

LSRCA Technical Guidelines for Stormwater Management Submissions

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Lake Simcoe Region
conservation authority



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1.0 INTRODUCTION

The purpose of this document is to provide guidance to the development community and their consultants regarding the stormwater management (SWM) requirements of the Lake Simcoe Region Conservation Authority (LSRCA) in accordance with the LSRCA Watershed Development Policies and Lake Simcoe Protection Plan. It is not intended to be a comprehensive stormwater management planning and design manual like the SWM manual published by the Ministry of the Environment (MOE, 2003) or similar documents. Detailed planning and design guidance can be found in those documents. 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

1.1 Environmental Planning and Stormwater Management

The MOE SWM manual 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. Urban development should be done in relationship with the environmental planning process. The SWM plan for the 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 SWM manual provides some guidance on the environmental design criteria.

The stormwater management policies of the Lake Simcoe Region Conservation Authority (LSRCA) are contained in the LSRCA Watershed Development Policies. They must be read in conjunction with local municipal standards and/or watershed/sub-watershed studies in respect of stormwater quantity and quality control. The LSRCA's requirements for all stormwater management submissions are outlined in the following sections, which include a description of LSRCA policies, guidance on approved methods and techniques, a summary of key hydrologic parameters, and a summary of submission requirements.

2.0 STORMWATER MANAGEMENT

Stormwater management technology is constantly being improved through research and implementation experience. It is not the intent of LSRCA to restrict innovative technology with these guidelines. Rather, LSRCA encourages the application of innovative green technologies in stormwater management and is willing to work with proponents wishing to explore green options. 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, <http://www.sustainabletechnologies.ca/> for further information.

Stormwater management reports are to be prepared in two main stages, Stage 1 and Stage 2.

Stage 1

Stage 1 is the preliminary planning stage where the conceptual SWM design is set out. In the case of site plans, Stages 1 and 2 can be combined into one report. The direction and the drainage constraints identified in the watershed/subwatershed plan are taken into account, e.g. target levels for peak flows, baseflow, infiltration, water quality parameters and water quality levels of protection. The SWM policies contained in the LSRCA Watershed Development policies are to be adhered to. Different SWM alternatives are then reviewed to develop the conceptual SWM or preliminary SWM design.

Stage 2

Stage 2 is the detailed design stage after the conceptual SWM design has been accepted. The details such as the size, location, grading, depth, side-slopes, inlet and outlet control structures for the various SWM facilities are to be completed. Modeling work and other details are to be updated according to the revised design information available. The detailed SWM report should have sufficient details to do detailed servicing drawings.

2.1 Stormwater Management Requirements

All SWM submissions for the site shall identify and meet the requirements of the watershed/subwatershed study for the watershed in which it is located, and any related approved stormwater management report. Supporting information should be provided as necessary. In addition, all submissions shall meet the requirements of the Ministry of the Environment's Stormwater Management Planning and Design Manual (March 2003) or the most current version of the document and must comply with the requirements of the Lake Simcoe Protection Plan - 2009. The MOE SWM manual 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 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
- Infiltration trenches
- Oil/grit separators
- Sand filters
- Dry ponds
- Wet ponds
- Wetlands
- Hybrid Ponds
- Filtration Devices
- Adsorptive Materials

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 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 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).

2.2 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. 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. More details about some of these SWM practices are provided in this 2010 manual.

SWM submissions to LSRCA 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 "Stormwater Management Planning and Design Manual" (2003) or most current version.

2.3 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.

Quantity control is not required if the site is directly adjacent to Lake Simcoe with a safe outlet or connected to a municipal system that is designed to discharge uncontrolled flows from the site to the Lake.

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 may be required to be controlled to the pre-development peak flow rate level.

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.

2.3.1 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. 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. The developer must be aware of potential liabilities associated with parking lot and rooftop controls, and that LSRCA will not be liable for any damages related to the installation, operation, modification or removal of any proposed parking lot or rooftop controls.

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 0.3m or in accordance with local Municipal standards.
- The maximum ponding extent, elevation and storage volume must be provided at each ponding location and must be shown on the design drawings.
- An emergency overflow system and overland flow route must 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 must 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 permitted. 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 will not be permitted.

Additional requirements for parking facilities are listed in the LSRCA Watershed Development Policies.

Specific Design Requirements for Rooftop Storage

Where rooftop controls are used, design submissions must 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 must also be indicated.

2.3.2 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. 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, all major overland flow routes are to be secured by the municipality through ownership or easement (i.e. a road R.O.W. or easement between houses etc.). Note: Regional storm convey may be required, where there are large external drainage areas flowing through a site.

2.3.3 Right Of Way

It is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm (the greater of the 1 in 100 year design storm or Hurricane Hazel / Timmins) 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. In the case of privately owned land, the proponent may be required to obtain a legal right of discharge registered on title.

2.4 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 LSRCA watershed is the Enhanced Protection Level (Level 1). It corresponds to the long-term average removal of 80% of suspended solids. For the purposes of phosphorus loading calculations, the phosphorus removal rates recommended in the MOE's Lake Simcoe Phosphorus Loading Development Tool, January 2012 (or subsequent versions) can be used. Typical MOE accepted removal rates for commonly used end-of-pipe facilities in the January 2012 version are as follows: Wet Ponds = 63%, Constructed Wetlands = 77% . Additional removal rates are listed in Appendix E. If different phosphorus removal rates are used for the BMP's listed in the MOE document as well as other stormwater quality control devices, not listed, these rates must be based on the results of acceptable third party field studies of the BMP.

The MOE SWM manual (Table 3.2) provides water quality storage volume requirements for different SWM practices for three protection levels. The storage volumes (m^3/ha) are given for different impervious levels. For the specified storage volumes for wet facilities, $40 \text{ m}^3/\text{ha}$ 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.

2.4.1 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 required within the LSRCA 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.

2.4.2 Phosphorus Loading Study

The high phosphorus levels in Lake Simcoe have led to excessive growth of plants and algae. Stormwater contributes a significant amount of phosphorus into the tributaries and the lake and therefore this loading needs to be controlled. For all new **major developments**, a Phosphorus Loading Study is to be done.

Major developments are defined in the Lake Simcoe Protection Plan as *development* consisting of:

- a. the creation of four or more lots;
- b. the construction of a building or buildings within a ground floor area of 500 m² or more,; or
- c. the establishment of a *major recreational use*.

A Phosphorus Loading Study is done by using an area load method (kg. / ha. / yr.) to determine the total existing load under pre-development conditions, the total post development load without quality controls and the post development loads with quality controls. Best efforts shall be employed such that any increase in loading (post development compared to pre development) is kept to a minimum. The target is “zero” increase in loading. Refer to Policy 4.8-DP of the Lake Simcoe Protection Plan - 2009. The LSRCA should be contacted regarding phosphorus removal requirements for a specific site.

2.4.3 The Use of Oil/Grit Separators and Filtration Devices in the Lake Simcoe Watershed

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). Based on current studies, Oil/Grit separators do not provide phosphorus removal and therefore do not comply with the LSRCA guidelines as a stand alone phosphorus removal system. In order to use a specific unit to provide a degree of phosphorus control (as part of a treatment train or as a phosphorus credit), sufficient third party field study results must be provided. At least two (2) field studies must show consistent phosphorus removal rates over a long period of time and must be reviewed and approved by the Ministry of the Environment. 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. Oil/Grit separators must meet the sediment removal standards of the New Jersey Department of Environmental Protection (NJDEP). The NJDEP Lab Test Protocol must be followed, verifying the ability to remove small particles (less than 50 microns), the ability to remove less dense particles (less than 2.65 specific gravity) and the ability to prevent Scour / Re-suspension. Appendix D shows more information regarding the New Jersey standards.

It is permissible to specify two (2) or three (3) alternate oil/grit separators on submitted drawings and reports. Sizing calculations and proof of NJDEP acceptance would need to be provided for each device. Sizing is to be done using the particle distribution shown in the table below:

Table 2.1 Particle Size Distribution

Particle Size (in microns)	Distribution (%)	Specific Gravity
20	20	1.3
60	20	1.8
150	20	2.2
400	20	2.65
2000	20	2.65

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 oil grit separators including sufficient field testing results. A similar approach will be applied to the use of Adsorptive Media as a quality control device.

2.5 Stream Erosion Control

Watershed and subwatershed studies and Master Drainage Plans should be referenced for specific stormwater management requirements to protect against stream erosion. In the absence

of watershed studies, guidance concerning design approaches from the MOE Stormwater Management Practices Planning and Design Manual 2003 will be applied. Erosion control studies may be required for discharges to the headwaters of a watercourse. LSRCA staff will advise whether a study is required. The criterion for an erosion control study is outlined in Appendix 'F'. For development sites < 2 ha, erosion control is normally not required. For larger areas, where an erosion control study is not specified, LSRCA will require that the runoff from a 25 mm design storm (4 hour, Chicago distribution) be detained and released over a period of at least 24 hours.

2.6 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.

The LSRCA Watershed Development Policies states that "the SWM plan must 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 Manual" (March 2003). For example, it is required if the site is in a recharge area, or an ESA. The consultant would be advised to contact LSRCA staff regarding the necessity of a water balance assessment. 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 must be completed (refer to Policy 4.8-DP of the Lake Simcoe Protection Plan – 2009). Refer to the MOE's "Stormwater Management Planning and Design Manual" (March 2003) section 3.2 for guidance.

2.7 Siting of Stormwater Management Facilities

End-of-pipe stormwater management facilities are to be located outside of the 1 in 100 year flood plain. If the SWM facility is used for flood control, it must be located above the highest design flood level. Facilities will not be accepted with the following:

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

Subject to the above, in some instances SWM facilities may be located within the floodplain between the 100 year storm and the Regional storm floodlines subject to the following technical requirements:

- No loss of floodplain storage, taking into consideration cumulative impacts.
- No obstruction to flood flows.
- No negative impacts on the fluvial processes in the floodplain.
- Outside environmental features and associated buffer areas
- No impact to environmental features.

The proponent should pre-consult with LSRCA staff to determine the acceptability of the location and any other required design constraints.

For LSRCA, the elevation of the permanent pool of the SWM facility must be above the 100 year flood elevation (i.e. the SWM facility must be outside the 100 year floodplain).

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 and LSRCA. 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 will be required. Refer to Section 3.4 and Appendix A for SWM pond design criteria and checklists.

2.8 Erosion and Sediment Control

A separate erosion and sediment control plan must be included with the submission. Erosion and sediment control for the site must be in accordance with the Erosion and Sediment Control Guidelines for Urban Construction, 2006, but must employ the LSRCA standards shown in Appendix G, as a minimum. The document was developed by the Greater Golden Horseshoe Area Conservation Authorities 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 must be shown on the erosion and sediment control drawings or referenced to a separate design drawing.

3.0 HYDROLOGIC MODELS AND SWM DESIGN

3.1 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).

LSRCA's watershed boundaries and subwatershed boundaries may be provided by the LSRCA in .pdf format upon request where available.

3.2 Rainfall Input

3.2.1 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:

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

where: I = intensity (mm/hr)

t = time in minutes

a, b, c = 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.

3.2.2 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, Hurricane Hazel is a historic storm used in parts of Southern 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 to be used for modeling sites with drainage areas greater than 5 hectares (refer to distribution tables in Appendix C):

- Regional Storm event
- 4 hour Chicago distribution
- 12 hour SCS Type II distribution
- 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. 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. This storm is required for use by LSRCA and the surrounding municipalities.

Hydrologic modeling must follow Watershed Plan recommendations when selecting storm distributions. The distributions selected in the Watershed Plan model should be used for modeling site developments. Additionally, the 4 hour Chicago and the 12 hour SCS Type II design storm distributions should be modeled to demonstrate peak flow control and to calculate the required storage volumes. The 12 hour SCS storm is derived from the steepest 12 hours of the 24 hour SCS curve. Rainfall amounts should be based on the intensity-duration-frequency (IDF) curves for the precipitation station outlined in the appropriate municipality's SWM standards. Appendix B shows precipitation information. 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.

3.3 Modeling

3.3.1 Hydrologic Modeling

Stormwater runoff calculations for site plans and subdivisions must be provided. The preferred runoff model is Visual Otthymo 2, although other ‘Hymo’ based models may be considered upon consultation. For small sites, less than five hectares, manual calculations such as the Rational or Modified Rational Method, may be accepted. All input parameters shall be provided in hard copy and their sources cited. All model input and output files shall be submitted in both digital and hard copy format. The simulations should be based on a calibrated model.

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 shall be used to determine the runoff coefficients for the development area. Impervious areas shall be determined by sampling a representative area in each sub-catchment for macro-level studies (refer to Appendix C). 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 at 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. More information on runoff coefficients is included in Appendix C.

Infiltration

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 3.1.

Table 3.1 (City of London, 2005)

Land cover	Initial abstraction
Impervious	2 mm
Pervious - lawns	5 mm
Pervious - meadows	8 mm
Pervious - woods	10 mm

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. The equation is:

$$f_t = f_c + (f_o - f_c)e^{-kt}$$

where: f_t is the infiltration capacity rate (in/hr or mm/hr) at time t

f_o is the initial infiltration capacity rate (in/hr or mm/hr)

f_c is the final infiltration capacity rate (in/hr or 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, F , accumulated into the soil before the start of the storm. In the OTTHYMO model, F 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:

$$Q = \frac{(P - Ia)^2}{P - Ia + S}$$

where: Q = runoff depth in mm

P = rainfall in mm

S = total potential losses or storage parameter in mm

Ia = 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, and D being for high runoff potential soils. The higher the CN, the higher the runoff potential. CN is given in tables in "Modern Sewer Design" or the "National

Engineering Handbook". In this procedure, there are also 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. AMC III conditions are assumed when modeling the final 12 hours of the Hurricane Hazel event. 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:

$$S = \frac{25400}{CN} - 254$$

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.

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. Typical values/sources are provided in Appendix C.

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 design charts for these methods are given in Appendix C.

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 shall equal 3 unless calibration results indicate otherwise. The Time to Peak should be calculated as $t_p = 0.67 t_c$, where t_c 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 shall be determined by preliminary hydraulic calculations of the backwater profile or by procedures available in the approved hydrologic model and shall 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 and from field surveys. Cross-sections shall 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/approaches set out in Appendix C.

Reservoir Routing

When calculating orifice discharge, the available head in the orifice equation shall 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 recommended for submission.

(Refer to Appendix I for weir and orifice equations)**3.3.2 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, although HEC2 is acceptable. 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 must be integrated into the existing model.

3.4 SWM Pond Design

The MOE SWM Planning and Design Manual provided 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 must be met. The checklist for the SWM Report in Appendix A serves as a reminder and summarizes the design criteria that should be met. Other criteria that are not explicitly discussed in the SWM Manual are as follows:

- overflow weir design - LSRCA requires the emergency overflow weir be designed to convey the uncontrolled one in 100-year peak flow. Detailed design calculations are required as well as a detail of the weir on an appropriate engineering drawing. Refer to Appendix I for weir equations.
- 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. Refer to Appendix I for weir and orifice equations.

- suitability of site - A geotechnical report regarding the suitability of the proposed site for construction of a SWM pond will be required.

Safety features must 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.

Vegetation forms an important functional component of a SWM facility. Therefore a vegetation planting plan for the SWM facility is required. 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.) must use native plants and non-invasive species only. Refer to Appendix H for planting requirements.

3.4.1 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 must be prepared and submitted. It is typically required by the municipality. The MOE SWM Manual provides guidelines on operation, maintenance and monitoring of SWM facilities. SWM facilities are infrastructure that need to be maintained just like other municipal infrastructure. The 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 is required to be submitted as part of the final submission. With 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.

3.5 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 on CD. 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 LSRCA. Final engineering plans and drawings must be signed and sealed by a Professional Engineer registered with Professional Engineers Ontario. A complete Stormwater Management Report will include, at a minimum, all items listed in the SWM checklist. The SWM Checklist is included in Appendix A. LSRCA 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.

3.5.1 Re-Submission

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

3.6 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. The Province of Ontario set up a committee in 2008 led by the Ministry of Environment 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 LSRCA technical guidelines can be modified accordingly.

4.0 REFERENCES

American Iron and Steel Institute, Modern Sewer Design, Canadian Edition, 1980.

Credit Valley Conservation (CVC), and Toronto and Region Conservation Authority (TRCA), Low Impact Development Stormwater Management Manual 20010.

The Corporation of the City of London, Stormwater Management Pond Requirements, Environmental and Engineering Services Department, December 2005.

Environment Canada, Methodologies to Improve Rainfall Intensity- Duration – Frequency (IDF) Estimates: A Southern Ontario Pilot Project - 2012

Greater Golden Horseshoe Area Conservation Authorities, Erosion and Sediment Control Guideline for Urban Construction, 2006.

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

Lake Simcoe Region Conservation Authority, Watershed Development Policies,

Lake Simcoe Region Conservation Authority, Lake Simcoe Basin Stormwater Management and Retrofit Opportunities, 2007.

Ontario Ministry of the Environment, Stormwater Management Planning and Design Manual, 2003.

Ontario Ministry of the Environment, Lake Simcoe Phosphorus Loading Development Tool, 2012

Ontario Ministries of Natural Resources, Environment, Municipal Affairs, and Transportation, Association of Conservation Authorities of Ontario, Municipal Engineers Association, Urban Development Institute, Urban Drainage Design Guidelines, 1987.

Ontario Ministry of Transportation, MTO Drainage Management Manual, 1997.

Ontario Ministry of Transportation, Stormwater Management Requirements for Land Development Proposals, 1999.

Toronto and Region Conservation Authority (TRCA), Watercourse Erosion Analysis Design and Submission Requirements in Support of Secondary Plans, 2007.

U.S. Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, 1964.

APPENDIX A
STORMWATER MANAGEMENT (SWM) REPORT
CHECKLIST
(TO BE READ IN CONJUNCTION WITH MUNICIPAL REQUIREMENTS)

The following information is required in a Stage 2 SWM report:

1. GENERAL

a) Site Description

- ☐ Location – nearest roads, watershed & subwatershed
- ☐ Existing Conditions – land use on site & surrounding areas
- ☐ Proposed Conditions
- ☐ Drainage Area – for the site, tributary & watershed
- ☐ Watercourses, Wetlands - present on site, and type (permanent or intermittent)
- ☐ Drainage patterns and ultimate drainage location/outfall

b) Background Information

- ☐ Watershed Plans
- ☐ Sub-Watershed Plans
- ☐ Master Drainage Plans (MDPs)
- ☐ Other Previous Reports and Relevant SWM Requirements
- ☐ Existing Models
- ☐ Geotechnical Report

c) Figures

- ☐ Location Plan
- ☐ Legal Plan of Survey
- ☐ Pre Development Drainage Area Plan
- ☐ Post Development Drainage Area Plan
- ☐ Proposed SWMF locations
- ☐ Proposed Site Plan – grading and servicing
- ☐ Erosion and Sediment Control Plan

2. QUALITY CONTROL

- (LID's may be considered for reducing quality control volume requirements)
- ☐ Level of Protection
- ☐ Drainage Area to Facility (ha)
- ☐ Percentage Impervious – total and directly connected
- ☐ SWM Facility Monitoring and Maintenance Requirements

a) Oil-Grit Separators (OGS)

- ☐ Approved Manufacturer

- ☐ Model Number
- ☐ Sizing Calculations Included
- ☐ TSS Removal (%)
- ☐ Annual Runoff Treated (%)
- ☐ Particle Size Distribution and particle specific gravity used in sizing
- ☐ Appropriate Lab Results and / or Field Study Results

b) Extended Detention Wet Ponds

- ☐ Drainage Area - minimum 5 ha (preferred ≥ 10 ha)
- ☐ Forebay - minimum depth 1 m.
- ☐ Forebay Area - % of Total Permanent Pool Area (maximum 33 %)
- ☐ Forebay - length-to-width ratio (minimum 2:1)
- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Permanent Pool Depth - maximum 3 m
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ Extended Detention Depth - maximum 1.5 m (water quality and erosion control), maximum 2 m (total including quantity control)
- ☐ Side Slopes at Permanent Pool Elevation - 5:1 for 3 m horizontally on either side of the permanent water line, maximum 3:1 elsewhere
- ☐ 0.3 m of freeboard
- ☐ Detention time - minimum 24 hrs
- ☐ Length to Width Ratio - minimum 3:1 (preferred 4:1 to 5:1)
- ☐ Emergency Overflow Weir Design
- ☐ Capacity of Overflow Weir
- ☐ Design of Overflow Weir
- ☐ Inlet Design - minimum 450 mm, preferred pipe slope $> 1\%$
- ☐ Outlet Design - minimum 450 mm outlet pipe, Pipe slope $> 1\%$
- ☐ Maintenance Access - Provided to approval of municipality, provision of maintenance drawdown pipe preferred
- ☐ Buffer- minimum 7.5 m horizontally above maximum water quality/erosion control water level.

c) Wetland

- ☐ Drainage Area - minimum 5 ha (preferred ≥ 10 ha)
- ☐ Forebay - minimum Depth 1 m.
- ☐ Forebay Area - % of Total Permanent Pool Area (maximum 20 %)

- ☐ Forebay - length-to-width ratio (minimum 2:1)
- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Permanent Pool Depth - Range from 150 mm to 300 mm
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ Extended Detention Depth - maximum 1.0 m for storms < 10 year event
- ☐ Side Slopes at Permanent Pool Elevation - 5:1 for 3 m horizontally on either side of the permanent water line, maximum 3:1 elsewhere
- ☐ 0.3 m of freeboard
- ☐ Detention time - minimum 24 hrs
- ☐ Length to Width Ratio - minimum 3:1 (12 hours if in conflict with minimum orifice size)
- ☐ Emergency Overflow Weir Design
- ☐ Capacity of Overflow Weir
- ☐ Design of Overflow Weir
- ☐ Inlet Design - minimum 450 mm, preferred pipe slope > 1 %
- ☐ Outlet Design - minimum 450 mm outlet pipe, Pipe slope > 1 %. If orifice control used, 75 mm minimum, minimum 100 mm orifice preferable
- ☐ Maintenance Access - Provided to approval of municipality, provision of maintenance drawdown pipe preferred
- ☐ Buffer - minimum 7.5 m horizontally above maximum water quality/erosion control water level.

d) Hybrid Wet Pond / Wetland

A hybrid wet pond/wetland system consists of a wet pond and a wetland connected in series.

- ☐ Drainage Area - minimum 5 ha (preferred ≥ 10 ha)
- ☐ Forebay - minimum Depth 1 m.
- ☐ Forebay Area - % of Total Permanent Pool Area (based on size of wet pond only, maximum 33%)
- ☐ Forebay - length-to-width ratio, minimum 2:1
- ☐ Permanent Pool Storage Requirements (m^3/ha)
- ☐ Permanent Pool Storage Requirements (m^3)
- ☐ Permanent Pool Volume Provided (m^3)
- ☐ Permanent Pool Depth - maximum 3 m for wet pond, 150 mm to 300 mm for wetland
- ☐ Extended Detention Storage Requirements (m^3/ha)
- ☐ Extended Detention Storage Requirements (m^3)
- ☐ Extended Detention Volume Provided (m^3)
- ☐ Extended Detention Depth - maximum 1.0 m

- ☐ Side Slopes at Permanent Pool Elevation - 5:1 for 3 m horizontally on either side of the permanent water line, maximum 3:1 elsewhere
- ☐ 0.3 m of freeboard
- ☐ Detention time - minimum 24 hrs
- ☐ Length to Width Ratio - Wet pond minimum 2:1 (higher ratio preferred)
- ☐ Emergency Overflow Weir Design
- ☐ Capacity of Overflow Weir
- ☐ Design of Overflow Weir
- ☐ Inlet Design - minimum 450 mm, preferred pipe slope > 1 %
- ☐ Outlet Design - minimum 450 mm outlet pipe, Pipe slope > 1 %
- ☐ Maintenance Access - Provided to approval of municipality, provision of maintenance drawdown pipe preferred
- ☐ Buffer - minimum 7.5 m horizontally above maximum water quality/erosion control water level.

3. QUANTITY CONTROL

- ☐ Required (*if not continue to next section*)
- ☐ Requirements:
- ☐ Runoff Coefficient or Imperviouness Calculations
- ☐ Pre Development Peak Flow (m^3/s)
- ☐ Post Development Uncontrolled Peak Flow (m^3/s)
- ☐ Post Development Controlled Peak Flow (m^3/s)
- ☐ SWMF Type
- ☐ Stage – Storage – Discharge Table
- ☐ Outlet design
- ☐ Total Storage Required (m^3)
- ☐ Total Storage Provided (m^3)
- ☐ Table to Compare Provided Versus Required

4. HAZARD LAND MANAGEMENT

- ☐ Regional and 100 year flood lines shown on plans
- ☐ Valley top of bank, stream erosion, steep slope allowances and meanderbelt assessed (confined stream systems only)
- ☐ Wetlands and required setbacks determined
- ☐ Wave uprush and/or wind setup elevations calculated (Lake Simcoe Shoreline)
- ☐ Limit of Development shown on plans

5. HYDROGEOLOGY

- ☐ Soils / Hydrogeology Report
- ☐ Groundwater Elevations
- ☐ Pre & Post Development Water Budget
- ☐ Special Construction Considerations and Recharge Measures

6. CONSTRUCTION SEDIMENT CONTROL

- ☐ Sediment Control Plan
- ☐ Sizing of Temporary Sediment Basins and details
- ☐ Rock check dam locations and details
- ☐ Silt fence location and details
- ☐ Outlet location
- ☐ 24 hour Extended Detention Calculations
- ☐ Sequencing and Maintenance/Inspection schedule and notes

7. OTHER

- 8. Digital Hydrologic Model including input and output files and associated rainfall input (4hr and 12hr storms)
- ☐ Schematic representation of pre and post development hydrologic models
- ☐ Digital Hydraulics Model including input and output files
- ☐ All engineering drawings must be included
- ☐ Rainfall Data
- ☐ Storm sewer design sheets
- ☐ Storm sewer design drainage plan, showing areas and runoff coefficients
- ☐ Hydrology Summary Output for pre and post development conditions
- ☐ Hydrology Detailed Output for one scenario
- ☐ Hydraulics Summary Output Table – Section Number, Flow, Water Surface Elevation, Velocity (if applicable)
- ☐ All reports and plans signed and sealed

APPENDIX B PRECIPITATION DATA

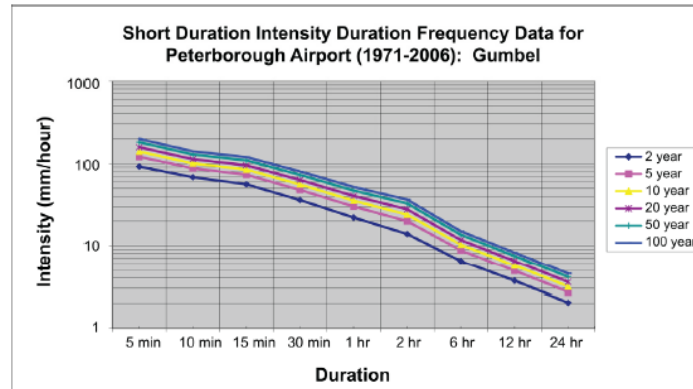
The LSRCAs must be contacted regarding appropriate rainfall data required to be used prior to the commencement of a Stormwater Management study.

Municipalities must also be contacted regarding the most current IDF curve formulae to use.

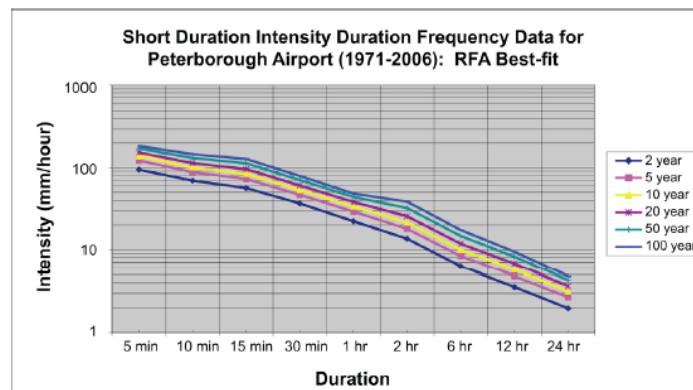
Environment Canada in cooperation with a number of Conservation Authorities in southern Ontario have completed a report entitled Methodologies to Improve Rainfall Intensity- Duration – Frequency (IDF) Estimates: A Southern Ontario Pilot Project - 2012.

The following 4 pages represent the Regional IDF Curves for Region 9 which includes the Lake Simcoe Watershed. These IDF curves (Best Fit Curves) should be used for large scale studies such as watershed and sub-watershed plans.

Peterborough Airport : Gumbel 1971-2002 IDF						EC 2003 IDF update			
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
100 year	17.0	23.9	30.5	40.6	52.6	73.2	88.0	95.4	102.8



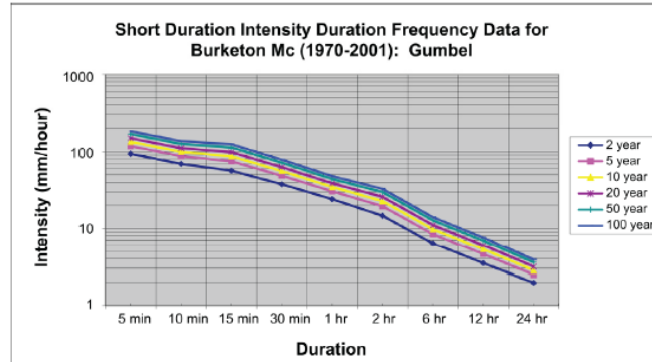
Single station Return Period Rainfall (mm) : Gumbel 1971-2006									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	7.7	11.4	14.0	18.0	22.1	27.7	38.7	44.4	49.0
5 year	10.1	14.6	18.3	23.9	30.1	39.8	52.4	58.9	65.0
10 year	11.7	16.8	21.1	27.8	35.4	47.8	61.5	68.5	75.6
20 year	13.2	18.8	23.8	31.6	40.5	55.5	70.2	77.7	85.7
50 year	15.2	21.5	27.4	36.4	47.0	65.4	81.4	89.5	98.8
100 year	16.7	23.5	30.0	40.1	52.0	72.9	89.9	98.4	108.7



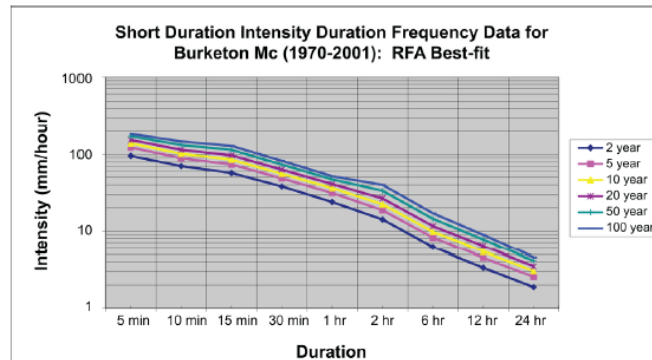
RFA Return Period Rainfall (mm) : Best Fit 1971-2006									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	7.9	11.6	14.1	18.3	22.3	27.2	37.7	42.9	47.3
5 year	10.1	14.7	18.2	23.3	29.2	36.0	50.2	57.7	64.4
10 year	11.5	16.8	21.0	26.8	33.8	43.0	59.9	69.0	76.4
20 year	12.7	18.9	23.9	30.3	38.2	51.2	70.9	81.0	88.1
50 year	14.2	21.8	28.2	35.3	44.0	64.4	88.3	98.6	103.2
100 year	15.3	24.2	31.8	39.5	48.3	77.0	104.4	113.4	114.5

Figure 62. Peterborough Airport - Region 09. Return period rainfalls (mm): EC 2003 IDF update (Gumbel), single station Gumbel: 1971-2006, and Regional Frequency Analysis (RFA): 1971-2006.

Burketon McLaughlin : Gumbel 1969-2001 IDF						EC 2003 IDF update			
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
100 year	16.0	23.1	31.1	39.1	47.5	64.8	83.1	90.1	92.4



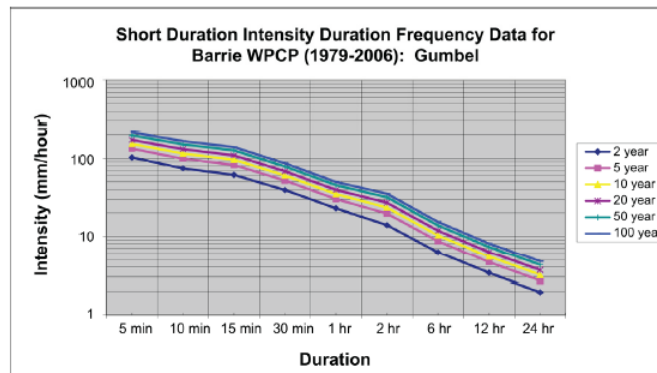
Single station Return Period Rainfall (mm) : Gumbel 1970-2001									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	7.8	11.5	14.1	18.8	24.0	29.2	38.0	41.8	47.4
5 year	9.8	14.5	18.6	24.2	30.4	38.9	50.3	54.9	59.6
10 year	11.2	16.5	21.7	27.9	34.6	45.3	58.5	63.6	67.7
20 year	12.4	18.5	24.6	31.3	38.7	51.5	66.2	71.9	75.5
50 year	14.1	20.9	28.3	35.8	44.0	59.4	76.3	82.7	85.5
100 year	15.3	22.8	31.1	39.2	47.9	65.4	83.9	90.8	93.1



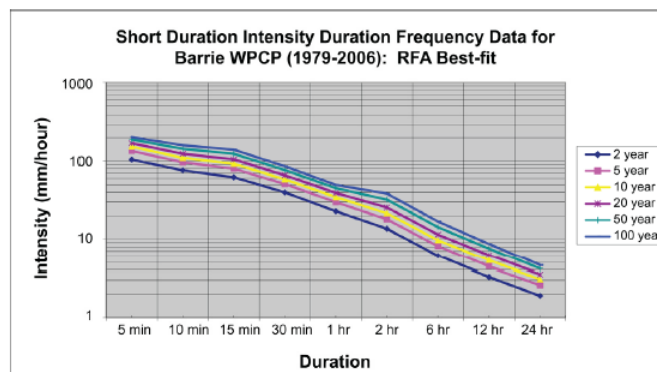
RFA Return Period Rainfall (mm) : Best Fit 1970-2001									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	7.9	11.7	14.2	19.0	23.8	28.2	36.9	40.3	45.1
5 year	10.2	14.8	18.4	24.2	31.2	37.3	49.1	54.2	61.5
10 year	11.6	16.9	21.2	27.8	36.1	44.6	58.6	64.7	73.0
20 year	12.8	19.0	24.2	31.4	40.9	53.0	69.3	76.0	84.1
50 year	14.3	22.0	28.5	36.6	47.0	66.8	86.3	92.5	98.6
100 year	15.4	24.5	32.1	41.0	51.7	79.7	102.1	106.4	109.3

Figure 63. Burketon McLaughlin - Region 09. Return period rainfalls (mm): EC 2003 IDF update (Gumbel), single station Gumbel: 1970-2001, and Regional Frequency Analysis (RFA): 1970-2001.

Barrie WPCP : Gumbel 1979-1990 IDF					EC 2003 IDF update				
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
100 year	16.9	19.1	23.4	30.5	37.9	56.9	85.0	87.5	124.4



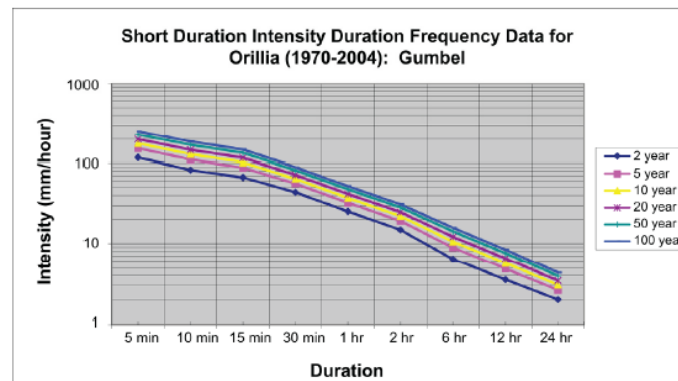
Single station Return Period Rainfall (mm) : Gumbel 1979-2006									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	8.5	12.4	15.3	19.6	22.9	27.8	37.2	40.4	46.6
5 year	11.0	16.5	20.5	25.9	30.1	39.2	51.8	55.5	64.5
10 year	12.7	19.2	24.0	30.1	34.8	46.7	61.5	65.5	76.5
20 year	14.3	21.8	27.3	34.1	39.4	54.0	70.8	75.0	87.9
50 year	16.4	25.1	31.6	39.2	45.3	63.3	82.8	87.4	102.7
100 year	17.9	27.7	34.8	43.1	49.7	70.3	91.8	96.7	113.8



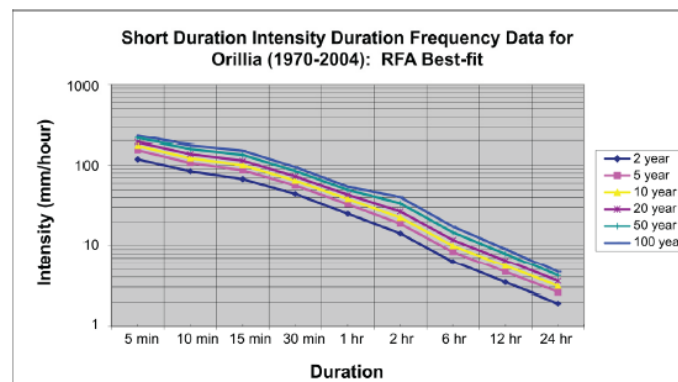
RFA Return Period Rainfall (mm) : Best Fit 1979-2006									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	8.7	12.7	15.5	19.9	22.9	27.2	36.6	39.4	45.4
5 year	11.3	16.1	20.0	25.4	29.9	36.0	48.6	53.0	61.8
10 year	12.8	18.4	23.1	29.1	34.7	43.0	58.0	63.3	73.4
20 year	14.1	20.7	26.4	33.0	39.2	51.2	68.6	74.3	84.6
50 year	15.8	23.9	31.1	38.4	45.1	64.4	85.5	90.4	99.1
100 year	17.0	26.6	35.0	43.0	49.6	76.9	101.1	104.0	109.9

Figure 64. Barrie WPCP - Region 09. Return period rainfalls (mm): EC 2003 IDF update (Gumbel), single station Gumbel: 1979-2006, and Regional Frequency Analysis (RFA): 1979-2006.

Orillia : Gumbel 1965-2003 IDF					EC 2003 IDF update				
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
100 year	20.5	30.4	36.3	45.7	53.6	64.1	92.8	96.7	98.7



Single station Return Period Rainfall (mm) : Gumbel 1970-2004									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	9.7	13.8	16.7	21.9	25.3	29.8	38.4	42.5	47.8
5 year	12.7	18.3	22.1	28.0	32.5	38.5	53.6	58.0	62.9
10 year	14.6	21.4	25.6	32.1	37.3	44.2	63.6	68.4	72.8
20 year	16.5	24.3	29.0	35.9	41.9	49.8	73.2	78.3	82.4
50 year	18.9	28.0	33.3	40.9	47.8	56.9	85.7	91.1	94.7
100 year	20.8	30.8	36.6	44.7	52.2	62.2	95.1	100.7	104.0



RFA Return Period Rainfall (mm) : Best Fit 1970-2004									
	5 min	10 min	15 min	30 min	1 hour	2 hour	6 hour	12 hour	24 hour
2 year	9.9	14.1	16.9	22.1	25.2	28.6	37.7	41.3	46.0
5 year	12.8	17.9	21.8	28.2	33.0	37.7	50.2	55.6	62.7
10 year	14.6	20.5	25.2	32.3	38.2	45.1	59.9	66.4	74.4
20 year	16.1	23.0	28.7	36.6	43.2	53.7	70.8	77.9	85.8
50 year	18.0	26.6	33.8	42.7	49.7	67.6	88.3	94.8	100.5
100 year	19.3	29.6	38.1	47.7	54.6	80.7	104.3	109.1	111.5

Figure 65. Orillia - Region 09. Return period rainfalls (mm): EC 2003 IDF update (Gumbel), single station Gumbel: 1970-2004, and Regional Frequency Analysis (RFA): 1970-2004.

APPENDIX C

TYPICAL HYDROLOGIC VALUES & SOURCES

Design Chart 1.03: Hurricane Hazel

	Depth		Percent of 12 hour
	(mm)	(inches)	
First 36 hours	73	2.90	
37th hour	6	.25	3
38th hour	4	.17	2
39th hour	6	.25	3
40th hour	13	.50	6
41st hour	17	.66	8
42nd hour	13	.50	6
43rd hour	23	.91	11
44th hour	13	.50	6
45th hour	13	.50	6
46th hour	53	2.08	25
47th hour	38	1.49	18
48th hour	13	.50	6
	285	11.21	100

Drainage Area (km ²)	Percentage
0 to 25	100.0
26 to 45	99.2
46 to 65	98.2
66 to 90	97.1
91 to 115	96.3
116 to 140	95.4
141 to 165	94.8
166 to 195	94.2
196 to 220	93.5
221 to 245	92.7
246 to 270	92.0
271 to 450	89.4
451 to 575	86.7
576 to 700	84.0
701 to 850	82.4
851 to 1000	80.8
1001 to 1200	79.3
1201 to 1500	76.6
1501 to 1700	74.4
1701 to 2000	73.3
2001 to 2200	71.7
2201 to 2500	70.2
2501 to 2700	69.0
2701 to 4500	64.4
4501 to 6000	61.4
6001 to 7000	58.9
7001 to 8000	57.4

Source: Ministry of Transportation, MTO (1989)

Design Chart 1.04: Timmins Storm

	Depth		Percent of 12 hour
	(mm)	(inches)	
1st hour	15	0.6	8
2nd hour	20	0.8	10
3rd hour	10	0.4	6
4th hour	3	0.1	1
5th hour	5	0.2	3
6th hour	20	0.8	10
7th hour	43	1.7	23
8th hour	20	0.8	10
9th hour	23	0.9	12
10th hour	13	0.5	6
11th hour	13	0.5	7
12th hour	<u>8</u>	<u>0.3</u>	<u>4</u>
	193	7.6	100

Drainage Area (km ²)	Percentage
0 to 25	100.0
26 to 50	97
51 to 75	94
76 to 100	90
101 to 150	87
151 to 200	84
201 to 250	82
251 to 375	79
376 to 500	76
501 to 750	74
751 to 1000	70
1001 to 1250	68
1251 to 1500	66
1501 to 1800	65
1801 to 2100	64
2101 to 2300	63
2301 to 2600	62
2601 to 3900	58
3901 to 5200	56
5201 to 6500	53
6501 to 8000	50

Source: Ministry of Transportation, MTO (1989)

The Chicago Hyetograph

The Chicago hyetograph is assumed to have a time distribution such that if a series of ever increasing "time-slices" were analyzed around the peak rainfall, the average intensity for each "slice" would lie on a single IDF curve. Therefore, the Chicago design storm displays statistical properties which are consistent with the statistics of the IDF curve. That being the case, the synthesis of the Chicago hyetograph starts with the parameters of an IDF curve together with a parameter (r) which defines the fraction of the storm duration which occurs before the peak rainfall intensity. The value of r is derived from the analysis of actual rainfall events and is generally in the range of 0.3 to 0.5.

The continuous curves of the hyetograph in Figure 3.6 can be computed in terms of the times before (t_b) and after (t_a) the peak intensity by the two equations below.

After the peak:

$$i_a = \frac{a \left[(1 - b) \frac{t_a}{1 - r} + c \right]}{\left(\frac{t_a}{1 - r} + c \right)^{1 + b}}$$

Before the peak:

$$i_b = \frac{a \left[(1 - b) \frac{t_b}{r} + c \right]}{\left(\frac{t_b}{r} + c \right)^{1 + b}}$$

where: t_a = time after peak
 t_b = time before peak
 r = ratio of time before the peak occurs to the total duration time (the value is derived from analysis of actual rainfall events)

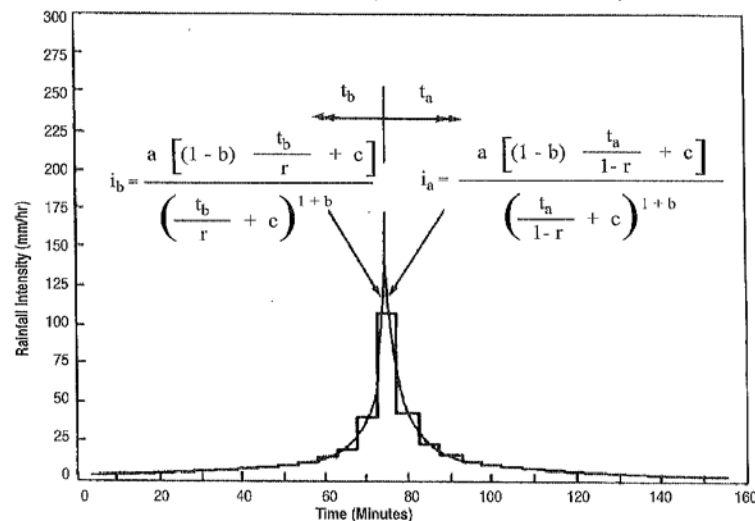


Figure 3.6 Chicago hyetograph.

Source: The Handbook of Steel Drainage and Highway Construction Products - Corrugated Steel Pipe Institute Nov. 2007

Design Chart 1.05: SCS Type II Distribution

6 hour			12 hour			24 hour		
Time end' g, hour	F _{inc} (%)	F _{cum} (%)	Time end' g, hour	F _{inc} (%)	F _{cum} (%)	Time end' g, 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	7	-	-
2.5	6	19	4.5	3	15	8	4.0	12.0
2.75	15	34	5	4	19	8.5	-	-
3	39	73	5.5	6	25	9	2.7	14.7
3.5	11	84	5.75	12	37	9.5	1.6	16.3
4	5	89	6	33	70	9.75	-	-
4.5	4	93	6.5	9	79	10	1.8	18.1
5	3	96	7	4	83	10.5	2.3	20.4
6	4	100	7.5	3	86	11	3.1	23.5
			8	3	89	11.5	4.8	28.3
			10	7	96	11.75	10.4	38.7
			12	4	100	12	27.6	66.3
						12.5	7.2	73.5
						13	3.7	77.2
						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

Source: MTO Drainage Manual (1989)

Upland's Method

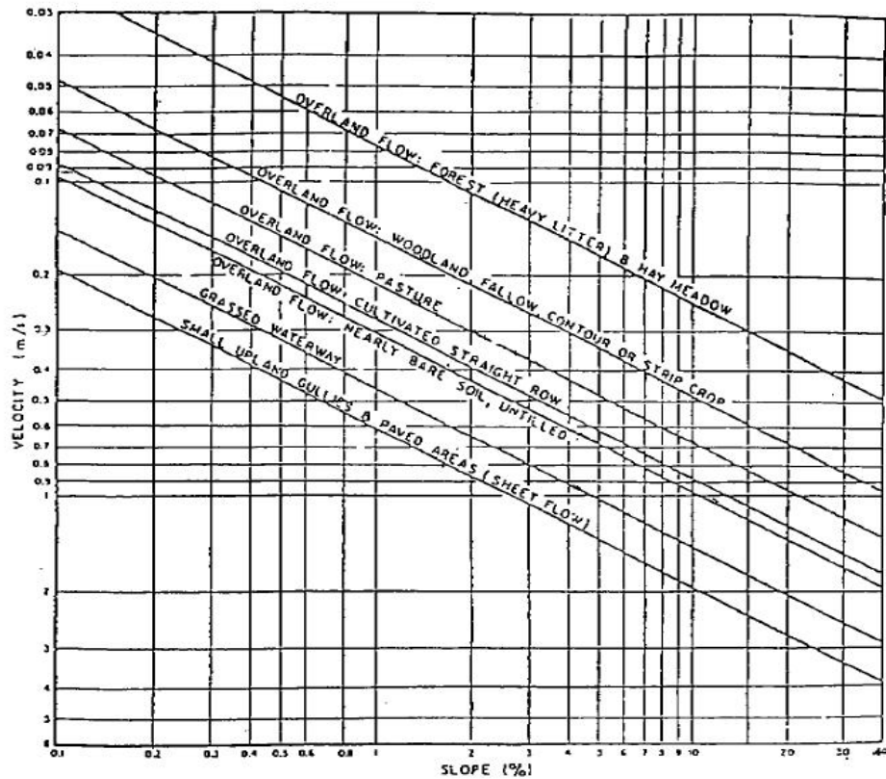
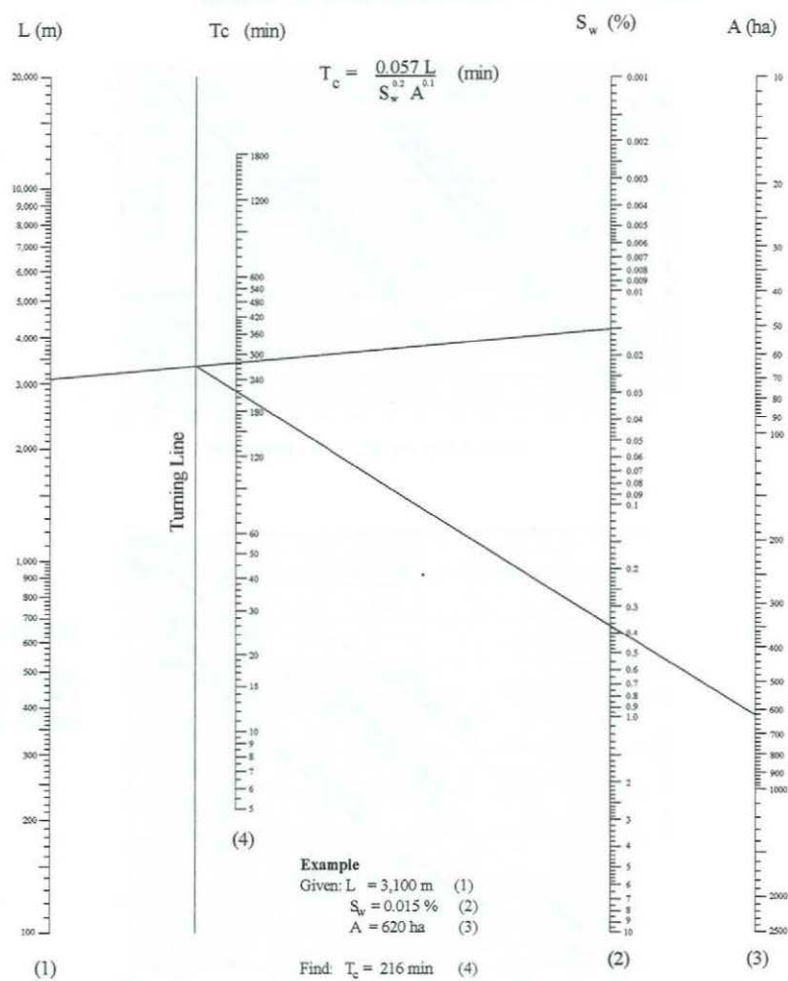


Figure 1: Uplands Method of Estimating Time of Concentration (SCS National Engineering Handbook, 1971)

With Upland's Method the average overland flow velocity is determined for a catchment based on the catchment slope and ground type, as shown in Figure 1. Once the velocity has been determined then the time of concentration is determined by dividing the catchment length by the overland flow velocity.

From: Visual OTTHYMO™ v2.0
Reference Manual April 2002

Design Chart 1.11: Time of Concentration - Bransby Williams Method



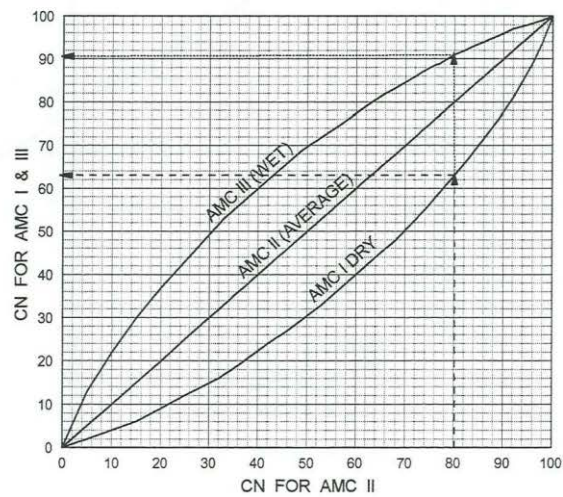
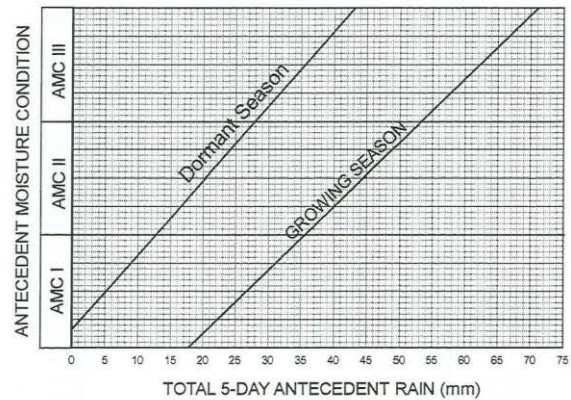
Source: French R., et al (1974)

The following table gives examples of suggested **TIMP** and **XIMP** values, based on land use, for the macro-level studies. These values can be used with the information supplied by the planner to determine area weighted values for the catchment of interest.

<u>Land Use</u>	<u>XIMP</u>	<u>TIMP</u>
Estate Residential	20	40
Low Density Residential (e.g. Single Units)	25	50
Medium Density Residential (e.g. Semi-detached Units)	35	55
High Density Residential (e.g. Townhouse Units)	50	60
School	55	55
Commercial	85	85
Park	0	0

Note: The best available modeling/planning information is to be utilized.

Design Chart 1.10: Antecedent Moisture Condition

**EXAMPLE**

AMC II CN = 80
 AMC I CN = 63
 AMC III CN = 91

Design Chart 1.12: Time of Concentration - Airport Method

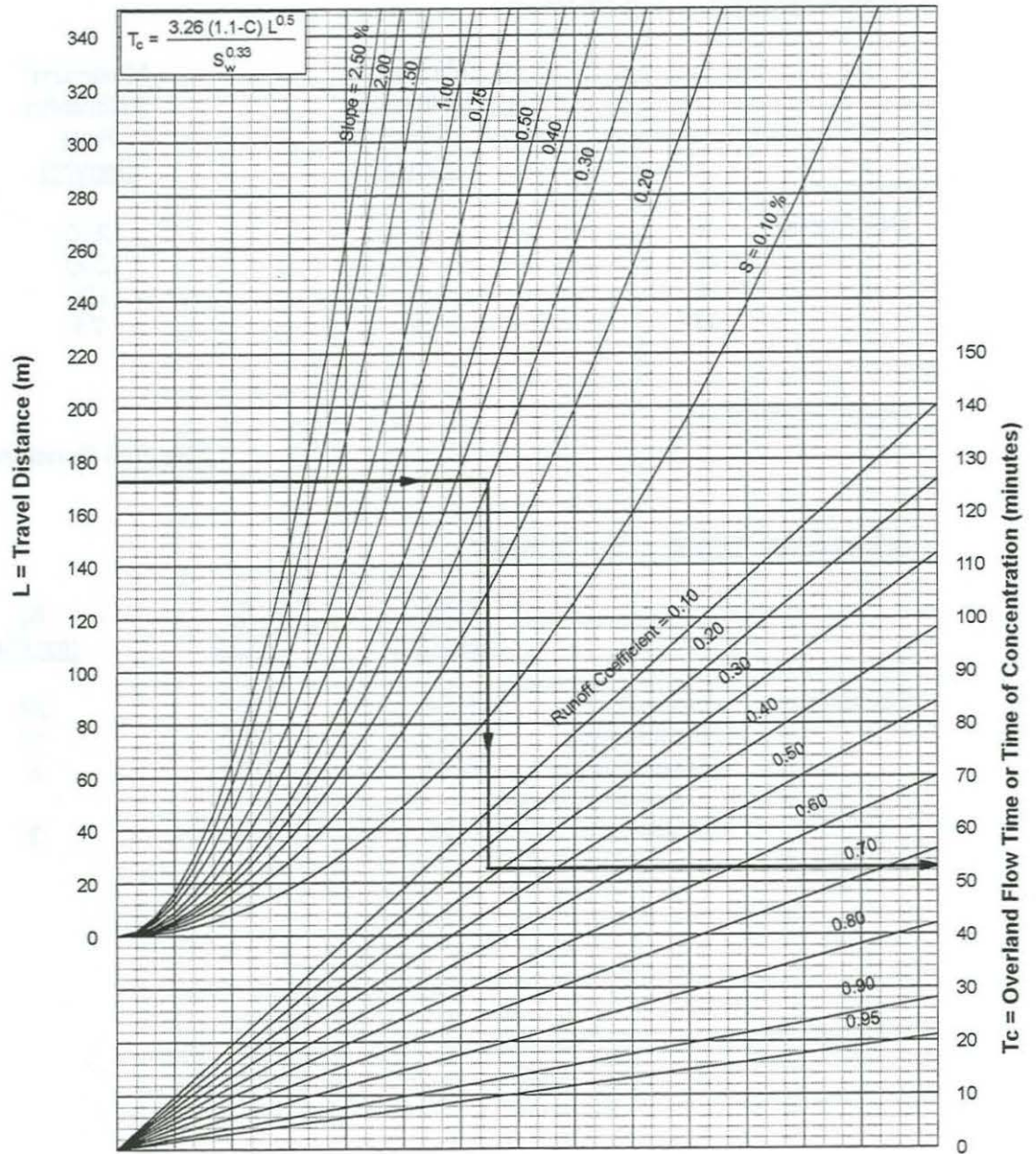


TABLE A.2 URBAN RUNOFF COEFFICIENTS¹

DESCRIPTION		Runoff Coefficient	
		Min.	Max.
Pavement	-asphalt or concrete	0.80	0.95
	-brick	0.70	0.85
Gravel roads and shoulders		0.40	0.60
Roofs		0.70	0.95
Business	-downtown	0.70	0.95
	-neighbourhood	0.50	0.70
	-light	0.50	0.80
	-heavy	0.60	0.90
Residential	-single family urban	0.30	0.50
	-multiple, detached	0.40	0.60
	-multiple, attached	0.60	0.75
	-suburban	0.25	0.40
Industrial	-light	0.50	0.80
	-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, to 2%	0.05	0.10
	-average, 2 to 7%	0.10	0.15
	-steep, over 7%	0.15	0.20
	-Clayey soil		
	-flat, to 2%	0.13	0.17
	-average, 2 to 7%	0.18	0.22
	-steep, over 7%	0.25	0.35

For storms having return period of more than 10 years, increase the listed values as follows, up to a maximum coefficient of 0.95:

25 yr. - add 10%
 50 yr. - add 20%
 100 yr. - add 25%

¹ MTO, Drainage Manual, Chart E4-2, Chapter E, 1983.

Regulatory Storms

The LSRCAs has 3 different regulatory storms within our jurisdiction. The following is an excerpt from Regulation 179/06 listing the locations where each storm is applied to generate the regional storm flood line:

11. (1) *The applicable flood event standards used to determine the maximum susceptibility to flooding of lands or areas within the watersheds in the area of jurisdiction of the Authority are the Hurricane Hazel Flood Event Standard, the Timmins Flood Event Standard, the 100 year Flood Event Standard and the 100 year flood level plus wave uprush, described in Schedule 1.*

O. Reg. 179/06, s. 11 (1).

(2) *The Hurricane Hazel Flood Event Standard applies to all watersheds within the area of jurisdiction of the Authority except for,*

(a) Bunker's Creek and Sophia Creek where the 100 Year Flood Event Standard applies;

(b) Talbot River and the Trent-Severn waterway where the Timmins Flood Event Standard applies; and

(c) Lake Simcoe where the 100 year flood level plus wave uprush applies. O. Reg. 179/06, s. 11 (2).

APPENDIX D

OIL / GRIT SEPARATORS

Oil/Grit separators must meet the sediment removal standards of the New Jersey Department of Environmental Protection (NJDEP). The NJDEP Lab Test Protocol must be followed, verifying the ability to remove small particles (less than 50 microns), the ability to remove less dense particles (less than 2.65 specific gravity) and the ability to prevent Scour / Re-suspension. 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.

As outlined in Section 2.4.3 of the guidelines, oil grit separators are not accepted as stand alone devices in relation to the Authority's requirement for 80% phosphorus removal. In order to use a specific unit to provide a degree of phosphorus control (as part of a treatment train or to obtain a phosphorus credit), sufficient third party field study results must be provided to the satisfaction of the LSRCA. At least two (2) field studies must show consistent phosphorus removal rates over a long period of time and must be reviewed and approved by the Ministry of the Environment.

The maximum flow directed into an oil/ grit separator must be no greater than the 2 hour 1:2 year pre-development peak flow (greater flows to bypass the OGS) unless the specific device has been shown (NJDEP protocol compliance) to be able to handle greater flows without re-suspension or scouring. An internal or external by-pass (off line OGS) may be used to achieve the bypass requirement provided that premature bypass does not occur. Orifice controls can also be used to control flows to the maximum allowable amount.

Hydraulic calculations are to be provided by a qualified professional demonstrating compliance with the above noted criteria.

See the following link to the New Jersey Department of Environmental Protection:

www.njstormwater.org

Testing procedure and other useful links:

http://www.njstormwater.org/docs/tss_test_procedure.pdf

<http://www.njstormwater.org/treatment.html>

http://www.njstormwater.org/pdf/MTD%20Certification%20Process%204_23_09.pdf

http://www.njstormwater.org/pdf/hydrodynamic_protocol_12_15.pdf

APPENDIX E

PHOSPHORUS LOADING

Phosphorus loads (kg/ha/year) are to be calculated based on the catchment area, the land use, level of control of the SWM facility where it exists, and the average load. Typical phosphorus reductions for various types of BMP's are as follows:

- Constructed Wetlands – 77%
- Dry Detention Ponds – 10%
- Perforated Pipe Infiltration / Exfiltration System – 87%
- Sand or Media Filters – 45%
- Infiltration Trenches – 60%
- Sorptive Media Interceptors – 79%
- Underground Storage – 25%
- Vegetated Filter Strips / Stream Buffers – 65%
- Wet Detention Ponds – 63%

These reduction estimates are based on data contained in the MOE's Lake Simcoe Phosphorus Loading Development Tool (2012). Subsequent versions of this tool should be used to obtain the latest MOE accepted removal rates.

Alternate BMP's or removal rates will be considered provided that the removal rates have been verified based on the results of acceptable third party field studies.

Phosphorus removal rates for oil/grit separators are assumed to be zero ("0") unless satisfactory field studies have been completed for the specific unit in accordance with the requirements of Appendix D and Section 2.4.3.

Loadings for existing and proposed land use can be based upon data contained within the MOE's Lake Simcoe Phosphorus Loading Development Tool (2012 or most recent version). Other methods can be used, subject to the approval of the LSRCA. LSRCA staff should be contacted prior to commencement of a phosphorus loading study for a specific site.

APPENDIX F

CRITERIA FOR STREAM EROSION CONTROL STUDY

The following are the criteria required for a stream erosion control study:

- Characterize the existing channel (i.e. determine the most sensitive reaches)
- Establish erosion thresholds based upon field measurements (i.e. determine critical discharge, velocity and depth of flow)
- Use stream modeling software such as Geo-X v.4.3b or approved equivalent to model the existing conditions and determine the targets of erosion thresholds.
- Model the proposed conditions with and without SWM controls.
- Compare the erosion potentials and adjust the proposed release rates and storage, such that the existing conditions are not exceeded.

A formal report must be submitted which will include the following typical components:

Introduction

- Background Information and Project Description

Description of Study Area

- Mapping and Air Photo Analysis
- Historic Channel Change
- Existing and Historic Land Use
- Geology
- Watershed Hydrology and Sediment Regime
- Delineation of Reaches and Rapid Characterization of Reaches
- Selection of Study Sites
- Cross-Section Geometry
- Profile and Plan Form
- Substrate Sampling and Characterization
- Bank Characterization
- Selection of Study Sites
- Hydraulic Modelling
- Bankfull Hydraulic Parameters
- Stability Thresholds
- Calculation of Threshold Discharges
- Hydrologic Model Configuration (existing & proposed scenarios)
- Model Calibration/Verification
- Flow Duration-Exceedance Analysis (for erosion threshold discharges - comparison of existing and proposed conditions)
- Sensitivity Analysis
- Conclusions and Recommendations

It is expected that in some instances, different components of the erosion analysis will be prepared by different consultants and more than one report may be produced. If this is the case, each report must clearly reference and summarize relevant data from the other.

Note: Geomorphic assessments must be prepared by a professional qualified to practice fluvial geomorphology.

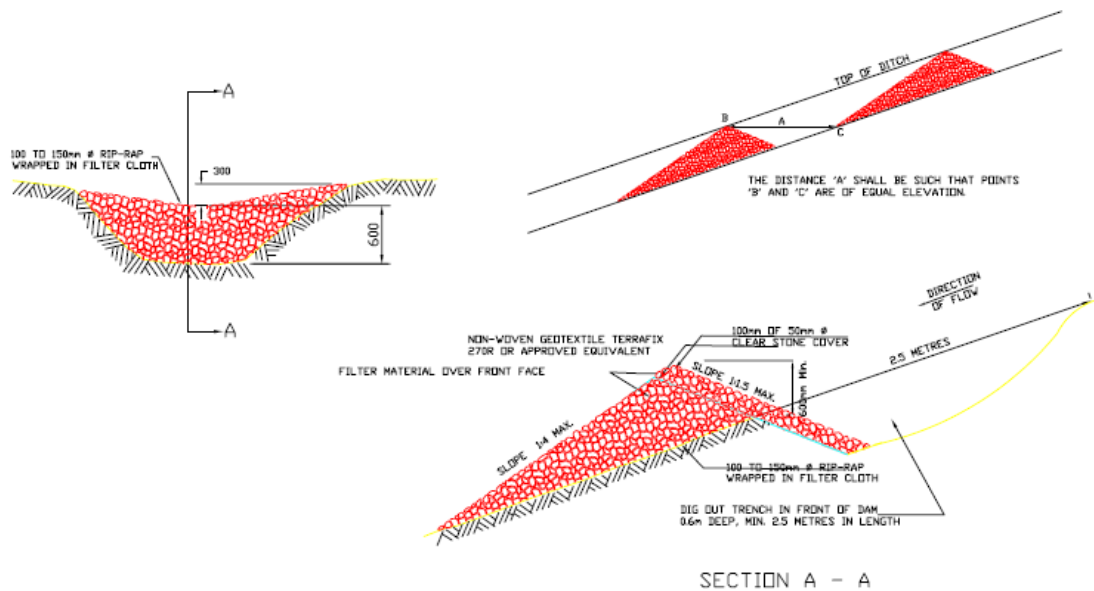
APPENDIX G

SEDIMENT CONTROL STANDARDS

Sediment and Erosion Control Plans must include the following:

- a) Contours and proposed storm sewer alignments.
 - b) Topsoil stockpile locations.
 - c) Stone mud mats at all construction entrances.
 - d) Rock check dams in all swales / ditches.
 - e) Sediment control fences downslope of all disturbed areas.
 - f) Temporary sediment control ponds at all low points. These ponds are to have filter fabric / clear stone wrapped Hickenbottom riser outfalls (with anti seepage collars) and rip rap overflow weirs. The riser should be surrounded by stone and this stone wrapped in filter fabric. A final layer of stone should then be placed on the filter fabric. This substantially increases the fabric surface area and thus reduces the potential for clogging.
- Ponds are to be sized to provide a minimum of 125 m³/ha. 24 hr. extended detention and 125 m³/ha. “permanent” pool storage. Larger ponds may be required depending on soil type and erosion potential.
- Notes on the construction of the pond berms (i.e. acceptable soils with low permeability to be used, inspection by a geo-tech and compaction %).
- g) Notes on the installation timing, inspection and maintenance of sediment controls. Sediment controls must be inspected on a regular basis and after every rain fall event. Repairs must be done in a timely manner to prevent movement of sediment into the water.
 - h) A clear statement that the SWM pond is to be constructed at the beginning of site grading and used as a sediment control facility. It may be necessary for temporary swales to be constructed to direct site flows to this pond during rough grading. Similarly all sediment control devices must be installed prior to the commencement of site grading.
 - i) Lines delineating the limit of cut and fill areas
 - j) Notes requiring the stabilization of all areas which will remain disturbed for more than thirty days.
 - k) A sediment control fence detail that is consistent with the Authority standard.
 - l) A sample site plan showing sediment controls to be installed during home building on individual lots (applicable to large estate residential lots only).

Sample details of various structures are attached to this page. Sediment controls used on site must be equal or better than the attached details.

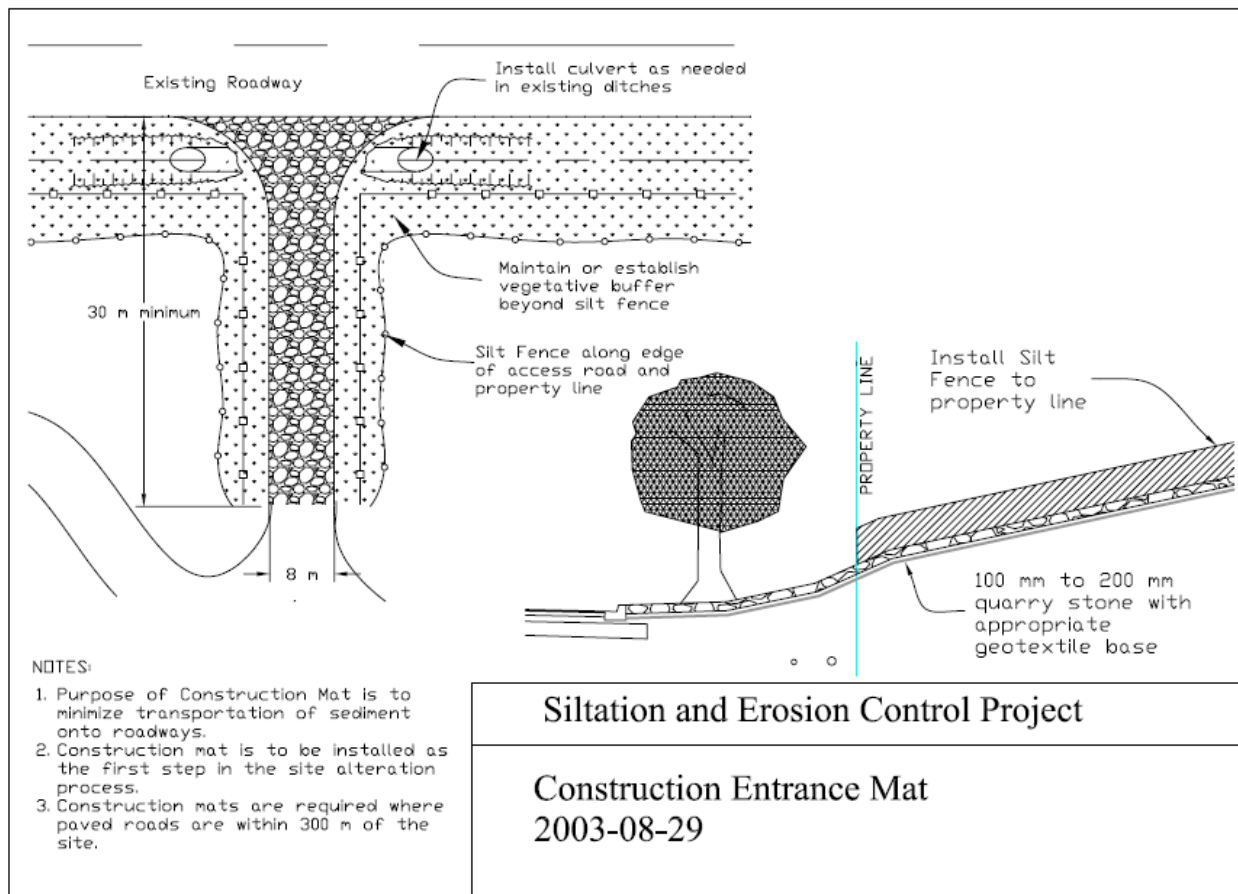


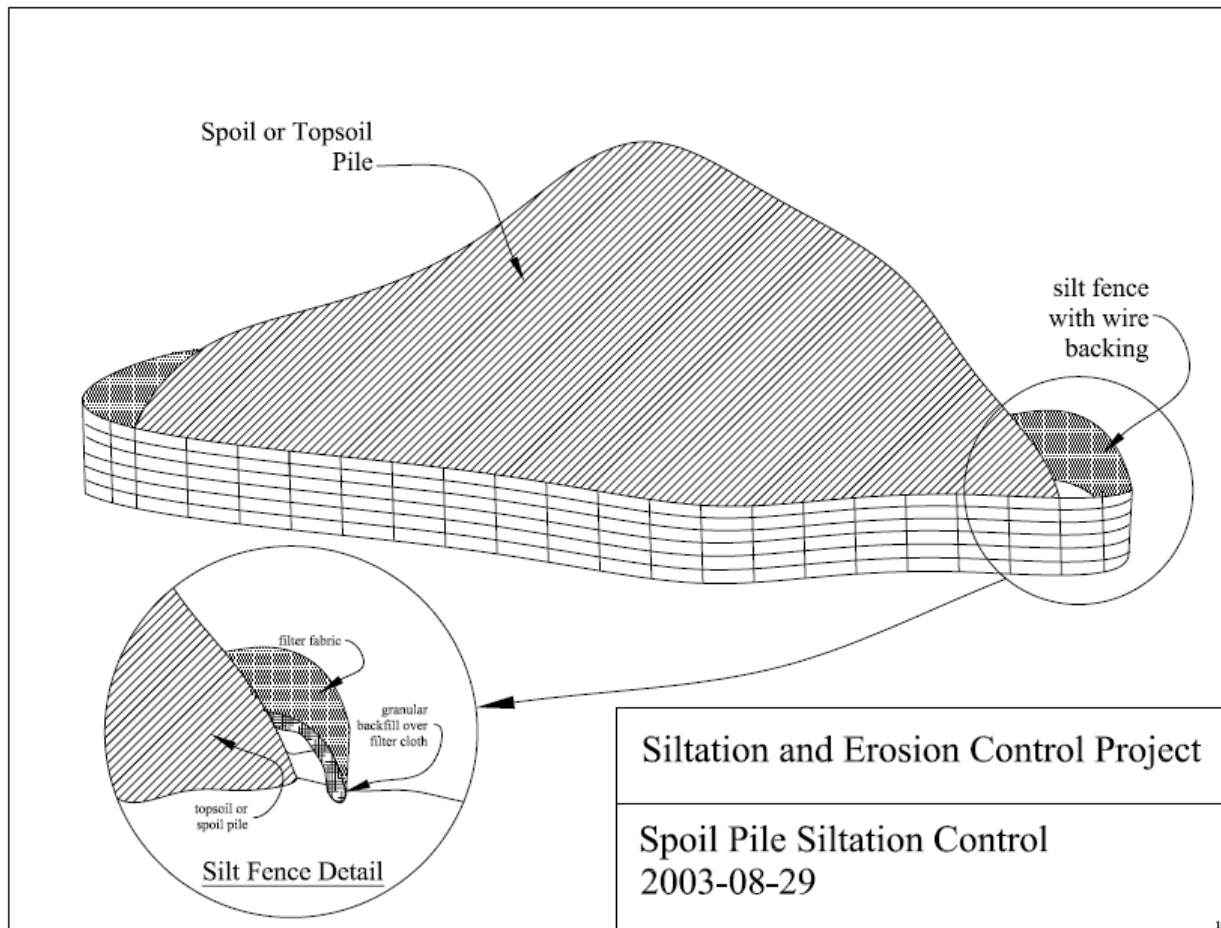
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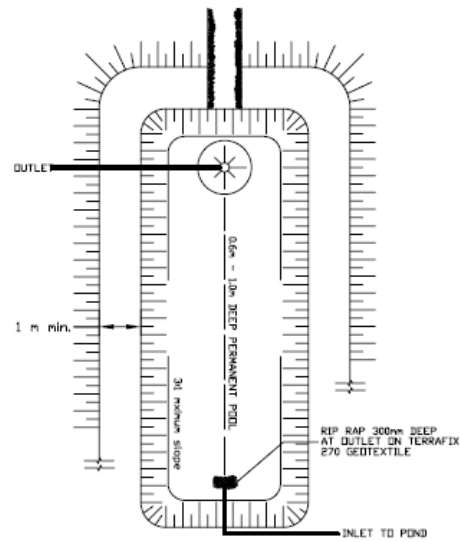
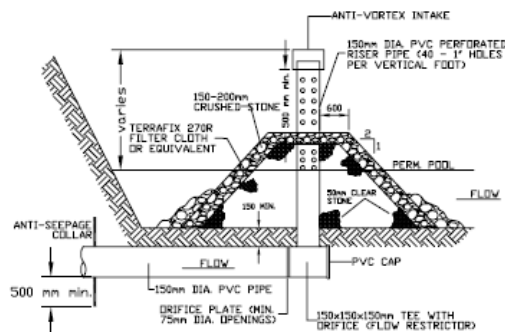
1. SEDIMENT SHALL BE REMOVED AND TRAP RESTORED TO ITS ORIGINAL DIMENSIONS WHEN THE SEDIMENT HAS ACCUMULATED TO 1/2 THE DESIGN DEPTH OF THE TRAP. REMOVED SEDIMENT SHALL BE DEPOSITED IN A SUITABLE AREA IN SUCH A MANNER THAT IT WILL NOT ERODE. THE STRUCTURE SHALL BE INSPECTED AFTER EACH RAIN AND REPAIRS MADE AS NEEDED. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION IS MINIMIZED.
2. ALL DIMENSIONS ARE IN MILLIMETRES UNLESS OTHERWISE SHOWN.

Siltation and Erosion Control Project

Granular Erosion Control Device 2003-08-29







PLAN VIEW

NOTES:

1. POND BERMS TO CONSTRUCTED USING IMPERVIOUS MATERIAL, COMPACTED TO 95% S.P.D, AND INSPECTED BY A PROFESSIONAL ENGINEER.
2. A 1.5m HIGH BARRIER FENCE SHALL BE ERECTED ALONG PERIMETER OF SEDIMENT BASIN. WARNING SIGNS SHALL BE ATTACHED TO THE FENCING STATING THE AREA IS OFF LIMITS TO THE GENERAL PUBLIC, AND ADVISING THAT THE BASIN IS USED FOR SEDIMENT CONTROL PURPOSES, AND THAT THE SUBJECT AREA IS SUBJECT TO FLASH FLOODING.
3. THE BASIN IS TO BE CONSTRUCTED ON THE BASIS OF A MIN. LENGTH TO WIDTH RATIO OF 4 TO 1.
4. APPROPRIATE PESTICIDE AND LAVICIDE CONTROLS SHOULD BE MAINTAINED TO CONTROL MOSQUITO BREEDING AS DIRECTED BY MEDICAL OFFICER OF HEALTH

Siltation and Erosion Control Project

Temporary Sediment Basin and Outlet Details 2003-08-29

APPENDIX H

PLANTING REQUIREMENTS

(TO BE READ IN CONJUNCTION WITH MUNICIPAL REQUIREMENTS)

The following guidelines are to be used to develop stormwater management planting plans. SWM facilities perform many functions; they receive runoff from developed lands, hold excess water during storm events, reduce the exchange of sediments and toxins into creeks and rivers, contribute to groundwater recharge, etc. Vegetation around SWM ponds helps to control erosion and the input of sediment, removes toxins from the water and decreases water temperatures. Appropriate species selection for these areas is critical for long-term survivability of the vegetation and function of the pond.

General Standards:

- Drawings should include a plan view showing planting locations, species and numbers, a detail showing the installation, and a note listing the species, size, and condition. Botanical names must be listed for all species.
- Include a key plan including location, project name, address and applicant and owner's name(s), etc.
- Signage in SWM pond area is recommended, indicating the purpose of the pond, safety considerations (i.e. no swimming/wading) and no mowing.
- To reduce thermal warming, shade southern exposure of pond, inflow and outflow channels whenever possible.
- Ground cover must include no-maintenance, non-invasive species with a minimum of 70% regionally native flowers and grasses, though we encourage the use of 100% regionally native due to the ready availability of these mixes.
- Species should be chosen with consideration given to environmental conditions specific to the site (e.g. moisture regime, shade, soil type, etc.).
- TIP: Geese use water as an escape route from predators. Planting dense shrubs around the perimeter of the pond will deter geese from the area, as their line of sight to the water will be obstructed.

Trees and Shrubs:

- All specified trees and shrub material is to be entirely native, non-invasive species and indigenous to the region. Cultivars are not acceptable.
- Plantings should be no fewer than 4-6 tree species and 4-6 shrub species.
- Planting plan layout should be random and natural.
- Proposed tree density after planting must be at least 5-7/100m². Trees spacing should be no closer than 2.5m on centre and shrubs should be planted 0.75m - 1.5m apart. The shrub to tree ratio should be approximately 5:1.

- Plant material with consideration for the moisture regime, water levels, etc.
- Consider soil bioengineering measures, as appropriate (ie. live staking on steep slopes)

Aquatic (when timing and conditions permit):

- Provide 4 - 6 aquatic species.
- Provide a minimum one species considered as submergent and floating, and one from robust, broadleaved and one from narrowleaved emergent plants.
- Use on-site wetland/wet meadow seedmix, as appropriate.
- Planting cattails is permitted only as interim vegetation in the sediment forebay to aid in sediment trapping (NOTE: it is accepted that this material will be removed with sediment cleanout prior to municipal assumption).

Stocking:

- Provide caliper vegetation (approx 5 to 6 cm) to aid in solar insolation of permanent pool, particularly for downstream coldwater systems - plant within 3m of permanent pool edge.
- Provide caliper material to screen adjacent private lands and facility infrastructure - ensure that spreading and suckering vegetation (ie. sumac, ash, willow) are setback approximately 3m from private property, access roads and sediment drying areas.
- Increase density of vegetation along that portion of the facility adjacent to the valley corridor to create a live fence.
- Use whips or bare-root small caliper stock for future canopy cover where larger stock in not appropriate.
- Plant in nodal groupings or natural configuration. The shrub to tree ratio should be approximately 5:1.
- Shrub material should be approximately 0.3 to 0.6 m in height.
- A calculation of the plant material should be provided on the appropriate landscape plan.
- Plant material should be guaranteed for a minimum of 2 years.

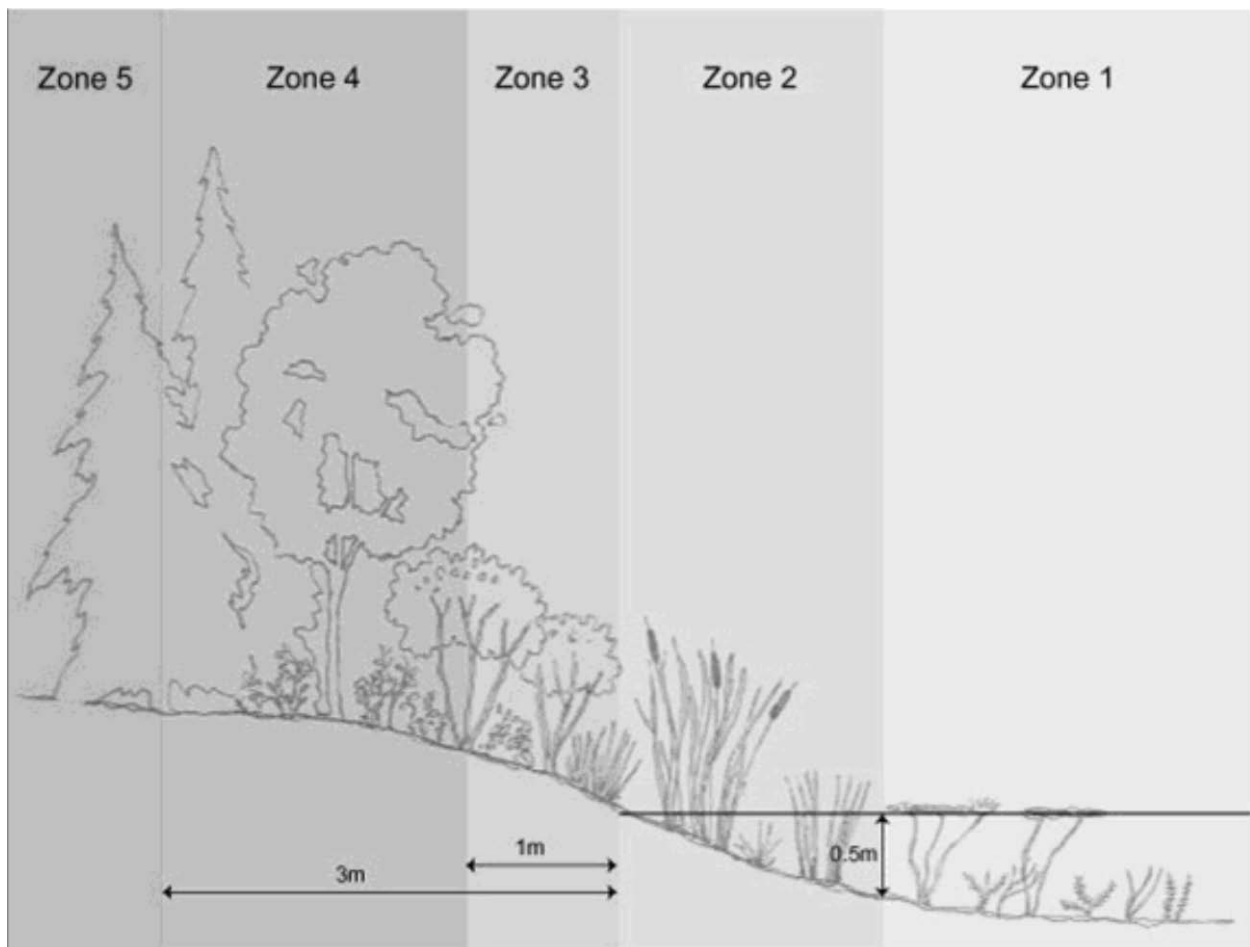
Topsoil Requirements:

- Terrestrial: Provide 0.45 m of topsoil for the first 1m above the permanent water level.
- Aquatic: Provide 0.3m of topsoil for the first 1m below the permanent water level.
- Design engineer and site supervisor should review suitability of subsoil material and compaction with landscape architect.

Plant List - Storm Water Management Ponds

This table is based on the SWM Planning & Design Manual issued by the MOE (2003) and native watershed species listed in the State of the Lake Simcoe Watershed Report (2003). The table of suggested species below is not exhaustive; please refer to appendix E in the MOE manual or the LSEMS report for a more expansive list.

There are five distinct moisture zones found within SWM ponds (see figure below). Plantings that are appropriate for the conditions of each zone should be provided. Please refer to the attached table for acceptable species. Early successional native species of trees, shrubs and herbaceous vegetation that are compatible and complementary to adjacent natural areas should be used. Depth and frequency of inundation, particularly during the growing season, are the primary factors controlling species survival. Water quality may be a secondary consideration.



Moisture Zones within Stormwater Management ponds. (TRCA SWMP planting guidelines, 2007).

Acceptable Floral Species for SWM Pond Planting:

Please note that acceptable native species may vary by Municipality due to Asian Longhorn Beetle, Emerald Ash Borer, etc.

Plant Type	Common Name	Scientific Name	Suitable Moisture Zone	Notes
Tree	Sugar Maple	Acer saccharum ssp. saccharum	5	
	Red Maple	Acer rubrum	3,4,5	
	Silver Maple	Acer saccharinum	3,4,5	
	Bur Oak	Quercus macrocarpa	4,5	
	Red Oak	Quercus rubra	5	
	White Ash	Fraxinus americana	5	
	Green Ash	Fraxinus pennsylvanica	4,5	
	Black Ash	Fraxinus nigra	3,4,5	
	Black Cherry	Prunus serotina	5	
	Balsam Poplar	Populus balsamifera	4,5	
	Trembling Aspen	Populus tremuloides	5	
	Paper Birch	Betula papyrifera	5	
	Bitternut Hickory	Carya cordiformis	5	Mid to upper slopes
	White Spruce	Picea glauca	4,5	
	White Cedar	Thuja occidentalis	3,4,5	
	Tamarack	Larix laricina	4,5	
	Shining Willow	Salix lucida	3,4	
	Black Willow	Salix nigra	3,4	
	Peach-leaved Willow	Salix amygdaloides	3,4,5	
	White Pine	Pinus strobus	5	

Plant Type	Common Name	Scientific Name	Suitable Moisture Zone	Notes
Tree	Red Osier Dogwood	Cornus stolonifera	3,4,5	
	Gray Dogwood	Cornus foemina	4,5	
	Alternate Leaved Dogwood	Cornus alternifolia	5	
	Chokecherry	Prunus virginiana	5	
	Maple-leaved Viburnum	Viburnum acerifolium	3,4,5	
	Nannyberry	Viburnum lentago	4,5	
	Highbush Cranberry	Viburnum trilobum	3,4	
	Serviceberry	Amelanchier spp.	5	
	Bush Honeysuckle	Diervilla lonicera	4,5	
	Black Chokeberry	Aronia melanocarpa	3,4	
	Common Winterberry	Ilex verticillata	3,4	
	Common Elderberry	Sambucus canadensis	3,4,5	
	Pussy Willow	Salix discolor	3,4	
	Sandbar Willow	Salix exigua	3,4	
	Shining Willow	Salix lucida	3,4	
	Peach-leaved Willow	Salix amygdaloides	3,4	
	Slender Willow	Salix petiolaris	3,4	
	Bebb's Willow	Salix bebbiana	3,4	
	Sage leaved/Hoary Willow	Salix candida	3,4	
	Black Willow	Salix nigra	3,4	
	Staghorn Sumac	Rhus typhina	5	
	Elderberry	Sambucus canadensis	3,4	
	Common Ninebark	Physocarpus opulifolius	3,4	
	Speckled Alder	Alnus incana spp. Ranus	3,4	
	Narrow-leaved meadowsweet	Spirea alba	3,4	

Plant Type	Common Name	Scientific Name	Suitable Moisture Zone	Notes
Aquatic – Submergent	Common Waterweed	<i>Elodea canadensis</i>	1	
	Coontail	<i>Ceratophyllum demersum</i>	1	
	Tape Grass	<i>Vallisneria americana</i>	1	
	Northern Water Milfoil	<i>Myriophyllum sibiricum</i>	1	Not to be confused with Invasive Eurasian Milfoil
	Water Starwort	<i>Callitriche hermaphrodita</i>	1	
	Slender/Small Pondweed	<i>Potamogeton pusillus</i>	1	
Aquatic – Floating	White Water Lily	<i>Nymphaea odorata</i>	1	
	Floating Pondweed	<i>Potamogeton natans</i>	1	
	Large-leaved Pondweed	<i>Potamogeton amplifolius</i>	1	
	Yellow Pond Lily	<i>Nuphar variegatum</i>	1	
Aquatic – Robust Emergent	Common Cattail	<i>Typha latifolia</i>	2	
	Bulrush	<i>Scirpus</i> spp.	2	
Aquatic – Broadleaved Emergent	Broadleaved Arrowhead	<i>Sagittaria latifolia</i>	2	
	Common Water Plantain	<i>Alisma plantago-aquatica</i>	2	
Aquatic – Narrowleaved Emergent	Burreed	<i>Sparganium</i> spp.	2	
	Grasses	<i>Leersia</i> spp.	2	
	Sedges	<i>Carex</i> spp.	2	

APPENDIX I

WEIR AND ORIFICE EQUATIONS

The following flow equations are to be used for free flowing hydraulic structures such as weirs, orifices and spillways:

Sharp Crested Weir with End Contractions

$$Q = C (L - 0.2H) (H)^{3/2}$$

Where,

Q = flow rate (m³/s)
H = head on the weir (m)
L = crest length of the weir (m)
C = weir coefficient

Sharp Crested Weir Without End Contractions and Broadcrested Weir

$$Q = (C) (L) (H)^{3/2}$$

Where,

Q = flow rate (m³/s)
H = head on the weir (m)
L = crest length of the weir (m)
C = weir coefficient

Orifice and Orifice Tube

$$Q = (C)(A)\sqrt{2g\Delta h}$$

Where,

Q = flow rate (m³/s)
Δh = differential head measured from the centroid of the orifice (m)
g = acceleration due to gravity (m/s²)
C = coefficient of discharge

Weir and Orifice Coefficients

Application	“C”
Orifice	0.63
Orifice Tube	0.80
Sharp Crested Weir	1.837
Broad Crested Weir (SWMP and Dam Spillway)	1.7
Broad Crested Weir (Road Crossing)	1.5

Orifice Flow for Pond Control – From the MIDUSS Version 2 Reference Manual - Chapter 8 (c) Copyright Alan A. Smith Inc.

The stage discharge equation for the orifice is calculated for two cases which depend on the relative value of the specific energy H relative to the invert of the orifice and the diameter of the orifice D .

In Case 1, $H > D$ and the orifice is fully submerged.

$$[8.60] \quad Q = C_c \frac{\pi}{4} D^2 \sqrt{2g(H - \frac{2}{3}D)}$$

where H = head relative to the invert of the orifice

D = orifice diameter

g = gravitational acceleration

C_c = coefficient of contraction

In Case 2, $H \leq D$ and the orifice acts as a broad-crested weir of circular shape. The critical discharge can be approximated by equation [8.61]

$$[8.61] \quad Q = f\left(\frac{H}{D}\right) C_c \sqrt{g} D^{5/2}$$

where

$$f\left(\frac{H}{D}\right) = 0.494\left(\frac{H}{D}\right)^{1.57} - 0.04\left(\frac{H}{D}\right)^{0.5}$$

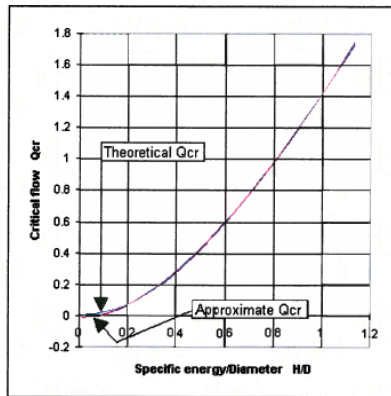


Figure 8.10 - Critical flow through a segment of a circle.

As shown by the comparative plot of Figure 8-10, equation [8.61] is a very reasonable approximation to the critical discharge through a segment of a circle.