufficient field testing results. A similar approach will be applied to the use of Adsorptive Media as a quality control device.

3.4.3 Bay of Quinte Remedial Action Plan Stormwater Guidelines

The Bay of Quinte had been identified by the International Joint Commission (IJC) as an Area of Concern (AOC) in the 1980's. In 1993 the Bay of Quinte Remedial Action Plan (BQ RAP) developed Stormwater Management Guidelines. These Guidelines were updated in 2006 and apply to a number of communities around the Bay of Quinte. In the Lower Trent Conservation watershed these guidelines apply to the four wards of the City of Quinte West: Sidney, Murray, Frankford and Trenton.

Enhanced stormwater quality control is required for any new development greater than or equal to one hectare.

3.5 Stream Erosion Control

Erosion is a natural process. However, changes in land use cause an increase in runoff flows and a change in sediment loading to watercourses. Downstream channels can suffer from channel instability, bank erosion, and channel migration due to upstream change in land use.

The main methods used to reduce erosion problem are: reducing the peak flow rate, decreasing the duration of storm flows, minimizing the volume of runoff, and implementing Low-Impact Development (LID) techniques in new construction.

Watershed and subwatershed studies and Master Drainage Plans should be referenced for specific stormwater management requirements to protect against stream erosion. Erosion control studies may be required for discharges to the headwaters of a watercourse. LTC staff will advise whether a study is required.

For development sites < 2 ha, erosion control is normally not required. For larger areas, where an erosion control study is not specified, guidance concerning design approaches from the MOE Stormwater Management Planning and Design Manual 2003 will be applied requiring the 25mm 4-hour Chicago storm to be stored and released over a 24-hour period.

3.6 Water Balance / Groundwater Recharge

Urbanization increases impervious cover which results in a decrease in infiltration. This infiltration decrease reduces groundwater recharge and soil moisture replenishment. It also reduces stream baseflow needed for sustaining aquatic life. Therefore, it is important to maintain the natural hydrologic cycle as much as possible. This will also reduce the potential for flooding and erosion.

Water balance provides for the accounting of water transfers across the boundaries of a system (i.e. a watershed) over some time period. It may be used to describe the hydrologic cycle. Unless there are circumstances that require a reduction in infiltration (i.e. high groundwater table), the SWM plan should make every feasible effort to maintain the pre-development infiltration and evapotranspiration rates and temperatures to the receiving waterbody and watershed. A water balance assessment may be required as per the MOE's *Stormwater Management Planning and Design Manua*l (March 2003). For example, it is required if the site is in a groundwater recharge area, or an environmentally sensitive area. As per the 2015 MOECC Interpretation Bulletin, water balance considerations should be assessed for most development plans.

Every attempt should be made to match post development infiltration volumes and recharge quality to pre-development levels on an annual basis. Infiltration targets may be achieved through the incorporation of a variety of stormwater management practices including: reduced lot grading, roof leaders discharging to ponding areas or soak away pits, infiltration trenches and grassed swales/enhanced grassed swales. Some existing approved plans of subdivision may only require the infiltration of water from rooftops. For all major developments, an evaluation of the water balance for the site should be completed and changes in water balance documented. The consultant would be advised to contact LTC staff regarding the necessity of a water balance assessment. Refer to the MOE's *Stormwater Management Planning and Design Manual* (March 2003) Section 3.2 for guidance.

3.7 Siting of Stormwater Management Facilities

End-of-pipe stormwater management facilities are to be located outside of the Regulatory floodplain. If the SWM facility is used for flood control, it must be located above the highest design flood level. Facilities will not be accepted within the following:

- Environmental features and associated buffers.
- Valley lands and associated setbacks.
- Unstable slopes and areas susceptible to erosion.
- Unstable soils or bedrock.

The proponent should pre-consult with LTC staff to determine the acceptability of the location and any other required design constraints. For LTC, the elevation of the permanent pool of the SWM facility must be above the regulatory flood elevation. Physical factors may determine the suitability of particular SWM facilities and where they may be located. These factors include:

- Topography
- Soil type
- Depth to bedrock
- Depth to seasonally high water table
- Drainage area

The siting location is also subject to municipal review and approval. All stormwater management facilities must include a maintenance access designed to the satisfaction of the municipality. The drawings must show the maintenance access, erosion protection, outlet details and detailed cross sections through the facility and controls. A geotechnical report supporting the facilities location, design and detailed drawings may be required.

3.7.1 Ontario Regulation 163/06

Hazardous land (such as unstable slopes, wetlands, floodplain, etc) within the LTC watershed is generally unsuitable for any type of development. Any proposal of land development is considered on an individual basis and requires unique engineering analysis for these following items:

- The straightening, changing, diverting or interfering in anyway with an existing channel, a river, creek, stream or watercourse
- The construction of any building or structure in or on a wetland, or in any area subject to flooding
- The placing, dumping or removal of fill of any kind in any defined part of the area over which the conservation authority has jurisdiction which, in the opinion of the conservation authority, the control of flooding or pollution or the conservation of land may be affected.

3.8 Erosion and Sediment Control

A separate erosion and sediment control plan should be included with the submission. Erosion and sediment control for the site should be in accordance with the Erosion and Sediment Control Guidelines for Urban Construction, 2019. The document was recently updated by Toronto and Region Conservation Authority (TRCA) and can be downloaded from the Sustainable Technologies Evaluation Program (STEP) web site (http://www.sustainabletechnologies.ca/). If construction phasing of a site is proposed, then separate phasing drawings of the erosion and sediment control plan will be required. Details of all erosion and sedimentation controls (including temporary sedimentation basins) should be shown on the erosion and sediment control drawings or referenced to a separate design drawing.

3.9 Climate Change

There is growing concern about the potential impacts of climate change on our municipal infrastructure. In recent years, in Southern Ontario, severe, intense storms have caused widespread flooding with thousands of flooded basements, broken trunk sewers, washed-out roads, resulting in damages estimated at hundreds of millions of dollars in cities such as Peterborough and Toronto. There is emerging guidance on the development and use future Intensity Duration Frequency (IDF) statistics to account for the expected change in climate; however, there is also a lack of consensus on the most appropriate methods.

The Province of Ontario set up a committee in 2008 led by the Ministry of Environment (now MECP) to review stormwater management in light of climate change. The objective is to make recommendations on whether legislation, or regulations or policies need to be written to regulate SWM practices to account for climate change. Some changes could also be made to the MOE SWM manual as a result of this review. This work is ongoing. When changes are made to provincial guidance, then the LTC technical guidelines can be updated accordingly.

A study of the comparison of future Intensity-Duration-Frequency (IDF) Curves based on downscaling global climate change models was led by TRCA and ERCA and released in 2016 as an addendum to an earlier paper. This 2016 paper acknowledged the complexity of this issue and eventually recommended

that future research needs to be conducted as a variety of solutions may be available.
https://climateconnections.ca/app/uploads/2014/01/IDF-Comparison-Report-and-Addendum.pdf

Until there is further direction from the Province, LTC recommends using the Ministry of Transportation Intensity Duration and Frequency (IDF) curves to address climate change impact. These can be accessed on the website: http://www.mto.gov.on.ca/IDF_Curves/terms.shtml

This tool has been developed to provide geographically distributed IDF curves in a gridded form based on Environment Canada and National Oceanic and Atmospheric Administration (NOAA) precipitation data. The method description is taken directly from the MTO IDF Curve website.

> “The method of analysis used is referred to as the Square Grid Technique because it uses UTM grid squares as elementary sub-catchments. The original Digital Elevation Model (DEM) is a set of gridded elevations and drainage fractions coded manually for each 10 km square of the Natural Resources Canada 1:250,000 topographic map series. The premise is that local climate is strongly influenced by local and regional topography. Thus, topographic parameters are useful interpolators of surface fields of interest, such as temperature, runoff and, in this case, IDF curve parameters A and B.
>
> The digital elevation model is used to derive physiographic characteristics that become independent variables in a regression analysis with station statistics. The regression analysis produces a set of generating equations for the parameters used to produce IDF curves. The technique also weighs station data by their length of record, which ensures that data that are more reliable have greater influence on the interpolation. The database consists of statistics from 352 MSC and NOAA stations with an average record length of 30 years.
>
> The result is a gradually varying regional IDF curve. Because the regional curve and station curves both have uncertainty, the regional estimates are different from the station records. However, the 95% confidence intervals overlap and the upper limit is generally higher than the mean station value.”

This IDF Curve tool has also incorporated trend analysis for future curve predictions.

> “The time trend analysis was done using observations from 1960 to 2014. A linear trend was observed and extrapolated from this period to 2060. Significantly less sources were available for data after 2010, so 2010 is the reference year used in this tool. IDF curve projections are extrapolated from the 2010 base year.”

LTC recommends that initial analyses be completed with the base 2010 year IDF curves for both existing and proposed conditions. Then a 50-year range for the IDF Curve be selected to conduct the hydrologic analysis to incorporate climate change impacts into the proposed design. This additional analysis should be used to assess whether any adjustments are required for the storage portions of the stormwater management facilities to account for climate change considerations. For example, if the analysis was completed in 2020, both the 2010 reference and 2070 IDF curves should be used for the hydrologic analysis. A comparison of the 2010 vs 2070 results should be reviewed to see if any changes to the design need to be incorporated for potential climate change impacts. Copies of the design IDF Curve data from the MTO website should be included in the Stormwater Management Report or Brief. Both the baseline (2010) IDF data and the future IDF data will be included in the report.

Other methods to address climate change may be entertained if defensible reasons are provided and the municipality is in agreement. The method of addressing climate change should be discussed during the Pre-Consultation for the proposed development. If the Province eventually provides direction on addressing climate change with respect to stormwater submissions, this document will be updated to reflect the direction from the Province.

4 MODELING

4.1 Subcatchment Delineation – Internal & External Drainage Areas

The internal and external drainage boundaries for pre and post-development conditions must be provided. This should be based on field reconnaissance supplemented through the use of topographic maps and aerial photo interpretation. Sources must be provided for all topographic information used in the analysis. Reference information should include the: map title, author, publisher, scale, publishing date and flown date, or surveyor name and survey date. Watershed points of interest must be included in the discretization scheme (i.e. ponds, road crossings, railways). LTC's watershed boundaries and subwatershed boundaries may be provided by the LTC upon request, where available.

4.2 Rainfall Input

4.2.1 Intensity-Duration-Frequency (IDF) Curves

In Canada, the Atmospheric Environment Service (AES) has collected rainfall records and performed the statistical analysis to derive the IDF curves for different locations across the country. Each IDF curve represents the rainfall intensity-time duration relationship for a storm of a certain return frequency. For a certain return frequency, the highest intensities occur for the shortest time intervals. For the storm with the highest intensities, the return period is the largest (i.e. least frequent). The IDF curve for each return frequency is represented by:

$$I = A\, t^{B}$$

where: I = intensity (mm/hr)
t = time of concentration (minutes)
A & B = constants for each IDF curve

The IDF curve is not a storm pattern. It shows the intensities over time durations for a storm of a certain frequency. IDF curves are widely used to derive storm events used for the design of SWM facilities. As noted earlier, LTC recommend the use of the gridded IDF curves developed by the Province and available on the MTO website, which allows for future climate change considerations. The IDF curve selected should reflect conditions 50 years into the future. It is noted that for future scenarios, the IDF curve parameters are not provided but the total depth of rainfall and intensities are provided for different storm return periods and durations. These numbers should be used in the modelling.

4.2.2 Design Storms

Hydrologic simulation models may be used to simulate a single storm event or a continuous period of rainfall data. For SWM design, models that use a single storm event are frequently used. The rainfall input for the model would be a hyetograph. The hyetograph may have been obtained as a historical record for that location through a rain gauge. For example, The Timmins Storm is a historic storm used in parts of Southern and Central Ontario for flood control design. It is also known as the Regional Storm.

Synthetic design storms are also constructed using established distributions and historical rainfall amounts. There are two methods generally used to derive synthetic design storms. One method develops the storm hyetograph from the IDF curve. Examples are the Uniform design storm and the Chicago design storm (Keifer & Chu, 1957). The second method develops the design storm from an analysis of historic storm events. Examples are the U.S. Soil Conservation Service (SCS) design storm, the Illinois State Water Survey design storm, and the Atmospheric Environment Service (AES) design storm.

The following design storms are recommended to be used for modeling:

- 1 hour and 4 hour Chicago distribution
- 6 hour and 12 hour AES Southern Ontario 30% distribution
- 12 hour and 24 hour SCS Type II distribution
- Regional Storm event (Timmins 12 hr event)
- Sub-watershed / watershed / master drainage plan storm distributions (if applicable)

The 4 hour Chicago storm hyetograph is widely used in Southern Ontario and has a sharp peak. Research at the University of Ottawa showed that the Chicago design storm gave peak flow predictions close to the flows from historic storm events for urban watersheds. It is recommended that the time step should be 10 minutes maximum.

The U.S. Soil Conservation Service (SCS) developed the Type I and Type II design storms which are two rainfall distributions for two different areas of North America. The Type II distribution applies to most parts of Canada. The distribution is a mass curve for percent of accumulated rainfall depth over a duration of 24 hours. First, a duration and a return period are selected. Then the corresponding volume is obtained from the IDF curve. The volume is then distributed over the steepest portion of the SCS 24-hour curve. The 12 hour SCS storm is derived from the steepest 12 hours of the 24 hour SCS curve. The SCS Type II Distribution is shown in Table 1 below.

Table 1: SCS Type II Distribution

6 – Hour			12 – Hour			24 – Hour		
Time Ending Hour	F_{inc} (%)	F_{cum} (%)	Time Ending Hour	F_{inc} (%)	F_{cum} (%)	Time Ending Hour	F_{inc} (%)	F_{cum} (%)
0	0	0	0	0	0	0	0	0
0.5	2	2	2	5	5	2	2.2	2.2
1	3	5	3	3	8	4	2.6	4.8
1.5	3	8	3.5	2	10	6	3.2	8.0
2	5	13	4	2	12	8	4	12.0
2.5	6	19	4.5	3	15	9	2.7	14.7
2.75	15	34	5	4	19	9.5	1.6	16.3
3	39	73	5.5	6	25	10	1.8	18.1
3.5	11	84	5.75	12	37	10.5	2.3	20.4
4	5	89	6	33	70	11	3.1	23.5
4.5	4	93	6.5	9	79	11.5	4.8	28.3
5	3	96	7	4	83	11.75	10.4	38.7
6	4	100	7.5	3	86	12	27.6	66.3
			8	3	89	12.5	7.2	73.5
			10	7	96	13	3.7	77.2
			12	4	100	13.5	0.7	77.9
						14	4.1	82.0
						16	6.0	88.0
						20	7.2	95.2
						24	4.8	100
Note: (From MTO Design Chart 1.05)								

Hydrologic modeling must follow Watershed Plan recommendations, if available, when selecting storm distributions. The distributions selected in the Watershed Plan model should be used for modeling site developments. Rainfall amounts should be based on the intensity-duration-frequency (IDF) curves from the MTO website as discussed earlier.

4.3 Hydrologic Modeling

Stormwater runoff calculations for site plans and subdivisions must be provided. The preferred runoff model is Visual OTTHYMO, although other HYMO based models may be considered upon consultation. For small sites, manual calculations such as the Rational or Modified Rational Method, may be accepted. The Rational method is a quick and accepted method to design conveyance systems (storm sewers) but should NOT be used to calculate post-development peak flow s and storage required for large or complex sites. The Modified Rational Method (MRM) can be effective to determine detention volumes for smaller sites and is a quick way to check that the modelling software is calculating reasonable peak discharge rates or detention volumes.

All input parameters should be provided in hard copy and their sources cited. All model input and output files should be submitted in both digital and hard copy format. The simulations should be based on a calibrated model if at all possible. The hydrologic modeling parameters that are commonly used are described in the following sections.

Imperviousness: An accurate estimate of the percentage of imperviousness is very important as the model is sensitive to this parameter. The parameter will affect the proposed SWM volumes and consequently the land requirements for SWM, and the size of the SWM block. OTTHYMO uses two parameters for imperviousness, which are the Total Imperviousness Percentage (TIMP) and the Directly Connected Imperviousness Percentage (XIMP). TIMP is the ratio of the impervious area to the total area. XIMP is the ratio of the impervious area that is directly connected to the conveyance system, to the total area.

As an example, a driveway is directly connected if it drains to the road with catch basins that drain to the sewer system. A roof area that has its roof leaders disconnected and drains to the backyard is not directly connected. The runoff from the non-directly connected impervious area that ends up in a pervious area is then subject to infiltration. Whatever exceeds the infiltration capacity is considered as runoff.

The total imperviousness for the catchment should be used to determine the runoff coefficients for the development area. Impervious areas should be determined by sampling a representative area in each sub-catchment for macro-level studies. For detailed level studies (ie. Site Plans) they should be calculated. XIMP must be less than or equal to TIMP. For the purposes of modeling post development conditions, gravel surfaces must be assumed to be impervious. For the Rational or Modified Rational Method, the runoff coefficient is to be increased as per MTO Design Chart 1.07 for the 1:25, 1:50 and 1:100 year storm events. This chart shows increases in runoff coefficient values for more intense storms. MTO Design Chart 1.07 is shown below in Table 2 (Urban) and Table 3 (Rural) landuses.

Table 2: Runoff Coefficients – Urban (5 to 10 year Storms)

Land Use	Runoff Coefficient	
	Minimum	Maximum
Pavement – Asphalt or Concrete	0.80	0.95
Pavement - Brick	0.70	0.85
Gravel – Roads & shoulders	0.40	0.60
Roofs	0.70	0.95
Business – Downtown	0.70	0.95
Business - neighbourhood	0.50	0.70
Business – light	0.50	0.80
Business – heavy	0.60	0.90
Residential – single family urban	0.30	0.50
Residential – multiple detached	0.40	0.60
Residential – multiple attached	0.60	0.75
Residential – suburban	0.25	0.40
Industrial – light	0.50	0.70
Industrial – heavy	0.60	0.90
Apartments	0.50	0.70
Parks, Cemeteries	0.10	0.25
Playgrounds (unpaved)	0.20	0.35
Railroad yards	0.20	0.35
Unimproved Areas	0.10	0.30
Lawns – Sandy Soil – flat - 0% to 2% slope	0.05	0.10
Lawns – Sandy Soil – average – 2% to 7% slope	0.10	0.15
Lawns – Sandy Soil – steep > 7% slope	0.15	0.20
Lawns – Clayey Soil – flat - 0% to 2% slope	0.13	0.17
Lawns – Clayey Soil – average – 2% to 7% slope	0.18	0.22
Lawns – Clayey Soil – steep > 7% slope	0.25	0.35

Note: (From MTO Design Chart 1.07)

- For flat or permeable surfaces, use the lower values.
- For steeper or more impervious surfaces, use the higher values.
- For return period of more than 10 years, increase above values: 25-year – add 10%; 50—year – add 20%; 100-year – add 25%.
- Coefficients listed above are for unfrozen ground

Table 3: Runoff Coefficients – Rural

Land Use	Soil Texture		
	Open Sand Loam	**Loam or Silt Loam**	**Clay Loam or Clay**
Cultivated – Flat 0% - 5%	0.22	0.35	0.55
Cultivated – Rolling 5% - 10%	0.30	0.45	0.60
Cultivated – Hilly 10% - 30%	0.40	0.65	0.70
Pasture - Flat 0% - 5%	0.10	0.28	0.40
Pasture – Rolling 5% - 10%	0.15	0.35	0.45
Pasture – Hilly 10% - 30%	0.22	0.40	0.55
Woodland or Cutover – Flat 0% - 5%	0.08	0.25	0.35
Woodland or Cutover – Rolling 5% - 10%	0.12	0.30	0.42
Woodland or Cutover – Hilly 10% - 30%	0.18	0.35	0.52
Bare Rock	**Coverage**		
	30%	**50%**	**70%**
Flat 0% - 5%	0.40	0.55	0.75
Rolling 5% - 10%	0.50	0.65	0.80
Hilly 10% - 30%	0.55	0.70	0.85
Lakes and Wetlands	0.05		

Initial abstraction: Both the impervious and pervious areas have initial abstraction (Ia) which is the interception and depression storage of the physical surface at the beginning of the storm events to capture the rainfall. Some typical values used for Ia are shown in Table 4.

Table 4: Initial Abstractions

Land Cover	Initial Abstraction (mm)
Impervious	2 mm
Pervious – lawn	5 mm
Pervious – meadow	8 mm
Pervious - woods	10 mm

Infiltration: After the initial abstraction, the rainfall on the pervious area is subject to infiltration. Three methods used for modeling infiltration are the Horton method, the Soil Conservation Service (SCS) method and the Green-Ampt method, with the first two methods more commonly used in Ontario.

Horton's Equation: In Horton's equation, the infiltration capacity rate decays exponentially as a function of time to a constant rate.

$$\mathbf{I = I_f + (I_o - I_f)\, e^{-kt}}$$

where: I - the infiltration capacity rate (mm/hr) at time t

I_f – the final infiltration capacity rate (mm/hr)

I_o – the initial infiltration capacity rate (mm/hr)

k - is the decay rate (1/hr)

The model parameters to be specified are the initial and the final infiltration capacity rates, and the decay rate. The antecedent moisture condition can be represented by the water accumulated into the soil before the start of the storm. In the OTTHYMO model, I_o can be directly specified.

SCS CN Procedure: The SCS method uses a parameter called the curve number (CN). CN is a measure of a watershed's hydrologic response potential. The SCS CN procedure uses the following equation:

$$\mathbf{Q = (P - I_a)^2 / ((P - I_a) + S)}$$

where: Q = runoff depth in mm
P = rainfall in mm
S = total potential losses or storage parameter in mm
I_a = initial abstraction in mm

The CN is related to the land use and the hydrologic soil groups, A,B,C, and D, with A being for low runoff potential soils (sands), and D being for high runoff potential soils (clay). The higher the CN, the higher the runoff potential. In this procedure, there are three levels of antecedent moisture conditions (AMC). AMC I is when the soils are dry. AMC II is the average case. AMC III is used to model saturated soil conditions. AMCII conditions are assumed when modeling for the Timmins Storm event. The CN is modified according to the antecedent moisture conditions. S is related to the curve number CN by:

$$\mathbf{S = (25400 / CN) - 254}$$

In the CN procedure, the initial abstraction Ia is calculated by 0.2 S. For small rainfall events, the runoff volumes may be underestimated as the Ia value can be high for some CN values. Therefore, in OTTHYMO the Ia value can be directly specified (i.e. 1.5 mm) as a more realistic estimate. The corresponding modified CN that result in the same runoff volume are called CN*. Charts can be plotted to compare CN and CN*. For different values of Ia, there would be different charts. Where available, use the calibrated CN's used in watershed plans, sub-watershed plans or master drainage studies. CN Number references can be found in Design Chart 1.09 of the *MTO Drainage Management Manual* (1997) or in Tables 5 and 6 below.

Table 5: Soil / Land Use Curve Numbers

Land Use	Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group			
			A	B	C	D
Fallow	Straight Row		77	86	91	94
Row Crop	Straight Row	Poor	72	81	88	91
		Good	67	78	85	89
	Contoured	Poor	70	79	84	88
		Good	65	75	82	86
	Contoured & Terraced	Poor	66	74	80	82
		Good	59	70	78	81
Small Grain	Straight Row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	Contoured & Terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes or Rotation Meadow	Straight Row	Poor	66	77	85	89
		Good	58	72	81	85
	Contoured	Poor	64	75	83	85
		Good	55	69	78	83
	Contoured & Terraced	Poor	63	73	80	83
		Good	51	67	76	80
Pasture or Range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
		Fair	25	59	75	83
		Good	16	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads			59	74	82	86
Roads	Dirt		74	82	87	89
	Gravel		74	84	90	92

Note: (From MTO Design Chart 1.09)

- For average antecedent soil moisture conditions (AMC II)

Table 6: SCS Curve Numbers

Land Use or Surface	Hydrologic Soil Group						
	A	AB	B	BC	C	CD	D
Fallow	77	82	86	89	91	93	94
Crop & other Improved Land	66** (62)	70** (68)	74	78	82	84	86 (AMC I)
Pasture & other Unimproved Land	58* (38)	62* (51)	65	71	76	79	81
Woodlots & Forests	50* (30)	54* (44)	58	65	71	74	77
Impervious areas (paved)							98
Bare Bedrock - Draining directly to stream by surface flow							98
Bare Bedrock - Draining Indirectly to stream as groundwater (usual case)							70
Lakes & Wetlands							50

Note: (From MTO Design Chart 1.09)

- All values are based on AMC II except those marked by * (AMC III) or ** (mean of AMC II and AMC III)
- Values in brackets are AMC II are to be used only for special cases
- Table is not applicable to frozen soils or to periods in which snowmelt contributes to runoff

Sources for all modeling approaches must be provided for the selection / calculation of Curve Numbers, Runoff Coefficients, Initial Abstraction, Time of Concentration, Overland Flow Lengths, Manning Roughness Coefficients, Infiltration Rates, Orifice and Weir Coefficients.

Hydrograph Computation: Hydrograph time of concentration can be calculated based on the Uplands Method, Airport Method (for catchments with a runoff coefficient less than 0.40), or the Bransby-Williams Equation (for catchments with a runoff coefficient greater than 0.40). The HYMO and OTTHYMO models use the unit hydrograph method to simulate the hydrograph. The "instantaneous unit hydrographs" or IUH provides the shape of the unit hydrograph. The IUH has a time to peak and a recession limb. For urban areas, the IUH can be simulated by that of a single linear reservoir. The number of linear reservoirs for the NASHYD command for rural areas should be 3 unless calibration results indicate otherwise.

The Time to Peak should be calculated as **Tp = 0.67 Tc**, where Tc is Time of Concentration. All hydrologic parameters must be compared to Master Drainage Plans, subwatershed or Watershed studies to ensure compliance. They should be based on a calibrated model. A table must be provided that compares the pre-development peak flows to the post-development uncontrolled and controlled peak flows at key locations.

Channel Routing: Sufficient channel routing should be incorporated into the hydrologic model. Rating curves and travel times used in channel routing should be determined by preliminary hydraulic calculations of the backwater profile or by procedures available in the approved hydrologic model and should be included in hard copy with the submission.

Hydrographs should be combined before being routed through watercourse reaches. Cross-sections required for the hydrologic model routing procedure must be obtained from 1:2,000 topographic mapping (or other source) and from field surveys. Cross-sections should be extended sufficiently to ensure that the flows do not exceed the range of the travel timetable. The routing computation time step must be relative to the smallest channel section, and at a maximum equal to the hydrograph time step. Selected Manning's roughness parameters must be in accordance with the values outlined in Design Chart 2.01 of the *MTO Drainage Management Manual* (1997).

Reservoir Routing: When calculating orifice discharge, the available head in the orifice equation should be the greater of the centroid of the orifice or downstream ponding elevation including depth of flow in the discharge pipe or channel. Where routing is applied, the technical report should discuss the method of routing used and the assumptions made in determining routed flows. A stage - storage - discharge table must be included and contain the elevations of the outlet and emergency spillway, as well as the elevation of each storm event. A schematic diagram showing the location of the outlet and other facility features is also required for submission.

4.4 Hydraulic Modeling

If the site may impact the floodline, hydraulic modeling must be provided. The preferred hydraulic model is the U.S. Army Corps of Engineers' HEC-RAS. New models will only be accepted in the most recent HEC-RAS software. If the Authority has an existing HEC2 or HEC-RAS model for the area, the model for the development should be integrated into the existing model.

5 SWM FACILITY DESIGN

The MOE SWM Planning and Design Manual provides detailed guidance for the design of SWM ponds and wetlands. The minimum criteria for the design of the SWM facilities, as outlined in the SWM Manual should be met. Other criteria that are not explicitly discussed in the SWM Manual are as follows:

- overflow weir design - LTC recommends that the emergency overflow weir be designed to convey the uncontrolled one in 100-year peak flow as well as the Timmins flow. Detailed design calculations should be included in the report and the details of the weir illustrated on an appropriate engineering drawing.
- berm design - Notes on the construction of the pond berms must be provided on the detailed design drawings (i.e. acceptable soils with low permeability to be used, inspection by a geo-technical engineer and compaction %). These notes are required for both the permanent stormwater management facilities and the temporary sediment ponds where a berm is required to form the facility.
- control structure design with sample detail in appendices - Detailed design calculations are required; the details of the outlet structure should be provided on an appropriate engineering drawing. The control structure should be designed to be aesthetically pleasing and integrated into the berm.
- suitability of site - A geotechnical report regarding the suitability of the proposed site for construction of a SWM pond may be required.

5.1 Safety Features

Safety features should be incorporated into the SWM pond design. The MOE SWM Manual provides guidelines on safety features such as the side slopes around the permanent pool, and buffer areas. The manual leaves the issue of permanent fencing up to the discretion of the local municipality due to liability concerns. Fencing may be aesthetically undesirable. Alternatives to fencing include the use of trees, shrubs and other vegetation to limit the access to the pond for safety. Another safety feature is the incorporation of a drop in elevation by using logs or stones to warn people who get into the pond about the increasing depth of the pond. Clear signs should also be put up around the pond to inform the public about the purpose of the SWM pond and to warn them about rising water levels during storm events, and thin ice conditions during winter.

5.2 Vegetation

Vegetation forms an important functional component of a SWM facility. Therefore, a vegetation planting plan for the SWM facility is highly recommended. The planting strategy is used to provide for safety, aesthetics, shading, and enhanced pollutant removal. The SWM Manual provides guidelines for the vegetation planting strategy, planting techniques as well as guidance on suitable species to be used in the design of SWM facilities. All facilities that are adjacent to a natural corridor (i.e. watercourse, wetland, etc.) should use native plants and non-invasive species only.

5.3 Infiltration Type Facilities

It is noted that Infiltration type of stormwater management facilities are not always appropriate for all sites. Infiltration practices should not be proposed in areas where the water table is shallow or where there is the potential for stormwater with high contaminant concentrations. Depression storage and infiltration practices should be designed with an overall outlet to ensure that positive drainage away from the basements of buildings is achieved in the event that the function of the installation is compromised or its capacity is exceeded.

5.4 Dry Pond Requirements

The design of a **dry pond** should follow Table 4.8 of the MOE's *Stormwater Management Planning and Design Manual* including the criteria listed below:

- maximum water depth of 3 metres
- 0.3 metre freeboard above the maximum operating water surface elevation
- 1.0% minimum, 5.0% maximum pond bottom slope
- minimum length:width ratio is 3:1

5.5 Wet Pond Requirements

The design of a **wet pond** should follow Table 4.6 of the MOE's *Stormwater Management Planning and Design Manual* including the criteria listed below:

- Permanent pool depth shall be a minimum of 1.0 metre, and a maximum of 3.0 metres
- Freeboard of 0.3 metres above the maximum flood flow level
- Side slopes shall be no steeper than 5:1 at the permanent water's edge (3 metres above and 3 metres below). Below this level, side slope should be no steeper than 3:1.
- Minimum length:width ratio is 3:1
-

5.6 Wetland Requirements

The design of a wetland facility should follow Table 4.7 of the MOE's *Stormwater Management Planning and Design Manual* including the criteria listed below:

- maximum extended detention depth of 1.0 metre above permanent pool elevation for storm events under 10-year flow
- 0.3 metre freeboard above the maximum operating surface water level
- permanent pool depth shall be a minimum of 0.15 metres, and a maximum of 0.3 metres

5.7 SWM Pond Requirements

The design for any end-of pipe SWM pond should also consider the following items:

- A gravity by-pass pipe may be provided to allow the facility to be drained to within 0.5 metres of pond bottom for emergency/maintenance work (not required for dry ponds) – check with municipal requirements
- The forebay bottom should be lined with Terrafix Blocks or equivalent for ease in maintenance
- Emergency overflow spillway:
    - sized for the Regulatory event
    - set at 100-year water surface elevation
    - erosion protection consisting of soil reinforcement with natural vegetated surface treatment required from the top to base of spill area
- Major flow inlets:
    - sized to convey 100-year or Regulatory event

  - directed to main cell, not forebay(s), if possible
  - flat-bottomed channel with maximum 3:1 side slopes
  - maximum 0.3 metre flow depth, and minimum 0.1 metre freeboard
  - erosion protection consisting of soil reinforcement with natural vegetated surface treatment
- Sizing of minor system inlet:
  - erosion protection between pipe invert and bottom of forebay may be required,
  - Invert can be at or above permanent water elevation or submerged; submerged inlet will require backwater analysis and additional scour protection
- Sizing of forebay berm meeting the following criteria:
  - Set at the permanent water elevation
  - minimum 2.0 metre top width
  - side slopes shall be no steeper than 3:1
  - incorporate flow-through culverts with minimum 0.3 metre cover
- Sizing outlet meeting the following criteria:
  - bottom draw pipe is recommended for cold water discharge locations,
  - protected from erosion
  - Controlling Invert is at permanent water elevation
  - Should consider incorporating shut-off capability to prevent flow from the facility in the event of a spill – if necessary
  - Should not outlet directly to a watercourse or at the top of steep valley slopes. Avoid placing at the outside bend of channel meanders. If possible, place outside meander belt.
- Planting recommendations:
  - slopes 5:1 and steeper ranging from a minimum horizontal distance of 3.0 metres from the permanent pool level to the property line (not including walkways and trails) should be planted
  - Shrub planting density may vary depending on the degree of slope
- Perimeter fencing & signs:
  - According to municipal standards or requirements
- Maintenance access recommendations – consult with operating authority:
  - required for the forebay, all inlets and all outlets
  - minimum 3.0 metre width
  - maximum 8% longitudinal slope
  - maximum 2% crossfall
  - minimum 10 metre turning radius
  - consists of 300 mm of 50 mm crusher run limestone base with suitable surface treatment on an appropriate base as approved by the municipality
- Sediment drying area (If required by Municipality):
  - located adjacent to forebay
  - 2%-5% crossfall to direct runoff to facility
  - Surface treatment consistent with access road sized for:
    - predicted 10-year sediment volume, piled 1.0 metre high, or
    - Equivalent to forebay bottom area

5.8 Phasing

If developments are proposed in Phases, the boundaries of each phase should be well defined and timing of the Phases described. Does each phase require a separate stormwater management plan? Erosion and sediment control should be described in detail for each phase including soil stockpile areas, temporary sedimentation ponds, etc. Is Draft Plan approval for the individual phase or for the entire development? The stormwater management plan should reflect these considerations.

5.9 Maintenance Requirements

It is very important that SWM facilities be maintained regularly. Otherwise, they will not function optimally or may even cease to function. Therefore, an Operation and Maintenance (O & M) manual should be prepared and submitted. It is typically required by the municipality. The MOE SWMPD Manual provides guidelines on operation, maintenance and monitoring of SWM facilities. SWM facilities are infrastructure that needs to be maintained just like other municipal infrastructure. A lack of maintenance will lead to the deterioration of the function of the SWM facility. Therefore, each SWM facility needs to follow an operations and maintenance (O & M) schedule. A facility maintenance manual that contains the O & M schedule should be submitted as part of the final engineering submission. If the facility incorporates an oil/grit separator, it is recommended that a separate maintenance manual be provided and approved by the municipality (including a means by which the yearly maintenance of these devices will be guaranteed), to highlight standard operating conditions and maintenance schedule and guide the site owner through recommended maintenance requirements for all aspects of the stormwater management system.

5.10 Assumption by Municipality

The SWM facility will be assumed by the Municipality as per the subdivision agreement, or once the entire subdivision is complete. The developer is to provide as-built drawings of the SWM pond block (surveyed within 2 months of the time of assumption) showing, as a minimum:

- Key elevations of all inlet and outlet structures:
    - Top of grate elevations
    - Invert elevations
    - Pipe sizes and lengths
    - Orifice sizes
- Adequate bathymetric elevations to confirm clean-out or working bottom elevation
- Perimeter elevations to confirm side slopes
- Elevations of emergency overflow

6 STORMWATER MANAGEMENT REPORT SUBMISSION

Technical reports are to be prepared in such a manner that they are considered 'stand-alone', such that the entire work can be recreated by any qualified person without the need to refer to any other material. Further, any qualified person must be able to recognize and understand all of the methods, approaches, basic data and rationale used in the design calculations.

With the exception of proprietary models, equations are required for all provided calculations. All model input and output files are to be provided in hard copy in the report and in digital format. All formulas and values used by the program must be clearly identified in the report. Supporting calculations are to be provided in the report. A complete set of engineering drawings and Stormwater Management Report outlining all of the proposed works must be circulated to LTC. Final engineering plans and drawings must be signed and sealed by a Professional Engineer registered with Professional Engineers Ontario (PEO). A complete Stormwater Management Report will include, at a minimum, all items listed in the SWM checklist. LTC reserves the right to return the submission if it is incomplete. A detailed description of the SWM facility is required. This will likely be a combination of a SWM report, design calculations and engineering drawings. Standard engineering practices will be applied for items not covered in the SWM Manual.

6.1 Submission/Review Process

All development submissions should include a report outlining stormwater controls. The level of report detail required is dependent on the type of development and the stage of approval being sought.

The purpose of the report is to:

- Identify the quality and quantity impacts of the change in stormwater runoff on the watercourses and existing infrastructure due to the proposed development
- Determine if any improvements to municipal infrastructure are required to support the proposed development
- Determine mitigation measures to minimize any negative impacts

6.2 Re-Submission

When consultants re-submit their SWM applications, they should include a cover letter detailing how they have addressed LTC's comments.

6.3 Report Requirements for Site Plans

The purpose of a SWM report for this type of development is to show:

- how SWM treatment will be accommodated on-site;
- the site is not encroaching into floodplain or other environmentally sensitive areas;
- the site has no adverse impact on downstream municipal infrastructure.

A design brief or letter report may be sufficient for sites less than 5.0 ha.

Surface storage for stormwater quantity control (i.e. parking lot and rooftop storage) will be considered if it is demonstrated that stormwater quantity control can be reasonably implemented and it is supported by the municipality. Other Stormwater technologies may be preferred. Above and below-ground stormwater storage can be achieved in parking lots on private sites by strategically placing a restriction in an outlet structure. For infrastructure that will remain under private ownership, orifice plates and catch basin (CB) inlet control devices (ICDs) are discouraged since they can easily be removed. Orifice tubes (short sections of undersized pipes) are recommended instead of orifice plates.

Stormwater can be stored on flat rooftops, with the outflow controlled by specialized roof drains. Runoff from rooftops is considered clean and will not typically require quality treatment, unless mixed with other runoff in the drainage system.

Copies of all relevant recent soils and/or hydrogeological investigations must be included with the submission.

The following items should be included in the SWM document:

a) An outline of all relevant background information (planning studies, OP, zoning plan, MDP)
b) Soils information derived from a soils or hydrogeological report written by a qualified engineer or geoscientist
c) Any other environmental constraints should be outlined as well including, depth to seasonally high groundwater table, depth to bedrock, wetland buffers, fisheries buffers, floodplain constraints, etc.
d) A discussion of the municipal engineering standards and design criteria applicable to the site, including screening of SWM approaches
e) Drainage area details
    - All drainage area plans should include:
        - source of topographic information (such as municipal GIS, provincial OBMs, local survey), collection date (survey date, LiDAR flight date), and benchmark (if applicable);
        - property limits;
        - watercourse(s), if applicable;
        - top of bank location(s), if applicable;
        - Regulatory floodline(s), if applicable;
        - Regulatory limit lines(s) or buffers, if applicable;
        - catchment areas (tagged with ID #, area size, and C or CN value);
        - natural l heritage areas.
    - In addition to the items above, the pre-development drainage area plan should include:
        - existing buildings and infrastructure
        - contours at 0.5 metre increments, extending to a suitable distance beyond the property limits to support off-site drainage patterns
        - all contributing external drainage areas
        - overland flow paths
        - the outlet of any tributary storm sewer network
    - The post-development drainage area plan should include:
        - proposed buildings and stormwater infrastructure
        - proposed storm sewer system
        - length, size, grade, and direction of flow for each section of storm sewer
        - SWM facility, its inlet(s), and outlet(s), if applicable
        - overland flow route(s)
        - all contributing external drainage areas

f) If parking lot storage is being proposed:
   - the design should ensure that the minimum freeboard is 0.3 metre (or as dictated by municipal standards) is obtained between the lowest opening of any buildings and the 100-year ponding level.
   - the site grading plan should include an emergency overflow, designed to route runoff safely for events greater than the 100-year storm. Runoff should be directed to a suitable downstream outlet.
   - the site servicing plan should show details of the orifice tube (or plate) and its outlet.
   - storm pipe inverts and manhole top of grate elevations should also be shown.
   - the maximum depth of ponded water should not exceed 0.3 metre

g) If rooftop lot storage is being proposed, the following are required:
   - Copies of building mechanical drawings to confirm the manufacturer, model type, and location of roof drains.
   - Copies of the roof drain product specifications to confirm release rates and surface ponding.
   - Calculations of ponding volume, release rate, and drawdown time. These must be for individual structures as well as for the total for the roof(s).
   - An overflow scupper/weir should be incorporated into the roof design.
   - The site servicing drawings should show the location, size, and type of connection between the roof(s) and the storm pipes.

h) A grading plan supporting the post-development drainage pattern. If any surface water ponding is proposed for the site, the 5-year and 100-year storage extents and elevations should be shown on the plan.

i) A servicing plan showing all above and below-grade infrastructure. The storm sewer design sheet must be included.

j) The rational method may be used for simple hydrology but not for calculation of storage requirements.

k) An erosion and sediment control plan that includes any phasing considerations

l) All calculations used to derive design variables and/or model input values (i.e. Curve number, runoff coefficients, initial abstraction, time of concentration, overland flow length, manning number, and percent impervious) must be included.

m) Calculations of pre- and post-development runoff (with and without control), using the appropriate variables as discussed. All assumptions must be stated, and reference tables/charts/documents used for design variables must be included in technical appendices. Discussion should include:
   - Calculation of permissible release rate and required on-site storage
   - Methods of run-off attenuation and on-site storage
   - Measures to maintain or improve water quality
   - Measures to minimize downstream impacts (i.e. erosion, flooding)
   - A table comparing peak pre-development, post-development uncontrolled, and post-development controlled flow rates
   - A stage-storage-discharge table, showing individual and total outlet flows.

n) If major/minor separation is incorporated into the design, a hydrology model such as VO2 should be used for runoff and storage routing. Design storm distributions and durations should match the recommendations of the appropriate subwatershed study or MDP. If no such study exists, the SCS type II, Chicago, and AES Southern Ontario 30% distribution should be applied for 1-hr, 6-hour, 12-hour, and 24-hour durations.

o) MTO IDF curves with 50-year projections are recommended to be used. Rainfall data may be extracted from the relevant municipal engineering standards.

p) Digital copies of all model files must be included in the submission; hardcopy printouts of the model should be included in the technical appendix. Paper copies of all calculations must be included in technical appendices.

q) A discussion of the quality treatment that will be provided should be included. All supporting calculations, drawing details, and manufacturer's specifications should be included.

r) The report and all engineering plans shall be stamped by a professional engineer.

6.4 Preliminary Submission for Subdivision Draft Plan Approval

The purpose of this report is to show at a conceptual level:

- the subdivision road pattern will properly direct major flow
- the lots are not encroaching into floodplain or other environmentally sensitive areas
- the SWM block is large enough to contain the minimum size of facility necessary to provide the required level of treatment
- SWM facilities will be on lands dedicated to the municipality in addition to any lands required to be dedicated for park purposes under the Planning Act.

A SWM report is required for submission for Subdivision Draft Plan Approval. The following items should be included in the SWM report:

1. Main body of report

a) An outline of all relevant background information (planning studies, OP, zoning plan, MDP)

b) Discussion of current and proposed land use

c) Soils information derived from recent soils and/or hydrogeological studies. If neither is available, soils maps or other reliable data may be used.

d) An explanation of the municipal engineering standards and design criteria applicable to the site, including screening of SWM approaches

e) Calculations of pre- and post-development runoff, using a hydrology model such as VO2. Discussion should include:

- Calculation of permissible release rate and required on-site storage
- Methods of run-off attenuation and on-site storage
- Measures to minimize downstream impacts (i.e. erosion, flooding)

f) Design storm distributions and durations should match the recommendations of the appropriate subwatershed study or MDP. If no such study exists, the SCS type II, Chicago, and AES Southern Ontario 30% distribution should be applied for 1-hr, 6-hour, 12-, and 24-hour durations. The event which produces the greatest runoff peaks and volumes should be used for sizing major systems. The Timmins Storm is the Regional storm. If only one or two storm events are selected for preliminary analysis, discussion of selection criteria and reasoning is required.

g) MTO IDF curves with 50-year projections are recommended to be used as well as the baseline 2010 MTO IDF curves. Rainfall data may be extracted from the relevant municipal engineering standards.

h) A table comparing peak flow rates for pre-development, post-development uncontrolled, and post-development controlled. Also included should be a discussion of the results, and how the SWM facilities meet municipal and LTC criteria.
i) The worst-case or emergency scenario is to be identified (i.e. plugged drains, blocked control structures). The resulting effect on the SWM facility should be identified (i.e. Maximum ponding limits, berm stability, emergency overflow route, etc.)

2. Appendices
   a) All technical reference tables/charts/documents used as a source for design variables
   b) Printout of hydrology model, including:
      - detailed printout of one scenario
      - summary printout of all other scenarios
      - a schematic of each unique model scenario
   c) Digital copies of all model files must be included
   d) Copies of all calculations must be included in technical appendices.
   e) Copies of any soils and/or hydrogeological reports.
3. Plans
   a) A copy of the draft plan signed by an Ontario Land Surveyor
   b) All drainage area plans should include:
      - Source of topographic information (such as municipal GIS, provincial OBMs, local survey), date of information (survey date, LiDAR flight date), and benchmark (if applicable)
      - Property limits
      - Any contributing external drainage areas
      - watercourse(s), if applicable
      - top of bank location(s), if applicable
      - Regulatory floodline(s), if applicable
      - Regulatory setback lines(s), if applicable
   c) In addition to the items above, the pre-development drainage area plan should include:
      - contours at 0.5 metre increments, extending to a suitable distance beyond the property limits to support off-site drainage patterns
      - overland flow paths
      - the outlet of any tributary storm sewer network
      - watercourse(s), swales, ponds
      - catchment areas (tagged with ID #, area size, and C or CN value)
   d) Post-development drainage area plan showing:
      - underlying draft plan layout (with lot, block, easement, and road pattern)
      - the major flow route
      - conceptual minor system layout
      - the SWM facility, inlet(s), and outlet(s)
   e) A rough grading plan must be provided showing proposed grades at key locations, to support the proposed major flow route.

A professional engineer must stamp and sign the report as well as all engineering drawings.

6.5 Detailed Submission for Subdivision

The purpose of this report is to provide detailed calculations, methodology, background criteria, and engineering drawings to support the preliminary concept. Typically, the report is an expansion of the report written for the draft plan stage. This is required to get clearance of draft plan conditions and is typically submitted with the detailed engineering drawing package.

The following items should be included in the Final SWM report in addition to the details for the preliminary SWM report:

1. Main body of report
   a) An outline of all relevant background information (planning studies, OP, zoning plan, MDP, draft SWM report and plans)
   b) An explanation of the applicable municipal engineering standards and design criteria used in the design
   c) Calculations of pre- and post-development runoff, using a hydrology model such as VO2. Discussion should include:
      - Calculation of permissible release rate and required on-site storage
      - Methods of run-off attenuation and on-site storage
      - Measures to maintain or improve water quality
      - Measures to minimize downstream impacts (i.e. erosion, flooding)
   d) Design storm distributions and durations should match the recommendations of the SWM report created for draft plan approval. If no such study exists, the SCS type II, Chicago, and AES Southern Ontario 30% distribution should be applied for 6-hour, 12-, and 24-hour durations. The event which produces the greatest runoff peaks and volumes should be used for sizing major systems. Timmins Storm is the Regional storm. If only one or two storm events are selected for preliminary analysis, discussion of selection criteria and reasoning is required.
   e) MTO IDF curves with 50-year projections are recommended to be used as well as the baseline 2010 MTO IDF curves. Rainfall data may be extracted from the relevant municipal engineering standards.
   f) A table comparing peak flow rates for pre-development, post-development uncontrolled, and post-development controlled. Also included should be a discussion of the results, and how the SWM facilities meet municipal and LTC criteria
   g) Stage-storage-discharge table for individual structures and total flows for all outlet structures
   h) Table(s) summarizing pre- and post-development catchment parameters (i.e. ID, area, Timp, Ximp, CN*, Ia, Tp)
   i) Discussion of maintenance and operation of SWM facility (i.e. Annual maintenance requirements, frequency of sediment cleanout)
2. Appendices
   a) All technical reference tables/charts/documents used as a source for design variables.
   b) Detailed soils report from a qualified professional engineer or geoscientist discussing:
      - the viability of using native soils for the SWM facility
      - soils data
      - groundwater elevations in the vicinity of the SWM block. A minimum of one borehole should be located near the centre of the SWM block

- recommendations for SWM facility bottom lining if native soils are not strong enough to support heavy maintenance equipment
- recommendations for pond liner and construction methods in cases of high groundwater
- recommendations for perimeter berm design. Validation must be provided if top width will be less than 3.0 metres.

c) All calculations used to derive design variables and/or model input values (i.e. Curve number, runoff coefficients, initial abstraction, time of concentration, overland flow length, manning number, and percent impervious) must be included.

d) Drawdown time calculations

e) Major system capacity calculations

f) Erosion protection sizing

g) Calculations for the sizing of major flow inlet(s) and emergency overflow(s). Although SWM facilities are not sized to store the Regulatory event, calculations may be required to show the Regulatory flow can be safely conveyed through the facility via the overland flow inlet(s) and emergency overflow(s).

h) Calculations for the sizing of minor system inlet(s)

i) SWM facility maintenance cleanout calculations

j) Printout of hydrology model, including:
- detailed printout of one scenario
- summary printout of all other scenarios
- a schematic of each unique model scenario

k) Digital copies of all model files must be included in the submission

l) Paper copy of storm sewer design and culvert design sheets

m) Paper copy of the hydraulic gradeline (HGL) sheets

n) A "How-To" SWM Facility Operators Manual to guide municipal Public Works staff to carry out routine maintenance, determine performance measures, calculate costs, and determine major cleanout requirements. Colour photographs should be included where required for identification of key components. This should be bound in a separate appendix that can be used as a standalone document.

3. Plans

a) Pre-development drainage area plan showing:
- property limits
- contours at 0.5 metre increments, extending to a suitable distance beyond the property limits to support off-site drainage patterns
- overland flow paths
- the outlet of any tributary storm sewer network
- watercourse(s)
- top of bank location(s)
- Regulatory floodline(s)
- Conservation Authority regulation lines
- environmentally sensitive areas and/or natural heritage areas
- any external tributary area
- catchment areas (tagged with ID #, area size, and C or CN value)

b) Post-development drainage area plan showing:

- lot, block, and easement layout and road pattern
- minor system: pipe network (showing length, size, and grade of pipe); ditch network; and culverts. All pipes and ditches should show direction of flow
- labeled manholes
- catchment areas (tagged with ID #, area size, and C or CN value)
- property limits
- the major flow route, limited to public property within the road right-of-way or dedicated easements
- the SWM facility, inlet(s), outlet(s), major inflow inlet(s), emergency overflow outlet(s)
- catchment areas (tagged with ID #, area size, and C or CN value)
- separate major and minor drainage area plans are necessary if the major and minor drainage patterns are substantially different

c) Grading plan showing, as minimum:
   - proposed and existing grades for all lot corners and boundaries
   - finished floor and basement elevations
   - detailed lot grading
   - for larger blocks, proposed elevation at 15m intervals along frontage, and at reasonable intervals along sides and rear of the block
   - extent of proposed overland flow inundation

d) SWM facility plans showing:
   - inlet structure detail (pipe size(s), invert elevation(s), pipe grate, MH size, MH top of grate elevation, headwall, erosion protection)
   - outlet structure detail (orifice/tube size(s), invert elevation(s), MH size, MH top of grate elevation, headwall, erosion protection, outlet grate)
   - minimum of two cross sections through pond (perpendicular to each other) indicating existing ground profile, bottom elevations, top of berm elevations, side slopes, soil/vegetation type, water surface elevations (permanent, 2-, 5-, 10-, 25-, 50-, and 100-year)
   - forebay length and width dimensions
   - forebay berm cross-section
   - major flow path(s) and detail
   - cross-section detail of maintenance access
   - emergency overflow weir location and cross-section detail
   - fence location (if required)
   - sign location (if required)
   - sediment drying area details and extents
   - Landscaping plans for the facility prepared by a qualified landscape architect
   - Erosion and sediment control plans

e) Plan and profile drawings, as per municipal requirements. The HGL and proposed basement floor elevations should also be plotted.

A professional engineer must stamp and sign the report as well as all engineering drawings.

7 STORM INFRASTRUCTURE DESIGN

Individual municipalities may have different requirements for storm water infrastructure design. Attempts have been made to include specifics below but developers should always contact the municipality to confirm any infrastructure design considerations.

7.1 Design Flows

The runoff directed to each storm pipe should be computed on standard storm sewer design sheets according to the Rational formula

Q = 0.002778 C I A

Where:

A = contributing drainage area in hectares
C = imperviousness, or runoff co-efficient dimensionless
I = rainfall intensity (mm/hr)
Q= volume of runoff in cubic metres per second

Runoff coefficients can be found in Tables 3 and 4 of this report which are based on the MTO Design Charts (1997).

7.2 Rainfall Intensity

For normal residential and industrial developments, the minor system should by sized for the 5-year flow unless otherwise specified by the Municipality. Rainfall intensities can be found on the Intensity-Duration-Frequency (IDF) Curves. As noted earlier, LTC recommends the use of the MTO IDF Curves with a 50-year projection. This information can be found on the website:
http://www.mto.gov.on.ca/IDF_Curves/terms.shtml

The City of Quinte West has specified the use of the Yarnell equation for storm sewer systems in the City. In this case the rainfall intensity should be determined from Yarnell's 5-Year Storm Curve:

I = 2464 / (t + 16)

where t is time in minutes using a 15-minute inlet entry time at the head of the system for residential developments. A longer inlet time may be used if the supporting time of concentration (Tc) calculations are included.

7.3 Runoff or Impervious Coefficients

It is recommended to use the MTO Runoff Coefficients from Design Chart 1.07 that are shown in Tables 2 and 3 of this report.

To account for a decrease in the perviousness during major storms, the recommended factors as identified in MTO's Drainage Design Standards (2008) should be used. For storms having a return period of more than 10 years, runoff coefficients should be increased by the following values, up to a maximum coefficient of 0.95.

- 25-year event – add 10%
- 50-year event – add 20%
- 100-year event – add 25%

7.4 Pipe Sizing

Pipe capacity should be determined on the basis of the pipe flowing full. The value of the roughness coefficient to be used are provided as follows or as defined in Design Chart 2.01 in the *MTO Drainage Management Manual* (1997):

- Concrete Pipe all sizes 0.013
- Concrete Box Culverts 0.013
- Corrugated Metal pipe 0.024
- PVC Pipe 0.013

All minor system flow must be intercepted at each catchbasin (CB) or catchbasin maintenance hole (CBMH) location. Calculations may be requested to show capture capability.

7.5 Overland Flow

The depths of flooding permitted on streets for the major system are as follows:

a) depth of flooding should be restricted to 0.3 metres,
b) on local roads, the flow may spread to the crown,
c) on collector roads, the flow spread must leave one lane free of water,
d) on arterial roads, the flow spread must leave one lane in each direction free of water.

Flow across intersections is discouraged.

The major flow should not be less than the difference between the 100-year design flow and the 5-year design flow, calculated as follows:

Qmajor = Q100year – Q5year

7.6 Culvert and Bridge Hydraulic Capacity

Bridges and culverts at watercourse crossings are recommended to be designed following WC-1 of *MTO Highway Drainage Design Standards* (2008), as well as the Canadian Highway Bridge Design Code, as follows:

- Driveway - 10-year flow
- Local road, span less than 6.0m - 10-year flow
- Local road, span greater than 6.0m - 25-year flow
- Collector road, span less than 6.0m - 25-year flow
- Collector road, span greater than 6.0m - 50-year flow
- Arterial road, span less than 6.0m - 50-year flow
- Arterial road, span greater than 6.0m - 100-year flow

Relief flow passage must be incorporated into the design of the roadway in cases where the Regulatory flow exceeds the design flow. Under Regulatory conditions, the maximum depth of flow on the roadway should not exceed 0.3 m, and the product of velocity and depth should not exceed 0.8 m^2/s.

7.7 Hydraulic Gradeline Calculations

Hydraulic gradeline calculations may be requested. The pipe system should be designed to provide at least 0.3 metre freeboard between the minimum basement floor elevation and the 25-year hydraulic gradeline (HGL). Spreadsheet calculations showing calculations should be included with the submission. The 25-year HGL and proposed basement floor elevations should be plotted on all plan/profile drawings.

7.8 Outlets

Outlet structures must be designed so that exit velocities minimize potential erosion or damage in the vicinity of the outfall. Where the discharge velocity is high or supercritical, energy-dissipating structures (such as rip rap, headwalls, wingwalls, stilling basins) are required to prevent erosion of the natural channel bed or banks.

Outfalls to natural watercourses should discharge at or above the bankfull water elevation of the watercourse. Submergence of the outlet during times of high watercourse water levels must be assessed with hydraulic grade analysis and backwater conditions. The outlet invert should be above the 25-year flood elevation of the receiving channel.

8 SEDIMENT AND EROSION CONTROL

8.1 Scope

The Sediment and Erosion Control Plan must illustrate how the site will be graded to provide erosion protection during the construction phase. Reference should be made to the 2019 manual by Toronto and Region Conservation Authority *Erosion and Sediment Control Guidelines for Urban Construction*. Other local standards should also be referenced.

8.2 Procedure

The base drawing for this Plan is to be the Grading Plan. Superimposed on these drawings, the Engineer is to indicate any temporary and/or permanent control devices and/or ditches and ponds required to keep all materials and surface runoff contained on site.

Quantity calculations, dimensions, and construction materials should be provided in separate letter brief, or contained within the SWM report.

All permanent sediment and erosion control devices are to be shown on the Plan and Profile Drawing while any temporary construction is to be shown on the Sediment and Erosion Control Plan.

8.3 Implementation

The Sediment and Erosion Control Plan must be submitted with the first submission at the detailed design stage.

8.4 Plan Requirements

The following is required to be shown:

- drawing scale, preferably 1:1000
- geodetic benchmark, or GIS reference
- legend
- north arrow
- key map including site boundary limits, and location of existing buildings
- existing contours at 0.5 metre intervals (minimum) to show flow direction. Contours to be extended beyond property limit by 15 -30 metres
- existing vegetation, showing trees to be retained/protected or removed
- location of any water body, such as wetlands, rivers, streams, or drainage course on or within 30 metres of the site. Regional floodline and Conservation Authority Regulated Area line should also be indicated
- embankments 6:1 or steeper to be shown with slope ratio
- temporary swales, with corresponding gradient (incl. typical swale detail)
- location of all proposed stockpiles, with perimeter fencing
- silt fence locations, with appropriate OPSD detail
- temporary sediment ponds, with outlet and inlet details, with minimum one cross-section
- check dam locations, with appropriate OPSD detail
- sedimentation detail for catch basins and manholes
- mudmat locations, with construction details
- signed professional engineer’s stamp

The following notes are required on the drawing:

- All erosion control measures are to be in place before starting construction and remain in place until restoration is complete
- Maintain erosion control measures during construction
- Prevent wind-blown dust

8.5 Construction Requirements

The following apply to land disturbance activities that result in runoff leaving the site:

- Any soil or dirt pile should be stockpiled in such a way that it will not erode and find its way to a watercourse or a roadway. Any stockpiles topsoil should not be uncovered more than thirty (30) days, after which it should be covered with mulch or vegetation. A sediment control fence should be erected around the storage pile during the entire time when it is left uncovered.
- A three (3) metre wide buffer strip of undisturbed land should be provided along the perimeter of the downslope of the site. It should be entirely located upon the site which is to be developed. The buffer zone should be increased to 30 meters when the site abuts warmwater or coldwater fisheries or a reduced buffer determined through an environmental impact study.
- A double row of heavy-duty silt fence should be installed adjacent to any watercourses, separated by a 3 metre vegetated strip.
- Temporary swales should be sized to convey a minimum 5-year flow

9 REFERENCES

Credit Valley Conservation (CVC), and Toronto and Region Conservation Authority (TRCA), Low Impact Development Stormwater Management Manual 2010.

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Keifer, C.S., Chu, H.H., Synthetic Storm Pattern for Drainage Design, Proc. A.S.C.E., 1957.

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