Lake Simcoe Region conservation authority

Technical Guidelines for Stormwater Management Submissions

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Executive Summary

This document is intended to provide stormwater management design guidance to municipalities and the development community and their consultants. This document is meant to be read in conjunction with applicable federal, provincial and municipal legislation, policies and guidelines.

The focus is on stormwater management design targets and criteria within the Lake Simcoe Watershed. These targets include guidance on stormwater quantity control, quality control, phosphorus reduction, water balance, volume control, outlets, manufactured treatment devices, erosion and sediment controls, hydrologic and hydraulic modelling and report submission.

This document contains guidance on submissions to Lake Simcoe Region Conservation Authority (the Authority) under the *Planning Act* and *Conservation Authorities Act* and Ontario Regulation 179/06, including pre-consultation and pre-submission consultation requirements.

This document has been formatted to include the requirements and targets within the text of the document and the supporting information, resources and technical references in the appendices.

Introduction

The mission of the Authority is as follows:

We collaborate to protect and restore the Lake Simcoe watershed with innovative research, policy and action.

A key component of this is to ensure development is done in an environmentally friendly and sustainable manner. One of the ways this is achieved is through development review under the *Planning Act*, the *Conservation Authorities Act*, the *Lake Simcoe Protection Act*, the Lake Simcoe Protection Plan and other applicable legislation, policies, and guidelines. Development review can include the need for the following, but not limited to:

- Floodplain Study / Analysis;
- Meanderbelt Width Delineation Analysis (unconfined systems);
- Geotechnical Report (confined systems, slope stability, soils, Low Impact Development measures, seasonally high groundwater measurements, etc.);
- Dynamic Shoreline Study;
- Coastal Engineering Study;
- Hydrogeological Report (in-situ infiltration testing, seasonally high groundwater measurements);
- Feature-Based Water Balance Report;

- Watershed or Sub-watershed Plan and Master Environmental Servicing Plans;
- Stormwater Management Report;
- Water Budget, Hydrological and Hydrogeological Studies;
- Watercourse and/or Valley Wall Stabilization Plans;
- Slope Stability-Erosion Study;
- Erosion Threshold Analysis;
- Environmental Impact Study (ecological EIS);
- Planting or Vegetation Plan, Vegetation Preservation Plans;
- Erosion/Sediment Control Plans;
- Any report or study required by the Authority to provide explanation/analysis of a specific concern; and
- Any report or study required by federal or provincial legislation, guidelines or policies.

Background

Over the years, the Authority's Technical Guidelines for Stormwater Management Submissions have evolved as the science leading best management practices improved.

In 2016, the Authority's Technical Guidelines for Stormwater Management Submissions underwent significant revisions following comprehensive industry and municipal partner consultation. After careful consideration, Authority staff recommended moving toward a more sustainable approach to manage stormwater and convened a Stormwater Management Policy Working Group in February of 2014. This group consisted of Authority staff, upper and lower tier municipalities, the Ministry of the Environment, now the Ministry of Environment, Conservation and Parks, the Building Industry and Land Development Association, various academic experts, engineering consultants and adjacent conservation authority staff. The group was assisted by staff from the environmental consulting firm Emmons & Olivier Resources, who in partnership with Tom Schueler and the Centre for Water Protection, developed the Minnesota Stormwater Manual, which is considered one of the best and most progressive documents in the United States (U.S.).

The focus of the recommended approach was not on conveying runoff, but on reducing and controlling runoff volume and mimicking natural hydrology treatment methods including capture and reuse using a variety of stormwater management treatment methods.

The Authority's 2016 Technical Guidelines for Stormwater Management Submissions were the culmination of the above noted efforts.

Since 2016, the Authority has implemented additional policies such as phosphorus, water balance and ecological offsetting. Additionally, information around stormwater management has continued to evolve. This document aims to update, clarify, and align with current policies and guidelines.

Additionally, this document aims to incorporate industry feedback from municipalities, the Building Industry and Land Development Association, and engineering consultants.

Purpose

The purpose of this document is to provide guidance to municipalities, the development community and their consultants regarding the stormwater management and erosion / sediment control requirements of the Authority in accordance with the Lake Simcoe Protection Plan and Provincial Policy Statement. It is not intended to be a comprehensive stormwater management planning and design manual like the Stormwater Management manual published by the Ministry of the Environment (M.O.E., 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 stormwater mangement submissions to the Authority. It should result in the following benefits:

- Enhanced protection of the natural environment and improved infrastructure resiliency to climate change;
- Designs that better reflect natural hydrology;
- Application of uniform and consistent stormwater management standards;
- Reduced need for re-submissions due to inadequate information; and
- Streamlined review process and improved client service.

Scope

This document focuses on guidelines and stormwater management criteria for use within the Lake Simcoe watershed. This document is not intended to replace documents prepared by the federal or provincial governments or municipalities. Documents referenced within these guidelines should be referred to directly.

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Appendices

Issues and Revisions Registry

Identification	Date	Description of issued and/or revision
Draft Report	April 26th, 2013	Updated to include reference to Ministry of the Environment Phosphorous Budget Tool; Updated Particle Size Distribution for Oil Grit Separator Sizing Updated Intensity Duration Frequency (IDF) Curve Guidance; Approved by Board of Directors
Draft Report	June 24, 2016	Added volume control requirements; Updated Erosion and Sediment Control; Updated Phosphorous Requirements; Approved by Board of Directors
Report to the Board of Directors Draft	April 22, 2022	Updates include references to Authority Offsetting Policies, housekeeping items, updates per discussions with the Building Industry and Land Development Associaton; to be reviewed by the Board of Directors for approval

Nomenclature

1D – One Dimensional

2D – Two Dimensional

3D – Three Dimensional

C.E.T. – Certified Engineering Technologist

Cm – Centimetre

CN – Curve Number

CN* – Modified Curve Number

G.I.S. – Geographic Information System

H.a. – Hectare

HEC2 – U.S. Army Corps of Engineering Hydraulic Modelling Software

HEC-RAS – U.S. Army Corps of Engineering Hydraulic Modelling Software

HYMO – Hydrologic Modelling Software

Ia – initial Abstraction

ICD – Inlet Control Device

ID – Identification

M – Metres

m^2 – Square Metres

m^3 – Cubic Metres

m^3/h.a. – Cubic Metres per Hectare

mm/hr – Millimeter per hour

Mm – Millimetre

O.Reg. – Ontario Regulation

P.Eng. – Professional Engineer

P.Geo. – Professional Geoscientist

SCS – United States Natural Resource Conservation Service formerly Soil Conservation Service

S.O. – Statues of Ontario

Tc – Time of Concentration

T.I.M.P. – Total Impervious Area

TP – Time to Peak

TSS – Total Suspended Solids

VO – Visual OTTHYMO Software Suite i.e., VO2, VO3, VO5, VO6 etc.

1.0 Environmental Planning and Stormwater Management

1.1. Stormwater Management Planning and Design Manual, March 2003 Ministry of the Enviornment

The Ministry of the Environment (M.O.E.) Stormwater Management (SWM) Planning and Design 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 SWM Report. Urban development should be done in relationship with the environmental planning process. The SWM plan for urban development 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 i.e.,where little future development is planned, the M.O.E. SWM manual provides some guidance on the environmental design criteria.

1.2. Provincial Policy Statement and Lake Simcoe Protection Plan

The Provincial Policy Statement (PPS) (Policy 1.6.6.7) and Lake Simcoe Protection Plan (LSPP) identifies SWM policies for development. These policies must be read in conjunction with local municipal standards and / or watershed / sub-watershed studies in respect of stormwater quantity and quality control.

1.3. General Authority Guidance

The Authorities requirements for all SWM submissions are outlined in the following sections, which include a description of the Authority SWM criteria, guidance on approved methods and techniques, a summary of key hydrologic parameters, modelling and mapping requirements and a summary of submission requirements. For more information on modelling and mapping standards, refer to the 2002 Ministry of Natural Resources (MNR) document entitled Technical Guide, River and Stream Systems: Flooding Hazard Limit and the March 2017 Technical Guidelines for Flood Hazard Mapping (Environmental Water Resources Group Ltd., 2017) or latest version as may be amended from time to time.

1.4. Climate Change

An additional consideration during the environmental planning process is climate change. The Ontario Climate Change Strategy (OCCS, 2015) defines climate change “as any significant change in long-term weather patterns. It can apply to any major variation in temperature, wind patterns or precipitation that occurs over time.” The OCCS states that extreme weather events such as storms and droughts are becoming more frequent around the world.

The OCCS further elaborates that in July 2013, a monumental rainstorm dropped 125 mm of rain in just a few hours over some parts of Ontario, leading to flooding and property damage estimated at $940 million in Toronto alone and states that climate change requires a shift in thinking and behaviour. The OCCS identifies vulnerabilities caused by changing weather patterns in areas such as public safety and emergency response, roads and other infrastructure, buildings and homes that need to be considered. These vulnerabilities should be considered during the environmental planning and SWM design processes. Refer to Section 7.0 for additional information on climate change.

2.0 Submissions to the Authority

Submissions to the Authority are generally made under the *Planning Act* for planning approvals or the *Conservation Authorities Act* and Ontario Regulation 179/06 for permits. Other forms of submissions may include technical reviews and Ministry of the Environment, Conservation and Parks (MECP) Environmental Compliance Approvals (ECAs). Please refer to the Authority website for a list of fees associated with various types of applications.

2.1. *Planning Act* Applications

Municipalities act as approval authorities under the *Planning Act* and are responsible for the planning process including pre-consultation under the Planning Act. The Authority's role in the planning process is that of a commenting agency as outlined in the Memoranda of Understanding that we have in place with each of our member municipalities.

2.1.1 *Planning Act* Pre-Consultation / Authority Pre-Submission Consultation

Requirements for pre-consultation on planning applications are provided by the *Planning Act* (ss.22(3.1), 34(10.01.1), 43(3.1) and 51(16.1). The pre-consultation process per the *Planning Act* is led by the municipality.

The Authority recognizes that pre-submission consultation is a critical value-added service and requires a technical pre-submission consultation / meeting, independent of the municipal pre-consultation, for all applications for Plan of Subdivision as well as applications for Site Plan Approval where the site is greater than two hectares. The purpose of this consultation is:

- To understand the general parameters of the proposed project and to confirm the SWM design requirements specific to the proposed land use;
- To discuss erosion and sediment control (ESC) implementation, inspection, and maintenance including during, and post construction, monitoring;
- To discuss any site-specific details in relation to sensitive environmental areas, surface and / or groundwater protection areas (Example: Significant Groundwater Recharge Areas) should also be discussed and confirmed during this meeting;
- To ensure the seasonal high groundwater levels and in-situ infiltration rates are obtained early in the planning and design process where infiltration based designs and facilities are being considered.

The Authority requires that a summary memorandum be circulated by the consultant following the pre-consultation meeting for all parties to review and comment on before finalizing. This summary memorandum will form the terms of reference for the project.

The SWM pre-consultation / pre-submission meeting should generally occur after the developable area on the property has been determined as it relates to natural heritage and natural hazard lands. Preliminary studies related to soils (i.e., to implement Land Use Policy (LUP-12) of the South Georgian Bay Lake Simcoe (SGBLS) Source Protection Plan (SPP), Wellhead Protection Area-Quantity2 (WHPA- Q2), etc.), natural heritage, and natural hazards, may be required to ascertain the developable area.

2.1.2 Design Charrette

The Authority encourages stormwater design charrettes as part of a pro-active review and approval process. Applicants who are preparing submissions for large sites are invited to engage Authority staff, as well as municipal staff, in a design charrette. Information requirements to support a comprehensive charrette can be found in Appendix A.

2.1.3 Data Collection

Effective planning and acquisition of site-specific data can assist in streamlining the submission/review process.

Seasonally high groundwater levels and in-situ infiltration rates obtained early in the planning/design process are required where infiltration-based designs and facilities are being considered. This information informs the placement of SWM facilities to maximize their benefits. This information may also reduce development costs and timelines by locating the facilities in an appropriate location early in the design process.

2.1.4 Initial Submission Checklists

The Authority requires that engineering and hydrogeological checklists be submitted with the initial applications for draft plan approval and detailed design. Please refer to Appendix A for copies of these checklists. Please note that these checklists may be updated from time to time.

2.1.5 Re-submission Comment Response

The Authority provides technical review comments to applicants in the form of a comment matrix. To facilitate a streamlined review process, the Authority requires the Applicant to provide a detailed response to the comments within the provided matrix which will form part of any re-submission package. The response comments should include any information directing Authority staff to any updated technical information such as report section, page and appendix.

2.1.6 Stormwater Management Report Submission

After the pre-submission consultation meeting has been held in accordance with Section 2.1.1 of this Guideline, 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 (i.e., P.Eng., P.Geo., or C.E.T.) must be able to recognize and understand all the methods, approaches, basic data, and rationale used in the design calculations.

Except for proprietary models, equations are required for all calculations provided. All model input and output files are to be provided within the report and in digital format via a submission link provided to the Authority or on a Compact Disc / Digital Video Disc or digital storage device that has been labelled and dated. All rainfall files are also to be provided in digital format with the submission. 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 a SWM Report outlining all the proposed works must be circulated to the Authority. Final engineering plans and drawings must be signed and sealed by a Professional Engineer registered with Professional Engineers Ontario, specializing in SWM. A detailed description of the SWM facility is required. This will likely be a combination of a SWM report, design calculations and engineering drawings.

A complete SWM Report will also include, at a minimum, all items listed Appendix A. The Authority reserves the right to return the submission if it is incomplete.

2.1.7 Functional Servicing and Detailed Design Reports

Functional approvals under the *Planning Act* include Official Plan Amendments, Zoning By-law Amendments, Draft Plan of Subdivision, Minor Variance and Consents. Submissions in support of these functional approvals shall demonstrate the following:

- Sufficient details to demonstrate that proposed SWM / Low Impact Development (L.I.D.) facilities size and configuration are suitable and can achieve applicable SWM targets.
- The direction of drainage and the drainage constraints identified in the watershed / subwatershed plan are to be considered, (i.e., sufficient outlet, target levels for peak flows, baseflow, infiltration, water quality parameters and water quality levels of protection).
- Wholistic coordination of water balance, erosion studies, SWM targets and L.I.D. design.
- Where SWM facilities are proposed to be infiltration-based, infiltration rates and seasonally high groundwater elevations should be based on collected in-situ testing data and not assumed.
- A complete digital submission of the functional servicing and SWM report is to be submitted to the Authority.

Detailed design approvals under the *Planning Act* include Site Plan Approval and Final Approval of Subdivisions. Submissions in support of these detailed design approvals shall demonstrate the following:

- Final details to demonstrate that proposed SWM / L.I.D. facilities are sized and configured in accordance with applicable legislation and guidelines achieve applicable SWM targets.
- The direction of drainage and the drainage constraints identified in the watershed / subwatershed plan are to be confirmed, (i.e., sufficient outlet, target levels for peak flows, baseflow, infiltration, water quality parameters and water quality levels of protection).
- Wholistic coordination of water balance, erosion studies, SWM targets and L.I.D. design.
- Where SWM facilities are proposed to be infiltration-based, in-situ infiltration rates and seasonally high groundwater elevations are to be used.
- Modelling work and other details are to be updated according to the revised design information available. The detailed SWM report should have sufficient details to complete detailed servicing and grading drawings.
- Detailed ESC plans.
- A complete digital submission of the detailed SWM report, including detailed drainage, grading and servicing drawings is to be submitted to the Authority.
- Please refer to Appendix A for a list of requirements for a detailed stormwater.

Please note that SWM is only one component and other disciplines such as natural heritage, hydrogeology and planning will also need to be addressed as part of the approval process under the Planning Act.

2.1.8 Offsetting Policies

The Authority has the following offsetting policies relating to the loss of natural heritage features, groundwater recharge deficit and post development phosphorus loads:

- Ecological Offsetting Policy
- Water Balance Recharge Policy for the Lake Simcoe Protection Plan
- Phosphorus Offsetting Policy

Any discussion concerning the intent to apply any of these policies should be had with Authority staff during pre-consultation.

2.2. Permit Applications under the Conservartion Authorities Act

This section of the document is intended to provide a general overview of the permit process.

This document is intended to be read in conjunction with the Lake Simcoe Region Conservation Authority Ontario Regulation 179/06 Implementation Guidelines, 2021 (Formerly Watershed Development Guidelines).

Chapter 2: Legislative Framework, found in the Lake Simcoe Region Conservation Authority Implementation Guidelines outlines the history, objectives, powers, regulation limits, and activities which require written permission under Ontario Regulation 179/06. Please refer to the Implementation Guidelines for details.

In summary, if development is proposed within an area regulated by the Lake Simcoe Region Conservation Authority, then permission is required under the *Conservation Authorities Act* and Ontario Regulation 179/06. This permission usually comes in the form of a permit from the Authority.

To obtain a permit, a complete permit application is required. Full permit requirements are provided through pre-consultation in accordance with the Authority's customer service strategy.

The permit application needs to demonstrate that the works are in accordance with applicable legislation as noted above along with policies and guidelines (as may be amended from time to time), including but not limited to:

- Lake Simcoe Region Conservation Authority Ontario Regulation 179/06 Implementation Guidelines
- Lake Simcoe Conservation Authority Technical Guidelines for Stormwater Management Submissions

As noted in Section 2.4 of the Implementation Guidelines, the Authority encourages a Planning First Philosophy to address environmental matters under the *Planning Act* and/or be approved under the *Environmental Assessment Act/Class Environmental Act* process in advance of submitting an application for approval under Ontario Regulation 179/06 under the *Conservation Authorities Act*.

Please note that a permit from the Authority under Ontario Regulation 179/06 under the *Conservation Authorities Act* is separate from a *Planning Act* Approval. Approval under the *Planning Act* does not constitute approval under the *Conservation Authorities Act* under Ontario Regulation 179/06 and vice-vera.

Please note that it is the applicant's responsibility to obtain all other necessary approvals including those required in accordance with other municipal, provincial, and federal legislation.

2.3. Environmental Compliance Approval (ECA) Submission under the Transfer of Review (ToR) Program

Under the Transfer of Review (ToR) program a designated municipal authority reviews the ECA application and supporting documentation on behalf of the MECP. The municipal authority then submits the application to the ministry with its recommendation for approval or its comments explaining why it is not recommending approval.

The types of works covered by the Transfer of Review program depend on individual agreements between the ministry and the designated municipal authority. However, for the Authority, these transfer of reviews generally include SWM facilities, and, in some cases storm sewers.

Please contact the Authority to confirm current agreements for the review of ECA applications under the transfer of Review program for specific municipalities.

Prior to submitting the ECA application, it is recommended that the Design Engineer pre-consult with the Authority engineering staff about the details of the submission

2.4. Submissions for Floodplain and Spills Analysis and Cut and Fill Balance

Every effort shall be made to avoid fill placement within the floodplain regulated under Ontario Regulation 179/06. Where this is not possible, fill placement shall be minimized and are subject to review and approval from the Authority. Please note that there may be other restrictions and requirements related to natural heritage, hydrogeology, regulations, or other policies specific to the application that may need to be considered.

A cut and fill analysis in accordance with the Authority Ontario Regulation 179/06 Implementation Guidelines is required to the satisfaction of the Authority for any grading activity within the floodplain (including but not limited to trails, watercourse crossings, bank restoration, and channel realignment). The analysis must include the following:

- A summary table showing the volume of cut and fill at every 0.3 m increment (up to and including the Regulatory flood elevation)
- A plan view drawing clearly delineating the proposed cut / fill area(s)
- A detailed grading plan with associated cross-section(s) locations shown
- A profile view of the cross-section(s) showing the Regulatory flood elevation and cut / fill area(s)
- A supporting geotechnical and slope stability report for the proposed cut / fill works may be required in some instances.

The submission needs to include an updated hydraulic analysis that demonstrates the proposed cut and fill has no negative impacts to flooding (water surface elevations), erosion (channel and overbank velocities), and conveyance of spills (if applicable - see Section 5.3.16 of the Authority Ontario Regulation 179/06 Implementation Guidelines) at the site including both upstream and downstream sections. Refer to Appendix I for further details of the hydraulic modelling and submission requirements.

3.0 Stormwater Management

SWM is required to mitigate the effects of urbanization on the hydrologic cycle including increased runoff and decreased infiltration, of rain and snowmelt. Without proper SWM, reduced base flow, degradation of water quality, and increased flooding and erosion can lead to reduced diversity of aquatic life, fewer opportunities for human uses of water resources and loss of property and human life. (M.O.E. 2003).

In developing an effective SWM approach for any project, Better Site Design Techniques are to be used (Minnesota Stormwater Manual, Minnesota Pollution Control Agency, 2016). Better Site Design involves techniques applied early in the planning and design process to preserve natural areas, reduce impervious cover, distribute runoff and use pervious areas to more effectively treat stormwater runoff. A major difference between the traditional development process and the Better Site Design process is that the site is designed using L.I.D. Better Site Design focuses on utilizing and treating rainfall as soon as it hits the ground.

The focus is not on conveying runoff, but on reducing and controlling runoff volume and mimicking natural hydrology treatment methods including, capture and re-use, using a wide variety of SWM and treatment methods. Better Site Design practices should address the following considerations:

Open space protection and restoration

- Conservation of existing natural areas (upland and wetland)
- Reforestation
- Restoration of wetlands
- Establishment of protection of stream, shoreline and wetland buffers
- Re-establishment of native vegetation into the landscape

Reduction of impervious cover

- Reduce impervious cover through redevelopment of existing sites and use of existing roadways, trails, etc.
- Minimize street width, parking space size, driveway length, sidewalk width
- Reduce impervious surface footprint
- Increase use of permeable pavers or permeable pavement

Distribution and minimization of runoff

- Utilize vegetated areas for stormwater treatment (i.e., parking lot islands, vegetated areas along property boundaries, front and rear yards, site landscaping)
- Direct impervious surface runoff to vegetated areas or to designated treatment areas
- Encourage infiltration and soil storage of runoff through grass channels, soil compost amendment, increased topsoil depths, vegetated swales, raingardens, etc.

Runoff utilization

- Capture and store runoff for use for irrigation in areas where irrigation is necessary.

Erosion and sediment control

- Perform site alteration in such a manner that release of sediment into receiving waters is kept to an absolute minimum with a goal of no sediment migration offsite. In certain circumstances, this may require that the release in sediment be controlled such that natural background rates/loads are not exceeded.
- Follow an "at source" approach to sediment and erosion control system design to avoid over reliance on downstream controls.
- Maintain and increase buffer areas.
- Stage installation of controls in such a manner to recognize the rough grading, servicing and house building phases of construction.
- Minimize extent and duration of disturbed areas.
- Utilize a multi-barrier approach.
- Additional information on ESC can be found in Section 5.0 and Appendix G.

3.1. Stormwater Management Technical Requirements and Criteria

The SWM criteria and requirements for SWM submissions within the Authority watershed are listed in Table 1 and discussed in the following sections.

Table 1 – Stormwater Management Criteria and their location within these guidelines.

SWM Criteria	Subcomponent	Section
Water Quantity	Peak Flow Control	3.2.1
Water Quantity	Volume Control	3.2.4
Water Quantity	Major-Minor System Conveyance	3.2.2
Water Quantity	External Drainage Conveyance	3.2.3
Water Quality	Suspended Solids	3.3.1
Water Quality	Phosphorous and Phosphorus Offsetting Policy (P.O.P.)	3.3.2
Water Quality	Winter Salt	3.3.3
Water Quality	Temperature	3.3.4
Water Quality	Other Contaminants	3.3.5
Stream Erosion	Stream Erosion	3.4
Water Balance/Groundwater Recharge/WBRP	Water Balance/Groundwater Recharge/WBRP	4.0
Erosion and Sedment Control	Soil Erosion	5.1
Erosion and Sediment Control	Erosion Control Requirments	5.2

In addition to the above criteria, all SWM submissions should be consistent with the most current version of the following documents, tools and websites:

- Applicable watershed / subwatershed study or SWM master plan;
- Approved SWM report;
- Stormwater Management Planning and Design Manual, March 2003, M.O.E.
- Lake Simcoe Protection Plan, 2009;
- Lake Simcoe Region Conservation Authority Guidelines for the Implementation of Ontario Regulation 179/06;
- Low Impact Development Stormwater Management Planning and Design Guide, 2010, Credit Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA);
- Sustainable Technologies Wiki Guide
- Erosion and Sediment Control Guide for Urban Construction, TRCA 2019;
- Canadian Standards Association (CSA) Standards W202-18 and W208-20
- MECP Lake Simcoe Phosphorus Budget Tool, March 2012

- Sustainable Technologies Evaluation Program (STEP) L.I.D. Treatment Train Tool (TTT) - For Phosphorus Removal Only.
- South Georgian Bay Lake Simcoe Source Protection Plan, July 1, 2015.
- Parking Lot Design Guidelines to Promote Salt Reduction, Lake Simcoe Region Conservation Authority, February 22, 2017.
- Environmental Technology Verifications, (ETV) Canada, ETVCanada.ca.
- All applicable future provincial and municipal documents.

One tool only must be selected and used (MECP Lake Simcoe Phosphorous Tool or STEP L.I.D. TTT) for phosphorus calculations. No mixing of the phosphorus tools, loading rates, or removal rates will be permitted.

In all cases, the SWM approach for any given site should consider catchment and receiver characteristics. SWM requirements must be addressed through 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
- Reduced % grade of lot
- Disconnecting roof leaders and directing the flow to soak away pits
- Porous pavement
- Rain gardens
- Water reuse systems

Conveyance Controls

- Grassed swales
- Pervious pipe systems
- Pervious catch-basins
- Bio swales
- Filtration systems
- Infiltration systems
- Capture and management systems with L.I.D.
- Filter strips
- Buffer strips

End-of-pipe (EOP) Stormwater Management

- Infiltration and biofiltration basins
- Infiltration trenches
- Manufactured Treatment Devices (i.e., oil/grit separators or filters)
- Sand filters
- Dry ponds
- Wet ponds
- Wetlands
- Hybrid Ponds
- Filtration Devices
- Adsorptive Materials
- Underground Storage

3.2. Stormwater Quantity Control

3.2.1 Quantity Control / Peak Flow Control

Typically, the increase in direct runoff as a result of uncontrolled development (i.e., increased impervious areas) combined with rapid storm conveyance systems, results in increased peak stream flows. The potential impacts of increased peak flows include flooding and increased risks to life and property.

In order to minimize these risks, the SWM Quantity Control requirements for major development and linear development projects are as follows:

- The post-development peak flow rates are not to 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 (unless specified otherwise by a subwatershed study or fluvial geomorphic analysis).
- In general, the following design storms are to be used for modelling sites with drainage areas greater than 5 hectares, (in addition to Municipal requirements):
    - 4-hour Chicago distribution; and
    - 12-hour SCS Type II distribution.

(Refer to Appendix C which clarifies the minimum requirements for storm distributions)

- Every effort must be made to maintain existing watershed boundaries and drainage patterns. As a rule, significant changes in drainage boundaries are not permitted. Pre-consultation is mandatory for any proposed change in drainage boundaries;
- If there is a known deficiency or significant erosion in the downstream conveyance system, additional peak flow or volume control may be required;

- Quantity control is not required if the site drains directly to Lake Simcoe (i.e. no separate property parcel between the subject site and the lake) with a sufficient outlet;
- Infiltration measures may be considered for peak flow control credits, subject to the conditions as described in Appendix B. Pre-consultation with the MECP, local municipality and the Authority is required; and
- If a site is not accounted for within a downstream SWM facility than quantity control will be required as per this section. Additionally, this may require over-control such as controlling the flows to a minimum of: the 2-year pre-development flow rate OR the specified municipal allowable flow rate OR an approved governing master drainage studies / documents.

3.2.2 Major Minor System Conveyance and Sufficient Outlet(s)

The major system may include overland flow routes, roadways, artificial channels, streams, and valleys. The major and minor systems are to be designed to safely convey stormwater flows to a sufficient outlet, without negative impacts on adjacent properties.

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 (typically 1 in 5-year design storm) while the major system conveys the runoff from infrequent storm events (typically 1 in 100-year design storm) that exceed the minor system capacity.

The minor system includes the lot drainage components i.e., lot grades, ditches, swales, street gutters, catch basins and the storm sewer system.

A hydraulic gradeline analysis may be required under certain circumstances and is to be completed as per municipal requirements.

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 into a municipal drainage system, approval may be required from that specific municipality. Municipal standards would apply to all such discharges.

All minor system, and major overland flow routes are to be secured by an appropriate easement or approval as per municipal requirements.

Where there is no sufficient outlet, or, if no agreements are anticipated for drainage through downstream privately owned lands, then the following will be required for the subject development in addition to the SWM criteria in Section 3.2.1 of these guidelines:

- Provide post to pre-volume control (2-100 Year)
- Maintain existing drainage patterns/regime (e.g., maintain sheet flow via spreader etc. vs single discharge point)
- Town supports the proposed outlets(s) and it is understood that the receiving landowner could potentially block flows.
- Where possible, secondary outlet option(s) should be considered and, where appropriate, a contingency

3.2.3 External Drainage Conveyance

Where there is an external drainage area flowing through a site, it is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm, through the development site to a sufficient outlet.

3.2.4 Volume Control Requirements

Any works that meet the major development definition outlined in the Lake Simcoe Protection Plan should demonstrate how volume control will be provided for the development.

Any new development or redevelopment that results in site disturbance that creates 0.5 hectare or more of new impervious surface, or, fully reconstructs 0.5 hectare or more of impervious surface, should demonstrate how volume control will be provided for the development.

Volume control requirements for types of developments are provided as outlined below:

New development volume control requirement

New, nonlinear developments, on sites without restrictions, shall capture and retain / treat on site, the post-construction direct runoff volume from 25 mm of rainfall from all impervious surfaces.

Redevelopment volume control requirement

Nonlinear redevelopments, on sites without restrictions, shall capture and retain / treat on site, the post-construction direct runoff volume from 25 mm of rainfall from the new and/or fully reconstructed impervious surfaces.

Linear development volume control requirement

Linear development on sites without restrictions that create 0.5 or more hectares of new and/or fully reconstructed impervious surfaces, shall capture and retain / treat on site, the larger of the following:

- The direct runoff volume from 12.5 mm of rainfall from the fully reconstructed impervious surface and newly constructed impervious area.

- The direct runoff volume from 25 mm of rainfall from the net increase in impervious area on the site.

If a proposed road is within a subdivision (i.e., future or proposed subdivision on at least one side of the road), it would be classified as being part of a major development such that the non-linear criteria would apply. If it is a road that connects between two major developments (i.e. no proposed lots on either side of the road), the linear development criteria would apply.

Please see Appendix L for an example calculation to determine the runoff volume.

If full compliance is not possible due to any of the factors listed at the end of Section 3.2.6, the site would be considered a “site with restrictions” and as such, the Flexible Treatment Alternatives referred to in Section 3.2.6 will apply.

The site-specific recommendations of hydrogeological and geotechnical reports and environmental impact studies need to be considered as part of any design and may override the requirements listed in this section.

3.2.5 Stormwater Volume Control Techniques

To enhance protection of the natural environment, better reflect natural hydrology, improve infrastructure resiliency to climate change, and as part of the Better Site Design techniques discussed in Sections 3.0, volume reduction techniques are to be contemplated and implemented based on the hierarchy of criteria below:

- Primary preference shall be given to L.I.D. features / Best Management Practices (BMPs) that promote infiltration;
- Secondary preference is to implement L.I.D. features / BMPs that use filtration techniques.

Please note that volume control is not only achieved through infiltration. Volume control may also be achieved through filtration when infiltration is not feasible due to site constraints such as high groundwater levels or low infiltration rates. In addition, a combination of infiltration and filtration measures may also be utilized. Please refer to Appendix D for additional L.I.D. design guidance.

Additional volume reduction techniques to consider may also include rainwater reuse / harvesting, canopy interception, evapotranspiration, rate control BMPs, and blue / green roofs.

Please note for the additional volume reduction techniques, supporting calculations, documentation, and studies may be required to support all assumptions. If these additional volume reduction techniques are proposed as part of a design, pre-consultation with the Authority is encouraged.

3.2.6 Flexible Treatment Alternative for Sites with Restrictions

The Proponent shall fully attempt to comply with the appropriate requirements described above. Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site. If full compliance is not possible due to any of the factors listed at the end of this section, the proponent must document the reason. If site constraints or restrictions limit the full treatment requirement, the following flexible treatment alternatives shall be used as described below.

Alternative #1:

- Retain runoff from a 12.5 mm event from all impervious surfaces if the site is new development or from the new and/or fully reconstructed impervious surfaces for a redevelopment or linear development site.
- Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site.

Alternative #2:

- Achieve volume reduction to the maximum extent practicable (minimum 5 mm from all impervious surfaces).
- Options considered and presented shall examine the merits of relocating project elements to address varying soil conditions and other constraints across the site.

Alternative #3:

- Mitigation equivalent to the performance of 25 mm of volume reduction for new development, redevelopment or linear development as described above in this section can be performed off-site to protect the receiving water body. Off-site treatment shall be achieved in areas selected in the following order of preference.
  1. Locations immediately upstream or downstream of the proposed construction activity on same tributary.
  2. Locations that yield benefits to the same tributary that receives runoff from the original construction activity.
  3. Locations within the same Authority catchment area as the original construction activity.

The Proponent shall document the flexible treatment alternatives sequence starting with Alternative #1. If Alternative #1 cannot be met, then Alternative #2 shall be analyzed. Proponents must document the specific reasons why Alternative #1 cannot be met based on the factors listed below. If Alternative #2 cannot be met, then Alternative #3 shall be met. Proponents must document the specific reasons why Alternative #2 cannot be met.

Factors to be considered for each alternative will include:

- Karst geology;
- Shallow bedrock;
- High groundwater;
- Hotspots or contaminated soils;
- Areas with high chloride concentrations;
- Significant Groundwater Recharge Area and WHPA or Intake Protection Zones or within 15 metres of a drilled drinking water well (within 30 metres of a dug well);
- Zoning, setbacks or other land use requirements;
- Property or infrastructure restrictions;
- Excessive cost;
- Poor soils (infiltration rates that are too low or too high, problematic urban soils, such as soils that are highly compacted or altered); and
- Highly vulnerable aquifer.

3.3. Stormwater Quality Control

Contaminants, such as oil, grease, metals, pesticides, fertilizers, winter salt and sediment tend to build up on surfaces in urbanized areas. These contaminants come from sources such as pavement deterioration, tire and brake pad wear, vehicle emissions, spills, construction and road maintenance. They may also come from yard and garden care. Stormwater runoff picks up these contaminants and can transfer them to streams or groundwater. Degradation of water quality can result in a decline in plant and animal diversity. It may also affect drinking water supplies and recreational uses of water such as swimming (M.O.E.,2013).

In order to protect water quality, the following sections outline the SWM Quality Control requirements for major and linear development projects.

3.3.1 Suspended Solids

The required suspended solids removal treatment is MECP Enhanced Protection Level (Level 1) This corresponds to a long-term average removal of 80% of suspended solids.

The M.O.E. SWM Manual (Table 3.2) provides water quality storage volume requirements for types of SWM practices. Refer to the M.O.E. Table 3.2 footnote with respect to SWM practices not listed.

3.3.2 Phosphorous and Phosphorus Offsetting Policy

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.

An application for major development shall be accompanied by a SWM plan that demonstrates through an evaluation of anticipated changes in phosphorus loadings, between pre-development and post-development, how the loadings from the proposed development shall be minimized (Refer to the Lake Simcoe Protection Plan, 2009).

In addition to the above requirement from the Lake Simcoe Protection Plan, a target onsite removal of 80% of the annual Total Phosphorus (TP) load from all major development areas should be achieved.

Furthermore, in addition to the above noted requirements, the removal of 100% (zero export target) of the annual TP load from all new or redevelopment as per the Phosphorus Offsetting Policy (P.O.P.) is required. To determine applicability of the P.O.P., the policy should be consulted in conjunction with authority pre-submission consultation.

Phosphorus loading/removal calculations can be completed by the following methods:

- M.O.E. Lake Simcoe Phosphorus Budget Tool, January 2012 (or subsequent versions)
- Low Impact Development Treatment Train Tool - L.I.D. T.T.T. v1.2.1 (or subsequent versions)

Notes:

1. The L.I.D. TTT is currently only supported for Phosphorus loading and removal (i.e., not for water balance, water quality or quantity control).
2. Please note for the L.I.D. TTT, the model must be run on an annual precipitation basis, not the 25 mm storm event or any other discreet storm event basis.
3. Removal rates in the L.I.D. TTT shall not be changed from the default values. If changes are proposed, please see note 9.
4. For any BMP applied in the M.O.E. Tool or The L.I.D. TTT, the BMP shall be designed in accordance with applicable guidance documents such as the STEP WIKI Guide to justify the applied phosphorus removal credit.
5. Phosphorus removal credit will not be provided for pre-existing features such as natural heritage buffers or wetlands.
6. The M.O.E. Lake Simcoe Phosphorus Budget Tool is mass-based while the L.I.D. TTT is Event Mean Concentration (EMC) based.
7. One tool only must be selected and used for phosphorus calculations. No mixing of the phosphorus loading tools, loading rates, or removal rates will be permitted.
8. Loading and percentage removal efficiency are to comply with the applicable tool and documentation unless otherwise specified in Appendix E.
9. If different or new percentage removal efficiencies are proposed for BMP’s or other stormwater quality control devices, these rates must be based on the results of third-party field studies, acceptable to the Authority.

10. In cases where studies provide maximum, median and minimum removal values, the median values shall be used, subject to the Authority approval.
11. Other phosphorus calculation methods may be considered for use, subject to the approval of the Authority. Authority staff should be contacted prior to commencement of a phosphorus loading study for a specific site if alternate calculation methods are proposed to be used.

3.3.3 Winter Salt

Winter salt is detrimental to freshwater aquatic species, in particular, Redside Dace (Clinostomus elongatus) which have endangered species status under the Ontario Endangered Species Act, 2007. The South Georgina Bay Lake Simcoe Source Protection Plan (January 26, 2015) has also identified road salt as a prescribed drinking water threat.

Winter salt dissolves in water and enters natural water systems via infiltration to groundwater, runoff to surface water and through storm drains. The salt remains in solution and there are currently no viable options for removal from stormwater.

Recent studies conducted within the Authority watershed have shown that, due to winter salting practices, SWM wet ponds can become stratified and the coolest water that is released from the bottom also has the highest salt concentration. Therefore, in order to minimize potential salt concentrations and provide some thermal mitigation, the Authority requires the use of submerged outlets which are to be located approximately at the midpoint of the permanent pool depth, and a minimum of 0.6m from the bottom of the facility, and 1.0m below the surface of the permanent pool. A multiple outflow configuration that blends flow from the top and bottom of the permanent pool between the depths noted above is preferred.

Note: The outlet configuration is also subject to other agency approvals.

In general, the design of roads and parking lots is to be done in such a manner that the need for excess salt use is minimized. This can be facilitated through the development of a salt management plan. A partial list of design practices includes proper location of snow storage, use of deciduous plants to reduce winter shading, permeable pavement, minimal road grades at intersections and rougher pavement. Infiltration systems are to be designed in accordance with applicable Source Water Protection requirements. Please refer to the Parking Lot Design Guidelines to Promote Salt Reduction (Lake Simcoe Region Conservation Authority, February 22, 2017) or most current version for additional design guidance for parking lots.

3.3.4 Temperature

Temperature is of vital concern to fish and their habitat, especially where the discharge is to a cold-water stream. Water that is too warm can have a negative impact on aquatic life since dissolved oxygen decreases as temperature rises, potentially leading to anoxic conditions. Many SWM wet ponds have made use of bottom draw designs in an effort to release the cooler water from the pond. However, a bottom draw outlet, while potentially effective at mitigating temperature concerns, may create concerns related to high salt concentrations as discussed in Section 3.3.3. Other factors that can assist with temperature mitigation and should be explored include cooling trenches, underground cooling chambers, cooling towers, providing shading, increasing permanent pool depth and orienting a facility to minimize the duration of sun exposure.

In order to minimize thermal impacts, end of pipe SWM facilities should be designed with the following configuration and features:

- Minimum length to width ratio of 5:1 to minimize large open areas of water or filtration media;
- Appropriate orientation and perimeter planting to maximize shade coverage throughout the facility (to be supported by detailed shading plans) while maintaining the viability of plants which may require full sun for optimum growth; and
- Multi-draw or blended outlets with cooling trenches that account for both temperature and salt (Section 3.3.3). For example, designing the bottom draw to be located approximately at the midpoint of the permanent pool depth, a minimum of 0.6 m from the bottom of the facility and 1.0 m below the surface and blending the top and bottom draws to dilute the salt and maintain some thermal mitigation.

Note: The outlet configuration is also subject to other agency approvals.

3.3.5 Other Contaminants

As per the 2003 M.O.E. SWM Planning and Design Manual, urban stormwater runoff may contain elevated levels of nutrients, bacteria, heavy metals, oil and grease, and pesticides.

It is of critical importance to understand the land use proposed for a site and the anticipated contaminants that will need to be targeted for removal from stormwater runoff when preparing a stormwater treatment design. Of equal importance is an understanding of the pollutant's interaction with water and by what mechanism a pollutant can or cannot be removed. In nearly all cases, a single SWM control will not be effective at mitigating all contaminants. Therefore, multiple SWM controls employed in series, comprising a treatment train become necessary.

3.3.6 Oil, Grease and Gas

Oil, grease and gas do not dissolve in water. Oil, gas and other hydrocarbons are light non-aqueous phase liquids that float on water. These products are toxic to the environment. Manufactured Treatment Devices (MTD) can be used effectively as part of a treatment train to reduce the amount of oil and grit in stormwater. In particular, MTD units can be used as a means of providing pre-treatment upstream of L.I.D. features and SWM facilities. For more information on MTDs refer to Section 6.4.4. To help trap Light Non-Aqueous Phase Liquid and minimize their escape from ponds, features such as baffles and/or inverted pipes may be considered and incorporated into the design of outlet structures.

It is strongly recommended that frequent and regular inspection and maintenance of MTD units be undertaken, in order to maximize their effectiveness and minimize the possibility of contaminants and sediments from being flushed out.

3.3.7 Heavy Metals

Heavy metals such as copper, nickel, zinc and cadmium are hazardous to human health and the environment. The metals are also commonly found and used for a variety of purposes. Heavy metals can adsorb onto sediment particles in runoff. As such, regular inspection and proper maintenance of L.I.D. and SWM facilities and Oil Grit Seperator (O.G.S.) units is recommended to identify and remove accumulated sediment. Additional benefits may be realized using filters which have a high affinity for metals.

3.4. Stream Erosion Control

Watershed and subwatershed studies, Master Drainage Plans and Master Environmental Servicing Plans should be referenced for specific SWM requirements to protect against stream erosion. In the absence of watershed studies, guidance concerning design approaches from the M.O.E. Stormwater Management Planning and Design Manual will be applied. The following are typical conditions where an erosion control study may be required:

- As part of a Master Drainage Plan for a Secondary Planning Area;
- For sites located upstream of a known erosion area;
- For sites tributary to small first and second order headwater streams;
- When the downstream creek flows through established urban areas and the site is greater than 1% of the catchment area; and
- Flow diversions are proposed between watersheds or sub-watersheds (the Authority must be pre-consulted with respect to any proposed flow diversions. In general, flow diversions will not be supported).

The requirements to complete a stream erosion control study are outlined in Appendix F.

For sites less than 2 hectares, erosion control is normally not required. For larger areas, where an erosion control study is not specified, the Authority 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. The Authority must be consulted about the need for an Erosion Study.

4.0 Water Balance/Groundwater Recharge/WBRP

4.1. Water Balance Requirements

Urbanization increases impervious cover which, if left unmitigated, 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, or sub-catchment) over some time period. Water balance may be used to describe the hydrologic cycle.

A SWM plan must make every feasible effort to maintain the pre-development infiltration rate and / or meet infiltration targets established in more comprehensive documents such as master plans, subwatershed plans and watershed plans, if applicable. In addition, a water balance assessment may be required to meet Oak Ridges Moraine Conservation Plan, Lake Simcoe Protection Plan (LSPP), the South Georgian Bay Lake Simcoe Source Protection Plan (SGBLS SPP) and the Provincial Policy Statement (PPS). Each one of these may have different requirements pertaining to water balance.

For example, a water balance is required if the site is in a WHPA-Q2 defined under the SGBLS SPP and it meets the definition of "major development" per the SGBLS SPP, which is "any construction of a building or buildings on a lot with the ground floor area cumulatively equal to or greater than 500 m^2 (5382 sq ft), and any other impervious surface, single detached residential properties are exempt from the definition." It should be noted that the SGBLS SPP definition of "major development" is different than the definition of major development in the LSPP. It is advised that Authority staff be contacted regarding the required scope of a water balance assessment.

Every attempt should be made to match post-development infiltration/recharge volumes to pre-development levels on an annual basis. It is common practice and an accepted method to provide estimates of surplus using a Thornthwaite and Mather approach where surplus is estimated based on precipitation minus evapotranspiration (Steenhuis and Van Der Molen, 1986). The infiltration portion of the surplus can be estimated by applying the infiltration factors provided in the Ministry of the Environment and Energy Hydrogeological Technical Information Requirements for Land Development Applications (1995). These factors consider slope, vegetation and soils. The remainder of the surplus is runoff.

The water balance should be prepared by subdividing the site into zones that reflect drainage outlets. In a simple case, there would be one catchment and one drainage outlet, whereas a more detailed case may have multiple stream catchments and several outlets.

These catchments would be further subdivided by similar infiltration properties (i.e., grades, soils and vegetation). Pre-development and post-development water balances may have different catchments depending on the change in drainage patterns, grading, soil and vegetation as a result of the proposed site works. These changes should be clearly documented in the report, and within a figure.

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, and;
- Infiltration

In general, infiltration credit will not be provided for the following:

- Amended topsoil thickness;
- Conveyance measures (e.g., grassed swales/enhanced grass swales), and;
- Measures/features where the minimum flow path over a pervious surface is less than 5 m.

Please note that for commercial, industrial and institutional sites, infiltration may only be permitted from clean surfaces such as rooftops and landscaped areas. Please see section 4.5.8 of the 2003 MECP SWMPDM. Similarly, for pollution hotspots, such as gas stations, infiltration is only permitted from clean surfaces such as rooftops and landscaped areas.

Please note that if a reduced clearance (based on current provincial guidelines) from the invert of the feature to the seasonally high groundwater elevation is requested, or if pro-rating (e.g., operating part of the year) of the facility is requested, then pre-consultation with the Authority, the municipality and the MECP is recommended. Please note that this only applies to volume control, phosphorus and water balance criteria.

Please note that if fill is proposed in the vicinity of infiltration measures, then the fill would need to be conducive to infiltration and match the permeability of the underlying native soils.

Please refer to Appendix D for infiltration facility design guidance.

Refer to the Hydrogeological Assessment Submissions, Conservation Authority Guidelines for Development Applications, (2013) for specific water balance and hydrogeological assessment requirements. At a minimum, the following are required when conducting a water balance analysis:

- Identify the applicable governing water balance policies (determined by mapping and in consultation with the Authority);
- For clarification regarding LSPP 4.8-DP, 6.26-DP, and 6.40-DP please see the Lake Simcoe Protection Plan;

- For clarification regarding LUP-12, please see the South Georgian Bay Lake Simcoe Source Protection Plan;
- Oak Ridges Moraine Plan, Greenbelt Plan and Provincial Policy Statement should also be referred to as applicable, and;
- Any other policies or legislation that may come into force from time to time.
- Hydrogeological checklist (See Appendix A);
- A standalone hydrogeological report completed by a qualified person is required to satisfy LSPP DP-6.40 and LUP-12 SGBLS SPP;
- If the applicable only policy to be satisfied is LSPP 4.8-DP, then the water balance may either be a standalone report or included within the SWM report;
- Obtain precipitation values from a reliable source such as Environment Canada Meteorological Services for the area (utilize closest station with adequate data);
- Estimate of local values for major water balance components (evapotranspiration, surplus, runoff, and infiltration) for pre-development, post-development and post-development with mitigation measures;
- Calculations of impervious areas that reflect actual conditions based on the proposed site plan or a reasonable range of impervious areas used in those cases where only a conceptual plan is provided;
- Runoff coefficients consistent with generally accepted numbers (i.e., MECP guidelines)
- The water balance is required to take into account the changes to grading / topography and land cover;
- Seasonal groundwater levels with a minimum of 12 continuous months of monitoring data, including the identified seasonally high groundwater elevation (required for L.I.D. design);
- Conduct a grain size analysis for on-site soils to estimate local recharge rates. If it is proposed to import soil from an off-site location, the imported soil must be shown (prior to commencement of earthworks) to have infiltration characteristics similar to what was assumed in the water balance and hydrogeological assessment;
- In-situ percolation testing (e.g .Guelph Permeameter Test) will be required for the detailed design of any infiltration facilities;
- Appropriate catchments should be used within the analysis (i.e., delineate catchments based on drainage, grades, vegetation, soils and show how infiltration and runoff will change within these zones for both pre-development and post-development);
- Figure of catchments used within the pre-development and post-development water balance;
- All calculations should be provided in a table format which clearly demonstrates that inputs (precipitation, additional runoff, water from municipal wells, etc.) are equal to outputs (i.e., infiltration, runoff, water use);

- Infiltration mitigation details, appropriate drawings, and calculations illustrating how the infiltration deficit will be mitigated;
- Borehole/test pit information including location figure; and
- If a catchment-based water balance in support of maintaining a natural heritage feature is required.

4.2. Water Balance Recharge Policy for the Lake Simcoe Protection Plan

Please refer to Section 2.1.8 for information on the Water Balance Offsetting Policy.

In general, the Water Balance Recharge Policy for the Lake Simcoe Protection Plan is applicable for areas outside of the York Region WHPA-Q2. For questions regarding the Water Balance Recharge Policy, the policy should be consulted in conjunction with pre-consultation with the Authority.

5.0 Erosion and Sediment Control

5.1. Soil Erosion

Soil erosion is a naturally occurring process where water picks up and transports soil particles. The degree of naturally occurring erosion will depend on a number of factors such as vegetative cover, slopes and soil type.

When a site is disturbed and soil is exposed, the potential for soil erosion is greatly increased. This increase in erosion results in sediment-laden runoff, which should be considered a pollutant. This sediment-laden runoff is damaging to natural downstream systems such as wetlands, creeks, rivers and wooded-areas. As such, measures should be implemented on sites with exposed soil with the intent of:

- Minimizing soil erosion at the source;
- Containing sediment on site;
- Treating sediment-laden runoff; and
- Being proactive, not reactive

Additional benefits such as construction phase phosphorus reduction may be realized from a well-designed and well-implemented ESC plan.

5.2. Erosion Control Requirements

The Authority recognizes that ESC methodologies have changed in recent years as technology has become more advanced and widely available. To this end, the Authority also recognizes the benefits of an on-going, site-based monitoring approach to ESC. The 2019 TRCA Erosion and Sediment Control Guide for Urban Construction provides many benefits in terms of a dynamic monitoring approach.

ESC for site alteration works must be in accordance with one of:

- the Authority requirements outlined later in this Section and in Appendix G, or
- the Erosion and Sediment Control Guide for Urban Construction, (TRCA, 2019).

Local Municipalities may have specific additional requirements above and beyond those outlined in the above documents which would need to be applied to ESC plans.

If the proponents wish to adhere to the current Authority ESC guidelines, they may do so. For proponents wishing to follow the 2019 TRCA Erosion and Sediment Control Guide for Urban Construction, pre-consultation with the Authority is encouraged and appropriate site monitoring must be conducted as per the TRCA Guide.

Please note that at some point in the future when additional monitoring studies and pilot projects have been completed, the Authority may fully shift towards a performance monitoring-based and real-time data collection approach to ESC.

As noted above in Section 3.0, Site alteration should be performed in such a manner that release of sediment into receiving waters is kept to an absolute minimum with a goal of no sediment migration offsite. In certain circumstances, this may require that the release in sediment be controlled such that natural background rates / loads are not exceeded.

Key points from the Authority requirements for ESC submission found in Appendix G are highlighted here:

- A separate ESC plan must be included with submissions;
- The phasing or stages must be clear from the plans (clearing and grubbing, topsoil stripping, grading/earthworks, site servicing, building construction, and restoration) and need to be itemized and shown on all ESC plans;
- Temporary sediment control basins or traps to be installed at low points accepting less than 2 hectares of overland drainage. The preferred sizing for temporary sediment control basin or trap is to provide a storage volume of 185 m^3/h.a. At a minimum, temporary sediment basins or traps are to be sized to provide a storage volume of 125 m^3/h.a. All temporary sediment control basins or traps are to provide appropriate outlet protection;
- In general, temporary sediment ponds should have a contributing drainage area of no more than 10 h.a. In some site-specific instances, there may be restrictions that need to be accommodated such as site outlet constraints, grading constraints and phasing. In cases where restrictions are present, intermediate controls (i.e., sediment traps used upstream of the temporary sediment pond) should be used to provide at source controls for contributing drainage areas greater than 10 h.a. and the temporary sediment pond would be sized for the full contributing drainage area;
- Temporary sediment ponds are to be sized to provide 185 m^3/h.a. of permanent pool storage along with a minimum of 125 m^3/h.a. (in some cases 185 m^3/h.a.) of active storage. Refer to Appendix G, note 4 for additional information;
- Swales and ditches at a minimum must be designed to convey the flow from a 5-year design storm. Municipalities may have additional requirements for swale sizing and capacity. The Authority may also require sizing for the flows resulting from 100-year storm as Site specific conditions dictate;
- Topsoil/spoil piles shall not exceed 8m in height and shall be located in such a manner as to respect the setbacks as outlined in Appendix G; and
- Given the importance of L.I.D. features as part of a holistic approach to stormwater management within the Authority watershed, it is imperative that L.I.D. features are not to be used for sediment control during construction.

The following additional references from the Canadian Standards Association may be useful in the preparation of ESC plans:

1. Erosion and Sediment Control Installation and Maintenance W208
2. Erosion and Sediment Control Inspection and Monitoring W202

Please note that the above standards W208 and W202 are not intended to replace the Authority guidelines or the information in the TRCA Guide, but are intended to be supplementary to existing standards.

5.3. Construction Dewatering

Dewatering during construction may need to be considered, depending on site conditions, as part of any ESC and/or construction plan. Please note that additional approvals such as a Permit to Take Water may be required from external approval agencies in accordance with applicable legislation such as the *Ontario Water Resources Act*.

6.0 Modelling and Stormwater Management Facility Design

This chapter introduces technical requirements for the design of SWM features, including the hydrologic and hydraulic modelling that can apply across the Authority watershed. Specific and supporting technical information for hydrologic and hydraulic analyses and mapping has been referenced in Appendix C, Appendix I and Appendix K respectively. The modelling sections in Appendix C and Appendix I are each divided into analytic components and modelling alternatives, as applicable.

The technical submission must be provided in a manner that the entire submission can be replicated by a licensed professional with the information provided in the submission. This means that the technical submission must include all materials used in the original analysis including modelling, calculations, background information, drawings and reports.

6.1. Hydrologic Analysis

There are several key components that must be prepared to begin the process of conducting a hydrologic analysis. The components and requirements to complete an analysis are similar whether completing a manual analysis, empirical analysis, or model simulation(s).

A summary of the minimum requirements for submissions including hydrologic modelling and analysis can found in Appendix C.

For detailed information on the various hydrologic parameters required for an analysis and tables of typical parameter values, please refer to Appendix C.

Please note that any assumption(s) made with respect to the hydrologic modelling need to be justified within the report. Similarly, supporting documentation to justify parameter selection(s) must be provided within the report.

6.2. Hydraulic Analysis

There are several key components that must be prepared to begin the process of conducting a hydraulic analysis. The components and requirements to complete an analysis are similar whether completing a manual analysis, empirical analysis, or model simulation(s).

A summary of the minimum requirements for submissions including hydraulic modelling and analysis can found in Appendix I.

For detailed information on the various hydraulic parameters required for an analysis and tables of typical parameter values, please refer to Appendix I.

Integrating geospatial data into hydraulic modelling and mapping is an important component of conducting a hydraulic analysis. The methodology of preparation and the analysis applied to geospatial data sets must be incorporated into the submission report. Details on the minimum requirements for submissions including survey and geospatial data can be found in Appendix K.

Please note that any assumption(s) made with respect to the hydraulic modelling and associated data processing need to be justified within the report. Similarly, supporting documentation to justify parameter selection(s) must be provided within the report.

Please note that prior to completing a hydraulic analysis, a hydrologic analysis may be required. Please refer to Section 6.1 for guidance on completing a hydrologic analysis.

6.3. Floodplain Analysis

Every effort should be made to keep proposed works and development outside of the floodplain. In some cases, this may not be possible. In those cases, the Authority should be pre-consulted about any proposed changes to the floodplain or works within the floodplain.

When dealing with proposed changes within the floodplain, (i.e cut/fill balance, watercourse crossings, etc.), it will need to be demonstrated that there are no negative impacts upstream or downstream in accordance with the Authority Ontario Regulation 179/06 Implementation Guidelines. Please note that the Authority Technical Guidelines for Stormwater Management Submission (this document) and the Authority Ontario Regulation 179/06 Implementation Guidelines need to be read in conjunction with each other.

A summary of the minimum requirements for floodplain analysis can found in Appendix I.

6.4. Stormwater Management Facility Design

The M.O.E. SWM Planning and Design Manual and STEP L.I.D. Stormwater Management Planning and Design Guide (L.I.D. WIKI Guide) provide detailed guidance for the design of SWM facilities. SWM facilities include but are not limited to the following: L.I.D. features, ponds, underground storage, etc. The minimum criteria for the design of the SWM facilities, as outlined in the M.O.E. SWM Planning and Design Manual must be met. Additional SWM facility design requirements and information are provided in the following sections.

6.4.1 Lot Level and Conveyance Controls or Low Impact Development

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. In 2007, the U.S .Environmental Protection Agency (EPA) put out a document on L.I.D. and defines it as:

"Low impact Development (L.I.D.) is a SWM strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution. L.I.D. 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".

The Sustainable Technologies Evaluation Program at the Toronto Region Conservation Authority developed the Low Impact Development Stormwater Management Planning and Design Guide (L.I.D. WIKI Guide). More details about some of these SWM practices are provided in this guide. Design of L.I.D.'s are to be done in accordance with the above noted L.I.D. guide, as well as with applicable MECP documents and are to incorporate all appropriate factors of safety. Please see Appendix D for L.I.D. design guidance. SWM submissions to the Authority must show that every possible effort has been made to follow the L.I.D. approach by incorporating lot level and conveyance controls.

The Authority will allow the permanent pool volume (water quality volume) of wet ponds to be reduced if sufficient L.I.D. measures are incorporated in the design. The types of L.I.D. features that could be used for this purpose are infiltration systems (trenches / galleries) and filtration systems (bioswales / rain gardens / enhanced swales).

These L.I.D. systems are to be accessible on municipal property or within an easement for long term monitoring and maintenance and be designed in such a manner that the original function can be fully restored in the event of failure. Furthermore, the L.I.D. would need to be one that provides an enhanced level of treatment, is designed in accordance with the Low Impact Development Stormwater Management Planning and Design Guide (L.I.D. WIKI Guide) and includes any applicable safety factors. The allowable volume reduction will be based on the amount of impervious area tributary to an L.I.D. that has been sized to treat the volume of runoff from a 25 mm rainfall event.

For example, the total imperviousness of a site is 55% (say 10 h.a. of a total site area of 18 h.a.). Of the 10 h.a., 3.6 h.a. drains to an L.I.D. and the remaining 6.4 h.a. are untreated by an L.I.D.. In this instance, the level of imperviousness for sizing the wet pond in Table 3.2 of the 2003 M.O.E. SWM Manual can be assumed to be 35% (6.4 h.a. represents approximately 35% of the total area of 18 h.a.).

The MECP, local municipality and the Authority are to be pre-consulted regarding the potential reduction of the permanent pool volume in the downstream SWM facility (wet pond) because of L.I.D. implementation. For the initial design of the ponds, during the Functional Servicing Report (FSR)/ Draft Plan Approval stage, it is to be assumed that no reduction of the permanent pool volume occurs. However, a condition of draft plan approval could state that the draft plan could be redlined to adjust the size of the pond block as a result of additional detailed analysis and design.

6.4.2 Design Requirements

In addition to the MECP and Low Impact Development Stormwater Management Planning and Design Guide (L.I.D. WIKI Guide), SWM facilities (i.e., Ponds, Underground Storage, L.I.D. features, and associated grading, etc.) are to be designed with the information and requirements outlined below, and Appendix D where applicable:

Emergency Overflow Weir

The emergency overflow weir (emergency spillway) for a SWM pond is to 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. Supporting calculations and documentation are to be provided to demonstrate the proposed surface treatment (erosion protection) for the weir can withstand the anticipated erosive forces and velocities.

Outlet Control Structures

The details of the outlet control structure are to be provided on an appropriate engineering drawing. For SWM ponds and L.I.D. features, the control structure is to be designed to be aesthetically pleasing and integrated into the berm/slopes. Refer to Appendix I for weir and orifice equations.

Outlet Headwall

Generally, the outlet headwall is to be located outside of the setback to the watercourse, all natural heritage features, and the Erosion Hazard Limit. The Authority is to be pre-consulted prior to designing an outlet headwall that encroaches into these features. A flow spreader weir is required to disperse and dissipate flows. Supporting calculations and documentation are to be provided to demonstrate the proposed surface treatment (erosion protection) for the outlet can withstand the anticipated erosive forces and velocities.

Geotechnical, Hydrogeological, and Structural Design

A Geotechnical report is required to support the SWM facility design, location, configuration, water levels, berms, slopes, retaining walls, clay liners, and anti-seepage collars (where applicable). Hydrogeological and structural design recommendations, details and reports are to be provided as necessary to support infiltration, seasonal high groundwater level, groundwater impacts (to / from facility), and structural components. All supporting design information and reports are to be signed and sealed by a qualified licensed professional (i.e., P.Eng .or P.Geo.)

The above listed requirements, as applicable to the construction of the facility, are to be included as notes on the SWM facility design drawings.

Berm and Slope Construction

Notes on the construction of the SWM pond berms and slopes 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.

Safety Features

Safety features must be incorporated into the SWM pond design. The M.O.E. 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. Alternatives to fencing include the use of trees, shrubs and other vegetation to limit access to the pond for safety.

Warning Signs

Warning signs should be provided 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.

Maintenance Access

All SWM facilities must include a maintenance access designed to the satisfaction of the Municipality and the Authority.

Vegetation Planting Plan

A planting plan is required for the SWM facility and outfalls.

- The planting strategy is to consider safety, aesthetics, shading, and enhanced pollutant removal.

- Appendix H 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. However, the Authority recommends the use of native plants and non-invasive species for all SWM facilities.

Location

The active storage of a SWM facility must be above the 100-year flood elevation of the watercourse.

SWM ponds, underground storage and associated grading should be located outside of the following:

- The Regulatory floodplain;
- Erosion hazard limits;
- Environmental features;
- Valley lands;
- Unstable slopes and areas susceptible to erosion; and
- Setbacks associated with the above features, established on a site specific basis. The Authority is to be pre-consulted with respect to any grading within setbacks or buffers.

Subject to the above, in some instances SWM facilities may be located within the floodplain between the 100-year storm and the Regulatory Storm flood lines 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; and
- No impact to environmental features and natural hazards.

Note: The location is also subject to municipal review and approval.

Freeboard

A 0.3 m freeboard is required above the maximum active storage of a SWM pond to the top of the pond berm.

Erosion Protection

Erosion protection details are required on the drawings for Overland Flow Routes, Emergency Overflow Weirs / Spillways, and Inlet / Outlet Splash pads. Calculations are required in the SWM Report to support the erosion protection material, configuration, sizing and depth.

Detailed Cross-Sections

The detailed SWM design drawings must include detailed cross sections through the facility, control structure and outfall. These cross sections are to show the design water levels.

6.4.3 Parking Lot Storage and Rooftop Storage

Parking lots and rooftops can be used to provide stormwater storage to reduce the peak flows in storm sewer systems. These methods of SWM have generally been used in commercial and industrial sites but not in residential areas due to the small parking areas and generally peaked roofs. These methods are also widely applied for infill projects. The developer must be aware of potential liabilities associated with parking lot and rooftop controls, and that the Authority will not be liable for any damages related to the installation, operation, modification or removal of any proposed parking lot or rooftop controls. The consultant is advised to consult with the governing municipality (and MTO if applicable) for guidance and details regarding parking lot and rooftop controls within their jurisdiction.

6.4.3.1. 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, prior to overflowing, is to be limited to 0.3 m 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 accurately shown on the design drawings.
- In the event of a blockage in the storm sewer system, 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 sufficient outlet (i.e., municipal right-of-way (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. Notes regarding how a permanent and tamper proof installation is to be provided must be included. The minimum size orifice allowed (typically 75mm diameter) is dependant upon the governing agency.
- Control structure details must be provided on the drawings.
- A stage-storage-discharge chart indicating all storm events must be provided to demonstrate the operation of the facility.

Additional requirements for parking facilities are listed in the most current version of Ontario Regulation 179/06 Implementation Guidelines.

6.4.3.2. Design Requirements for Rooftop Storage

Where rooftop controls are used, design submissions must include the following:

- 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;
- Emergency weir overflow or scuppers provided at the maximum design water elevation. Splash pads or erosion protection must also be indicated; and
- Supporting manufacturer's design information in an appropriate report appendix.

6.4.4 Manufactured Treatment Devices

Manufactured Treatment Devices (MTDs) are proprietary systems that may be used for water quality treatment of stormwater runoff through the removal of Total Suspended Solids (TSS) and associated pollutants, debris, oil and other floatables.

Two common types of MTDs used to meet SWM requirements include:

- **Gravity-settling MTDs** – A common type of gravity-settling MTD is an Oil-Grit Separator (O.G.S.). These devices remove large-particle suspended solids through the process of hydrodynamic separation.
- **Filtration-based MTDs** – These devices typically consist of filtration cartridges or filter media that targets the removal of fine-particle suspended solids and/or other target pollutants (e.g., nutrients or metals).

Both types of MTDs are typically installed within the stormwater sewer system in an on-line or off-line configuration.

Each of these technologies is discussed further in subsequent sub-sections.

Sizing calculations are to be provided by a qualified professional demonstrating compliance with the criteria noted in Appendix N.

For any type of manufactured treatment device, a maintenance plan is required detailing the frequency, cost and method of MTD inspection and maintenance along with a program that ensures these tasks are conducted at the recommended frequency (as noted in Section 6.4.5) over the lifespan of the device.

6.4.4.1. Oil and Grit Separators

Oil/Grit separators are water quality control devices designed to allow grit to separate from stormwater and allow oils to float and be separated out. They may also be used for spill control.

Generally, they are not to be used as a standalone system for water quality control, but rather be part of a multi-component 'treatment train' system for water quality control. They may also be a useful tool to provide pre-treatment upstream of SWM facilities. Oil/Grit separator systems should be used in conjunction with other quality control measures, such as naturalized buffers, grassed swales, etc. They are typically used for small sites or infill development (typically 5 h.a. or less). For linear development, an O.G.S. may be considered as a standalone control device, if the use of other quality control measures is not feasible. The Authority is to be pre-consulted in these circumstances.

As per Section 3.3.1, the required suspended solids removal treatment is MECP Enhanced Protection Level (Level 1) from a development site. This corresponds to a long-term average removal of 80% of suspended solids. If a proposed MTD is not capable of providing a minimum of 80% TSS removal, then other/additional measures to achieve TSS removal will required.

Sizing calculations are to be provided by a qualified professional demonstrating compliance with the criteria noted in Appendix N.

6.4.4.2. Filtration Devices

Filtration Devices are water quality control devices with the ability to remove fine particles (less than 20 microns). Typically, filtration devices should be used as part of a treatment train approach as outlined in Section 6.4.4.1. Pre-treatment of stormwater is advised to reduce the maintenance frequency and prolong the life of the filter(s).

Filtration devices are to 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.

Sizing calculations are to be provided by a qualified professional demonstrating compliance with the criteria noted in Appendix N.

6.4.5 Maintanence 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 for SWM facilities associated with subdivisions and site plans whether municipal or private. It is typically required by the municipality. The M.O.E. 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 schedule. A facility maintenance manual that contains the operations and maintenance schedule is required to be submitted as part of the final submission. With manufactured treatment devices, 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 SWM system.

7.0 Climate Change

As mentioned in Section 1.4, there is growing concern about the potential impact 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, and washed-out roads, resulting in damages estimated at hundreds of millions of dollars in cities such as Peterborough and Toronto. In current model forecasts for the time period of 2040-2049, climate in the Lake Simcoe watershed is described as:

- Less snow, more rain in winter;
- Considerably warmer with higher humidity;
- More frequent and intense summer rain events;
- Lower winds generally; and
- More extreme weather events with high winds and heavy rain.

There are a number of implications regarding SWM in Ontario. These can be summarized as follows:

- Increased thermal impacts of stormwater on the receiving water body;
- An increased occurrence of algae blooms;
- Undersized infrastructure as designed based on historical IDF curves;
- More sediment wash-off due to intense rainfall;
- Increased urban flooding (surcharging sewers, basements, roadways);
- Die-off of certain native plant species; and
- Mid-winter flood events caused by rainfall.

In 2010, the MECP (then M.O.E.) released a document entitled Policy Review Municipal Stormwater Management Light Climate Change.

The summary report outlines key findings of a review of the need for a new policy, act or regulation to deal with Ontario municipal SWM systems in light of a changing climate.

One of the key recommendations in this report is as follows:

"Several ministries are responsible for aspects of storm water management (i.e., M.O.E., Ministry of Municipal Affairs and Housing , Ministry of Natural Resources (MNR), Ministry of Infrastructure and Ministry of Transportation (MTO)). The M.O.E. recommends that the ministries work together with municipalities and conservation authorities to seek solutions for resilient municipal stormwater management systems that are adaptive to climate change and to collaborate on new and existing municipal tools for source control stormwater management."

The approach outlined in the Authority's SWM Technical Guidelines include a number of requirements for new or re-development that align with the recommendations of the above noted document.

Due to the uncertainties involved with the impacts of climate change, future decision-makers will need to be dynamic and adapt to the new conditions. Adaptive management is a process that promotes flexible decision making that can be adjusted in the face of uncertainty as new outcomes from management actions and other events develop (National Research Council, 2004).

In 2021, the Regional Public Works Commissioners of Ontario (RPWCO) developed a report titled *A Climate Resilience Roadmap for Municipal Infrastructure and Systems*. The report was developed as a roadmap to address climate risks. One of the key steps outlined in the report is to create a climate change adaptation strategy, which includes adaptive management approaches. The report defines adaptive management approaches as those "which involve putting into practice incremental adaptation options rather than undertaking large-scale adaptation all at once. Adaptive management further implies measures are adopted in a sequential manner following an iterative evaluation of risks, costs, feasibility, etc. as knowledge, experience and technology evolve" (RPWCO, 2021).

The Authority Climate Change Adaptation Strategy, developed in 2020, aims to enhance the resiliency to climate change within the Lake Simcoe Watershed through an adaptive management approach.

For more information on this plan, refer to the Authority Climate Change Adaptation Strategy, dated 2020 (or most current version as may be amended from time to time).

The Better Site Design approach (as per Section 3.0), coupled with low impact development requirements, volume control, phosphorus control and improved temperature mitigation through better site design will aid in building better climate change resiliency in the Lake Simcoe watershed.

8.0 Glossary

"Award Drain" a drain built under the authority of the Ditches and Watercourses Act.

"Development" means the creation of a new lot, a change in land use, or the construction of buildings or structures, any of which require approval under the Planning Act, the Public Lands Act, the Conservation Authorities Act, or that are subject to the Environmental Assessment Act.

"Freeboard" A safety factor built into the design of SWM features, typically a minimum 0.3 m elevation above the design water surface elevation.

"Hurricane Hazel" A storm which was the remnant of a hurricane that hit Ontario in October 1954 .The storm rainfall distribution is used for regulatory design in specific locations across the Authority watershed.

"Impervious area" impermeable surfaces including both directly or indirectly connected areas.

"Linear development" is defined as a road or highway project that results in full road reconstruction and/or increases in total impervious area. Mill and overlay and other resurfacing activities are not considered linear developments.

"Major Development" is defined in the Lake Simcoe Protection Plan as development consisting of:

- The creation of four or more lots;
- The construction of a building or buildings within a ground floor area of 500 m^2 or more; or
- The establishment of a major recreational use.

"MDP" Master Drainage Plan

"MESP" Master Environmental Servicing Plan

"Municipal Drain" a drain that is regulated under the authority of the Drainage Act.

"Non-linear Development" is development which meets the definition of major development in the Lake Simcoe Protection Plan.

"Watercourse" is defined as an identifiable depression in the ground in which a flow of water regularly or continuously occurs (Conservation Authorities Act).

"Pre-Development" The predominant site condition over the past 10 years. A maximum of 50% impervious area is to be assumed for pre-development runoff calculations where there is a known flooding / erosion concern in the area, or adequate controls do not exist downstream.

"Post-Development" Site condition after land development has taken place.

“Reconstructed Impervious Surface” Roadways and parking lots in which the complete pavement structure includes granular base and concrete / asphalt surface is completely rebuilt. Mill and overlay and other resurfacing activities are not considered full reconstruction.

“Redevelopment” Development, expansion and phased projects on previously developed sites and roadways. Mill and overlay and other resurfacing activities on existing roads and parking lots are not considered redevelopment.

“**Regulatory Storm”** The regulatory storm identified under Ontario Regulation 179/06 used to complete a regulatory riverine floodplain analysis. In general, Hurricane Hazel is the regional event, which is applied across the Authority watershed, with the Timmins Storm being applied in the Talbot River watershed. In specific locations, the 1:100-year event has been identified as the regulatory event.

“Sufficient outlet” is considered to be a watercourse, lake, municipal SWM system, drainage easement, municipal drain, and award drain.

“Site Alteration” means altering the grade of a site by the placement or removal of fill.

“Timmins Storm” A storm which occurred in Timmins Ontario on September 1961. This storm rainfall distribution is used for regulatory design in the Talbot River watershed.

9.0 References

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Sustainable Technologies Wiki Guide

Appendix A

Stormwater Management Report Minimum Requirements

(to be read in conjunction with municipal requirements)

1.0 Submissions to the Authority

1.1 Design Charrettes

The Lake Simcoe Region Conservation Authority (the Authority) encourages stormwater design charrettes as part of a pro-active review and approval process. Information requirements to support a comprehensive charrette are outlined below.

Lake Simcoe Region
conservation authority

www.LSRCA.on.ca

LSRCA STORMWATER MANAGEMENT DESIGN CHARRETTE
REQUIRED INFORMATION

- Applicant should review the Pre-Submission Consultation section of the LSRCA SWM Technical Guidelines for SWM Submissions to prepare for the charrette
- Ensure the developable area has been determined (NH, Buffers, Natural Hazards, Floodplain Etc.)
- Provide ELC Mapping
- Minimum Preliminary soils testing for the site (site specific soils info is required to inform LID discussions) In-situ testing is preferred with seasonally high groundwater elevations
- Assurance that a groundwater monitoring program is in place
- Acknowledgement that the water balance and LIDs are to be addressed early in the process (i.e., not left until detailed design for consideration)
- A sufficient outlet location (watercourse, lake – See SWM Technical Guidelines)
- The proposed method for conveying flow through a NH area and buffer to an outlet – to be shown on drawings and included as a separate, specific item for discussion in the charrette (with the ultimate goal of staying out of the NH area, minimizing erosion, considering grading at the start of the process, ensuring the sizing of the SWM block is large enough and will not encroach into an NH area. This may mean an increased SWM block size if grading is a constraint
- Site contours (survey preferred)
- Existing drainage plan showing adjacent properties and outlets and all external drainage areas that impact the property
- Proposed drainage plan demonstrating how external drainage is to be handled and drainage boundaries maintained
- Master Plans, SIS, Watershed Studies – where applicable
- Specific SWM Criteria for Watershed studies (erosion control targets, peak flow targets, overcontrol)
- A walk-through of LSRCA technical checklist (HydroG and SWM) to discuss how each criterion will be addressed. Note: this does not need to be onerous, a couple of slides to get people thinking about each criterion separately, rather than having confusion about water balance vs. volume control, filtration vs. infiltration, LSPP Phosphorus vs. 80% onsite vs LSPOP etc.

LSRCA Technical Guidelines for SWM Submissions
https://www.lsrca.on.ca/Shared%20Documents/permits/swm_guidelines.pdf

Hydrogeological Assessment Submissions – Conservation Authority Guidelines for Development Applications
https://www.lsrca.on.ca/Shared%20Documents/permits/hydrogeological%20_guidelines.pdf?pdf=Hydrogeological-Guidelines

120 Bayview Parkway
Newmarket, Ontario L3Y 3W3
Member of Conservation Ontario

T 905.895.1281
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Figure 1: Design Charrette Requirements

1.2 Initial Submission Checklists

The Authority requires that engineering and hydrogeological checklist be submitted with the initial applications for draft plan approval and detailed design. Please note that these checklists may be updated from time to time.

1.2.1 Engineering Submission Checklist

LSRCA Engineering Submission Checklist (V6 – March 2022) Required to Accompany ALL Engineering Submissions

LSRCA Engineering Submission Acknowledgement

I, Name:______________________________, Credentials:_______(i.e. P.Eng., C.E.T.), confirm that I am a professional familiar with applicable documents, guidelines and criteria pertaining to stormwater management, erosion / sediment controls and natural hazards in the province of Ontario and that the submission entitled Report Name:____, with associated drawings Drawings:____, has been reviewed by me and addresses the key components in the checklist included below.

I acknowledge that engineering sign-off or sign-off from another discipline pertaining to this submission or a portion of this submission does not constitute a permit from LSRCA. A permit will be required for all works within an LSRCA Regulated Area in accordance with Ontario Regulation 179/06 and additional information may be required as part of the permit process.

I acknowledge that an incomplete submission will result in processing delays and may be returned or rejected at the discretion of the Municipality in consultation with the LSRCA and/or additional information may be requested.

Signature:____________________________________Printed Name:____

Name of Consulting Firm:____

Date:____________________(mm/dd/yy)

LSRCA Engineering Submission Checklist

The following checklist refers to the requirements when submitting a detailed stormwater management submission. These same requirements apply to functional servicing reports (FSRs) as well, with the exception of the detailed design drawings. The FSR needs to provide sufficient detail to demonstrate the proposed development concept will be capable of meeting the stormwater management requirements at the detailed design stage.

For items that have been included in the submission, please fill in the report section and report page along with appendix location or drawings pertaining to each item in the checklist below.

For items not included, check "No" or "N/A (Not Applicable)" for each item in the checklist below. If "No" or "N/A" are checked, please provide an explanation of why the criteria do not apply in a particular instance and note that the submission may be deemed incomplete and that additional consultation with LSRCA will likely be required prior to submission acceptance. The sections noted in this check list refer to those contained within the **LSRCA Technical Guidelines for Stormwater Management Submissions**:

Figure 2: The Authority Engineering Submission Checklist

LSRCA Engineering Submission Checklist (V6 – March 2022) Required to Accompany ALL Engineering Submissions

Yes			No	N/A	Item	Comment
Report Section	Report Page	Drawing/ Appendix				
					Pre-submission consultation with LSRCA has been completed as per Section 2.1.1.	
					The SWM report has been prepared as per Section 2.1.6 as a **standalone document** (i.e. all references, calculations and modelling are included within the document or a referenced appendix).	
					A **Digital Copy** of all reports and all drawings has been submitted for LSRCA review via a digital submission link.	
					Stormwater Quantity **Peak Flow Control** as per Section 3.2.1.	
					Stormwater Quantity **Volume Control** as per Section 3.2.4.	
					Safe conveyance of stormwater to a **sufficient outlet** as per Sections 3.2.2 / 3.2.3.	
					Stormwater Quality Control **(80% TSS removal/Enhanced Level Treatment/Level 1 Treatment)** as per Section 3.3.1.	
					Stormwater Quality Control **(Phosphorus Removal)** as per Section 3.3.2 and as outlined in the Lake Simcoe Protection Plan.	
					Stormwater Quality Control **(Other Pollutants)** as per Sections 3.3.3 – 3.3.7	
					Stream **Erosion Control** as per Section 3.4.	
					A **Water Balance / Groundwater** analysis as per Section 4.0.	
					The Lake Simcoe Phosphorus Offsetting Policy (LSPOP) including a **Phosphorous Budget** completed for the site using the MOE PTool or STEP's LID TTT as per Section 3.3.2	
					Natural Hazards including floodplain (hydraulics, hydrology, mapping and cut / fill balance if applicable.)	
					SWM Modelling (hydrology and hydraulics) including digital files and all supporting SWM **calculations**.	
					Erosion and Sediment Control as per Section 5.0. (Drawings to be provided at the detailed design stage)	
					The general requirements, as per **Appendix A** of the LSRCA Technical Guidelines for SWM Submissions. Please note that this Appendix is not an exhaustive list and that additional site-specific requirements may apply.	

2 | Page

Figure 3: The Authority Engineering Submission Checklist (Continued)

Submission/Resubmission Requirements:

1. A completed response matrix which includes a detailed response outlining how each of the comments above have been addressed with reference to applicable reports/drawings (i.e. specific sections/pages/details or tab identifiers).
2. The response matrix is to also include a summary of any additional changes to the design (i.e. in addition to those not identified in the detailed response to comments, and includes changes to reports, drawings, details, facility design, etc.).
3. Reports and engineering drawings/details are to be signed and sealed by a Professional Engineer.
4. Reports are to include a digital copy of applicable models within the submission link or on a Data CD or USB Thumb Drive.
5. All submissions/reports are to include applicable technical components which achieve the minimum requirements outlined in the LSRCA Technical Guidelines for Stormwater Management Submissions, March 2022.

Important Notes and References:

1. Please contact the LSRCA to scope any required Environmental Impact Study or Natural Heritage Evaluation
2. The stormwater management submission is required to be prepared in accordance with "LSRCA Technical Guidelines for SWM Submissions" https://www.lsrca.on.ca/Shared%20Documents/permits/swm_guidelines.pdf
3. Submissions are to be in accordance with the LSRCA Ontario Regulation 179/06 Implementation Guidelines https://www.lsrca.on.ca/Shared%20Documents/permits/watershed-development-guidelines.pdf?pdf=Watershed-Development-Guidelines
4. The hydrogeological analysis is required to be prepared in accordance with "Hydrogeological Assessment Submissions: Conservation Authority Guidelines for Development Applications" https://www.lsrca.on.ca/Shared%20Documents/permits/hydrogeological%20_guidelines.pdf?pdf=Hydrogeological-Guidelines
5. Where the LSPOP applies, submissions are to be in accordance with the LSPOP found here: https://www.lsrca.on.ca/watershed-health/phosphorus
6. Low Impact Development Treatment Train Tool can be found here: https://www.lsrca.on.ca/Pages/LIDTTTool.aspx
7. LSRCA Review Fees can be found here: https://www.lsrca.on.ca/permits/permit-fees

Figure 4: The Authority Engineering Submission Checklist (Continued)

1.2.2 Hydrogeological Submission

LSRCA Hydrogeological Submission Acknowledgement

I, Name:______________________________, Credentials:_______(i.e. P.Geo, or exempted P.Eng. as determined within the *Professional Geoscientists Act of Ontario*), confirm that I am a professional familiar with applicable documents, guidelines and criteria pertaining to groundwater management and that the submission entitled: Report Name:_______________________________________, with associated Drawings: ____has been reviewed by me and addresses the key components in the check list included below.

I acknowledge that hydrogeological sign-off or sign-off from another discipline pertaining to this submission or a portion of this submission does not constitute a permit from LSRCA. A permit will be required for all works within an LSRCA Regulated Area in accordance with Ontario Regulation 179/06 and additional information may be required as part of the permit process.

I acknowledge that an incomplete submission will result in processing delays and may be returned or rejected at the discretion of the Municipality in consultation with the LSRCA and/or additional information may be requested.

Signature:____________________________________Printed Name:_______________________________________

Name of Consulting Firm:____

Date:_____________________(mm/dd/yy)

LSRCA Hydrogeological Submission Checklist

The following checklist refers to the requirements when submitting a detailed design submission. These same requirements apply to functional design submissions as well, with the exception of the detailed design drawings. The functional design needs to provide sufficient detail to demonstrate the proposed development concept will be capable of meeting the hydrogeological requirements at the detailed design stage.

For items that have been included, please fill in the report section and report page along with appendix location or drawings pertaining to each item. For items not included, check "No" or "N/A" (Not Applicable) for each item. If "No" or "N/A" are checked, please provide an explanation in the note section of why the criteria do not apply in a particular instance. Please note that the submission may be deemed incomplete and that additional consultation with LSRCA may be required prior to submission acceptance.

The checklist below refers to requirements for every development type, therefore the **LSRCA Hydrogeological Submission Guidelines (2013)** should be referred to for specific study requirements for your type of Planning Act application. For example, the study scope may be reduced for single lot residential applications. Please contact LSRCA to scope study requirements prior to undertaking work.

Figure 5: The Authority Hydrogeological Submission Checklist

Yes			No	N/A	Item	Comment
Report Section	Report Page	Drawing/ Appendix				
					Pre-submission consultation with LSRCA has been completed as recommended in the Hydrogeological Assessment Submission Guidelines (2013).	
					The hydrogeological report has been prepared as a **standalone document**. (i.e., all references, calculations and drawings, Thornthwaite-Mather water balance assessment, are included within the document).	
					A **Digital Copy** of all reports and all drawings has been submitted for LSRCA review via a digital submission link.	
					Geological Characterization as per Section 3.1	
					Test pits/Boreholes as per Section 3.1.6 (Required for detailed design)	
					Monitoring Wells as per Section 3.1.7 (Preliminary data required for functional design)	
					Private Well Survey as per Section 3.1.8	
					Characterization of the local hydrostratigraphy/hydrogeology as per Section 3.1.9	
					Description of Surface Water Features and Functions as per Section 3.1.10	
					Water Quality as per Section 3.1.12	
					D-5-5 Water Supply (private servicing only) as per Section 3.1.13	
					Groundwater Levels as per Section 3.2.1 (Preliminary data required for functional design)	
					Pumping Tests as per Section 3.2.2	
					Groundwater Discharge (Baseflow) as per Section 3.2.3	
					Pre- and Post-Development Water Balance Assessment as per Section 3.2.4	
					D-5-4 (Onsite Sewage Systems only) as per Section 3.2.6	
					Infiltration/recharge mitigation plan as per Section 3.3	
					In-situ infiltration testing as per Section 3.3	
					Low impact development design calculations	

Figure 6: The Authority Hydrogeological Submission Checklist (Continued)

Submission/Resubmission Requirements:

1. A completed response matrix which includes a detailed response outlining how each of the comments above have been addressed with reference to applicable reports/drawings (i.e. specific sections/pages/details or tab identifiers).
2. The response matrix is to also include a summary of any additional changes to the design (i.e. in addition to those not identified in the detailed response to comments, and includes changes to reports, drawings, details, facility design, etc.).
3. Reports and engineering drawings/details are to be signed and sealed by a Professional Geoscientist of Professional Engineer as appropriate.
4. Reports are to include a digital copy of applicable models within the submission link or on a Data CD or USB Thumb Drive.
5. All submissions/reports are to include applicable technical components which achieve the minimum requirements outlined in the LSRCA Technical Guidelines for Stormwater Management Submissions, March 2022.

Important Notes and References:

1. Please contact the LSRCA to scope any required Environmental Impact Study or Natural Heritage Evaluation
2. The stormwater management submission is required to be prepared in accordance with "LSRCA Technical Guidelines for SWM Submissions" https://www.lsrca.on.ca/Shared%20Documents/permits/swm_guidelines.pdf
3. Submissions are to be in accordance with the LSRCA Ontario Regulation 179/06 Implementation Guidelines https://www.lsrca.on.ca/Shared%20Documents/permits/watershed-development-guidelines.pdf?pdf=Watershed-Development-Guidelines
4. The hydrogeological analysis is required to be prepared in accordance with "Hydrogeological Assessment Submissions: Conservation Authority Guidelines for Development Applications" https://www.lsrca.on.ca/Shared%20Documents/permits/hydrogeological%20_guidelines.pdf?pdf=Hydrogeological-Guidelines
5. Where the LSPOP applies, submissions are to be in accordance with the LSPOP found here: https://www.lsrca.on.ca/watershed-health/phosphorus
6. Low Impact Development Treatment Train Tool can be found here: https://www.lsrca.on.ca/Pages/LIDTTTool.aspx
7. LSPP Water Balance Offsetting Policy: applies to all new applications under the planning act received after 1 January 2019, details can be found here: https://www.lsrca.on.ca/Shared%20Documents/lspp-water-budget-policy.pdf
8. LSRCA Review Fees can be found here: https://www.lsrca.on.ca/permits/permit-fees

Figure 7: The Authority Hydrogeological Submission Checklist (Continued)

2.0 General Requirements

A detailed design Stormwater Management (SWM) report must include the following information:

- All reports are to be prepared as a standalone document (i.e., all references and calculations must be included within document and appendix),
- The report will contain complete and comprehensive sections for Water Quantity, Water Quality, Stream Erosion, Water Balance, Phosphorus Loading and Erosion and Sediment Control,
- All issues related to Ontario Regulation 179/06 (floodplain, erosion, wetland, etc.) are to be addressed in the report. Refer to Lake Simcoe Region Conservation Authority Ontario Regulation 179/06 Implementation Guidelines,
- All reports and plans are to be signed and sealed by a professional engineer (P.Eng.), and
- All modelling (hydraulic and hydrologic) is to be provided in digital format (input / output files).

2.1 Site Description

- Location (key plan, municipal address, nearest roads, watershed and subwatershed),
- Existing Conditions (land use on site and surrounding areas),
- Natural Heritage features,
- Proposed Conditions,
- Drainage Area (for the site, tributary and watershed),
- Watercourses, Wetlands present on site, and type (permanent or intermittent), and
- Drainage patterns and ultimate drainage location/outfall.

2.2 Background Information

- Pre-Submission meeting verification,
- Pre-Consultation with Ministry of the Environment, Conservation and Parks (MECP) and other agencies (especially related to Low Impact Development (L.I.D.) Credits),
- Watershed Plans,
- Sub-Watershed Plans,
- Master Drainage Plans,
- Other Previous Reports and Relevant SWM Requirements,
- Existing Models,
- Geotechnical Report, and
- Hydrogeological Report.

2.3 Figures and Drawings

- Location Plan in the report,
- Key Plan on the drawings,
- All watercourses and names of watercourses shown on all Figures and drawings,
- Pre-Development and Post-Development Drainage Plans for Hydrologic model(s) which include:
  - Existing contours,
  - Drainage direction (minor and major system),
  - Catchments IDs,
  - Areas and imperviousness,
  - Uncontrolled areas,
  - 100-year capture,
  - Site outlets, and
  - SWM facility location and associated tributary areas.
- Model Schematics (As per minimum requirements in Appendices C, I and K),
- Storm Drainage, Grading and General Servicing Plans,
- SWM Facility Design Drawings and Details, and
- Erosion and Sediment Control Plans (As per minimum requirements in Appendix G).

3.0 Design Information

- Consistent hydrology modelling to be utilized for each development application and/or consistent with Master Environmental Servicing Plans (MESP)/ Master Servicing Plan (MSP)/Studies,
- Supporting information has been included for all modelling parameters and calculations,
- Stage-Storage-Discharge calculations provided for each SWM facility including design information on control and emergency overflow weirs,
- Flow and storage summary tables provided which reference the associated drainage area, catchment ID, outlet(s) and differentiate between controlled and uncontrolled areas,
- Identify and show seasonal high groundwater levels in report and on drawings,
- Per Ministry of the Environment (MOE) Planning and Design Manual (i.e., Drainage Area, Required Volume, Slopes, Forebay, etc.),
- Per L.I.D. Planning and Design Guide (i.e., depth to ground water, media, configuration, infiltration capacity factor of safety),
- The SWM report and drawings are to include a table summarizing required storage, provided storage and associated elevation and flow for the permanent pool, 25mm (extended detention), and 2 through 100-year return period storm events where applicable for each facility,
- An operations and maintenance manual should be included in the SWM Report for all SWM facilities (i.e., SWM Pond, L.I.D. facilities, Manufactured Treatment Devices (MTD)) in accordance with Municipal requirements,

- Complete information on proposed MTD is to be provided including current status under Technology Assessment Protocol-Ecology (T.A.P.E.) and Environmental Technology Verification (ETV) protocols, and
- An operations and maintenance manual is to be provided that includes a maintenance schedule.

3.1 Quantity Control Section

- Runoff coefficient or imperviousness calculations,
- Analysis using appropriate storm distributions,
- Pre-development peak flow (m^3/s),
- Post-development uncontrolled peak flow (m^3/s),
- Post-development controlled peak flow (m^3/s),
- SWM facility type,
- Stage – storage – discharge table,
- Outlet design and calculations,
- Total storage required (m^3),
- Total storage provided (m^3),
- Table to compare provided versus required,
- Overland flow conveyance and design,
- External drainage conveyance (100 year and Regional).

3.2 Quality Control Section

- Level of Protection,
- Drainage Area to Facility in hectares,
- Percentage Impervious – total and directly connected areas, and
- SWM Facility Monitoring and Maintenance Requirements.

4.0 Hazard Land Management

- Regional event and 1:100-year flood lines under existing and proposed conditions shown on appropriate plan drawings,
- Valley top of bank, stream erosion, steep slope allowances (for confined stream systems) and meanderbelt assessed (for unconfined stream systems) plus applicable 6m erosion access allowance,
- Wetlands and required setbacks determined and identified on plans,
- Erosion assessment and applicable setback identified on plans,
- Wave uprush and/or wind setup elevations calculated (Lake Simcoe Shoreline),
- “Limit of development” shown on plans,
- Survey and floodplain mapping submitted (as per minimum requirement in Appendix K), and
- Hydraulic modelling and analysis including digital files (as per minimum requirements identified in Appendices C and I).

5.0 Other

- Upon approval of the SWM design, a digital copy of the stormwater drainage plan is to be submitted including the location and size of the SWM facility in G.I.S. format.

Note: If there is a discrepancy between the Authority, Municipal, NDMNRF or MECP requirements, then the more conservative criteria will apply.

Appendix B

Peak Flow Control Credits for Infiltration Systems

1.0 Peak Flow Control Credits—Infiltration Systems

The size of a downstream peak flow control pond may be reduced by the implementation of infiltration systems as outlined in this appendix. Prior to proceeding with any designs incorporating these measures, the Authority, municipality and Ministry of the Environment and Parks (MECP) will need to be pre-consulted. The initial design of Stormwater Management (SWM) peak flow control ponds (during the Functional Service Report (FSR) and Draft Plan Approval phase) must be done assuming that infiltration systems are not in place. Once the development site has been fully stabilized, testing / monitoring of the as-constructed infiltration systems will be required. Once these systems have been shown to satisfactorily meet all design specifications, the size of the SWM peak flow control pond can be reduced.

1.1 Step 1: Initial Screening

The site will need to exhibit characteristics that reflect its long-term suitability for the use of infiltration measures. It is anticipated that the sites that would potentially qualify for this approach will be those with soils with hydrologic soil group (HSG) A and B characteristics.

HSG A is sand, loamy sand or sandy loam types of soils. It has low runoff potential and high infiltration rates even when thoroughly wetted. They consist chiefly of deep, well to excessively drained sands or gravels and have a high rate of water transmission. HSG B is silt loam or loam. It has a moderate infiltration rate when thoroughly wetted and consists chiefly of moderately deep to deep, moderately well to well drained soils with moderately fine to moderately coarse textures.

The initial screening is to be done prior to the commencement of preliminary design. If any of the constraints listed in Table 1 exist, the site will not be eligible for a peak flow control infiltration credit.

Table 1 – Screening Constraints

Constraint	Constraint Exists	Constraint Does Not Exist
Low Infiltration Rate Is the infiltration rate less than 15 mm/hr in location where infiltration facility / L.I.D. is proposed?	No Infiltration Credit for Peak Flow Control	Potential Credit for Peak Flow Control, proceed to Step 2
High Groundwater Levels* Are seasonably high groundwater levels within 1 metre of the bottom of the infiltration facility?	No Infiltration Credit for Peak Flow Control	Potential Credit for Peak Flow Control, proceed to Step 2.

Constraint	Constraint Exists	Constraint Does Not Exist
Water Quality Issues Are there water quality constraints (source water protection, brownfield, nitrate plume etc.) that cannot be addressed through design?	No Infiltration Credit for Peak Flow Control	Potential Credit for Peak Flow Control, proceed to Step 2

*Geotechnical Hydrogeological Study plus in-situ infiltration testing.

1.2 Step 2: Design Phase and Post Construction Phase

If any of the six (6) criteria listed in Table 2 below is not met, no credit will be provided.

Table 2 – Criteria Required to be Met

Criteria	Credit (Criteria Not Met)	Credit (Criteria Met)
Native Soil Infiltration Rate In situ testing shows soil infiltration rate is 15 mm/hr or greater in the location where infiltration facility is proposed, i.e., the soil conditions at the infiltration facility site are suitable, based on the proposed grading plan.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Imported Soil Infiltration Rate The imported soil infiltration rate will be 15 mm/hr or greater in location where infiltration facility is proposed, based on proposed site grading.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
High Groundwater Levels Seasonably high groundwater levels are more than 1 metre below the bottom of the infiltration facility, based on proposed site grading.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Infiltration Facility Design Features Minimum safety factor of 2.5 used in sizing.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.

Criteria	Credit (Criteria Not Met)	Credit (Criteria Met)
Infiltration Facility Design Features Located below frost line.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Infiltration Facility Design Features Draw down of water levels within 24 hours of the end of the design rainfall event.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Infiltration Facility Design Features Design features include visible indicators such as surficial ponding such that it is easily evident that the infiltration facility is not meeting design specifications.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Infiltration Facility Design Features 100% active storage is available, or function can be fully restored in case of reduced infiltration capacity	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Security and Ease of Maintenance Infiltration facility is on private property with good access and municipal easement / agreement in-place.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
Security and Ease of Maintenance Infiltration facility is on public property with good access.	No Credit	100% of the design infiltration amount to a maximum of 25 mm.
One Full Year of Monitoring / Testing Results by a Qualified Individual after site is 100% stable. Results meet 100% of the design parameters for infiltration	No Credit	100% of the design infiltration amount to a maximum of 25 mm.

2.0 General Notes

- As noted above, the Authority, municipality and MECP will need to be pre-consulted, prior to proceeding with any designs incorporating the infiltration credit for peak flow control.
- A sensitivity analysis may be required to determine potential peak flow impacts immediately downstream in the event of failure of the infiltration systems. Based on the results of this analysis, additional quantity control measures may be required within the watercourse reach or on the site itself.
- The following is a typical example on how the infiltration credit can be applied in a typical site:

    A 20 h.a. development site has 10 h.a. of its total area draining to an acceptable infiltration low impact development (L.I.D.). If the total credit is 25 mm, based on the above table, the calculation of the peak flow quantity credit is as follows:

    0.025 m x 10 h.a. x 10000 m^2/ h.a. = 2500 m^3

    The 10 h.a. L.I.D. area is to be routed through a "pond" that mimics the effect of the credit (no outflow for the first 2500 m^3 of run off volume), and the resultant hydrograph added to the uncontrolled 10 h.a. hydrograph. The combined hydrograph is then routed through a traditional SWM pond. Alternate modelling approaches such as an increased Initial Abstraction (IA) may be considered at the detailed design stage.

Appendix C

Typical Hydrologic Values and References

1.0 Hydrology Analysis

There are two general approaches to simulating overland run-off and streamflow involving empirical methods or software modelling. Abstraction of rainfall can be determined through either the empirical methods or modelling taking into consideration depression storage, infiltration and soil water conditions. The following section identifies the variables that will be reviewed in support of any Site-specific hydrology analysis.

1.1 Hydrologic Analysis Components

This section highlights the key components that a hydrology submission will incorporate at a minimum such as sub-catchment delineation, rainfall input and design storms.

1.1.1 Sub-catchment Delineation

The first step in the hydrologic analysis is delineating the Site internal and external contributing drainage catchments. These sub-catchments are to be delineated for both pre- and post-development overland flow conditions and include flow direction arrows as applicable. Key watershed points of interest must be included in the discretization scheme (i.e., ponds, road crossings, railways). This should be based on field reconnaissance supplemented through the use of topographic maps, aerial photo interpretation, site survey and other supporting information. There may be additional supporting information from approved reports, such as Master Drainage Plans (MDP), Master Environmental Servicing Plans (MESP) or Secondary Plans that may apply to the Site. Please contact the Authority to confirm if there is specialized information that may be incorporated into the submission.

Sources must be referenced for all topographic or survey information used in the analysis. Reference information at a minimum should include the: drawing and / or survey title, author, publisher, scale, publishing date and / or flown date, surveyor name and date. It may be a requirement that the source data be provided in electronic format in support of the submission. Additional requirements exist for submissions incorporating survey and geospatial details into mapping and these are identified in Appendix K. A specific example of geospatial analysis of digital surface data would be automated catchment delineation using software.

1.1.2 Rainfall Input

There are currently several approved methods of generating synthetic rainfall hyetographs to apply across the delineated sub-catchments in the hydrologic analysis. These include generating rainfall from Intensity Duration Frequency (IDF) curves using the Canadian Atmospheric Environment Services (AES) historical rainfall and applying various single event or continuous design storm distributions. The rainfall distributions applied to a site depend on the design requirements which should be decided in conjunction with the subject Municipality and the Authority.

1.2 Synthetic Design Storms

Hydrologic simulation models may be used to simulate a single storm event or a continuous period of rainfall data. For Stormwater Management (SWM) design, models that use a single storm event are frequently applied. The rainfall input for the model would be a hyetograph data provided in various formats. The hyetograph may have been obtained as a historical record for that location through a rain gauge or be generated from a synthetic design storm. For example, Hurricane Hazel is a historic storm used in parts of Southern Ontario for flood control design, reference Section 22.0 of this Appendix for excerpts of provincial legislation which indicate the regulatory storms that are to be applied across the watershed.

In the Authority's watershed, there are two regional storms which are used in analysis, Hurricane Hazel and the Timmins 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 or using uniform rainfall methods. Examples include the Chicago design storm (Keifer and Chu, 1957) or the Rational Method. The second method develops the synthetic design storm from an analysis of historic storm events. Examples of this type of historical analysis included the methods applying the U.S. Natural Resource Conservation Service formerly Soil Conservation Service (SCS) design storm, and the Canadian Atmospheric Environment Service (AES) design storm.

The Rational Method assumes that a uniform rainfall or synthetic hyetograph is applied to a site. This method is recommended when there is total development area of less than 5 hectares. It is an empirical formula used to determine flow that results from a rainfall of specific intensity applied to an area based on an average catchment land use condition. Refer to this Appendix Section 8.0 for additional information regarding the Rational Method.

There may be some applications where the modified rational method and its variations including the Bowstring Method may not be accepted by the Authority. Please contact the Authority if you plan on using this methodology in the analysis.

In general, the following design storms are to be used for modelling sites with drainage areas greater than 5 hectares (refer to distribution formulas and tables later in this Appendix):

- Regional Storm event;
- 4-hour Chicago distribution;
- 12-hour SCS Type II distribution;
- Sub-watershed/watershed/master drainage plan storm distributions (if applicable); and
- In specific instances the 6 and 24-hour SCS type II distributions may be required.

The 4-hour Chicago storm hyetograph is widely used in Southern Ontario and has a sharp peak, providing a conservative response for overland flow in urban systems. It is recommended that the time step should be 10 minutes maximum. Refer to Section 13.0 of this Appendix, reference on the Chicago storm hyetograph for additional 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.

The SCS developed the Type I, Type II and Type III design storms. The Type II distribution applies to most parts of Canada. The Type II distribution is a mass curve for percent of accumulated rainfall depth over a duration of 6, 12 or 24 hours. First, a storm 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 6, 12 or 24-hour curve. The SCS II design storm is required for use in hydrologic analysis by the Authority and the surrounding municipalities.

Hydrologic modelling must follow Watershed Plan recommendations when selecting storm distributions. The rainfall distributions selected in the Watershed Plan model should be used for modelling site developments. Generally, the 4-hour Chicago and the 12-hour SCS Type II design storm distributions should be modelled to demonstrate peak flow control and to calculate the required storage volumes. Additionally, the 6 hour and 24-hour SCS Type II design storms may be required in the analysis. The 12-hour SCS storm is derived from the steepest 12 hours of the 24-hour SCS curve. See this Appendix Section 10.0 for a copy of the mass storm distributions for the SCS Type II distribution.

Rainfall amounts should be based on the IDF curves for the precipitation station outlined in the appropriate municipality's SWM standards. Municipalities must be contacted directly regarding the most current IDF curve formulae to use. Supporting IDF information must be referenced and included in a report appendix. Refer to further in this Appendix Section 4.0 for the typical IDF curve formula and variables. In submissions where Regional Frequency Analysis IDF values are required, please contact the Authority for the most recent charts. Local municipalities must be contacted to obtain their most recent IDF curve information.

2.0 Hydrologic Modelling

Stormwater runoff calculations for site plans and subdivisions must be provided to demonstrate control of overland peak runoff, calculated required storage volumes and conveyance. The Authority preferred runoff software model is Visual Otthymo (VO), although other 'HYMO' based models may be considered upon consultation. For small sites, less than 5 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 digitally. The simulations should be based on a calibrated watershed model.

It is unlikely that flow validation will be required as a component of site plan or subdivision plans due to pre-existing Master Drainage Plans, MESP and Secondary Plans. In the event that flow validation is required, accepted methods can be discussed in further detail with Authority staff. Examples of current approved validation methodologies include modified flood index by Ontario Ministry of Transportation (MTO), northern Ontario hydrology method by MTO, consolidated frequency analysis by Environment Canada (EC) and regional flood frequency analysis by the Ministry of Natural Resources (MNR).

There may be specific situations where pro-rating flows for a smaller area within a larger area having a flow calculated in a hydrologic analysis, is applicable using the MTO method. Refer to Section 7.0 in this Appendix for further references on the application of pro-rating flows and it is recommended to confirm with Authority staff to ensure that this approach will be accepted.

The hydrologic modelling parameters that are commonly used are described in the following sections.

2.1 Imperviousness

An accurate estimate of the percentage of imperviousness is very important as the hydrologic model is generally sensitive to this parameter. The parameter will affect the proposed SWM runoff volumes and consequently the land requirements for SWM features, and the size of the SWM block. Impervious calculations in HYMO based software incorporate parameters including the Total Imperviousness Percentage (T.I.M.P.) and the Directly Connected Imperviousness Percentage (X.I.M.P.). T.I.M.P. is the ratio of the impervious area to the total area. X.I.M.P. is the ratio of the impervious area that is directly connected to the conveyance system, to the total area. Typical values for T.I.M.P. an X.I.M.P. are found in Section 13.0 of this Appendix.

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 overland runoff.

The total imperviousness for a 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. For detailed level studies (i.e., Site Plans) they should be calculated. X.I.M.P. must be less than or equal to T.I.M.P.

For the purposes of modelling hydrologic post-development conditions within this watershed, gravel, permeable pavement, permeable asphalt, and green roof surfaces must be assumed to be impervious (such as asphalt). For low impact development (L.I.D.) credits for peak flow reductions, please refer to Appendix B.

For the Rational or Modified Rational Method, the runoff coefficient is to be increased per MTO Design Chart 1.07 for the 1:25, 1:50 and 1:100-year storm events, see later in this Appendix Section 21.0. This chart shows increases in runoff coefficient values for more intense storms.

2.2 Infiltration Approach

Both the impervious and pervious areas in sub-catchments have initial abstraction (IA) values. Initial abstraction is the interception and depression storage of the physical surface at the beginning of the storm events which is available to retain the rainfall.

After taking into account the IA, the rainfall on the pervious area is subject to infiltration. Three methods used for modelling infiltration are the Horton method, the Soil Conservation Service (SCS) method and the Green-Ampt method, with the first two methods more commonly used across the Authority Watershed. Refer to Section 5.0 and Section 6.0 of this Appendix for further elaboration on the formulas and key references in the application of these different infiltration approaches.

In the SCS method, the CN selected for a catchment area is related to 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 from a sub-catchment. Typical CN values are given in tables in Modern Sewer Design – Canadian Edition 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 and is typically applied in regional event analysis.

AMC III conditions are assumed when modelling the final 12 hours of the Hurricane Hazel event. AMCII conditions are assumed when modelling for the Timmins Storm event and the 2 through 100-year design storms. The CN should be modified according to the different antecedent moisture conditions. Refer to Section 12.0 of this Appendix for a copy of the MTO Design Chart 1.10 for the CN conversion between the AMC conditions. It should be noted that for the 1997 MTO Drainage Manual MTO Design Chart 1.09 referenced on page 26 of that 1997 MTO Manual will not be accepted for AMC conversion.

Depending on the size of sub-catchment areas used in regulatory storms analysis, areal reduction distributions will need to be applied to the calculated hydrologic flows. Section 16.0 and Section 17.0 of this Appendix include copies of the MTO Design Chart 1.03 and MTO Design Chart 1.04 which include the various areal reductions that apply to the Hurricane Hazel and the Timmins Storm regulatory events. For the regulatory event analysis, it will be necessary to present results of the application of the areal reductions to the subcatchment area.

Where available, use the calibrated CN's referenced in watershed plans, sub-watershed plans or master drainage studies.

For small rainfall events, the runoff volumes may be underestimated as the IA value can be high for some CN values. Therefore, in HYMO software the IA value can be directly specified (i.e., 1.5 mm). Due to limitations with runoff volume validation in HYMO software, a CN* conversion may be required. Refer to this Appendix Section 15.0 for the recommended CN to CN* calculation approach.

In a technical submission, assumptions, values, sample calculations and sources for all hydrologic modelling approaches and parameters must be included in the submission.

2.3 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 Section 18.0, Section 19.0 and Section 20.0 found later in this Appendix. When generating the hydrographs, the Time to Peak should be calculated as tp = 0.67 tc, where tc is time of concentration.

In specific scenarios, the Authority may require additional methods for comparison in calculating time of concentration. These additional calculations could include the Kirpich Method, HYMO two-parameter, HYMO three-parameter time to concentration calculations. Please contact the Authority for additional information.

In the Visual OTTHYMO software, which is commonly used in hydrologic studies, there are several input parameters required for modelling sub catchments including both the STANDHYD and NASHYD representations of sub-catchments in the hydrologic modelling. The STANDHYD commands include calculated overland flow lengths and slope based on a digital terrain model (DTM) surface, topographic survey and other mapping as available. Typical methods for determining slope length include the equivalent slope method and the 85/10 method. Input parameters for these methods include area, X.I.M.P., T.I.M.P. and manning's n for overland flow. NASHYD commands include input data such as area, CN*, IA and manning's n for overland flow. All sub catchment modelling commands must be supported in the report text with references and sample calculations.

HYMO based hydrologic modelling programs are generally accepted in hydrologic submissions to the Authority and in specific cases, U.S. EPA SWMM5 and Computational Hydraulics Incorporated PCSWMM may also be acceptable. Refer to Section 3 in this Appendix for additional information on software packages used in hydrologic analysis. The SWMM5 and PCSWMM storm water management models are rainfall runoff simulation hydrologic models that can be used for both single event and continuous event modelling. The supporting catchment delineation and parameter selection for input in these models must follow the same requirements for documentation; referencing and electronic submission as with the HYMO based hydrologic modelling.

All hydrologic parameters must be compared to MDP, 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. All input variables must be documented with references and calculations using best engineering practices.

2.4 Channel Routing

Sufficient channel routing should be incorporated into the hydrologic model as represented by the site conditions. 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 at a minimum from DTM data 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 shortest channel section, and at a maximum equal to the hydrograph time step. Selected Manning's roughness parameters for overland flow must be selected in accordance with the values / approaches set out in the Section 7.0 of this Appendix. Parameter selection must be supported through the submission documentation.

2.5 Reservoir Routing

In the hydrologic models, there are several uses for reservoir routing commands. They include modelling natural storage areas and SWM facilities. Reservoir routing commands in the modelling are to be applied where applicable with the 2 through 100-year design storms, and omitted from the regional storm hydrologic modelling. When calculating orifice discharge in an outlet control structure from a SWM facility, 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. In some watersheds, additional consideration should be given to confirming that the routing includes the entire period of the rainfall hydrograph flow.

In the hydrologic analysis submission, a stage-storage-discharge table or rating table with drawdown time must be included and contain the elevations of the outlet and emergency spillway, as well as the water surface elevation of each storm event. A schematic diagram showing the location of the outlet and other facility features is recommended for submission.

Appendix I includes a selected list of formulas and typical coefficients for conveyance structures used in the design of rating tables. Examples include broad crested weir, trapezoidal weir, emergency spillway and orifice flow.

3.0 Software Recommendations

There are several industry standard versions of software for single event and continuous event hydrologic analysis. Due to the continual updates to these software programs, prior to submission the Authority is to be contacted to confirm the current software packages which will be accepted in modelling submissions. If the submission does not use software that the Authority has, the proponent could be directed to resubmit their analysis using the software in use at the Authority.

4.0 Intensity Duration Frequency 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 = rainfall intensity (mm/hr);
- t = time in minutes; and
- a, b, c are constants for each Intensity Duration Frequency 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. Local municipalities must be contacted to obtain their most recent IDF curve information.

5.0 Natural Resource Conservation Service Formerly Soil Conservation Service Curve Number Method

The Natural Resource Conservation Service formerly the Soil Conservation Service (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:

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

- Q = the overland runoff depth (mm);
- P = the rainfall (mm);
- S = the total potential losses or storage parameter (mm); and
- IA = the initial abstraction (mm).

S is related to the curve number CN through the following formula:

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

The historical solution approach assumed the IA was equivalent to 0.2 S; however, due to that approach resulting in conservative flows the IA values may be determined and input directly into the equation above.

6.0 Horton's Method

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

When the rainfall intensity is less than the maximum infiltration capacity, ft is equal to the infiltration rate. ft is the infiltration capacity rate (in / hr or mm / hr) at time t.

When the rainfall intensity is greater than or equal to the maximum infiltration capacity of the soil the equation is:

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

Where:

- ft = the infiltration capacity rate (inches per hour or mm/hr) at time t;
- fo = the initial infiltration capacity rate (inches per hour or mm/hr);
- fc = the final infiltration capacity rate (inches per hour or mm/hr); and
- k = 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.

Typical values for fo and fc are presented in the figure below.

	Loam, Clay K = 0.08		Clayey Sand K = 0.06		Sand, Loess, Gravel K = 0.04	
Land Surface Types	f_o	f_c	f_o	f_c	f_o	f_c
Fallow land field without crops	15	8	33	10	43	15
Fields with crops (grain, root crops, vines)	36	3	43	8	64	10
Grassed verges, playground, ski slopes	20	3	20	3	20	3
Noncompacted grassy surface, grass areas in parks, lawns	43	8	64	10	89	18
Gardens, meadows, pastures	64	10	71	15	89	18
Coniferous woods	53*	53*	71*	71*	89*	89*
City parks, woodland, orchards	89	53	89	71	89*	89*
*K=0						

Figure 1: Typical Values for the Horton Equation Parameters (mm/hr)

Source: The Handbook of Steel Drainage & Highway Construction Products, Canadian Edition Corrugated Steel Pipe Institute, American Iron and Steel institute (2007)

7.0 The Ontario Ministry of Transportation Pro-Rating Methodology

In some modelling situations, it may be applicable to pro-rate the flows from a large catchment to a smaller subcatchment with similar topography, watershed morphology and land cover. The accepted method for pro-rating flows is using a simplified version of the Modified Index Flood Method formula from the MTO section on non-hydrographic methods of flow rate calculation.

The Modified Index Flood Method referenced in the MTO Drainage Management Manual is the following formula:

$Q_2 = Q_1(A_2/A_1)^{0.75}$

Where:

- A1 = the known larger area;
- A2 = the smaller area;
- Q1 = the available flow available for the A1 area; and
- Q2 = the unknown variable.

If catchment areas have significantly different hydrologic characteristics, another method for flow calculation should be applied.

Source: Ontario Ministry of Transportation, MTO Drainage Management Manual, (1997).

8.0 Rational Method

The Rational Method formula is:

$$Q = k\,C\,i\,A$$

where the peak runoff flow in (m3/s) is determined from:

- A = the drainage area (h.a.);
- k = a metric constant of 0.00278;
- i = rainfall intensity (mm/hr); and
- C = the coefficient that takes into account recommended values for volumetric overland run-off. Typical parameters for C values are included later in this Appendix Section 21.0.

The assumptions when applying the rational method is such that the rainfall intensity is uniform across the catchment.

9.0 The Chicago Design Storm

9.1 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:

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

Before the peak:

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

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)

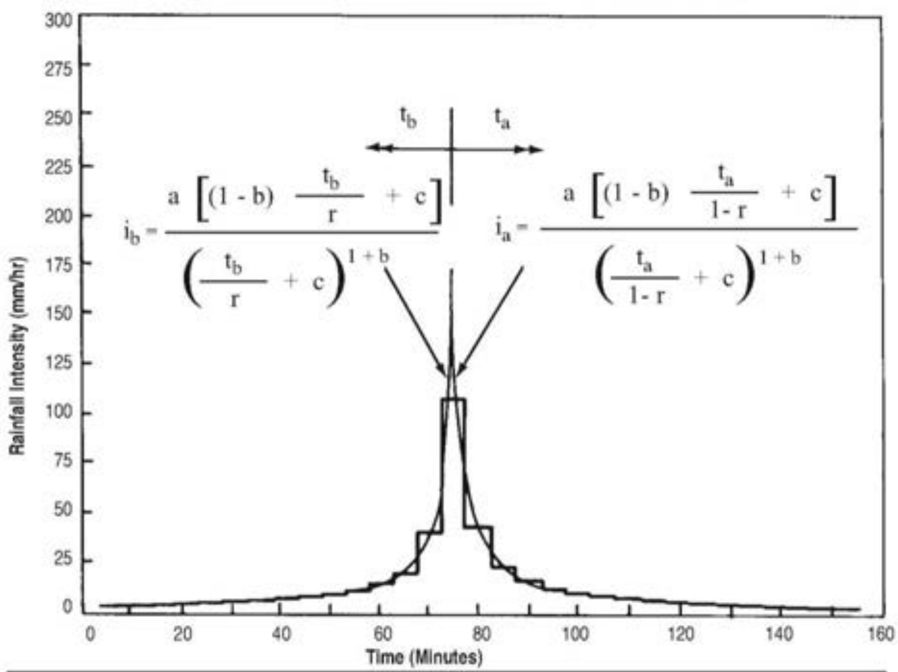

Figure 2: Chicago Hyetograph

Source: The Handbook of Steel Drainage & Highway Construction Products, Canadian Edition Corrugated Steel Pipe Institute, American Iron and Steel institute (2007)

10.0 Natural Resource Conservation Service Formerly Soil Conservation Service, Type II Mass Storm Distributions

The figure below presents the typical SCS Type II 6 hour and 24-hour Storm Distributions.

24-hour storm						6-hour storm		
		P_t/P_{24}						
Hour t	$t/24$	Type I	Type IA	Type II	Type III	Hour t	$t/6$	P_t/P_6
0	0	0	0	0	0	0	0	0
2.0	0.083	0.035	0.050	0.022	0.020	0.60	0.10	0.04
4.0	0.167	0.076	0.116	0.048	0.043	1.20	0.20	0.10
6.0	0.250	0.125	0.206	0.080	0.072	1.50	0.25	0.14
7.0	0.292	0.156	0.268	0.098	0.089	1.80	0.30	0.19
8.0	0.333	0.194	0.425	0.120	0.115	2.10	0.35	0.31
8.5	0.354	0.219	0.480	0.133	0.130	2.28	0.38	0.44
9.0	0.375	0.254	0.520	0.147	0.148	2.40	0.40	0.53
9.5	0.396	0.303	0.550	0.163	0.167	2.52	0.42	0.60
9.75	0.406	0.362	0.564	0.172	0.178	2.64	0.44	0.63
10.0	0.417	0.515	0.577	0.181	0.189	2.76	0.46	0.66
10.5	0.438	0.583	0.601	0.204	0.216	3.00	0.50	0.70
11.0	0.459	0.624	0.624	0.235	0.250	3.30	0.55	0.75
11.5	0.479	0.654	0.645	0.283	0.298	3.60	0.60	0.79
11.75	0.489	0.669	0.655	0.357	0.339	3.90	0.65	0.83
12.0	0.500	0.682	0.664	0.663	0.500	4.20	0.70	0.86
12.5	0.521	0.706	0.683	0.735	0.702	4.50	0.75	0.89
13.0	0.542	0.727	0.701	0.772	0.751	4.80	0.80	0.91
13.5	0.563	0.748	0.719	0.799	0.785	5.40	0.90	0.96
14.0	0.583	0.767	0.736	0.820	0.811	6.00	1.0	1.00
16.0	0.667	0.830	0.800	0.880	0.886			
20.0	0.833	0.926	0.906	0.952	0.957			
24.0	1.000	1.000	1.000	1.000	1.000			

Figure 3: SCS Rainfall Distributions

Source: Chow, V.T., D.R. Maidment and L.W. Mays; Applied Hydrology (1988)

The following excerpt from MTO's Design Chart 1.05 provides the typical SCS II distributions for the 12-hour mass storm.

12 hour		
Time end' g, hour	F_{inc} (%)	F_{cum} (%)
0	0	0
2	5	5
3	3	8
3.5	2	10
4	2	12
4.5	3	15
5	4	19
5.5	6	25
5.75	12	37
6	33	70
6.5	9	79
7	4	83
7.5	3	86
8	3	89
10	7	96
12	4	100

Figure 4: Typical SCS II Distributions for the 12-hour Mass Storm

Source: The Ontario Ministry of Transportation, MTO Drainage Management Manual; (1997)

11.0 Typical Curve Numbers

The following excerpt from the USDA report presents typical CN values for various land uses.

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description: Cover type and hydrologic condition	Average percent impervious area [2/]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

Figure 5: Typical CN Values for Various Land Uses

Source: United States Department of Agriculture, Urban Hydrology for Small Watersheds (1986)

12.0 Antecedent Moisture Conditions (AMC) Conversion Chart

The following MTO Design Chart 1.10 is to be used in the CN conversion between AMC II and AMC III.

Design Chart 1.10: Antecedent Moisture Condition

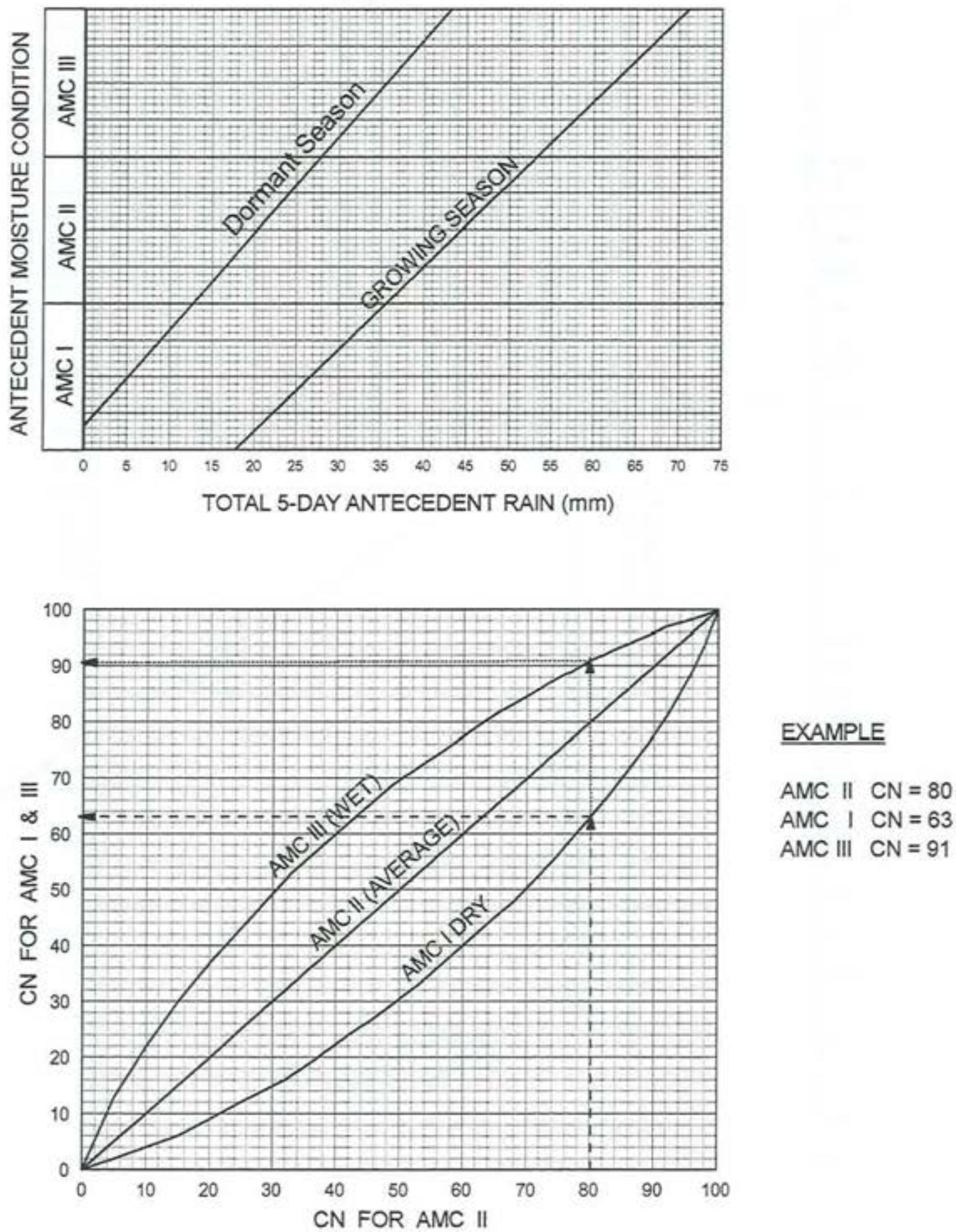

Figure 6: CN Conversion Design Charts

Source: The Ontario Ministry of Transportation, MTO Drainage Management Manual, (1997)

13.0 Typical Total Impervious Area and Directly Connected Impervious Area Values

Table 1 gives examples of suggested total impervious area (T.I.M.P.) and directly connected impervious areas (X.I.M.P.) values, based on land use, for the macro-level studies. These values can be used with the information available for the Site to determine area weighted values for the catchment of interest. The best available information should be utilized in the design, modelling and calculations.

Table 1 – Suggested T.I.M.P. and X.I.M.P. Values

Land Use	X.I.M.P.	T.I.M.P.
Estate Residential	20	40
Low Density Residential (i.e., Single Units)	45	55
Medium Density Residential (i.e., Semi-detached Units)	45	65
High Density Residential (i.e., Townhouse Units)	55	75
School	55	55
Commercial	85	85
Park	0	0

14.0 Typical Initial Abstraction Values

The following table includes a selection of land cover types and their typical abstraction values which are commonly accepted. The best available information should be utilized in the design, modelling and calculations.

Table 2 – Typical Initial Abstraction Values

Land Cover Type	Initial Abstraction (mm)
Impervious areas	2
Pervious areas – i.e., lawns	5
Pervious areas – i.e., meadow lands	8
Pervious areas – i.e., wood lands	10

15.0 Modified Curve Number (CN*) Calculation Methodology

The following excerpt from the VO2 2.0 Reference Manual outlines the steps necessary to follow for the CN to CN* modification. CN* is a required input for hydrologic modelling using HYMO software.

15.1 Modified Curve Number, CN*

The Modified Curve Number method was first proposed by Paul Wisner & Associates in 1982, and was based on their research and monitoring of rural and urban catchments in Canada. This method has been used successfully in Canada for the past 20 years and has correlated well with measured flows.

Rather than having a varying **IA** parameter, as in the SCS method, the **IA** is fixed, as described above, and the **CN** is altered. The modified **CN**, called **CN*** is a function of the **IA**, and total rainfall. **CN*** is calculated as follows:

- Select an appropriate **IA** (see above) for catchments being modelled.
- Determine the SCS **CN** value from soils maps and/or calculations. Convert the **CN** (AMC II conditions) to a **CN** (AMC III conditions).
- Determine the largest precipitation volume, P, for a rainfall event that would just represent AMC III soil moisture conditions. In most cases this is the 100 year storm event. For example, in Markham Ontario the 100 year storm volume for the 3 hour storm is 80 mm.
- Calculate the soil storage S, based on the SCS Method using CN (AMC III conditions). The metric equation is $S = (25400 / CN) - 254$ and the imperial equation is $S = (1000 / CN) - 10$. This will give you the soil storage during your large storm event.
- Calculate the **IA** based on the SCS Method, where $IA = 0.2S$. Note that this relationship is also valid for the Modified CN Method because it is assumed that the runoff volume, Q, for large events is the same using both methods.
- Determine the runoff volume, Q, based on the familiar:
  $Q = (P - IA)^2 / (P - IA + S)$
- Next calculate S* using the above equation again but this time setting **IA** to the value calculated for the Modified CN method (i.e. 1.0mm to 5.0mm). This IA will be the value used in the model simulations.
- Once you have calculated S*, calculate **CN*** from the equation:
  $S^* = (25400 / CN^*) - 254$ metric
  $S^* = (1000 / CN^*) - 10$ imperial
- The above calculation will give you the **CN*** for AMC III soil conditions. You now finally determine the **CN*** for AMC II soil conditions by using published tables relating CN for AMC II and AMC III conditions.

The above method is easily adaptable to a spreadsheet so that for future uses, you can easily and quickly calculate the **CN*** once you know the **IA**, P, and **CN**.

Figure 7: Modified Curve Number (CN*) Calculation Methodology

Source: Visual OTTHYMO v2.0., Reference Manual, (July 2002)

16.0 Hurricane Hazel Areal Reductions

The areal reductions for drainage catchments larger than 25 square kilometres are presented in Design Chart 1.03 from the MTO manual below.

	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

Figure 8: Hurricane Hazel Areal Reductions

Source: Ministry of Transportation Ontario, MTO Drainage Management Manual, (1997)

17.0 Timmins Storm Areal Reductions

The areal reductions for drainage catchments larger than 25 square kilometres are presented below. Reference Design Chart 1.04 from the MTO manual below.

	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	8	0.3	4
	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

Figure 9: Timmins Storm Areal Reductions

Source: Ministry of Transportation Ontario, MTO Drainage Management Manual, (1997)

18.0 Time Of Concentration Calculation – Uplands Method

The Upland's Method is a technique used for calculating time of concentration in relationship to the catchment slope, catchment flow length and velocity. The following table should be used to determine time of concentration.

Upland's Method

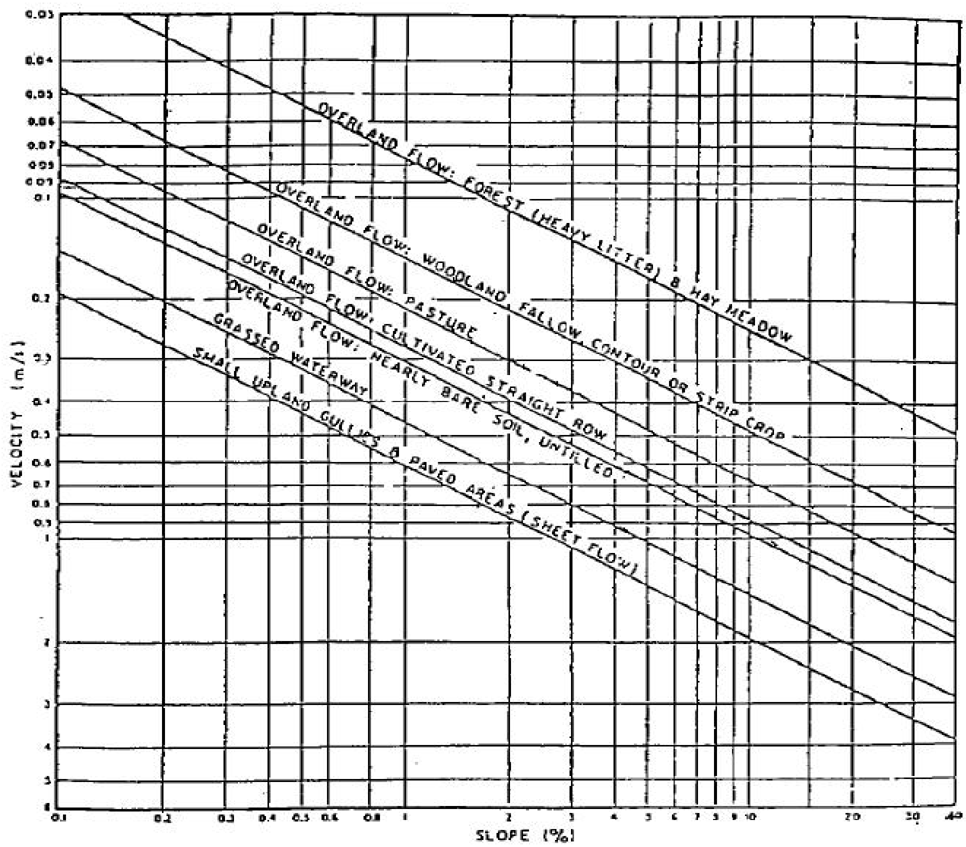

Figure 1: Uplands Method of Estimating Time of Concentration (SCS National Engineering Handbook, 1971)

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.

Figure 10: Time of Concentration Calculation – Uplands Method

Source: Visual OTTHYMO v2.0., Reference Manual, (July 2002)

19.0 Time of Concentration Calculation – Bransby Williams Method

The following Bransby Williams method for determining Time of Concentration applies where the run-off coefficient (C) value is greater than 0.4. Reference Design Chart 1.11 from the MTO manual below.

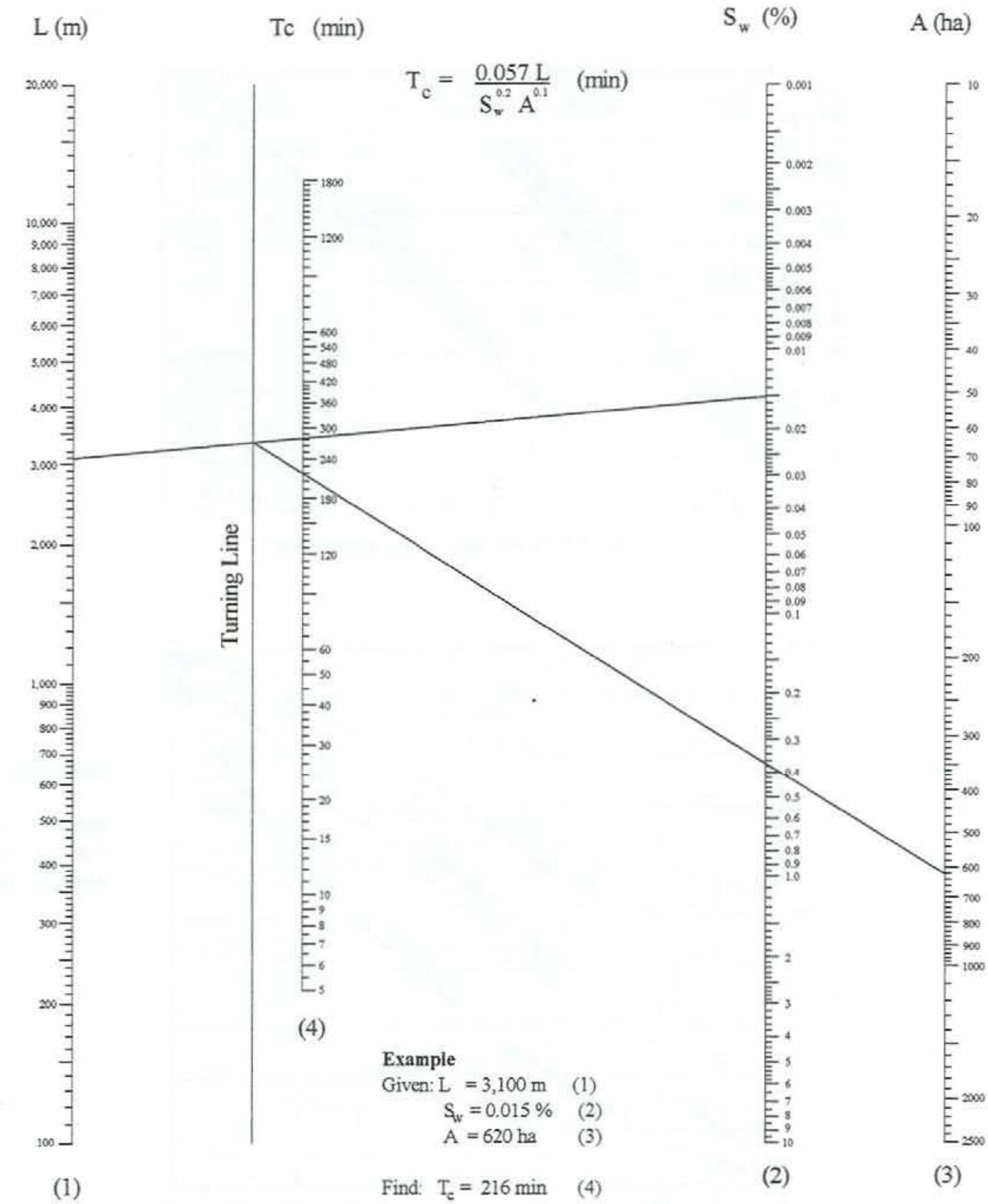

Figure 11: Time of Concentration Calculation – Bransby Williams Method

Source: The Ontario Ministry of Transportation, MTO Drainage Management Manual, (1997)

20.0 Time Of Concentration Calculation – Airport Method

The following Airport method for determining Time of Concentration applies where the run-off coefficient (C) value is less than 0.4. Reference Design Chart 1.12 from the MTO manual below.

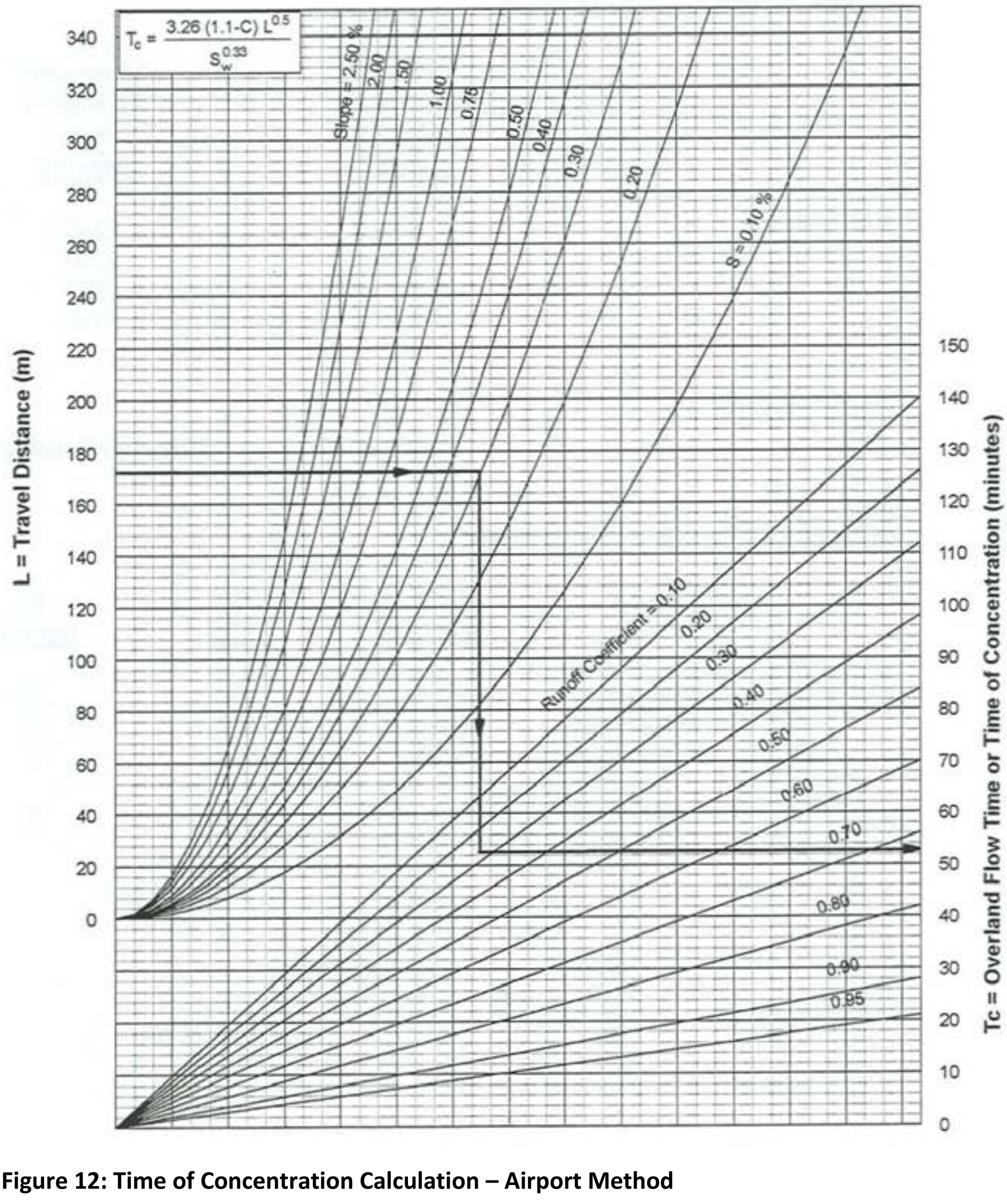

Figure 12: Time of Concentration Calculation – Airport Method

Source: The Ontario Ministry of Transportation, MTO Drainage Management Manual, (1997)

21.0 Run-Off Coefficients

21.1 Urban

The following Design Chart 1.07 from the MTO manual outlines urban land use runoff coefficients for the 5 and 10-year storms.

Land Use		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 flat or permeable surfaces, use the lower values. For steeper or more impervious surfaces, use the higher values. For return period of more than 10 years, increase above values as 25-year - add 10%, 50-year - add 20%, 100-year - add 25%.

The coefficients listed above are for unfrozen ground.

Figure 13: Urban Runoff Coefficients

Source: Ministry of Transportation Ontario, MTO Drainage Management Manual, (1997)

21.2 Rural

The following Design Chart 1.07 from the MTO manual outlines rural land use runoff coefficients.

Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED			
Flat 0 - 5% Slopes	0.22	0.35	0.55
Rolling 5 - 10% Slopes	0.30	0.45	0.60
Hilly 10- 30% Slopes	0.40	0.65	0.70
PASTURE			
Flat 0 - 5% Slopes	0.10	0.28	0.40
Rolling 5 - 10% Slopes	0.15	0.35	0.45
Hilly 10- 30% Slopes	0.22	0.40	0.55
WOODLAND OR CUTOVER			
Flat 0 - 5% Slopes	0.08	0.25	0.35
Rolling 5 - 10% Slopes	0.12	0.30	0.42
Hilly 10- 30% Slopes	0.18	0.35	0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes	0.40	0.55	0.75
Rolling 5 - 10% Slopes	0.50	0.65	0.80
Hilly 10- 30% Slopes	0.55	0.70	0.85
LAKES AND WETLANDS	0.05		

2 Terrain Slopes

3 Interpolate for other values of % imperviousness

Figure 14: Rural Runoff Coefficients

Source: Ministry of Transportation Ontario, MTO Drainage Management Manual, (1997)

22.0 Ontario Regulation 179/06 Defining Regulatory Storms

The Authority has three different regulatory storms within our jurisdiction. The following excerpt, taken from the Ontario Regulation 179/06 Implementation Guidelines, defines the watershed/watercourses where each storm is applied to generate the regulatory storm flood limit.

Flood Event Standards:

> 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).

23.0 Minimum Requirements for Hydrologic Modelling and Analysis

If there is a discrepancy between the Authority, Municipality, NDMNRF or MECP requirements for hydrologic modelling and analysis, then the more conservative criteria will apply.

The minimum requirements for hydrologic modelling and analysis include the following:

- Pre- and post-development scenarios including,
  - Catchment delineation and schematics
  - Digital copy of input and detailed output files and associated rainfall input (i.e., 4hr Chicago; 6hr, 12hr, 24hr SCS Type II; design storms; regional storms with areal reductions)
- Excerpt of Municipal IDF data (where applicable),
- Digital copies of the topographic information,
- Future conditions land use plan mapping,
- Summary tables and sample calculations at a minimum for supporting model input parameters:
  - catchment area
  - flow length and slope
  - time to peak
  - CN and CN*

- runoff coefficients
- initial abstraction
- total and directly connected imperviousness such as X.I.M.P. and T.I.M.P.
- Manning's roughness coefficients
- channel routing slope and cross-sections
- reservoir and pond rating tables
- natural storage area information
- AMC conditions
- Areal reductions applied

- Calibration or validation methodologies and their results, as applicable,
- Documentation of the analysis and citations for all supporting reference information (if applicable), and
- All engineering drawings signed and stamped as applicable to the minimum requirements identified in Appendix K.

24.0 References

American Iron and Steel Institute, Modern Sewer Design, Canadian Edition, 2007.

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Chow, V.T., D. R. Maidment and L. W. Mays, Applied Hydrology, Mc-Graw-Hill. 1988.

Clarifica. Visual OTTHYMO Version 2.0, Reference Manual, April 2002.

Cole Engineering Group Ltd. Visual OTTHYMOTM v2.4 Reference Manual, September 27, 2011.

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

Lake Simcoe Protection Act, 2008, S.O. 2008, c.23.

Lake Simcoe Region Conservation Authority, Ontario Regulation 179/06 Implementation Guidelines, 2021.

Ontario Ministry of Natural Resources, River and Stream Systems: Flooding Hazard Limit Technical Guide, 2002.

Ontario Ministry of Natural Resources, Technical Guide River and Stream Systems: Flooding Hazard Limit, 2002.

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 Natural Resources, Technical Guide – River and Stream Systems: Erosion Hazard Limit, 2002b.

Ontario Ministry of Transportation, MTO Drainage Management Manual, Queens Printer for Ontario, 1997.

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

U.S. Department of Agriculture, Natural Resources Conservation Service, Urban Hydrology for Small Watersheds TR55, June 1986.

Appendix D

Low Impact Development Design Guidance

Low impact development (L.I.D.) facilities may be used to address volume control, water quality, phosphorus reduction, and water balance criteria, subject to specific site conditions. L.I.D. design guidance is outlined below.

Seasonally High Groundwater Levels

- The groundwater levels need to be determined early in the process and prior to the selection and design of an appropriate L.I.D. measure(s).
- The seasonally high groundwater levels need to be determined using monitoring wells with measurements obtained throughout the year (i.e., 12 months of continuous monitoring data), at the location of the proposed L.I.D. facility.
- A 1 m vertical separation distance is recommended between the seasonal high groundwater table and the bottom of the L.I.D. facility.
- Please note that if a reduced clearance (based on current provincial guidelines) from the invert of the feature to the seasonally high groundwater elevation is requested, or if pro-rating of the facility is requested, then pre-consultation with Authority, the municipality and the MECP is recommended. (This only applies to volume control and water balance criteria).
- The ability to infiltrate utilizing below ground facilities is dependent on final grading.

In-situ Infiltration Rates

- In-situ infiltration testing needs to be determined early in the process and prior to the selection and design of an appropriate L.I.D. measure(s).
- Refer to the Site Evaluation and Soil Testing Protocol for Stormwater Infiltration section with the Low Impact Development Stormwater Management Planning and Design Guide.
- To convert hydraulic conductivity to percolation time, to infiltration rate please use Table C1 (Approximate relationships between hydraulic conductivity, percolation time and infiltration rate), Appendix C, of the Low Impact Development Stormwater Management Planning and Design Guide.
- Please note that if fill is proposed in the vicinity of infiltration measures, then the fill would need to be conducive to infiltration.

Safety Factor

- The infiltration rate used to design an infiltration L.I.D. must incorporate a safety correction factor that compensates for potential reductions in soil permeability due to compaction or smearing during construction, gradual accumulation of fine sediments, etc.
- Refer to Table C2 (Safety correction factors for calculating design infiltration rates), Appendix C, of the Low Impact Development Stormwater Management Planning and Design Guide.

Sizing Requirements

The following sources can assist with sizing L.I.D. facilities with respect to drawdown times, maximum allowable depth, bottom area, target design volumes, water quality and volume control, etc.:

- MOE, Stormwater Management Planning and Design Manual, March 2003
- Sustainable Technologies Wiki Guide
- Low Impact Development Stormwater Management Planning and Design Guide, 2010

Phosphorus Loading / Reduction

The following sources can be used to determine phosphorus reduction / loading for individual L.I.D. measures:

- MECP P-Tool
- Low Impact Development Treatment Train Tool (L.I.D. TTT)

Please note these two tools are independent of each other and can not be mixed and / or matched.

Contributing Drainage Area, Groundwater levels, and Design Details

- Provide a plan showing which drainage areas (labelled in hectares, and percent impervious) contribute to the proposed L.I.D. measure(s)
- Provide several cross-sections through the L.I.D. measure showing the seasonally high groundwater table
- Provide a design detail for each selected measures with dimensions displayed

Commercial / Industrial / Institutional Sites, and Hot Spots

- For commercial, industrial and institutional sites, infiltration may only be permitted from clean surfaces such as rooftops and landscaped areas.
- For pollution hotspots, such as gas stations, infiltration is only permitted from clean surfaces such as rooftops and landscaped areas.

Quantity Control

- Infiltration is generally not permitted for quantity (peak flow) control without pre-consultation with the Authority and following Appendix B.

L.I.D. Protection During Construction Phase(s)

- L.I.D. practices that may be compromised because of inadequate protection during construction are those applied at or below ground level to infiltrate stormwater.
- Please refer to the Erosion and Sediment Control Guide for Urban Construction 2019 prepared by TRCA, for appropriate ESC measures.

Hydrologic Modelling for L.I.D. Facilities

- Hydrologic parameters should not be adjusted to reflect proposed L.I.D. facilities (no accounting for IA, no changing of hydrologic parameters, no routing of inflow, absolute capture volume, etc.).

Building Structural Setbacks

- All L.I.D. measures should have a minimal setback of 4 m from any building structure.
- Roof top disconnect should end 3m away from any building structure and should ideally discharge to a splashpad.

L.I.D. Facilities on Private Property

It is preferred that L.I.D. facilities are on public lands or within an easement in favour of the municipality and accessible for inspection and maintenance. This should always be the first approach taken as it would ensure the long-term viability of the SWM feature.

If this is not possible, the Authority may consider L.I.D. facilities on private property on a site-by-site basis, subject to municipal support (1) and (2):

- L.I.D. facilities are to be accessible for inspection and maintenance.
- L.I.D. facilities should be located in such a way as to prevent future interference (not across property lines, i.e., not continuous)
- Written confirmation from the municipality that they agree to include a warning clause within the subdivision agreement, as well as registered on title, indicating that all future purchasers/owners are informed about the SWM infrastructure on their properties and are obligated to maintain this infrastructure.
- A landowner's information package provided to all existing and current property owners outlining how the systems are to be maintained.

(1) Credit may be considered only for water balance, volume control and phosphorus (subject to site conditions).

(2) Please note that the above is based on policies in place at the time of publication of this document. Should provincial guidance or requirements change, the policies around L.I.D. facilities on private property may change.

L.I.D. Planting Guidelines

Please refer to Appendix H.

Infiltration vs Filtration Facilities

Infiltration and filtration facilities are both useful to achieve stormwater management targets. Careful consideration of the type of facility to be implemented (infiltration vs filtration) needs to occur on a site-specific basis, depending on soils and groundwater conditions.

It should be noted that infiltration and filtration L.I.D. facilities have separate and distinct design criteria (no liner vs liner, no underdrain vs underdrain, storage volume calculations, etc.)

Infiltration facilities requirements would include, but not limited to:

- Pre-treatment is required (e.g., vegetated filter strips, grassed swales, gravel diaphragm, etc.)
- No liner
- Generally, greater than 15 mm/hr in-situ infiltration rate (before the factor of safety is applied)
- Greater than 1 m of clearance from the invert of the measure to the seasonally high groundwater elevation
- Overflow pipe (located above active storage/top of facility)
- Generally, storage volume provided/calculated below the invert of an overflow pipe is eligible for infiltration and volume control credit.

Examples of Infiltration facilities would include:

- Soak-away pits
- Infiltration trenches / basins / chambers
- Permeable pavements with an infiltration substructure
- Bioretention areas
- In some instances, Enhanced grass swales
- Etc.

Filtration facilities requirements would include, but not limited to:

- Pre-treatment is required (river stone or rip rap and/or dense vegetation, gutter screens, etc.)
- Impermeable liner
- Less than 1 m clearance from the invert of the measure to the seasonally high groundwater elevation
- Generally, less than 15 mm/hr in-situ infiltration rate (before the factor of safety is applied)
- Would include an underdrain/subdrain
- Generally, storage volume provided/calculated above the obvert of the sub-drain is eligible for infiltration and volume control credit.

Examples of Filtration facilities would include:

- Soak-away pits with impermeable liner and a sub-drain
- Porous pavements with a filtration substructure
- Rain gardens
- Etc.

Appendix E

Phosphorus Loading

To obtain a phosphorus removal credit, a best management practice (BMP) needs to be constructed as part of the proposed development. Phosphorus removal credit(s) will not be applied to existing natural features such as wetlands or stream buffers.

Phosphorus loading and percentage removal efficiencies are to comply with the applicable phosphorus tool (Ministry of the Environment (MOE) Tool, 2012 or latest version, or the low impact development (L.I.D.) TTT Tool) and associated documentation, unless otherwise specified below.

Supported Phosphorus Percentage Removal Efficiency by Tool

Ministry of the Environment (MOE) Tool

MOE Lake Simcoe Phosphorus Loading Development Tool (2012), including the supporting report titled "Phosphorus Budget Tool in Support of Sustainable Development for the Lake Simcoe Watershed" (Hutchinson, March 2012).

Land uses are to be consistent with Table 1 in the Hutchinson report.

Subsequent versions of this tool and documentation should be used to obtain the latest Ministry of the Environment, Conservation and Parks (MECP) accepted removal rates:

- Constructed Wetlands – 77%
- Dry Detention Ponds – 10%
- Infiltration Trenches – 60%
- Perforated Pipe Infiltration / Exfiltration System (not infiltration trenches) – 87%
- Sand or Media Filters – 45%
- Sorbtive Media Interceptors – 79%
- Vegetated Filter Strips / Stream Buffers – 65%
- Wet Detention Ponds – 63%
- Enhanced swale – 25%
- Oil and Grit Separators (O.G.S.) units, Environmental Technology Verification (ETV) verified – 20% (unless otherwise stated by ETV)
- Filter units (ETV verified/ Technology Assessment Protocol-Ecology (T.A.P.E.) approved) – 40% (unless otherwise verified by ETV/ T.A.P.E.)

Note: Facilities are to be designed in accordance with the MECP and Sustainable Technologies Evaluation Program (STEP) World Internet Knowledge Index (WIKI) L.I.D. Guidelines, to achieve enhanced quality control in order to be eligible for the above phosphorus reduction credits.

L.I.D. TTT Tool

- The default rates included within the L.I.D. TTT Tool should not be altered.

Note: 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. In cases where studies provide maximum, median, and minimum removal values, the median values shall be used, subject to Authority approval.

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 modelling software such as a current version of stream modelling softwater (Geo-X) or approved equivalent to model the existing conditions and determine the targets of erosion thresholds;
- Model the proposed conditions with stormwater management (SWM) controls;
- Compare the erosion potentials and adjust the proposed release rates and storage, such that the existing conditions are not exceeded; and
- Depending on site-specific conditions, a frequency – duration - exceedance analysis may be required using a continuous simulation to compare pre-development and post-development conditions.

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
- Hydraulic Modelling
- Bankfull Hydraulic Parameters
- Stability Thresholds
- Calculation of Threshold Discharges
- Hydrologic Model Configuration (existing and 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

Erosion and Sediment Control Minimum Requirements

1.0 Erosion and Sediment Control Plans, Drawings and Details

This section includes the minimum requirements for erosion and sediment control (ESC) plans, drawings, details, reports and supporting calculations. If there is a discrepancy between these minimum requirements and local Municipal requirements, then the more conservative requirements will apply. Typical ESC details sheets are included at the end of this section.

a) Identify approved development and regulatory limits on submitted plan:
   - Development limits for site i.e., to clarify that all works are within the development limit;
   - Floodplain elevations and floodplain limit for the 100-year storm event and the regulatory event as applicable, within the area of interest. Include a reference for the modelling and mapping source;
   - Identify the erosion hazard limit and source; and
   - Any other regulatory limit as applicable, within the area of interest.

b) Separate phase and / or stage drawings including notes and details sheets:
   - The phasing or stages must be clear from the plans (clearing and grubbing, topsoil stripping, grading/earthworks, site servicing, building construction, and restoration) and need to be itemized and shown on all ESC plans;

c) Drawings should clearly identify the following ESC information and details as applicable:
   - Contours and / or digital terrain model (DTM) points for existing and proposed elevations at each phase of construction;
   - A note indicating that all sediment control measures must be installed prior to the commencement of site works;
   - Notes on the inspection and maintenance of sediment controls are to be included in the ESC drawing set. Sediment controls should be inspected on a regular basis and after every significant rainfall event. Repairs to ESC measures must be completed in a timely manner to prevent sediment migration;
   - Notes requiring that additional materials such as clear stone, filter fabric, pumps, hoses and siltsoxx to be kept onsite at all times for conducting repairs to sediment control measures;
   - A statement is to be provided in the ESC drawing notes requiring "all disturbed areas left inactive for more than thirty days are to be stabilized". Identify seed mix and / or stabilization measures within note and / or detail;
   - A note must be included on the ESC drawing that engineered changes to the ESC measures may be required as Site conditions change;
   - Construction access mats are to be installed at all construction entrances and exits;
   - A sediment control fence detail that is consistent with the Authority standard is to be used. Heavy duty sediment control fences are to be installed downslope of all disturbed areas, see detail ESC-4. Double row sediment control fence will be required upstream of natural heritage features and as Site conditions require, see detail ESC-5;

- Cut-off swales and ditches are to be shown as directing overland flow to the appropriate sediment trap or temporary sediment pond;
- Check dams are to be shown in all swales and ditches. Swales and ditches at a minimum must be designed to convey the flow from a 5-year design storm. Municipalities may have additional requirements for swale sizing and capacity. The Authority may also require sizing for the flows resulting from 100-year storm as Site specific conditions dictate;
- Temporary sediment control traps are to be shown at low points accepting less than 2 hectares (h.a.) of overland drainage. The preferred sizing for temporary sediment control trap is to provide a storage volume of 185m^3 / h.a. At a minimum, temporary sediment traps are to be sized to provide a storage volume of 125 m^3 / h.a. All temporary sediment control traps are to provide appropriate outlet protection;
- In general, temporary sediment ponds should have a contributing drainage area of no more than 10 h.a. In some site-specific instances, there may be restrictions that need to be accommodated such as site outlet constraints, grading constraints and phasing. In cases where restrictions are present, intermediate controls (i.e. sediment traps used upstream of the temporary sediment pond) should be used to provide at source controls for contributing drainage areas greater than 10 h.a. and the temporary sediment pond would be sized for the full contributing drainage area. Refer to Note 4 below for additional clarification on temporary ESC Pond required components. Additional reference information can be found on details sheet ESC-7;
- A general overall Site plan showing areas of cut and fill is to be provided. i.e. the typical green / red mass balance drawing is an example of this information;
- For fill within regulated areas, the volume and source of the fill are to be shown on a drawing(s). The supporting calculations are to be provided for the cut and fill analysis;
- Stockpile locations are to be shown on the drawing(s) in accordance with the following criteria:
  - The height of the stockpile material shall not exceed 8.0 metres;
  - The side-slope of the stockpile shall not exceed 2:1;
  - The bottom of the stockpile shall be located a minimum distance of 15.0 metres from a municipal road, provincial road, waterway and/or a waterbody;
  - The bottom of the stockpile shall be located a minimum distance of 8.0 metres from the property-line or alteration limit, whichever is most conservative;
  - Erosion control shall be provided at the base of the stockpile to intercept sediment;
  - Stockpiles are to be located outside of the regulatory floodplain limit;
  - Stockpiles left in place more than 30 days shall be stabilized with a tarp, mulch, vegetated cover, other acceptable means or as directed by the engineer; and
  - Construction operations are to be carried out in a manner that erosion and sediment migration of sediment is minimized;

- Dewatering notes and details must be identified in the ESC drawing set at the appropriate ESC stage / phase, and as needed due to changing Site conditions;
- A drawing note is required identifying that "the Site trailer location, equipment storage, refueling area and hydrocarbon storage are to be located outside of the regulated area limit". If the entire site falls within a regulated area, the Authority and municipality should be consulted to determine a suitable refuelling and storage locations. This location is to be clearly shown on the drawings;
- A note is required identifying Ministry of Environment, Conservation, and Parks (MECP) spills action centre contact and number on ESC drawings;
- A note indicating that the contractor will be responsible for clean-up and restoration, including all costs, due to the release of sediment from the Site;
- Include proposed storm sewer alignments on appropriate phase or stage drawing; and
- A sample site plan showing sediment controls to be installed during home building on individual lots (applicable to large estate residential lots only).

d) Temporary ESC Pond components identified as applicable:
- Temporary ESC ponds are to be individually sized for both the permanent pool component and active storage component based on the following requirements:
    - For the permanent pool component, temporary ESC ponds are to be sized to provide 185 m^3/h.a. of storage; and
    - The active storage component is to be sized to provide a minimum storage of 125 m^3/h.a. with a minimum 48-hour drawdown time and a minimum 4:1 length to width ratio. If the minimum 48-hour drawdown time and / or the minimum 4:1 length to width ratio cannot be met, then an active storage volume of 185 m^3/h.a. will be required.
- Temporary ESC pond sized as outlined above and supported with calculations and appropriate ESC measures. i.e. as applicable outlet with orifice, emergency overflow weir, low flow outlet dispersion dam, animal protection grate, all components in details, freeboard, spot elevations, sections provided through outlet and across pond, etc.;
- Temporary ESC ponds are to have filter fabric / clear stone wrapped hickenbottom riser outfalls (with anti-seepage collars) and rip rap (or equivalent erosion protection) overflow weirs. Reference Detail Sheet ESC-7. The outlet must have an animal protection grate and a flow dispersion dam or suitably designed flow spreader, unless outletting directly to a storm sewer. The emergency overflow weir must be sized at a minimum to convey the 100-year storm event;
- Notes on the construction of the pond berms to be included on the appropriate ESC drawing (i.e., acceptable soils with low permeability to be used, 95% Standard Proctor Maximum Dry Density compaction, inspection to be completed by a geo-technical engineer);
- Stage / storage table with supporting calculations for the temporary ESC pond is to be included in the design submission; and

- Emergency overflow weir and orifice included on drawing detail. Drawdown calculations are to be provided in the submission.

e) ESC details must be provided to support the ESC plan. Erosion and sediment control measures used on Site must be equal or better than those identified in the Erosion and Sediment Control Drawing Index in section 2.0.

2.0 Erosion And Sediment Control Drawing Index

Table 1 – ESC Drawing and Corresponding Number

Drawing	Drawing Number
Erosion and Sediment Control Plan Notes	ESC-1
Swale and Rock Check Dam	ESC-2
Construction Access Mat	ESC-3
Sediment Control Fence	ESC-4
Double Row Sediment Control Fence	ESC-5
Stockpile Siltation Control	ESC-6
Temporary Sediment Pond and Outlet Details	ESC-7

The Authority's applicable ESC design detail drawings can be found on the following pages.

EROSION AND SEDIMENT CONTROL NOTES:

1. ALL SEDIMENT CONTROL MEASURES SUCH AS SEDIMENT CONTROL FENCE, TEMPORARY PONDS, CONSTRUCTION ACCESS MATS, SEDIMENT TRAPS, SWALES AND CHECK DAMS MUST BE INSTALLED PRIOR TO THE COMMENCEMENT OF SITE WORKS.
2. SEDIMENT CONTROLS SHOULD BE INSPECTED ON A REGULAR BASIS AND AFTER EVERY SIGNIFICANT RAINFALL EVENT. REPAIRS TO ESC MEASURES MUST BE COMPLETED IN A TIMELY MANNER TO PREVENT SEDIMENT MIGRATION.
3. ADDITIONAL MATERIALS SUCH AS CLEAR STONE, FILTER FABRIC, PUMPS, HOSES AND SILTSOXX TO BE KEPT ONSITE AT ALL TIMES FOR CONDUCTING REPAIRS TO SEDIMENT CONTROL MEASURES.
4. ALL DISTURBED AREAS LEFT INACTIVE FOR MORE THAN THIRTY DAYS ARE TO BE STABILIZED.
5. THE STABILIZATION SEED MIXTURE IS TO BE AS SPECIFIED ON THE EROSION AND SEDIMENT CONTROL PLAN.
6. THE STABILIZATION SEED MIXTURE IS TO BE APPLIED AT A MINIMUM RATE OF 25 kg/ha.
7. ENGINEERED CHANGES TO THE ESC MEASURES MAY BE NEEDED AS SITE CONDITIONS CHANGE THROUGHOUT THE CONSTRUCTION PROCESS. THESE UPDATES MUST REFLECT BEST MANAGEMENT PRACTICES TO CONTROL SEDIMENT AND EROSION ONSITE AND SHOULD BE COMPLETED BASED ON DIRECTION FROM THE SITE ENGINEER. ADDITIONAL MEASURES MAY BE REQUIRED AS DIRECTED BY AN ENGINEER THROUGHOUT THE CONSTRUCTION PROCESS.
8. THE CONSTRUCTION ENTRANCE MAT IS TO BE INSTALLED AS THE FIRST STEP IN THE SITE ALTERATION PROCESS.
9. SEDIMENT CONTROL FENCE IS TO BE INSTALLED DOWNSLOPE OF ALL DISTURBED AREAS. A DOUBLE ROW OF SEDIMENT CONTROL FENCE IS TO BE INSTALLED SURROUNDING ALL NATURAL HERITAGE FEATURES AND AS DIRECTED BY THE SITE ENGINEER. SEDIMENT CONTROL FENCE IS TO BE AS PER LSRCA STANDARD ESC-4 or ESC-5 AS A MINIMUM. LIGHT DUTY SEDIMENT CONTROL FENCE IS NOT ACCEPTABLE.
10. CUT-OFF SWALES OR DITCHES ARE TO BE INSTALLED AS SHOWN ON THE ESC PLANS AND AS NECESSARY BASED ON CHANGING SITE CONDITIONS TO DIRECT OVERLAND FLOW TO THE APPROPRIATE SEDIMENT TRAP OR TEMPORARY SEDIMENT POND.
11. CHECK DAMS ARE TO BE INSTALLED IN ALL SWALES AND DITCHES IN ACCORDANCE WITH DRAWING LSRCA ESC-2, AS A MINIMUM
12. TEMPORARY SEDIMENT TRAP(S) ARE TO BE CONSTRUCTED AT THE BEGINNING OF SITE GRADING AND IF THE SITE DRAINAGE CHANGES DURING CONSTRUCTION. IT MAY BE NECESSARY FOR TEMPORARY SWALES TO BE CONSTRUCTED TO DIRECT SITE FLOWS TO THE TEMPORARY SEDIMENT TRAP(S) DURING ROUGH GRADING AND AS CONSTRUCTION PROGRESSES.
13. TEMPORARY SEDIMENT POND(S) ARE TO BE CONSTRUCTED AT THE BEGINNING OF SITE GRADING AND IF THE SITE DRAINAGE CHANGES DURING CONSTRUCTION. IT MAY BE NECESSARY FOR TEMPORARY SWALES TO BE CONSTRUCTED TO DIRECT SITE FLOWS TO THE TEMPORARY SEDIMENT POND(S) DURING ROUGH GRADING AND AS CONSTRUCTION PROGRESSES.
14. FILTREXX SILTSOXX OR APPROVED EQUIVALENT TO BE INSTALLED DOWNSTREAM FROM SEDIMENT TRAP AND TEMPORARY SEDIMENT POND OUTLETS TO A MINIMUM HEIGHT OF 300mm.
15. IF STOCKPILES ARE USED ON-SITE FOR THE STORAGE OF EXCESS MATERIAL, THEY ARE TO BE IN ACCORDANCE WITH DETAIL DRAWING LSRCA ESC-6 OR BETTER.
16. ANY DEWATERING OCCURRING ONSITE MUST BE IN ACCORDANCE WITH AN APPROVED DEWATERING PLAN. ADDITIONAL DEWATERING REQUIREMENTS MAY BE DEEMED NECESSARY AND SHALL BE IMPLEMENTED AS DIRECTED BY THE ENGINEER, CONTRACT ADMINISTRATOR OR LOCAL MUNICIPALITY.
17. THE SITE TRAILER IS TO BE LOCATED ONLY AT THE DESIGNATED LOCATION SHOWN ON THE PLANS.
18. EQUIPMENT AND HYDROCARBON STORAGE IS TO OCCUR ONLY WITHIN THE DESIGNATED AREA SHOWN ON THE PLANS.
19. REFUELING IS TO TAKE PLACE ONLY WITHIN THE DESIGNATED AREA SHOWN ON THE PLANS AND SHALL BE A MINIMUM OF THIRTY METRES FROM ANY WATERCOURSE OR ENVIRONMENTALLY SENSITIVE AREA.
20. AN APPROVED SPILLS MANAGEMENT PLAN IS TO BE KEPT ONSITE.
21. SPILL CLEANUP EQUIPMENT SUCH AS ABSORPTIVE MEDIA IS TO BE MAINTAINED ONSITE FOR IMMEDIATE USE IN THE EVENT OF A SPILL.
22. SPILLS ARE TO BE REPORTED IMMEDIATELY TO THE MECP SPILLS ACTION CENTRE AT 1-800-268-6060.
23. THE CONTRACTOR WILL BE RESPONSIBLE FOR CLEAN-UP AND RESTORATION, INCLUDING ALL COSTS, DUE TO THE RELEASE OF SEDIMENT FROM THE SITE.
24. LOW IMPACT DEVELOPMENT (LID) MEASURES ARE NOT TO BE USED AS SEDIMENT CONTROL DEVICES.
25. ADDITIONAL SEDIMENT CONTROL DEVICES MAY BE DEEMED NECESSARY AND AS SITE CONDITIONS CHANGE AND SHALL BE INSTALLED AS DIRECTED BY THE SITE ENGINEER, CONTRACT ADMINISTRATOR OR LOCAL MUNICIPALITY.

NO.	REVISION	DATE
1	SWM GUIDELINES UPDATE	06.2016
2	SWM GUIDELINES UPDATE	11.2021

EROSION AND SEDIMENT CONTROL PLAN NOTES

DATE: 11.2021

SCALE: NTS

LSRCA ESC-1

Figure 1: Erosion and Sediment Control Plan Notes (ESC-1)

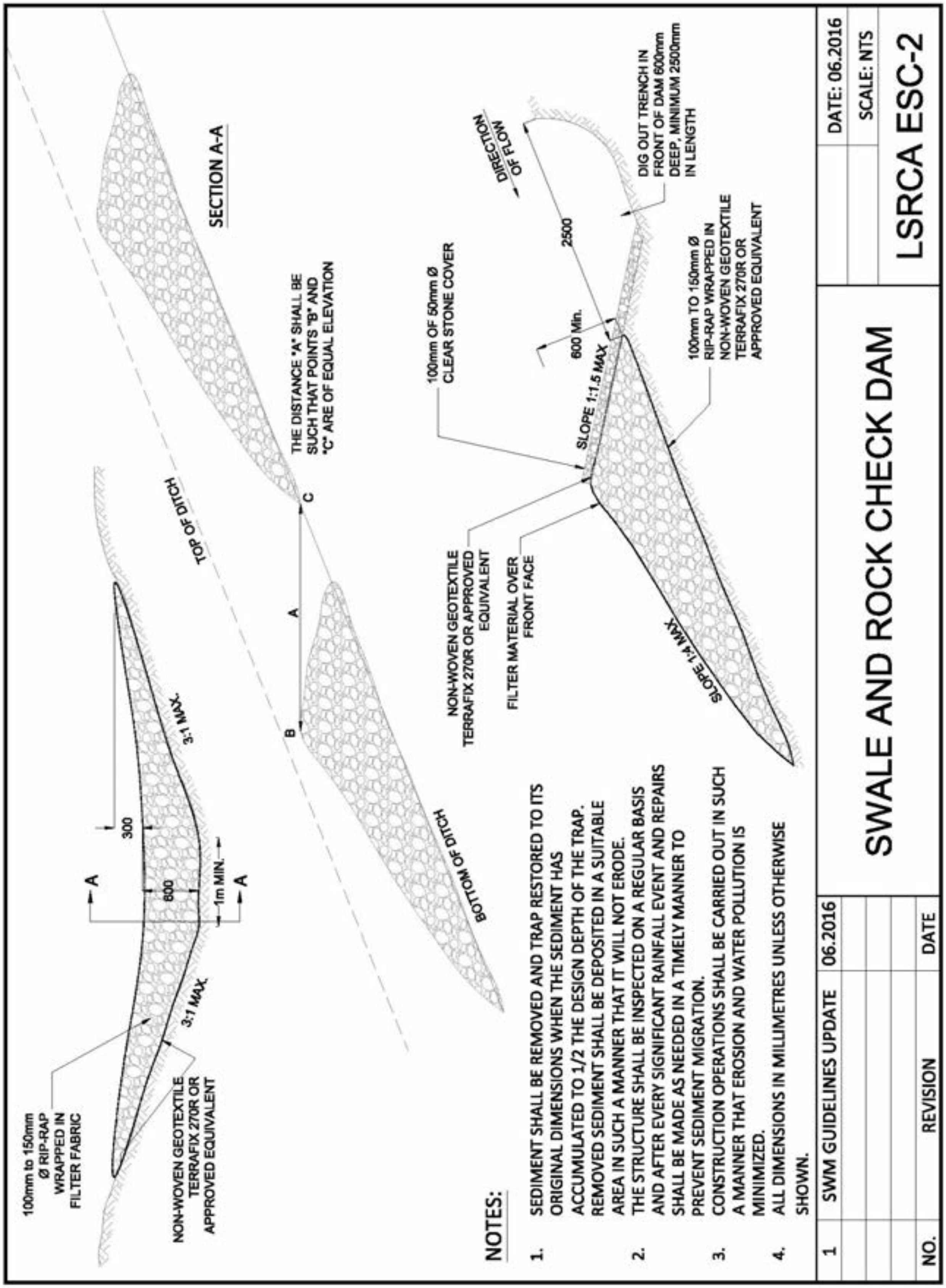


Figure 2: Swale and Rock Check Dam (ESC-2)

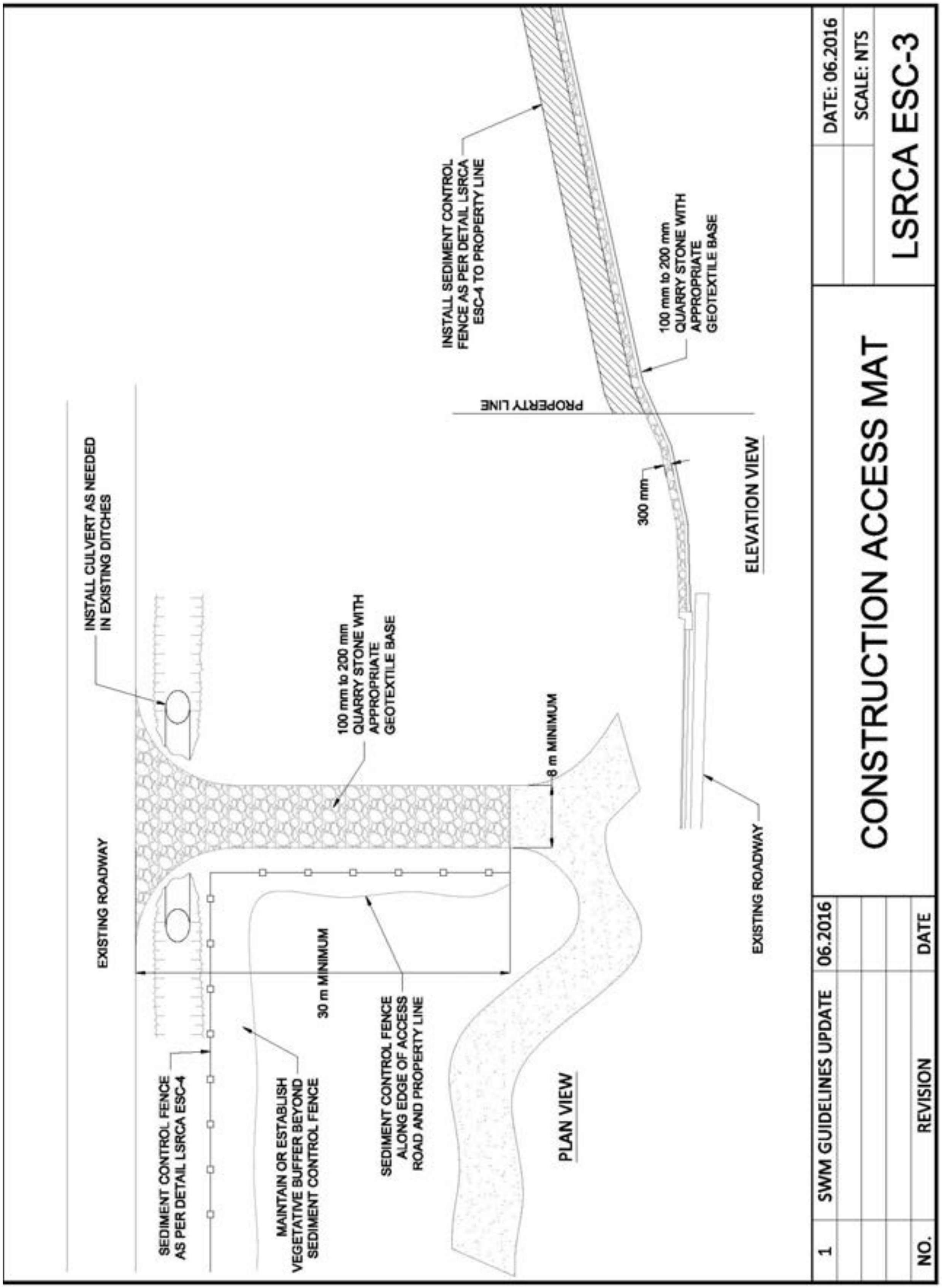
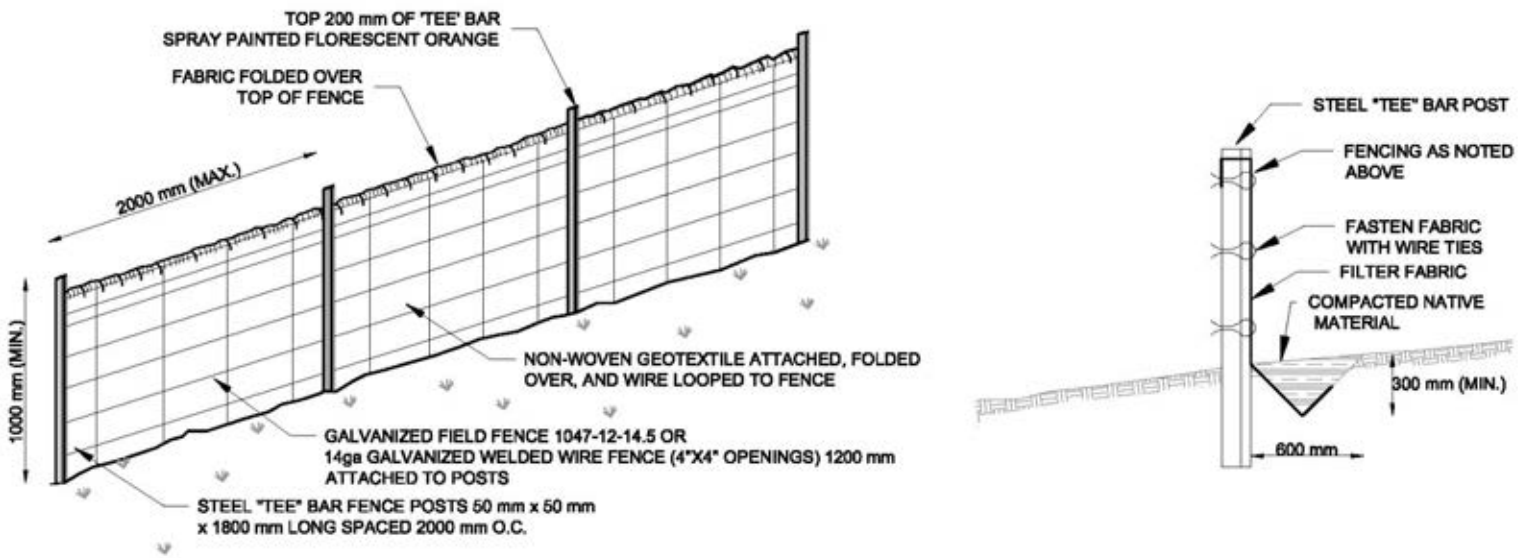


Figure 3: Construction Access Mat (ESC-3)



NOTES:

1. SEDIMENT CONTROL FENCE SHOULD BE ALIGNED WITH CONTOURS FOR SHEET OVERLAND FLOW.
2. SEDIMENT CONTROL FENCE IS TO BE LOCATED IN AREAS OF LOW SEDIMENT YIELD ON SLOPES THAT CONFORM TO MTO DRAINAGE MANUAL VOLUME 2 CHART F4-3C TOPOGRAPHIC FACTOR LS BASED ON SLOPE LENGTH AND GRADIENT.
3. SEDIMENT CONTROL FENCE SHALL BE INSTALLED WITH FILTER MEDIA FABRIC TIED INTO THE SOIL A MINIMUM OF 300 mm BY EITHER STATIC SLICING OR TRENCH METHODS WITH COMPACTION OF TRENCH MATERIAL MEETING 95% STANDARD PROCTOR DENSITY.
4. STEEL 'T' BAR POSTS ARE TO BE SPACED A MAXIMUM DISTANCE OF 2000 mm ON CENTER.
5. FROZEN GROUND CONDITIONS REQUIRE FILTER FABRIC TO BE BACKFILLED IN TRENCH WITH CLEAR STONE.
6. GEOTEXTILE FABRIC TO BE COMPRISED OF NON-WOVEN U.V. STABILIZED MATERIAL FABRIC TO BE FOLDED OVER TOP OF FENCE A MINIMUM OF 300 mm AND WIRE FASTENED.
7. CONSTRUCTION OPERATIONS SHALL BE CARRIED OUT IN SUCH A MANNER THAT EROSION AND WATER POLLUTION IS MINIMIZED.
8. ALL DIMENSIONS IN MILLIMETRES UNLESS OTHERWISE SHOWN.

NO.	REVISION	DATE
1	SWM GUIDELINES UPDATE	06.2016

SEDIMENT CONTROL FENCE

DATE: 06.2016
SCALE: NTS
LSRCA ESC-4

Figure 4: Sediment Control Fence (ESC-4)

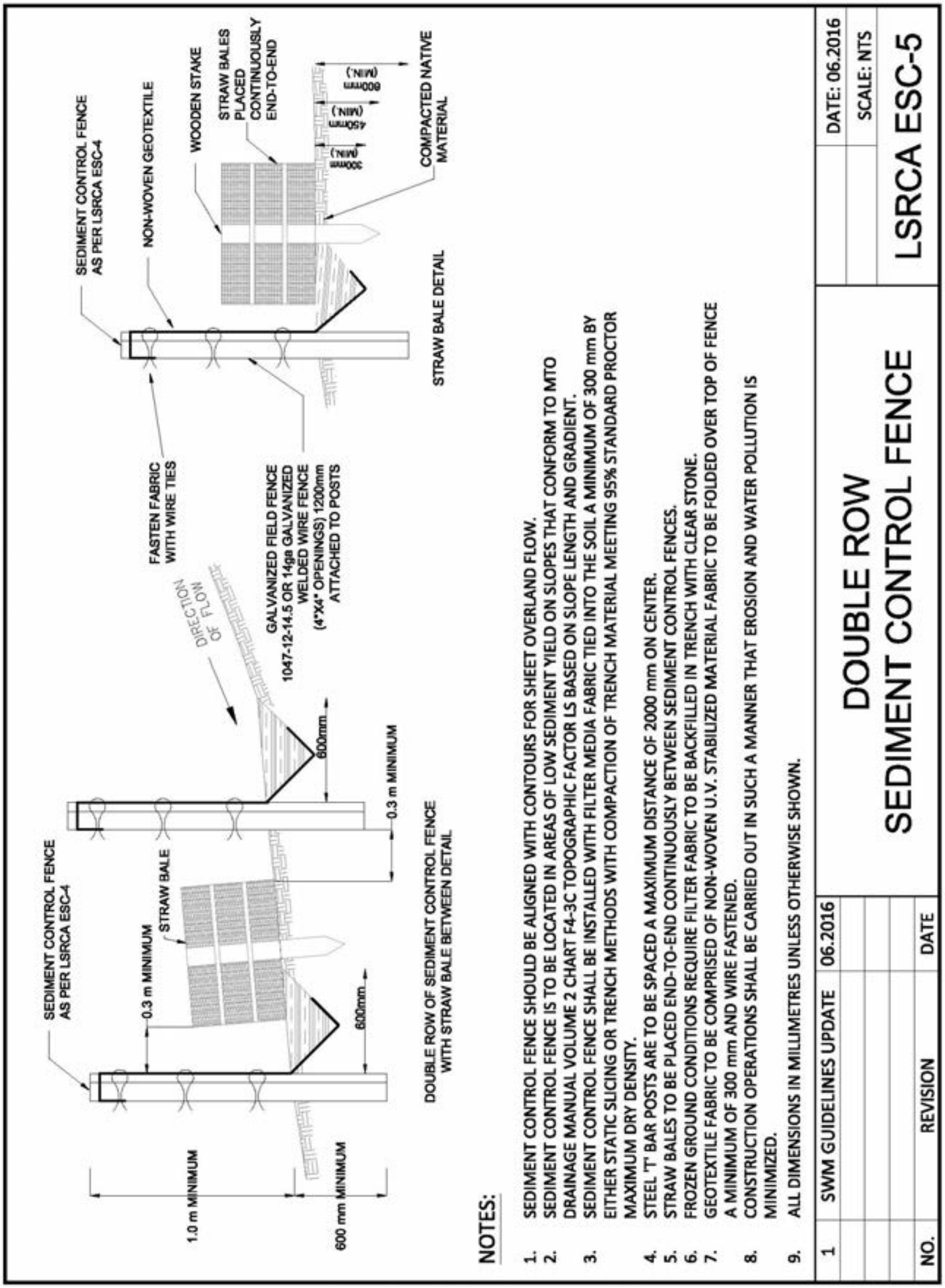


Figure 5: Double Row Sediment Control Fence (ESC-5)

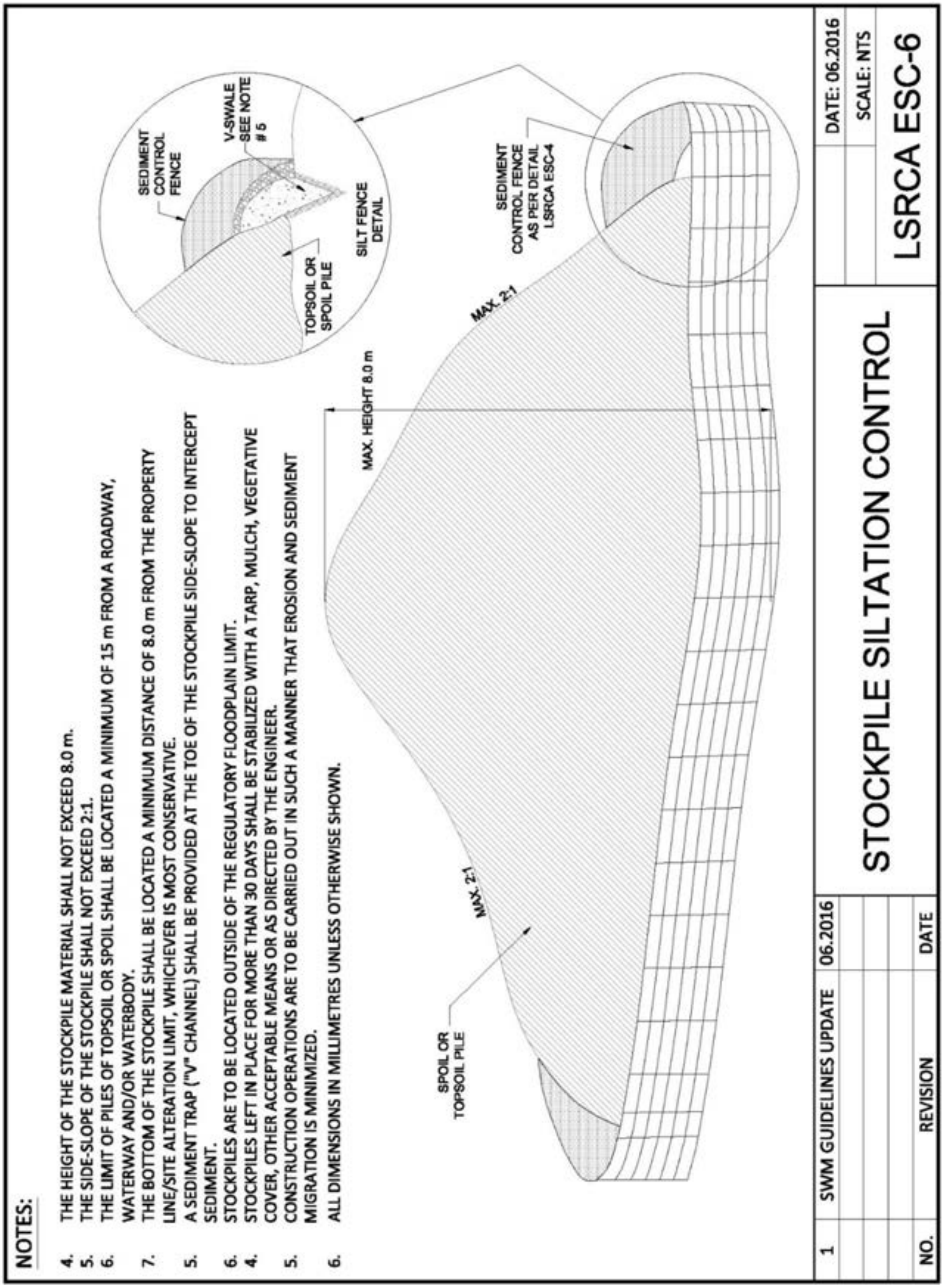


Figure 6: Stockpile Siltation Control (ESC-6)

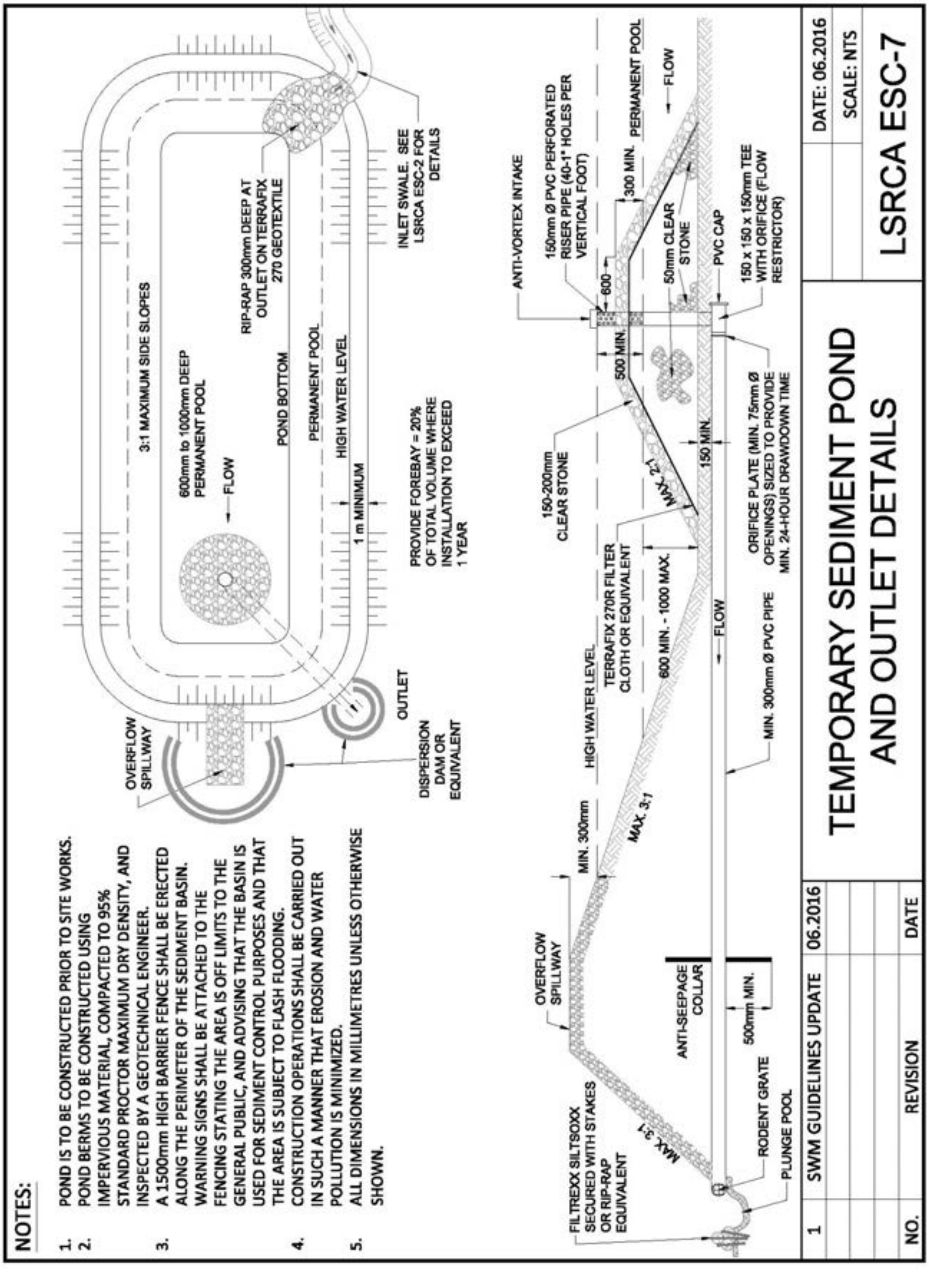


Figure 7: Temporary Sediment Pond and Outlet Details (ESC-7)

3.0 References

City of Barrie, Typical Granular Erosion Control Device Detail BSD-23B, Revision #2.

City of Barrie, Temporary Sediment Basin and Outlet Details Detail BSD-23C, Revision #1.

City of Barrie, Construction Entrance Mat Detail BSD-23D, Revision #1.

Town of Innisfil, Siltation Control Fencing Detail TOISD 503, April 2015.

Town of Innisfil, Siltation Control Fencing (Alternate) Detail TOISD 504, April 2015.

Toronto and Region Conservation Authority Sustainable Technologies Evaluation Program, Erosion and Sediment Control Guide for Urban Construction, 2019

Appendix H

Landscape and Planting Requirements Stormwater Management Facilities

(to be read in conjunction with municipal requirements)

In general, the Conservation Halton Guidelines for Landscaping and Rehabilitation Plans (Conservation Halton, July 2021), section 3.3, should be followed when preparing landscape and planting plans for stormwater management facilities. Please note that municipalities may have additional or different requirements and should be consulted.

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. The municipality is to be consulted regarding their specific planting requirements and acceptable species of plants in SWM facilities.

Appendix I

Typical Hydraulic Values and References

1.0 Hydraulic Analysis

Hydraulic analysis and/or modelling would be provided in a submission where there is potential for a revised water surface elevation and the flood limits for a Site are to be evaluated. In many cases a hydraulic analysis is accompanied by updated floodplain mapping. Floodplain mapping would be required when there are changes to floodplain elevations and changes to the floodplain delineation in a regulated area. Hydraulic analysis could be required due to alterations of existing topography, the design of a hydraulic structure or designing conveyance features. The intent of this section is to provide a summary of components that will be reviewed in support of the hydraulic submission.

1.1 Hydraulic Analysis Components

This section highlights the key components that a hydraulic submission will incorporate at a minimum, such as boundary and initial conditions, cross section data and structures. It is recognized that there could be additional information required to complete Site specific hydraulic analysis and corresponding floodplain delineation.

Boundary and Initial Conditions

Upstream and downstream boundary conditions are required inputs for any hydraulic model. Generally, the downstream boundary condition where a hydraulic model flows into Lake Simcoe has a starting water surface elevation of 219.5 m above sea level (asl). When a hydraulic model is building on a downstream existing model, the downstream boundary condition should correspond to the water surface elevation from the existing model.

For upstream boundary condition, steady state models require inflows for specific design storms which are directed by local municipalities and the Authority. Unsteady state models would require an inflow hydrograph. Model inflows are generated through hydrologic analysis. When transposing the flow values from hydrologic flow nodes into the hydraulic model, the hydraulic insertion points should be placed at the upstream limit of the corresponding catchment.

It is essential that the inflows used for the hydraulic analysis matches the supporting hydrologic analysis. There may be situations where the flow values are referenced from an approved Master Drainage Plan (MDP) or Master Environmental Servicing Plan (MESP), and excerpts must be included as an Appendix in the hydraulic analysis documentation.

Cross-Section Data

The geometry of cross-sections used to represent a topographic surface generally includes station and elevation data, as well as co-ordinates for geo-referenced analysis. Within the cross-section data there are other key pieces of information such as bank station locations, Manning's roughness parameters, contraction/expansion coefficients, downstream reach lengths and various control parameters such as blocked obstructions, ineffective area and levee points. The combination of the values provides for a mathematical analysis of Site hydraulics.

Typical values for Manning's roughness selection are provided in this Section 7.0. Consideration should be given to the different Manning's n for pipe flow as compared to those values characterizing overland flow.

Cross-sections should extend across the Site and be of sufficient length to contain the entire floodplain. Cross-sections are to be located at key points of contraction and upstream and downstream of conveyance features, with a maximum allowable distance between cross-sections along the length of the reach with continuous conditions to be no more than 100 m. The cross-section layout must be presented in a figure provided in the submission, including floodplain delineation and elevations to support this key input information.

It is important to note that the Authority has hydraulic models developed through various periods. Historically, the orientations of cross-sections were coded left to right looking upstream. In the current standard, the cross-section orientations are coded left to right looking downstream. Care must be taken when revising existing models to ensure that the cross-section orientation is considered accordingly.

Key cross-section data identified above must be collected through topographic survey or where applicable using orthophotogrametric information. As well, there are geographic information system (G.I.S.) requirements for integrated surface data, which must be incorporated into the formal submission, and these are identified in Appendix K.

Hydraulic Structures

There are various hydraulic structures that can be analyzed using hydraulic software and these conveyance structures include culverts, bridges, weirs, lateral structures and natural spill areas. Within the modelling options for culverts and bridges there is consideration given to control parameters such as structure dimensions, elevations, centerlines, tailwater on inlet control conditions, manning's roughness and losses. There are various coefficients to model losses on specific hydraulic structures and these can be found in the software reference manuals for the specific software in use.

Natural storage areas as well as natural and man-made spill areas are common features in hydraulic analysis. Although there may be no built structure information available for natural features, supporting survey information is a key component of the analysis. It is important to note that there are different loss coefficients for in-line flow control structures as compared to lateral weirs, refer to the reference manual for the specific software being used i.e., Section 8.0 for lateral coefficients used in hydraulic modelling softwater (HEC-RAS) analysis.

The general guidance for spills analysis is identified in the Ministry of Natural Resources' (MNR's) Technical Guide River and Streams Systems: Flooding Hazard Limit, but it is still recommended that the modeler contact the Authority for additional requirements to model these features.

Where hydraulic structure analysis is completed, there is a requirement for survey information and G.I.S. information is to be included in the submission documentation. A list of the key requirements is included in Appendix K.

Hydraulic Results and Reporting

There are specific requirements for the submission contents which directly reflect the analysis being completed. The submission brief would include water surface elevations, channel and overbank velocities with the design information for the structures being analyzed. This information needs to be prepared and presented for both existing and proposed conditions.

Where floodplain elevations are revised in a regulated area, updated floodplain mapping will be provided as a part of the submission. In a technical hydraulic submission values, sources and electronic copies of the models for all hydraulic modelling and calculations must be supported and reproducible by a qualified professional.

2.0 Hydraulic Modelling

Hydraulic modelling and supporting calculations at a minimum must be provided if the proposed development may impact a floodplain limit or hydraulic structures are included in the design. It is possible to complete this analysis from first principles using empirical methods or design charts; however, there is industry standard software packages that are available online, which is often the preferred analytic option.

Common empirical methods for culvert design are provided by the Ontario Ministry of Transportation (MTO) in the Drainage Management Manual and not referenced further in this manual. The various software packages for culvert design based on single location currently used for analysis within the watershed include U.S. Federal Highway Administration Hydraulic Modelling Software (HY-8) and Bentley CulvertMaster. There are other software packages for analysis of stream reaches and continuous water surface profiles and these include the HEC-RAS suite of software. These software packages and the preferred options are discussed further in this section.

The preferred steady and unsteady state hydraulic model for analysis in stream reaches is the U.S. Army Corps of Engineers' HEC-RAS. The US Army Corps of Engineers version of HEC2 is only accepted when the existing hydraulic model for a watercourse is in HEC2. Newly submitted models will only be accepted in the most recent version of HEC-RAS software and the model must be properly geo-referenced. If the Authority has an existing HEC2 or HEC-RAS model for the area under analysis, the Site-specific model update must be submitted in a way that it is integrated into the existing model. It is the responsibility of the modeler to obtain the most recent and up to date hydraulic modelling from the Authority prior to commencing their analysis.

Structure Design Hydraulic Analysis

There are specific stormwater conveyance design instances where inlet / outlet control hydraulics, open channel hydraulics as well as weir and orifice modelling are required. Commonly used software programs include HY8 and Bentley FlowMaster and CulvertMaster. It is important that proper boundary conditions are incorporated into the scenario being modelled. Model output of the analysis results are required as well as summary tables identifying key components.

Where hand calculations are completed, the worksheets identifying energy grade lines, hydraulic grade lines, water surface elevations, discharge and velocities are required. Any formulas, sample calculations, empirical tables used in the analysis are also required as a part of the submission.

Stream Reach Based Hydraulic Analysis

The most commonly applied watercourse based hydraulic modelling in the Authority watershed is the HEC-RAS one dimensional model. The HEC-RAS 1D hydraulic analysis applies a standard step or step-backwater analysis to the input data. The key information that HEC-RAS calculates is a water surface elevation based on the various input parameters described earlier and that the water surface is level at the cross-section under analysis. The main limitations to the 1D steady state approach is that the engine is only able to calculate water surface elevations one cross-section at a time.

Within one dimensional hydraulic analysis there are two modelling categories including steady flow and unsteady flow discharges. Steady flow hydraulic models include analysis that is based on constant flow discharge along the channel. In general, steady state is based on a hydraulic engine calculation that applies the Manning's equation and step / backwater solution. Unsteady state hydraulic models include analysis based on flow discharge that varies over time. In general, unsteady state hydraulic modelling uses the St. Venant unsteady flow equation for the solution methodology.

In addition, unsteady flow analysis allows for both 1D and 2D modelling options. With unsteady state in 1D, modelling is applied along the watercourse in the direction of flow. In the 2D modelling scenarios, the unsteady state analysis allows for conveyance in the overbank with integrated analysis for off-channel areas and spills. It is important to note that there will be differences in water surface elevation calculated at crossings between a similar 1D and 2D models in HEC-RAS due to different calculation methodologies in the two different analytic approaches.

Within the unsteady state modelling engine, there are computational and post-processing controls that manage what is happening in the model computation. For example, an incorrect hydrograph output interval and time step can cause the routed hydrograph peak to be missed and result in erratic outflow hydrographs. It is important to document these key control parameters in any summary documentation to assist the reviewer.

After the analysis is complete there are different graphical and tabular presentations of water surface elevation and velocities which are available. These include cross-section graphical, profile graphical, 3D graphical, rating curves, profile tables, cross-section output tables. With the integration of geo-referenced topographic information into hydraulic models, the review of the 3D graphical and profiles is a key component on top of the traditionally provided cross-sectional graphic and tabular output.

The hydraulic model should be calibrated, and results compared to measured high water marks when these values are available. However, it is recognized that this information is not available in all watercourses across the various design storms.

For a submission where a hydraulic analysis is a required component, there are minimum requirements for submission reporting. For hydraulic structures analysis, the water surface elevation and velocities accompanying the key design information must be presented. When considering reach based hydraulic analysis the water surface elevation, discharge rates and overbank velocities are the key pieces of information. In regulated areas, there will be additional mapping requirements related to the floodplain delineation. At a minimum the post to pre floodplain elevations must be compared, including overbank velocities and proving continuity of flow. Any submission where a hydraulic model was prepared in support of the analysis must include the electronic model files in the report package.

3.0 Software Recommendations

The industry standard versions of HEC-RAS software for unsteady and steady state, 1D and 2D hydraulic analysis are accepted for hydraulic analysis in support of floodplain mapping. Due to the continual updates to these software programs, the Authority is to be contacted to confirm any new requirements of updated or other software packages which will be accepted for modelling submissions.

4.0 Typical Weir Formulas

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 (m^3/s),
H = head on the weir (m),
L = crest length of the weir (m), and
C = weir coefficient

Sharp Crested Weir Without End Contractions and Broadcrested Weir

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

Where:

Q = flow rate (m^3/s),
H = head on the weir (m),
L = crest length of the weir (m), and
C = weir coefficient

Orifice and Orifice Tube

$Q = C * A * (2 * g * h)$ ^$^{0.5}$

Where:

Q = flow rate (m^3/s),
A = area of the orifice opening in m^2,
h = differential head measured from the centroid of the orifice (m),
g = constant acceleration due to gravity (9.81 m/s^2), and
C = coefficient of discharge

5.0 Typical Weir and Orifice Coefficients

The following table identifies commonly used coefficients (C) for orifice and weir analysis.

Table 1 – Typical C Values for Weir and Orifice Calculations

Application	Typical C Values
Orifice	0.63
Orifice Tube	0.80
Sharp Crested Weir	1.837
Broad Crested Weir (SWM Facility and Dam Spillway)	1.7
Broad Crested Weir (Road Crossing)	1.5

6.0 Orifice Discharge

When calculating orifice discharge, the orifice equation should only be applied when the water surface is higher than the centroid of the orifice.

$Q = C * A * (2 * g * h)^{0.5}$

Where:

Q = flow through the orifice (m^3/s),
C = orifice coefficient,
A = area of the orifice opening (m^2),
g = constant acceleration due to gravity (9.81 m/s^2), and
h = height of water (m)

7.0 Typical Manning Roughness Coefficients

The following excerpt from the MTO's Design Chart 2.01 outlines typical Manning Roughness Coefficients.

	Manning Roughness Coefficients
I. Sewers	
A. Concrete pipe storm sewers	0.011 - 0.013
B. Verified clay pipe	0.012 - 0.014
C. Steel pipe (smooth)	0.009 - 0.011
D. Monolithic concrete:	
1. Wood forms, rough	0.015 - 0.017
2. Wood forms, smooth	0.012 - 0.014
3. Steel forms	0.012 - 0.013
E. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017 - 0.022
2. Natural floor	0.019 - 0.025
F. Laminated treated wood	0.015 - 0.017
G. Smooth walled polyethylene pipe	0.011 - 0.013
Corrugated interior polyethylene pipe (tentative)	0.024
H. Corrugated steel pipe or pipe arch	
68 x 13 mm corrugation (riveted, annular)	
Unpaved	0.024
25% paved	0.021
100% paved	0.012
68 x 13 mm helical	
Unpaved: 600 to 1525 mm ϕ range:	0.016 - 0.024
25% paved: 600 to 1525 mm ϕ range:	0.015 - 0.021
100% paved: all sizes	0.012
68 x 25 mm riveted (annular)	
Unpaved	0.027
25% paved	0.023
100% paved	0.012
76 x 25 mm helical	
Unpaved: 900 to 1980 mm dia.:	0.021 - 0.027
25% paved: 900 to 1980 mm dia.:	0.019 - 0.023
100% paved: all sizes	0.012
152 x 51 mm corrugation (annular)	
Unpaved 1550 - 4500 mm dia.or	0.030 - 0.033
1900 to 5050 mm span	0.026
25% paved	
II. Road Gutters	0.012
A. Concrete gutter, trowelled finish	
B. Asphalt pavement:	0.013
1. Smooth texture	0.016
2. Rough texture	
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015

Figure 1: Manning Roughness Coefficients

	Manning Roughness Coefficients
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. Brick	0.016
For gutters with small slope where sediment may accumulate, increase values by 0.002.	
III. Lined Open Channels	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013 - 0.017
2. Trowel finish	0.012 - 0.014
3. Float finish	0.013 - 0.015
4. Float finish, some gravel on bottom	0.015 - 0.017
5. Gunite, good section	0.016 - 0.019
6. Gunite, wavy section	0.018 - 0.022
B. Concrete bottom float-finished, sides as indicated:	
1. Dressed stone in mortar	0.015 - 0.017
2. Random stone in mortar	0.017 - 0.020
3. Cement rubble masonry	0.020 - 0.030
4. Dry rubble (riprap)	0.020 - 0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017 - 0.020
2. Random stone mortar	0.020 - 0.023
3. Dry rubble (riprap)	0.023 - 0.033
D. Asphalt	
1. Smooth	0.013
2. Rough	0.016
E. Wood, planed, clean	0.011 - 0.013
F. 1. Good section	0.017 - 0.020
2. Irregular section	0.022 - 0.027
G. Riprap	0.035 - 0.040
H. Rock cut	0.025 - 0.045
IV. Unlined Open Channels	
A. Earth, uniform section:	
1. Clean, recently completed	0.016 - 0.018
2. Clean, after weathering	0.018 - 0.020
3. With short grass, few weeds	0.022 - 0.027
4. In gravelly, soil, uniform section, clean	0.022 - 0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022 - 0.025
2. Grass, some weeds	0.030 - 0.035
3. Dense weeds in deep channels	0.030 - 0.035
4. Sides clean, gravel bottom	0.025 - 0.030
5. Sides clean, cobble bottom	0.030 - 0.040

Figure 2: Manning Roughness Coefficients (continued)

	Manning Roughness Coefficients
C. Dragline excavated or dredged:	
1. No vegetation	0.028 -0.033
2. Light brush on banks	0.035 -0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035 -0.040
b. Jagged and irregular	0.040 -0.045
E. Channels not maintained, vegetation uncut:	
1. Dense weeds, high as flow depth	0.08 - 0.12
2. Clean bottom, brush on sides	0.05 - 0.08
3. Clean bottom, brush on sides, high stage	0.07 - 0.11
4. Dense brush, high stage	0.10 - 0.14

V. Grassed Channels and Swales[2]

Depth of Flow:	Up to 0.2 m	0.2 - 0.5 m
Velocity		
	0.6 m/s 1.8	0.6 m/s 1.8
A. Kentucky bluegrass:	m/s	m/s
1. Mowed to 0.05 m		
2. Length 0.1 to 0.15 m	0.07 - 0.045	0.050 - 0.035
B. Good stand, any grass:	0.090 - 0.060	0.060 - 0.040
1. Length 0.30 m		
2. Length 0.60 m	0.180 - 0.090	0.120 - 0.070
C. Fair stand, any grass:	0.300 - 0.190	0.200 - 0.100
1. Length 0.30 m		
2. Length 0.60 m	0.140 - 0.080	0.100 - 0.060
	0.250 - 0.130	0.170 - 0.090

VI. Natural Watercourses

	Manning Roughness Coefficients
A. Minor stream (surface width at flood stage < 30 m).	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030 -0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035 -0.050
c. Some weeds, light brush on banks	0.035 -0.050
d. Some weeds, heavy brush on banks	0.050-0.070
e. Some weeds, dense willows on banks	0.060-0.080
f. For trees within channel with branches submerged at high stage, add 0.01 to 0.02 to above values.	

Figure 3: Manning Roughness Coefficients (continued)

	Manning Roughness Coefficients
2. Irregular section with pools, slight channel meander; channels (a) to (e) above, add 0.01 to 0.02.	
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.040 - 0.050
b. Bottom of cobbles with large boulders	0.050 - 0.070
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030 - 0.035
b. High grass	0.035 - 0.050
2. Cultivated areas:	
a. No crop	0.030 - 0.040
b. Mature row crops	0.035 - 0.045
c. Mature field crops	0.040 - 0.050
3. Heavy weeds, scattered	0.050 - 0.070
4. Light brush and trees:	
a. Winter	0.050 - 0.060
b. Summer	0.060 - 0.080
5. Medium to dense vegetation:	
a. Winter	0.070 - 0.110
b. Summer	0.010 - 0.160
6. Dense willows, summer, not bent over by current	0.150 - 0.200
7. Cleared land with tree stumps, 250 - 370 per hectare	
a. No sprouts	0.040 - 0.050
b. With heavy growth of sprouts	0.060 - 0.080
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.100 - 0.120
b. Flood depth reaches branches (n increases with depth)	0.120 - 0.160
C. Major stream (surface width at flood stage > 30 m): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Roughness values may be somewhat reduced. Follow general recommendations if possible. The roughness value for larger streams of mostly regular section, with no boulders or brush, may be in the range.	0.028 - 0.033

Figure 4: Manning Roughness Coefficients (continued)

Source: Ministry of Transportation Ontario; MTO Drainage Management Manual, (1997)

8.0 Typical Lateral Weir Coefficients

The commonly accepted lateral weir coefficients for use in HEC-RAS hydraulic analysis are outlined below.

What is being modeled with the Lateral Structure	Description	Range of Weir Coefficients
Levee/Roadway – 3ft or higher above natural ground	Broad crested weir shape, flow over levee/road acts like weir flow	**1.5** to **2.6** (2.0 default) SI Units: 0.83 to 1.43
Levee/Roadway – 1 to 3 ft elevated above ground	Broad crested weir shape, flow over levee/road acts like weir flow, but becomes submerged easily.	**1.0** to **2.0** SI Units: 0.55 to 1.1
Natural high ground barrier – 1 to 3 ft high	Does not really act like a weir, but water must flow over high ground to get into 2D flow area.	**0.5** to **1.0** SI Units: 0.28 to 0.55
Non elevated overbank terrain. Lat Structure not elevated above ground	Overland flow escaping the main river.	**0.2** to **0.5** SI Units: 0.11 to 0.28

Figure 5: HEC-RAS User's Manual, Range of Lateral Weir Coefficients

Source: HEC-RAS River Analysis System, 2D Modeling User's Manual (February 2016)

9.0 Typical Subcritical Flow Contraction And Expansion Coefficients

The commonly used contraction and expansion coefficients for application in HEC-RAS analysis of watercourse crossings, typically using a subcritical flow solution are identified below.

	Contraction	Expansion
No transition loss computed	0.0	0.0
Gradual transitions	0.1	0.3
Typical Bridge sections	0.3	0.5
Abrupt transitions	0.6	0.8

Figure 6: Subcritical Flow Contraction and Expansion Coefficients

Source: HEC-RAS River Analysis System, Hydraulic Reference Manual (January 2010)

10.0 Minimum Requirements for Submissions Including Hydraulic Modelling and Analysis

For all hydraulic modelling and analysis associated with floodplain and flood hazards, the 2017 Technical Guidelines for Flood Hazard Mapping shall be referenced where background information is available and/or sufficient. The requirement outlined herein should be read in conjunction with the Authority Ontario Regulation 179/06 Implementation Guidelines. If there is a discrepancy between the Authority, Municipal, Ministry of Northern Development, Mines, Natural Resources and Forestry (NDMNRF) or Ministry of Environment, Conservation, and Parks (MECP) requirements for hydraulic modelling and analysis, then the more conservative criteria will apply. The submission must include a Hydraulic Report with the following information:

Digital copy of hydraulic model existing and modified existing (if applicable) and proposed scenarios including input and output files, software version documented. The model should include a detailed model text description (i.e., date, HEC-RAS model version, reason for revision, summary of revisions, author, source of survey including date and surveyor etc.)

Information to clearly identify changes to the existing Authority hydraulic model with a summary table showing the comparison of the existing Authority, modified existing, and proposed condition model. At a minimum, the table should include Cross Section, Profile, Flow (Return events & Regional), Water Surface Elevation, Channel Velocity (Left Overbank, Right Overbank, Channel) and Volume. Please also include all cross-sections/flood elevations impacted by proposed works.

Summary tables, sample calculations and documentation for model input including:

- Flow file input, boundary and initial conditions for both upstream and downstream conditions, flow values or hydrographs and identification of model insertion points,
- Common hydraulic model parameters including: manning's n for channel and overbank; bridge or culvert crossing and survey information; contraction and expansion coefficients, blocked obstructions, coefficients of expansion and contraction;
- Bridge, culvert, inline structure, weirs, lateral structure, and spills information supported with Site survey and reflected in geometry file,
- Digital copy of all supporting survey information (i.e., topo, road weir, culvert size/inverts etc.) and include survey type/accuracy, company/source of survey,
- Calibration or validation methodologies and their results, as applicable,
- Sensitivity analysis and appropriate summary,
- If grading is proposed within the floodplain:
  - Incremental cut/fill analysis at 0.30 m interval
  - Detailed grading and cross section plans including stage/storage tables and plan views which clearly delineates the cut/fill area
  - Revisions of the affected sections of the hydraulic model and supported with drawings
- Steady State model minimum summary output: tabular results including section number, discharge value, water surface elevation, velocity in channel and left and right overbanks, lateral weir, profile results as applicable,
- Unsteady state models minimum summary output: documentation of upstream inflow hydrograph computational settings, stage and flow hydrographs for key features and profile results as applicable,
- A digital copy (AutoCAD Software Program or G.I.S. shapefile format) of the Existing and Proposed Floodplain mapping,
- Revised hydraulic models must be submitted in the format they were originally provided or in a newer version of HEC-RAS, provided the conversion is validated,
- New hydraulic models must be geo-referenced and include geospatial data unless there is discussion with the Authority for an alternative approach, and

The following are additional requirements for structures design analysis:

- Hydraulic structures design approach summary and documentation,
- Storm sewer design drainage plan, catchment areas and design sheets,
- Summary tables, sample calculations and parameter selection used in the design of structures such as: culverts, bridges, weirs, lateral structures, spills, and storage areas, and

For any drawings or figures presenting updated floodplain elevation(s) and limit(s), at a minimum, the following engineering components must be provided:

- Hydraulic sections with regulated floodplain elevations and cross-section identification,
- Existing and proposed floodplain delineation,
- Topographic information including elevations and contours,
- Conveyance structures including dams, bridges, culverts, and weirs,
- Man-made structures as applicable including buildings, roads, railways, and trails,
- Natural reservoirs or natural storage areas,
- Spills analysis as applicable,
- Cut/fill analysis in the regulated area as applicable,
- Natural features such as watercourses and wetlands, and
- Floodplain mapping and supporting documentation signed and stamped by a P.Eng.; and accompanying document identifying overall approach and methodology for hydrologic and hydraulic analysis including the minimum requirements identified in Appendix C and the sections above.

Note that if changes are proposed within the floodplain (i.e. cut/fill balance, new watercourse crossing, etc.), it must be demonstrated that there are no negative impacts upstream or downstream in accordance with the Authority Ontario Regulation 179/06 Implementation Guidelines.

The methodology for geospatial data generation, all modelling, digital files, and calculations must be provided to the satisfaction of the Authority in the manner outlined in this document. There are the minimum survey and geospatial drawing components required for drawing such as floodplain mapping or other drawings included in an engineering submission. These minimum requirements are outlined in Appendix K.

It is recommended to contact the Authority for additional requirements for submissions with integrated G.I.S. components and to confirm that supplied digital files are compatible with the current version of Authority’s G.I.S. software. The digital base layers and electronic copies of finished drawings must be provided in a labelled and dated electronic data storage device such as a Digital Video Disc (DVD) or digital storage device.

11.0 References

American Iron and Steel Institute, Modern Sewer Design, Canadian Edition, 2007.

Chow, V.T., Open Channel Hydraulics, McGraw-Hill, 1988.

Lake Simcoe Protection Act, 2008, S.O. 2008, c.23.

Lake Simcoe Region Conservation Authority, Guidelines for the Implementation of Ontario Regulation 179/06, 2015.

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

Ontario Ministry of Natural Resources, River and Stream Systems: Flooding Hazard Limit Technical Guide, 2002.

Ontario Ministry of Natural Resources, Technical Guide River and Stream Systems: Flooding Hazard Limit, 2002.

Ontario Ministry of Natural Resources, Technical Guide – River and Stream Systems: Erosion Hazard Limit, 2002b.

Ontario Ministry of Transportation, MTO Drainage Management Manual, Queens Printer for Ontario, 1997.

U.S. Army Corps of Engineers, HEC-RAS River Analysis System 2D Modeling User's Manual, August 2015.

U.S. Army Corps of Engineers, HEC-RAS River Analysis System Hydraulic Reference Manual Version 4.1, January 2010.

U.S. Department of Transportation Federal Highway Administration. HDS-5 Hydraulic Design of Highway Culverts 3rd Ed., April 2002.

Appendix J

Flood Plain Stability Chart for Humans

This excerpt from MNR shows the floodplain stability chart for humans in relationship to depth and velocity.

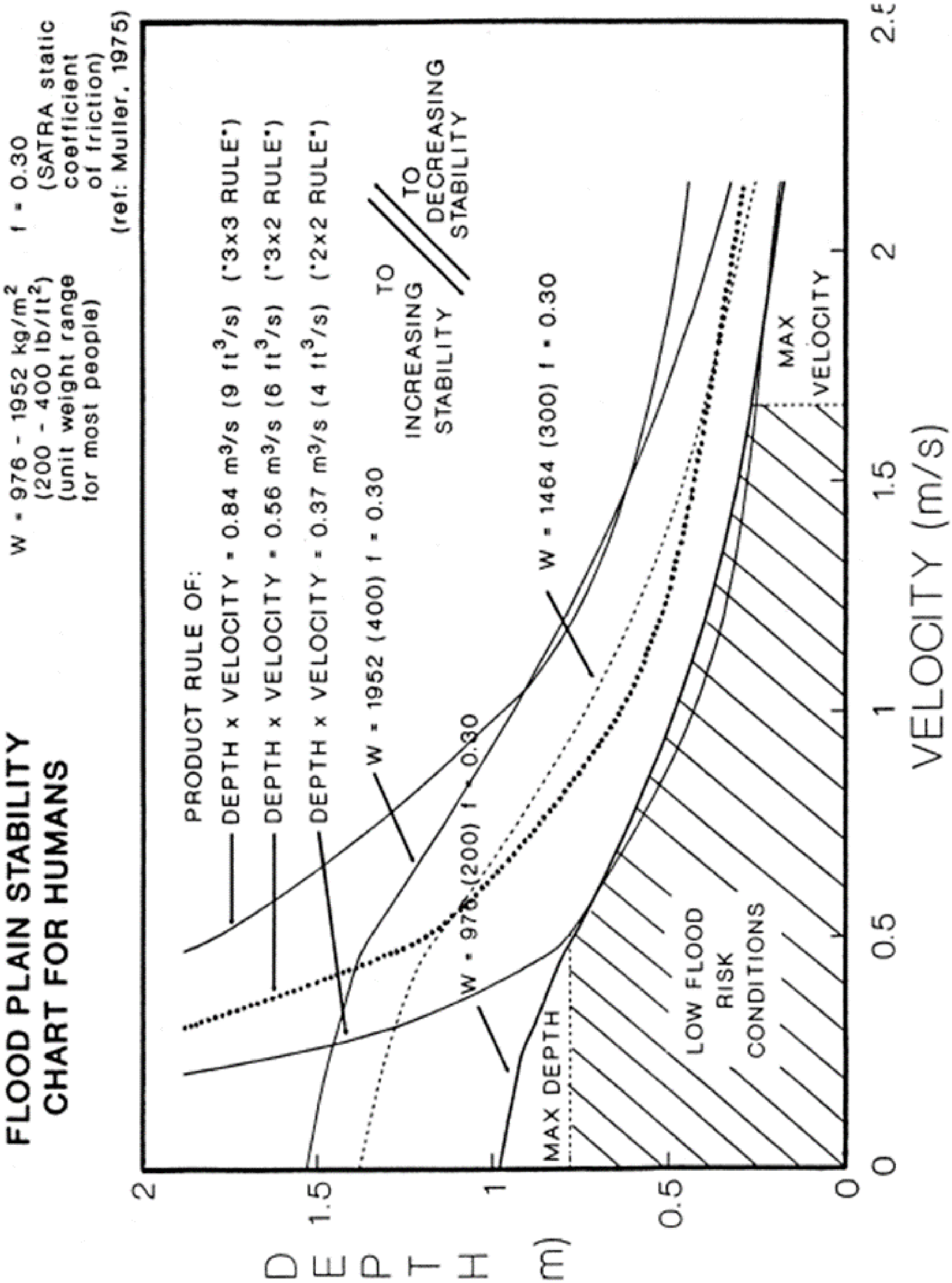


Figure 1: Flood Plains Stability Chart for Humans

Source: Flood Plain Planning Policy Statement, Implementation Guidelines, Ministry of Natural Resources, October 1988

Appendix K

Minimum Requirements for Engineering Submissions: Survey and Geospatial Data

1.0 Survey Documentation Minimum Requirements

For a submission which contains drawings or figures that present survey information, the following list of minimum requirements must be included:

- Document with text descriptor identifying overall approach and methodology,
- Drawing/Figure Title,
- Date, and Revision List where applicable,
- Legible Scale and North direction arrow,
- Ontario Land Surveyor (O.L.S.) Name and contact information, as applicable,
- Geodetic benchmark data used in survey, as applicable,
- Available survey data for topographic surface, structures, features, etc.,
- Structures invert, obvert elevations and dimensions as applicable,
- Bathymetry as applicable,
- Documentation to support reported data accuracy,
- Methodology for survey data collected i.e., Total Station, Geographical Information System (G.I.S.), Rod and Level,
- Photo log of structures survey including upstream, downstream and structures completed with structure survey,
- Drawings and/or figures to be submitted electronically as per submission minimum requirements identified in Appendix A,
- Digital copy of the survey data when applicable, and
- Submission components to be stamped and signed by an O.L.S., Professional Engineer (P.Eng.) or Certified Engineering Technologist (C.E.T.).

These minimum requirements will be refined as technology and software are updated.

2.0 Geospatial Data Submission Minimum Requirements

For a submission which contain drawings, figures, reports, modelling and / or memos that present geospatial information and its analysis; the following list of minimum requirements must be included:

- Text summary identifying methodology and software used in geospatial analysis,
- Acquisition type i.e., Light Detection and Ranging Survey Technology (LIDAR), orthophotos, etc.,
- Date of data acquisition,
- Name of supplier of digital information and their contact information,
- Quality Assurance / Quality Control methodology for geo-spatial as applicable,
- Data Co-ordinate system,
- Data Projection,
- Data Horizontal and vertical resolution,
- Data Accuracy for each axis as applicable,

- Description of grid resolution,
- Drawing and / or figure scale identified as applicable,
- Contours presented at minimum 0.5 m increments,
- Orthophoto Elevation Data i.e., study area break lines and digital terrain model (DTM) points,
- LIDAR Elevation Data i.e., study area point cloud (as applicable),
- Digital Elevation Model (DEM) as applicable,
- Description of modifications to surface including adjustments to the triangular irregular networks (TIN) from other sources (i.e., surveyed culverts, new infrastructure invert and obvert elevations etc.),
- Flood limit data, incorporating the minimum requirements from Section 1 above,
- Drawings and / or figures to be submitted electronically as per submission minimum requirements identified in Appendix A,
- In modelling files and documentation to maintain existing watercourse naming conventions were applicable,
- Projected Co-ordinate system: Preferably North American Datum 1983 Universal Transverse Mercator Zone 17N,
- Accepted Original Geospatial Data file format: File Geodatabase or Shapefiles, and
- Submission components to be stamped and signed by an O.L.S., P.Eng. or C.E.T. as relevant.

These minimum requirements will be refined as technology and software are updated.

Appendix L

Volume Control Guidance

Volume Control Example Calculation

The post-construction direct runoff volume shall be captured and retained / treated on-site from 25mm of rainfall from all impervious surfaces. See Section 3.2.4 of the Technical Guidelines for Stormwater Management Submissions.

When computing the direct runoff volume to be captured there is to be no changing of hydrologic parameters (i.e., no reductions in initial abstractions, no changes in runoff coefficients, no routing, etc.). The direct runoff volumes should be used to size the low impact development (L.I.D.) facilities.

When calculating the required 25 mm capture volume target, the total impervious area (h.a.) is multiplied by the 25 mm rainfall depth.

For example:

Overall Site Area: 5 h.a.
Percentage Impervious: 65%
Total Impervious Area: 5 h.a. X 0.65 = 3.25 h.a.
Target Volume Control Required: 3.25 h.a. X 25 mm X 10 (unit conversion) = **812.5** m^3

Therefore, an appropriate measure will need to be designed to capture and hold **812.5** m^3 of runoff volume. This measure can be an infiltration measure, filtration measure, combination of infiltration and filtration (See Appendix D) or an additional volume reduction technique outlined in section 3.2.6 (providing the appropriate supporting information is provided).

Appendix M

Catchment Based Water Balance in Support of Maintaining a Natural Heritage Feature

1.0 Catchment-based Water Balance in Support of Maintaining a Natural Heritage (NH) Feature

A catchment-based water balance is generally required for any development application adjacent to a Natural Heritage feature such as a wetland, woodlot, watercourse, or other protected area. Pre-consultation with the Authority is highly recommended to scope both the general water balance and catchment-based water balance requirements which may overlap and be completed in conjunction with one another. Please note that assessment should be undertaken by a Professional Geoscientist or an exempted Professional Engineer as defined by the *Professional Geoscientists Act, 2000*.

The catchment-based water balance is similar to and often confused for a 'feature-based' water balance. Rather than accounting for the change in water balance components (inputs and outputs) for the entire feature, the catchment-based water balance focuses on the subject development area and the changes to the drainage inputs to the feature. Changes to both groundwater (infiltration) and surface water (runoff) inputs are considered in the evaluation and need to be mitigated through the development process.

When conducting a water balance in support of maintaining the portion of the natural heritage feature contained on or adjacent to the subject property, the following should be completed/provided:

- Consultation with an Authority's planner, ecologist, hydrogeologist, and an engineer,
- Standalone Hydrogeological Assessment document with all supporting water balance, drawings, monitoring results, etc. Separate section on water balance methodology,
- A pre-development catchment-based water balance assessment using the Thornthwaite-Mather method is required,
- A post-development catchment-based water balance assessment using the Thornthwaite-Mather method is required,
- The submission shall address the requirements set out in the Lake Simcoe Protection Plan DP-6.26 or latest version, and
- The Hydrogeological Assessment Submission – Conservation Authority Guidelines for Development Applications, June 2013 or latest version are to be followed.

1.1 Pre-Development Conditions

The purpose of data collection is to understand the hydrology of the feature and how it will be affected by the proposed development. It will also inform potential design alternatives and adaptive management options that will mitigate any impacts identified through the review process. In addition to the requirements determined at pre-consultation, the following will be required:

- Continuous collection of data to determine pre-development conditions of both surface water and groundwater (i.e., seasonal fluctuations, average hydro periods (depth and duration), water depth monitoring, length of standing water period, capture of spring melt, etc.). **Note**: minimum of 1 year, unless pre-determined by specific governing studies or reports or site-specific conditions.
- Determine how the feature is supported in pre-development conditions hydrologically, (whether by surface water or groundwater or both). Identify the quantity of the surface water and the groundwater contributions to the feature supported by a a catchment-based water balance (Thornthwaite-Mather method) according to the hydrogeological assessment guidelines.

1.2 Post-Development Conditions

The catchment-based water balance will identify the need for, and the design of mitigation measures to ensure there is a minimal difference between pre- and post-development conditions (water balance scenarios). At a minimum, the following should be provided:

- Demonstrate how the feature is supported in post-development conditions hydrologically,
- Provide a post development Thornthwaite-Mather Water Balance Assessment with and without mitigation,
- Demonstrate the mitigation measures / strategies that will be implemented in the post-development conditions to mimic the existing conditions hydrologic conditions,
- Demonstrate how the water balance target will be achieved, and/or otherwise demonstrate there will be no negative impact to the feature,
- Demonstrate the measures that will be implemented to ensure the quality of the water being directed to the feature in post-development will meet Provincial Water Quality Objectives, and
- Provide supporting drawing(s), calculations, etc., to demonstrate the post-development conditions will not have a negative impact on the feature.

Appendix N

Manufactured Treatment Devices

The following information needs to be submitted in support of a proposal to use a manufactured treatment device (MTD):

- Environmental Technology Verification (ETV) verification (Oil and Grit Separator (O.G.S.), Filtration Devices) or Technology Assessment Protocol-Ecology (T.A.P.E.) (Filtration Devices) certification as appropriate,
- Model Number,
- Approved median total suspended solids (TSS) Removal (%) (ETV, T.A.P.E.),
- Annual Runoff Treated (%), and
- Particle Size Distribution and particle specific gravity sized per ETV / New Jersey Department of Environmental Protection (N.J.D.E.P.) requirements.

The Authority requests that two (2) or three (3) alternate O.G.S. separators are specified on submitted drawings and reports.

The ETV was established by Environment Canada in 1997 to support the implementation of innovative environmental technologies in Canada. It is designed to provide objective and quality-assured performance data on environmental technologies.

Oil and Grit Separators

Only O.G.S. units verified through the Canadian ETV program will be allowed.

Oil and grit separators are to be sized to capture and treat at least 90% of the runoff volume that occurs for a site on a long-term average basis, based on ETV sizing requirements. Calculations and documentation regarding ETV registration, verification and / or re-verification must be provided in the SWM report for any proposed O.G.S.

For any O.G.S. unit proposed as part of a submission to the Authority, an ETV verification must be provided in the SWM report.

Starting on September 1, 2022, Toronto and Region Conservation Authority – Sustainable Technologies Evaluation Program O.G.S. sizing sheet must be submitted along with the ETV verification in the SWM report.

Where an ETV verified O.G.S. does not have verification for phosphorus removal, a maximum removal rate credit of 20% shall be acknowledged.

Filtration

Filtration-based MTDs will be accepted if they have been tested and verified through International Organization for Standardization (ISO) 14034: ETV standard or other recognized field testing programs, such as T.A.P.E. as long as applicable criteria outlined below are met.

Filtration-based MTDs require field testing following the general principles and procedures of the State of Washington's T.A.P.E. program test protocol. The field testing program must include a minimum of 3 rain events that exceed the 75th percentile event determined from 30 year historical rainfall data.

a) **TSS Removal Performance** – The selected MTD will achieve a minimum median Total Suspended Solids (TSS) removal rate of 80% in the field test, including bypass, for all events with influent TSS concentrations equal to or greater than 100 mg/L. For events with influent concentrations between 20 and 100 mg/L, the effluent TSS event mean concentration shall be less than 20 mg/L, including bypass, in a minimum 95% of sampled events. Events with influent concentrations below 20 mg/L should not be included in the TSS performance evaluation. Bypass should be limited to flows greater than the 95th percentile event.
b) **Installation Configuration** – All filtration MTDs must be installed off-line or contain an internal bypass for on-line installation. Note that the internal bypass must ensure complete bypass of high flows to the outlet pipe, rather than simple diversion of flows through a different flow path within the unit.
c) **Scaling Provisions** – The selected MTD will meet scaling procedures in accordance with N.J.D.E.P. Protocol for Filtration MTDs when compared to the tested unit.
d) **Operations and Maintenance** – The selected MTD must be sized for a maintenance frequency of no more than once a year.

For any filtration device proposed as part of a submission to the Authority, the field testing certification or ETV verification must be provided in the stormwater management (SWM) report.

Where an ETV verified filtration device or field certified filtration device does not have verification for phosphorus removal, a maximum removal rate credit of 40% shall be awarded, provided the filtration unit is capable of achieving 80% removal of total suspended solids.

A similar approach (pre-treatment & treatment train) will be applied to the use of adsorptive media as a quality control device.

For ETV verified MTDs, please visit ETV Canada.