Stormwater Management Design Guidelines

City of Burlington

Prepared for:

City of Burlington

426 Brant Street, Burlington, ON, L7R 3Z6

5/21/2020

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A. INTRODUCTION AND GENERAL INFORMATION

1.0 Introduction to Stormwater Management

1.1 Stormwater Management Context

Stormwater Management (SWM) broadly refers to the process of how water, stemming from precipitation (rain and/or snowmelt events) is managed and controlled. In natural settings, precipitation is largely infiltrated through pervious landscapes or evapotranspirated back into the atmosphere, particularly in areas with high vegetation coverage. Any remaining water which is not infiltrated will typically run off and be directed to overland features, and ultimately to larger creeks and watercourses.

When natural areas are converted to urbanized land uses, pervious areas are typically reduced, and impervious land coverage (buildings, roadways, parking areas, etcetera) increased. Without the implementation of stormwater management controls, this conversion of land use results in a shift in the hydrologic cycle. Infiltration and evapotranspiration are reduced, due to the reduced availability of pervious surfaces and vegetation cover, and surface runoff is correspondingly increased. Furthermore, in these urban settings, conveyance infrastructure (ditches, storm sewers and roadways) is required to convey and direct surface runoff safely to receivers. In addition, the water quality of the resulting increased stormwater runoff is typically reduced by the urbanization process, given the build-up of contaminants on impervious surfaces and corresponding rapid wash-off ("first flush") during storm events. Without properly designed and implemented stormwater controls, both quantity (erosion, flooding, water balance) and quality (contaminant, sedimentation) issues result, with associated impairment to receivers (watercourses and lakes), and the overall natural environment, including aquatic life/habitat.

The impacts of uncontrolled stormwater, particularly in urban settings, have long been recognized as a concern. The City of Burlington was one of the earliest municipalities in Southern Ontario to develop Stormwater Management Design Guidelines (ref. Storm Drainage Criteria Manual, prepared by M.M Dillon Ltd, dated April 27, 1977). The current document is intended to build upon this foundational document and incorporate the numerous advances in SWM since the preparation of the original guidelines, including updated methodologies and tools, updated regulatory requirements, and current "best practices". It is the City of Burlington's intent to remain at the forefront of the stormwater management field and ensure that appropriate guidelines are provided to practitioners and designers within the City, specifically to guide future development and redevelopment as well as infrastructure renewal projects.

1.2 Document Purpose

The Stormwater Management (SWM) Design Guidelines are intended to be used by practitioners in the design of storm drainage infrastructure within the City of Burlington. The Guidelines are to be used, in conjunction with other relevant and companion documentation, to support the planning and design process for new land development and re-development (infills/intensification) as well as infrastructure renewal projects. The Guidelines provide standards including desired attributes of stormwater infrastructure, as related to the City of Burlington's overall governing policies and vision.

The Stormwater Management Design Guidelines provide hierarchal guidance, direction and consistency for the various stages of development, specifically related to the planning, design and review of:

- Master Environmental Servicing Plans (MESP),
- Functional Service Reports (FSR), and
- Stormwater Management (SWM) Reports

These design guidelines also assist practitioners by detailing specific submission requirements including:

- Series of study specific processes
- Deliverables and associated requirements
- Submission checklists.

1.3 City Drainage System Context

A number of distinct watercourses, and associated watersheds, are located within the City of Burlington. Area watersheds are presented in Drawings 1 and 2 (attached). The following watersheds are located wholly or partly within the City limits:

- Grindstone Creek,
- West Aldershot Creek,
- La Salle Creek,
- Forest Glen Creek,
- Teal Creek,
- Falcon Creek,
- Edgewater Creek,
- Stillwater Creek,
- Indian Creek,
- Upper Hager/Rambo Creek,
- Lower Hager/Rambo Creek,
- Roseland Creek,
- Tuck Creek,
- Shoreacres Creek,
- Appleby Creek,
- Sheldon Creek, and
- Bronte Creek,

The largest watersheds within the City limits are generally Bronte Creek, Grindstone Creek, the Upper Hager/Rambo Creeks and Indian Creek systems.

The City of Burlington is located entirely within the jurisdiction of Conservation Halton. The watersheds within the City of Burlington are generally split between those outletting to Hamilton Harbour, and those outletting to Lake Ontario.

Development within the City of Burlington is focused primarily within the southern limits along the Hamilton Harbour and Lake Ontario shoreline; generally south of Highway 403/407 and Dundas Street (Highway 5). The developed area consists largely of residential and mixed-use land uses, with employment land uses along the QEW corridor. To the north of Highway 407/Dundas Street, the City is generally rural/undeveloped in nature with no current plans for urbanization. Further, there are numerous Provincial Policies and Designations on these lands (Niagara Escarpment, Greenbelt, etcetera) which limit any such potential development.

1.4 Relevant Stormwater Drainage Studies

The City, Halton Region (Region), and Conservation Halton (CH) have prepared several documents to support the planning, design and implementation of stormwater management systems within the City's watersheds. Practitioners and regulators should be familiar with this information, as the recommendations contained within these documents include specific requirements for the City's watersheds. Relevant guidelines and studies specific to individual watersheds are listed below.

Practitioners should note that findings/recommendations from these documents may be refined further through subsequent studies/reports. It is important that practitioners are aware of the most current information through consultation with the City and other relevant agencies.

Overall City- Specific Studies

- Region Wide Basement Flooding Mitigation Study: Final Report and Recommendations (Halton Region, 2015)
- Urban-Area Flood Vulnerability, Prioritization, and Mitigation Study (Amec Foster Wheeler, July 2017)
- Mobility Hubs – Scoped Environmental Impact Study/SWM Plan (Wood, ongoing)

Lake Ontario and Burlington Bay

- Remedial Action Plan for Hamilton Harbour Stage 2 Update (HH RAP Forum, 2002)
- Burlington Beach Regional Waterfront Park Master Plan (Halton Region et al, 2015)

Aldershot Area Creeks (including Grindstone Creek, Falcon Creek, Edgewater Creek, Stillwater Creek, and other adjacent systems)

- Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995)
- Grindstone Creek Watershed Study (Conservation Halton, 1998)
- North Shore Watershed Study (Conservation Halton, 2006)
- Falcon Creek Hydrology and Hydraulics Study (Valdor, 2012)
- Class Environmental Assessment for Aldershot Community Stormwater Master Plan (AMEC Environment & Infrastructure, 2013)
- Grindstone Creek Flood Mapping (Matrix, Ongoing)

Indian, Hager/Rambo Creeks, and Roseland Creek

- Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Philips Engineering Ltd, 1997)
- North Shore Watershed Study (Conservation Halton, 2006)
- Roseland Creek Flood Control Class Environmental Assessment (Philips Engineering Ltd, 2009)
- Roseland Creek Erosion Control Class EA – From Upper Middle Road to Guelph Line (Aquafor Beech, April 2014)
- Municipal Class Environmental Assessment for Roseland Creek Culvert Upgrades at New Street and Lakeshore Road (Aquafor Beech, May 2018)
- Downtown Stormwater Quality Control Plan (Wood, 2019)

Tuck Creek

- Tuck Creek Erosion Control Municipal Class Environmental Assessment (Aquafor Beech, June 2012)
- Tuck Creek Flood Assessment and Crossing Upgrades between New Street and Spruce Avenue – Class Environmental Assessment (Aquafor Beech, June 2016)
- Tuck Creek Flood Assessment and Crossing Upgrades at Rockwood Drive and Rexway Drive – Municipal Class Environmental Assessment (IBI Group, ongoing)

Shoreacres Creek

- Shoreacres Creek Floodplain Mapping Updates (EWRG, 1997)
- Shoreacres Creek Class Environmental Assessment (Cole Engineering, September 2015)

Appleby Creek

- Appleby Creek Floodline Mapping Updates (EWRG, 1997)
- Municipal Class Environmental Assessment for Appleby Creek Flood Mitigation between Fairview Street and New Street (Aquafor Beech, February 2019)
- Appleby Creek Erosion Control Class EA (Aquafor Beech, ongoing)

Sheldon Creek

- Alton Community -Subwatershed Impact Study (Sernas, 1995)
- Sheldon Creek Hydrologic and Hydraulic Study – DRAFT FINAL (Amec Foster Wheeler, 2019)

Bronte Creek

- Bronte Creek Watershed Study (Conservation Halton, March 2002)

1.5 Integrated Approach

1.5.1 Overview

Since the release of the original City of Burlington Storm Drainage Criteria Manual (1977), there has been a clear and noticeable shift in the planning and design approach for new communities and their supporting infrastructure. Formerly, community planners and engineers established land uses and servicing infrastructure largely independent of natural system protection and function. As such, the role of the drainage engineer was to design systems which would capture runoff as efficiently as possible and convey it to the nearest outlet. Current, more contemporary planning and design approaches have adopted a much more focused philosophy related to the natural and social environment, and many communities are now designed with an "environment-first" perspective. This shift represents an ecosystem–based approach to stormwater management which integrates the concepts of community and development sustainability, with the requirements of the natural system. This overarching shift has inherently changed the way in which new communities are planned and operated, including changes to the way stormwater is managed and valued. An ecosystem approach to stormwater management adopts a broad definition of the environment including natural, physical, social, cultural and economic issues.

Water resources are a key element in the overall function of natural ecosystems sustaining their health and existence. The protection of the functions of water and stormwater resources, through proper and effective stormwater management is paramount to a sustainable community.

1.5.2 Planning and Design Process

Planning and design processes affecting land use and infrastructure need to recognize the role of stormwater management related to the protection of ecological attributes and functions of the watershed. An integrated planning and design process requires that the constraints and opportunities afforded by the physiography (land-based approach, including natural hazards) be considered concurrently with natural features and functions (ecological approach) in the planning and design of stormwater management systems. A multi-disciplinary team of specialists is required, including:

- Engineers (Water Resources, Civil, Geotechnical)
- Land Use Planners (Environmental, Policy);
- Terrestrial and Aquatic Ecologists;
- Geoscientists (Hydrogeologists and Fluvial Geomorphologists); and
- Landscape Architects/Urban Designers.

Contractors and End Users (municipal staff, the public) may also be included. Although the relative contribution of each discipline will vary throughout the planning and design processes depending on the setting, the continued involvement of the multidisciplinary team from concept to implementation is critical, in order to ensure project objectives are addressed as the process moves forward. Where possible, the integrated planning for stormwater management practices should be conducted early in the planning process (i.e. Conceptual Master Plan or Secondary Plan level), in order to clearly establish stormwater management planning from an integrated and multi-disciplinary perspective.

1.5.3 The Ecosystem Approach

Like many municipalities in Ontario, Burlington has embraced environmental principles in its community and neighbourhood planning. The City of Burlington was an early adopter of this approach, as documented in "Ecosystem Approach to Land-Use Planning", by the City of Burlington's Sustainable Development Committee (April, 1993). Common values in the ecosystem planning approach include:

- Ecosystem Conservation, Protection and Restoration
- Watershed and Subwatershed Planning
- Groundwater and Surface Water Resources Management
- Stormwater Management
- Natural Hazards Management
- Emergency Preparedness

These principles are best addressed through an integrated land use and environmental planning process which involves the preparation of various plans at various stages of development. The following outlines the general relationship between land use and environmental/stormwater plans, however depending on the location, features of interest and related issues, they may overlap between various study phases.

Land Use Planning	**Environmental & Stormwater Planning**
Official Plan	Watershed Plan
Secondary Plan	Subwatershed Plan
Tertiary Plan (Neighbourhood)	Master Environmental Servicing Plan (MESP)
Plan of Subdivision/Site Plan	Functional Servicing Report (FSR)
Detailed Plan	Stormwater Management Design Report

Furthermore, the redevelopment of lands (infill/intensification), as is prevalent in Burlington, often takes guidance from more locally specific studies in conjunction with the above planning stages, scaled to the extent necessary to fully capture the factors influencing the environment and infrastructure.

Partnership with environmental regulatory agencies (specifically Conservation Halton) during the preparation of planning documents, is integral to their development.

The preparation of the land use, environmental, and stormwater plans within the City of Burlington should be based on the ecosystem approach and must not only protect, but where possible enhance the natural environment. The following objectives are to be considered:

i. Consider the protection of sensitive natural resources and propose appropriate restoration/naturalization measures for areas where these resources have been previously impacted;

ii. Provide peak flow control, and water quality protection, habitat enhancement, water balance and erosion control;

iii. Avoid natural hazards where there is an unacceptable risk to public safety or property damage, and not create new or aggravate existing natural hazards;

iv. Avoid negative impacts on wetlands, Areas of Natural and Scientific Interests (ANSI), and the Regional Natural Heritage System;

v. Maintain groundwater recharge through infiltration practices in areas confirmed as significant recharge areas or supporting key hydrologic and natural features;

vi. Protect, Rehabilitate and Enhance ecological linkages which secure wildlife movement and the biodiversity of plants and animals, such as valley buffers.

vii. Promote visual (aesthetic) and passive recreational use of natural features and corridors;

viii. Restore eroded stream banks and degraded vegetation to natural conditions;

ix. Protect and Enhance aquatic habitats; and

x. Ensure public input opportunities are provided at multiple points in the process.

2.0 Land Use Planning Framework

2.1 Planning and Servicing Studies

2.1.1 General Process

As noted in Section 1, Stormwater management planning and design generally occurs through a multi-phase process which is completed in conjunction with the land use planning process. Figure 2.1 illustrates the relationship between environmental planning studies and the municipal planning process, together with the corresponding approval agencies for new greenfield development. Specific stormwater management considerations at various stages of the land use planning processes are presented in Table 2.1. It should be noted that Figure 2.1 is primarily intended for greenfield re-development (not the most common type of development in the City of Burlington), however the information is informative and serves as a point of reference to the discussion of infill/intensification and re-development in subsequent sections.

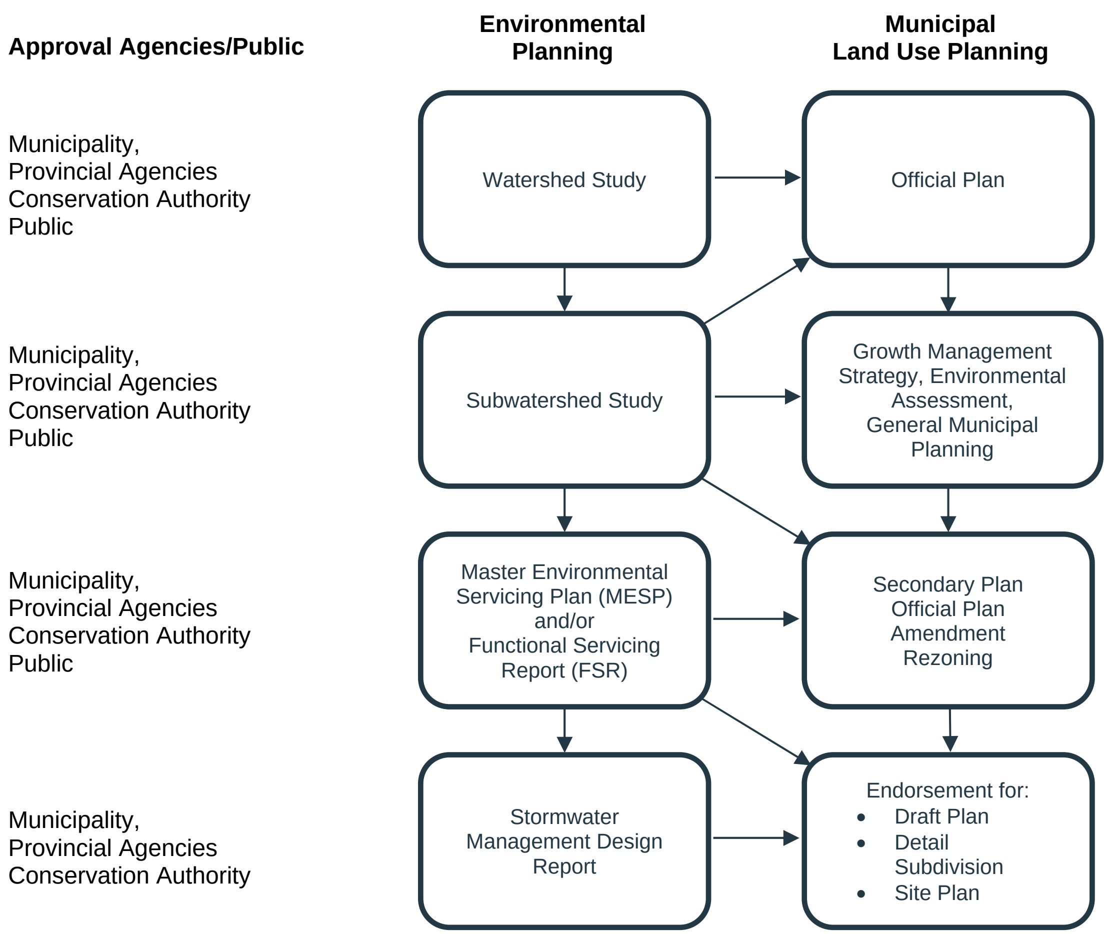


Figure 2.1: Relationship between Municipal Land Use Planning and Environmental Planning (Adapted from MOE SWM Planning and Design Manual, 2003)

Table 2.1: SWM Considerations at Various Stages of the Land Use Planning Process	
Planning Stage	**Description**
Official Plan (OP)	OP identifies land use type, density, and mitigation requirements to meet watershed objectives, including protection of sensitive features through land use designations. Applicable Watershed Plans represent resource documents for development of Official Plans and completion of Subwatershed Studies. It is at this stage where a natural heritage system (NHS) is established.
Secondary Plan/Official Plan Amendment (OPA)	Full range of opportunities to achieve stormwater management and environmental objectives are identified, establishing a template for the more detailed resolution of the site-specific design of stormwater management facilities at subsequent stages in the planning and design process. The NHS is refined and the limits of specific features are established.
Draft Plan of Subdivision	The location of lots, roads, parks and open space blocks, natural heritage features and buffers and stormwater management facilities are defined. The approach to achieve stormwater management objectives and how these objectives influence the location and configuration of each of the components listed above must be defined.
Site Plan	Opportunities are presented to integrate stormwater management facilities into all of the components of a development including landscaped areas, parking lots, roof tops and subsurface infrastructure. Solutions must be considered in the context of the overall stormwater management strategy for the block or secondary plan area to ensure that functional requirements are achieved.

The preceding considerations focus upon greenfield developments (the conversion of rural, undeveloped land). Infill and intensification also requires consideration, specifically within the City of Burlington given the expectation that this form of development will become more predominant as available greenfield land is developed. Land use and environmental planning studies are also necessary for these types of development.

Environmental planning studies such as Watershed/Subwatershed Studies (SWS), Master Environmental Servicing Plans (MESPs), Functional Servicing Reports (FSRs) and Stormwater Management (SWM) Reports are prepared in support of municipal land-use studies and plans at various stages of the development process, to help guide land use decisions and ensure that practical and effective plans are prepared which manage impacts to natural resources. Depending on the stage of development, the study and documentation process will effectively need to address the needs of the respective plan requirements. The basic objectives and deliverables for each of these various studies are discussed in the following sub-sections.

2.1.2 Watershed Plans

Watershed studies or plans are higher level documents providing guidance on resource management at a broad scale. Reference is made to Section 1.3, and Drawings 1 and 2 (attached) which present the watersheds within the City of Burlington.

A watershed study area consists of the natural drainage boundary of the watercourse and all of their tributaries. A watershed plan typically establishes environmental resource management at an Official Plan scale and is used as a guide for managing human activities that affect water, land/water interactions, and terrestrial and aquatic resources. The watershed plan outlines areas for protection, enhancement, and rehabilitation and high-level direction and policy, such that the health of the watershed's ecosystem can be protected, as land uses and management practices change.

The Watershed Plan is over-arching in that it provides direction for subsequent more detailed and localized subwatershed studies. It establishes high-level environmental goals and objectives and identifies the actions required to meet those goals. A Watershed Plan is typically developed co-operatively between government agencies, conservation authorities and stakeholders, particularly since watersheds are often multi-jurisdictional.

2.1.3 Subwatershed Studies

Subwatershed studies essentially implement the high-level recommendations from watershed plans and related policies which would ultimately provide environmental and water resources input into the Secondary Planning (Official Plan Amendments) process for local communities (notwithstanding that the majority of the expected growth in the City of Burlington is from infill/intensification). Subwatershed studies are most often driven by urban development and led by the municipality with direct involvement from the Conservation Authority and proponent landowners. The Subwatershed study process generally consists of the four phases as shown in Figure 2.2:

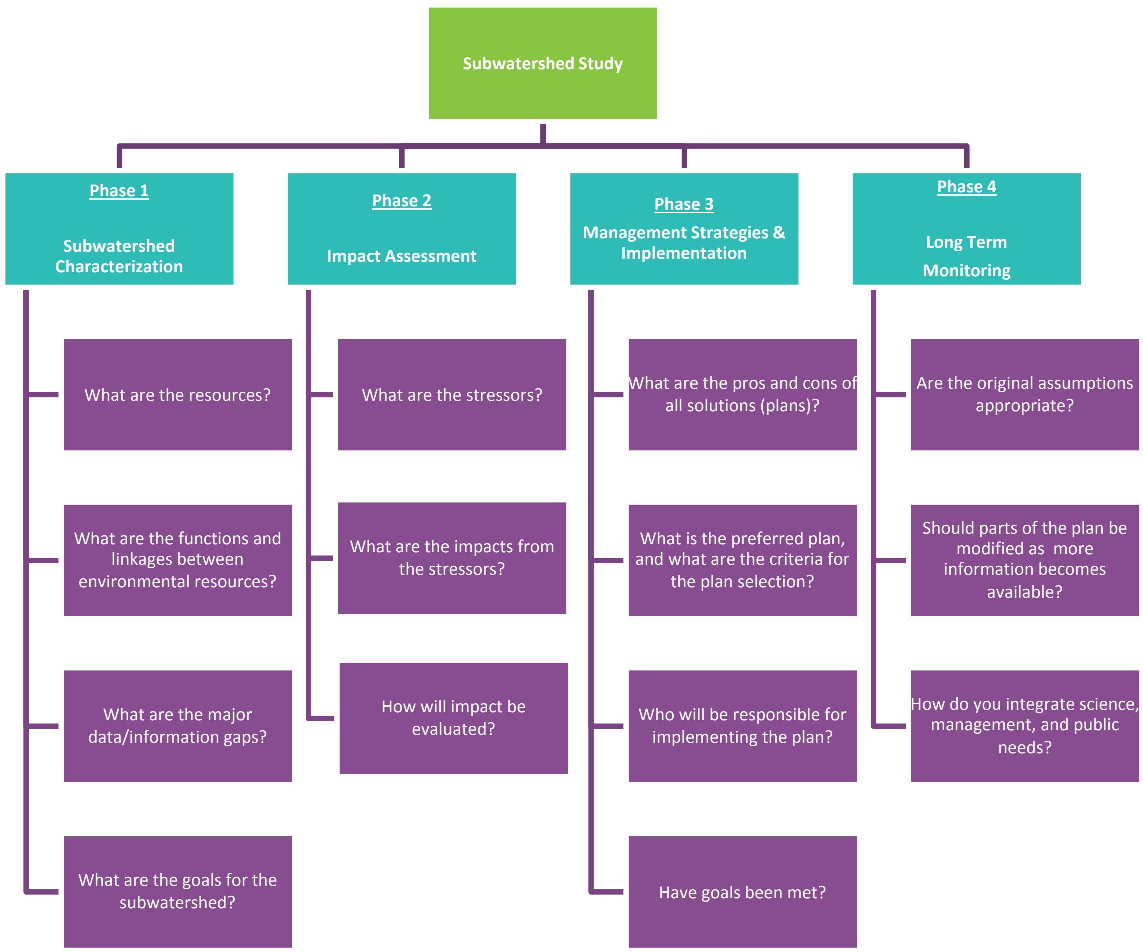


Figure 2.2: Subwatershed Study Process

- **Phase 1 "Subwatershed Characterization."** This phase involves an integrated assessment of the resources of the subwatershed by various study disciplines including hydrology and hydraulics, hydrogeology, water quality, stream morphology, aquatic and terrestrial ecology. Background and supplemental field data are collected for each discipline and then considered across disciplines in an integrated manner to establish an understanding of the form, function, and linkages of the environmental resources. During this phase, preliminary "working" goals and objectives are developed to guide future development and management in the subwatershed.

- **Phase 2 "Impact Assessment."** In this phase, the future impacts of various potential future land use scenarios are determined and assessed related to multiple subwatershed scale parameters. It is during this phase that the assessment considers a range of appropriate mitigation strategies to meet the preliminary working goals and objectives established during Phase 1.
- **Phase 3 "Management Strategies & Implementation".** This phase finalizes the alternative solutions and establishes the preferred management strategy by taking direction from Phase 2. By considering the potential impacts and predicted effectiveness of various management strategies and based on a finalized form of land use, a set of management strategies is established to achieve the identified goals and objectives. The implementation plan for the subwatershed study and its associated recommendations provides input on:
  - priorities;
  - performance targets for overall system function (e.g. high level SWM objectives);
  - staging/phasing;
  - monitoring; and
  - future study requirements.
- **Phase 4 "Long Term Monitoring".** This phase of the Subwatershed Study follows substantial implementation of the development and associated management; this phase is traditionally executed by the Municipality or local Conservation Authority or a partnership and funded by development. The purpose of the monitoring is to evaluate the effectiveness of the Proposed Management Strategy over time (both locally and holistically) and adjust or adapt the plan as possible and as required.

2.1.4 Master Environmental Servicing Plans

Master Environmental Servicing Plans (MESPs) are completed in support of Secondary Plans and /or Tertiary Plans. The MESP includes supporting technical analyses including hydrology, hydraulics, hydrogeology, geotechnical investigations, and fluvial geomorphology. The MESP is conducted at a higher level of resolution and typically would involve a neighbourhood or block plan scale, not necessarily co-incident with the subwatershed(s). MESPs would inherently integrate the evaluation of aquatic habitat and terrestrial features, as part of an Environmental Impact Study (EIS). The purpose of the MESP is to provide an integrated and more detailed analysis of management requirements with the benefit of more detailed and refined land use information than was available to the Subwatershed Study. The MESP highlights the key recommendations and requirements to be addressed through the future draft plans of subdivision and/or site plans. In general, the MESP involves the following steps:

- **Review Existing Information**
  - Review Subwatershed Study data, analyses and recommendations, where applicable and appropriate, in conjunction with other companion studies, to identify any information gaps relating to the conservation of natural heritage areas, features and functions.
- **Refine data for Existing Environmental Conditions**
  - Based on the review of the existing information, carry out the necessary studies to fill local scale data gaps with respect to natural features and systems.
- **Update Constraint/Opportunity Mapping**
  - Based on the refined land use plan and using existing information as a base ('starting point') conduct a functional analysis of the ecologically-sensitive lands constituting the natural heritage system, including natural hazards, and thereby prepare an updated detailed constraint and opportunity map.
- **Assess Detailed Land Use Impacts to Establish Preferred Environmental and Stormwater Management Strategy**
  - Refine the land use plan(s) so that it best addresses the environmental and stormwater management requirements and practices identified by the higher-level studies (as appropriate), reflecting the detailed constraint and opportunity mapping. The impact assessment of the proposed land use should be updated and refined to determine if alternative environmental and stormwater management strategies may be necessary, considering other economic and social issues such as interim servicing, cost sharing, development timing etc.

2.1.5 Functional Servicing Reports

Functional Servicing Reports (FSRs) provide details specific to the functional serviceability for a proposed development related to the water, wastewater, and stormwater network ensuring that it can function to Municipal, Regional, and Provincial criteria. The FSR describes the location and nature of existing municipal water, wastewater, and stormwater infrastructure that may be available to provide servicing for the proposed development. It should outline in detail the proposed servicing requirements for the development and indicate the capacity of the existing infrastructure to support the development. It should also identify the necessity to dedicate lands to proposed stormwater infrastructure, and the extents/area of land required for this purpose, as appropriate.

FSRs are prepared in support of development/re-zoning and intensification projects to identify how servicing will be provided while meeting approved environmental targets from preceding studies (i.e. MESP). For large developments with significant environmental considerations, a three-step process may be appropriate, requiring an MESP followed by underlying FSRs and Functional Stormwater Management Reports for individual subdivisions and servicing facilities, respectively. In some instances where the extent of land use change is limited, it may be appropriate to complete only an FSR and single Stormwater Management Report. If the proposed development does not include a stormwater management facility, then a separate Stormwater Management Report may not be required, although the FSR will be required to document the stormwater management strategy for the site (e.g. stormwater management within an off-site facility). However, if a stormwater management facility is proposed for the development, then a Preliminary Stormwater Management Report shall be submitted.

2.1.6 Stormwater Management Reports

Detailed SWM reports need to be prepared to support detailed site design. As such, they are required in order to meet the conditions set at the Draft Plan stage of the subdivision process or as part of a Site Plan approval process. The preparation, review and approval of the SWM Report should be the final step in the approval of the proposed SWM plan. The SWM Report must provide the required design and detailed supporting calculations for all component elements of the proposed stormwater management system. The SWM Report should contain the detailed design of stormwater controls, delineation/confirmation of constraint boundaries, and hydraulic and hydrologic analyses. The report should include and/or reference supporting geotechnical/ hydrogeological studies, environmental restoration reports, preservation and restoration/ remediation plans, sediment/erosion control plans, monitoring plans, and long term operations and maintenance. The components of the SWM Report may vary depending upon whether an MESP and/or Subwatershed Study have been completed.

Should the proposed development occur within, or near Region of Halton capital project limits, the SWM report will require review and approval by the Region of Halton.

2.2 Legislation, Acts, Regulations and Guidelines

The City and its key stakeholder agencies have prepared relevant documents to support the planning and design of stormwater and environmental management systems. Practitioners and regulators should be familiar with the direction offered in these companion documents (and any new updated versions) in order that future designs of stormwater-based and associated environmental systems can be effective and consistent with the broadest set of environmental considerations. The following offers some of the relevant companion information which practitioners should be familiar with. The list may not be complete or current, hence proponents should pre-consult with the various agencies and the City of Burlington to confirm the requirements and applicable guidance documents for the specific projects. Halton Region would be expected to be involved in the approval process for any project where drainage is directed to a Regional Road.

2.2.1 City

- Official Plan
- City of Burlington By-law 52-2018 or newest version (A by-law to regulate the altering of grades or drainage on Low Density Residential Lands)
- City of Burlington By-law 086-2002 or newest version (Storm Sewer Discharge by-law to regulate, inspect any discharge into land drainage works, private branch sewers & connections to any sewer, sewer system or sewage works carrying away waste).

2.2.2 Halton Region

- Region of Halton Sewer Use By-law 02-03
- Halton-Hamilton Source Protection Plan
- Hydrogeological Studies & Best Management Practices for Groundwater Protection
- Regional Official Plan
- Design Guidelines for Regional Roads

2.2.3 Conservation Halton and Conservation Authorities

- Conservation Authorities Act (1990, https://www.ontario.ca/laws/statute/90c27)
- Erosion and Sediment Control Guidelines for Urban Construction (Greater Golden Horseshoe Area Conservation Authorities, December 2006)
- Low Impact Development Stormwater Management Planning and Design Guide (STEP, https://wiki.sustainabletechnologies.ca/wiki/Main_Page)
- Policies and Guidelines for the Administration of Ontario Regulation 162/06 and Land use Planning (CH, April 2006, amended August 2011 and November 2015)
- Evaluation, Classification and Management of Headwater Drainage Features Guidelines (TRCA/CVC, January 2014)
- Approved Shoreline Policies (December 2015)
- Approaches to Manage Regulatory Event Flow Increases Resulting from Urban Development (TRCA, June 2016)
- Large Fill Policies & Guidelines (December 2016)
- Landscaping and Tree Preservation Guidelines (2017)
- Conservation Halton Seed Mixes (May 2018)
- Conservation Halton Native Species List (August 2018)
- CH Guidelines for Ecological Studies (August 2017)
- CH Monitoring Protocols (February 2017)
- Requirements for completion of hydrogeological studies to facilitate Conservation Halton's reviews (November 2014)
- CH SWM Guidelines (Draft Form Only)

CH policy documents and regulation mapping can be accessed through the following link: https://www.conservationhalton.ca/planning-permits

2.2.4 Provincial

- Ontario Water Resources Act (1990 and as amended)
- Conservation Authorities Act (1990 and as amended)
- Hamilton Harbour Remedial Action Plan (1992 and 2002)
- Water Management Policies, Guidelines and Provincial Water Quality Objectives (MOEE, July 1994)
- Ministry of Transportation (MTO) Drainage Management Manual (1997)
- Technical Guide, River & Stream Systems: Flooding Hazard Limit, MNR (2002)
- Stormwater Management Planning and Design Manual, MOE (2003)
- The Provincial Policy Statement (2014 and as amended)
- The Greenbelt Act / Greenbelt Plan (2005 and as amended)
- Ontario Regulation 162/06: Conservation Authority Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (May 2006 and as amended)

- Ontario Regulation 406/19: On-site and Excess Soil Management
- The Clean Water Act (2006 and as amended)
- Endangered Species Act (2007 and as amended)
- Highway Drainage Design Standards (Ministry of Transportation, 2008)
- Water Opportunities Act (2010)
- MNR Draft Guidance for Development Activities in Redside Dace Protected Habitat (February 2011)
- Thermal Mitigation Checklist for Stormwater Management Ponds Discharging into Redside Dace Habitat – Version 1.1 (MNRF Aurora District, June 18, 2014 and as amended)
- Interpretation Bulletin, Ontario Ministry of Environment and Climate Change, Expectations re: Stormwater Management (MOECC, 2015)
- MOECC Low Impact Development Stormwater Management Guidance Manual (Draft) (Aquafor Beech Limited, 2017)
- Technical Guidelines for Flood Hazard Mapping (EWRG et al, March 2017)

2.3 Areas of Environmental Resources and Constraint

In conjunction with the preceding review of the planning process, and relevant legislation, acts and regulations, proponents should be aware of available information with respect to areas of environmental resources and constraint. These areas would include (but are not necessarily limited to):

- Floodplains
- Lake Ontario Shoreline
- Hamilton Harbour Shoreline
- Valleys (including watercourse meander belts) and slopes
- Areas along the Niagara Escarpment
- Unstable soils and bedrock (e.g. karst)
- Sourcewater Protection areas
- Swamps and wetlands (including Provincially Significant Wetlands)
- Woodlots and forests
- Areas of Natural and Scientific Interest
- Habitat areas for Species at Risk (SAR)

It is the proponent's responsibility to contact the relevant regulatory agencies noted previously to obtain and review this information, and to consider these constraints as part of the overall land use planning.

2.4 Submission Requirements and Supporting Studies

In order to ensure that the expectations of the City of Burlington are addressed for technical submissions, and to avoid unnecessary delays, a pre-consultation with the Stormwater Engineering group is recommended. The City may also provide checklists to outline the minimum submission requirements for applications and studies. Different checklists may be provided depending on the type of submission.

As part of submissions to the City of Burlington, it is recommended that proponents provide a copy of the completed checklist, and an agreed upon Terms of Reference (established through the pre-consultation process) in order to demonstrate that they have satisfied minimum City requirements for submission.

3.0 Stormwater Drainage System Policies

3.1 Overview

As discussed in Section 1.1, Stormwater Management is a fundamental requirement of development, and impact management. When natural areas are converted to urbanized land uses, pervious areas are typically reduced, and impervious land coverage (buildings, roadways, parking areas, etcetera) increased. Effective stormwater management is necessary to ensure that these impacts are prevented or minimized to the extent possible, to the overall benefit of the City of Burlington.

Stormwater management practices should apply strategies which effectively mimic the characteristics of natural drainage systems; this includes promoting strategies which consider all components of the hydrologic cycle and the changes resulting from development. Strategies which promote water balance, including on-site infiltration and recharge, runoff volume reduction, as well as peak flow and velocity control, should be applied. This approach is consistent with currently accepted best practices, as well as the current direction of the Province of Ontario's Ministry of the Environment, Conservation and Parks (MECP).

Fundamental to the foregoing approach is the understanding that stormwater is a resource, rather than a waste product. Opportunities to retain and beneficially re-use stormwater should be considered, and implemented where feasible, as part of the overall stormwater management strategy.

3.2 Hazard Lands

The City of Burlington defines Hazard Lands as having "inherent environmental hazards" such as flood susceptibility, erosion susceptibility, unstable bedrock (e.g. karst), unstable soil, or any other physical conditions which may be severe enough to pose a threat to the occupants of the lands.

The Conservation Authorities Act (RSO 1990, Chapter C27, Section 28(1), and subsequent updates), allows for regulation of development activities in areas that are hazardous lands; wetlands; river or stream valleys; adjacent or close to the shoreline of the Great Lakes-St. Lawrence River System or to an inland lake; or other areas as determined through regulations. It also allows for regulation of activities to change or interfere in any way with a watercourse or wetland.

The City of Burlington supports the policies of Conservation Halton, which require that development generally be directed away from areas of natural hazards. An activity may be permitted within a regulated area where the activity is not likely to affect the control of flooding, erosion, dynamic beaches, pollution or conservation of land and where the activity is not likely to create conditions or circumstances that, in the event of a natural hazard, might jeopardize the health or safety of persons or result in the damage or destruction of property.

Flood hazard mapping may be riverine-based, shoreline-based or urban-based (i.e. roadway systems – overland flow). The riverine "Regulatory Flood" in Burlington is the greater of the Regional Storm (Hurricane Hazel) or the 100-year storm event (based on a frequency analysis of observed data or hydrologic/hydraulic simulation modelling). Along the shoreline of the Great Lakes, the flooding hazard limit is based on the 100-year flood level plus an allowance for wave uprush and other water-related hazards. The most current floodplain mapping, as available from Conservation Halton or the City of Burlington, shall be used to define the flood hazard. Depending on the location and availability of data, the proponent may be required to update or create floodplain mapping to the satisfaction of the City of Burlington (and Conservation Halton for regulated areas), in order to adequately delineate the flood hazard limits.

Other natural hazard mapping (e.g. erosion hazards) should be obtained from Conservation Halton, with the proponent responsible for updating this information as necessary to the satisfaction of the City of Burlington and Conservation Halton, in order to adequately delineate other hazard.

3.3 Flood Control

In the past, uncontrolled urbanization/development resulted in increased runoff volume and peak flows, due to the associated increase in impervious land coverage. Without adequate quantity (flood) controls, increased peak flows could compromise the capacity of downstream conveyance systems (urban systems and open channels) and result in flooding impacts/damages to adjacent properties.

Proponents are thus required to provide flood control management in accordance with the specified level of control outlined within a Watershed Study, Subwatershed Study (SWS), Master Drainage Plan (MDP), or Master Environmental Servicing Plan (MESP) that encompasses the proponent's site.

Where a SWS or MESP does not exist, the proponent is required to consult with the City and Agencies (including Conservation Halton) regarding the acceptable level of runoff controls to be applied to the proponent's site. At a minimum, post-development to pre-development peak flow control is required for the 2 through 100-year return periods, as established through hydrologic simulation based on the City of Burlington's currently specified rainfall dataset, and associated intensity-duration-frequency (IDF) values.

The City of Burlington generally considers that existing systems are at, or near, full capacity, hence infills and re-developments may need to over-control flows, as specified by the City and any governing studies.

Existing drainage patterns should be maintained to the extent possible. Minor changes may be considered by the City (in consultation with Conservation Halton when appropriate), in its sole discretion, if the proponent is able to justify the need for the diversion and is able to fully mitigate the impacts.

The City of Burlington may (in consultation with Conservation Halton where appropriate), in its sole discretion, consider a reduced quantity (flood) control requirement if the proponent is able to clearly demonstrate that the impacts of the proposed development would not result in any off-site impacts. This could potentially apply in locations outletting directly to Lake Ontario.

Quantity controls are not currently required for the Regional Storm (Hurricane Hazel). This is consistent with the approved direction of the MNRF (2002), which does not credit SWM facilities in the establishment of Regional Storm impacts. It has been previously assumed that due to saturated soils under the Regional Storm, no significant flow increases would be expected from development (i.e. impervious surfaces would respond generally the same as saturated pervious areas). This approach has been increasingly questioned by practitioners including Conservation Authorities, as documented in "Approaches to Manage Regulatory Event Flow Increases Resulting from Urban Development (TRCA, 2016). Current and potential future MNRF criteria will need to consider this issue. The City of Burlington will continue to work with Conservation Halton and the Province to address the requirement for, and recognition of, quantity controls for the Regional Storm Event. The City of Burlington will assess the requirement for Regional Storm controls in conjunction with high level studies such as Subwatershed Studies or Master Environmental Servicing Plans. Where a SWS or MESP does not exist, the City of Burlington may consider the requirement for quantity controls for the Regional Storm Event should updated direction be provided by the MNRF or Province of Ontario.

3.4 Erosion Control

Increased runoff volumes, and increased durations of erosion causing flows, have the potential to have detrimental erosive impacts to downstream receiving watercourses, unless adequately controlled.

Similar to flood control requirements, proponents are required to provide erosion control in accordance with the specified level of control outlined within a higher-level study (SWS, MDP, MESP or otherwise) that encompasses the proponent's site. Where a higher-level study does not exist, the proponent is required to consult with the City and Agencies (including Conservation Halton) regarding the acceptable level of runoff controls to be applied to the proponent's site. For erosion control, the proponent is required to mitigate any potential erosion impacts in accordance with Provincial guidelines. At a minimum, the proponent should provide extended detention control (detention of the 4-hour, 25 mm storm event over at least 24 hours, with a preference for 48 hours). Alternatively, the proponent should demonstrate the retention of the 90th percentile rainfall (27 mm for the City of Burlington) consistent with potential pending Provincial guidelines, and subject to review and discussion with the City of Burlington. Erosion controls are credited towards overall on site quantity control measures.

Existing drainage patterns should be maintained to the extent possible. Minor changes may be considered by the City (in consultation with Conservation Halton when appropriate), in its sole discretion, if the proponent is able to justify the need for a diversion and is able to fully mitigate the impacts on both the receiving and the losing systems.

The City of Burlington may (in consultation with Conservation Halton where appropriate), in its sole discretion, consider reduced erosion control requirement if the proponent is able to clearly demonstrate that the impacts of the proposed development would not result in any off-site impacts. This could potentially apply in locations outletting directly to Lake Ontario, or areas outletting to insensitive watercourse receivers (such as lined channels with no natural systems located downstream).

Storm sewer outfalls to natural channel systems shall incorporate proper protection against local erosion, including bank scour protection. Where storm sewer outfalls outlet to steep and/or deep valleys, drop structures shall be incorporated and designed to address these concerns. All erosion mitigation measures at outfalls should be designed to blend with the natural receiving watercourse system to the extent possible. Designs for outfalls to Lake Ontario and Burlington Bay shall appropriately consider coastal processes.

3.5 Infiltration and Water Budgets

Uncontrolled urbanization/development typically alters the natural hydrologic cycle due to the associated increase in impervious land coverage and changes in the nature of pervious areas (e.g. agricultural to manicured lawn). Infiltration and evaporation/transpiration are typically reduced, while runoff (peak flow and volume) is increased. These changes have the potential to result in both flooding and erosion impacts, as well as impacts to groundwater resources in terms of quantity and quality. Consideration of nearby groundwater users (e.g. private wells) should also be considered.

Proponents are required to maintain a Water Budget (a general accounting for the amount of rainfall input which becomes runoff, is infiltrated, or is lost through evapotranspiration) in accordance to the specified level of control outlined within a higher-level study that encompasses the proponent's site. Where a higher-level study does not exist, the proponent is required to ensure that pre-development infiltration volumes are maintained under post-development conditions. Consistent with potential pending Provincial guidelines, the proponent may achieve this requirement by managing the retention and/or infiltration of the 90th percentile rainfall (27 mm for the City of Burlington) consistent with pending potential Provincial guidelines. At a minimum, the City of Burlington recommends that the proponent ensures that the first 5 mm of rainfall which lands on the site is retained and infiltrated on site (i.e. zero runoff for the first 5 mm of rainfall).

The City of Burlington supports the application of Green Infrastructure (GI) and Low Impact Development Best Management Practices (LID BMPs) to achieve these requirements, however it does not credit its benefit with respect to quantity control requirements given the potential for loss of functionality due to a lack of maintenance, particularly for sub-surface infiltrative measures. Notwithstanding the preceding, a quantity control benefit can be credited to surface based LID BMPs, specifically grassed swales and bioswales/bioretentiona areas, if equipped with an acceptable outlet control structure.

The City of Burlington may (in consultation with Conservation Halton where appropriate), in its sole discretion, consider a reduced infiltration and water budget requirement if the proponent is able to clearly demonstrate that achievement of the preceding is not feasible on the site, due to physical constraints such as an elevated groundwater condition, bedrock or other constraints. In these cases, the City of Burlington may require proponents to provide a cash-in-lieu contribution, to allow the City to support equivalent measures in other areas. Proponents must consult with the City regarding the potential application of a cash-in-lieu policy.

Features based water budgets may also be required to maintain important watershed features and functions (e.g. wetlands, watercourses). Pre-consultation with the City of Burlington and Agencies (including Conservation Halton) should be undertaken to establish the appropriate Terms of Reference for the study depending on the receiving system and nature of development.

3.6 Water Quality Control

Uncontrolled urbanization/development can result in negative impacts to water quality, through the addition of impervious surfaces (primarily roadways and parking areas) and contaminant sources which contribute elevated levels of chemical, physical or biological contaminants (total suspended solids, heavy metals, nutrients, bacteria, chlorides, etcetera) to downstream receivers.

Proponents are required to provide water quality control in accordance with the specified level of control outlined within a higher-level study which encompasses the proponent's site. Where a higher-level study does not exist, the proponent is required to consult with the City and Agencies (including Conservation Halton) regarding the acceptable level of quality control for the site. The City of Burlington requires Level 1 Protection (Enhanced – 80% Average Annual Removal of Total Suspended Solids) for all developments. This requirement shall apply for the total impervious coverage of the development site, regardless of the existing impervious coverage. Specifically for re-development applications, the City of Burlington requires that proponents provide treatment for the whole of the redevelopment site, regardless of its current use. Rooftop areas may be considered as "clean" impervious area for the purposes of calculating water quality treatment requirements, provided that these flows are separated from runoff from other areas.

The increase of impervious surfaces on development sites, particularly parking and roadway areas, can result in elevated temperatures for stormwater discharges. Increased temperature in stormwater flows can have a negative impact to downstream receivers. The City of Burlington promotes consideration of thermal mitigation measures within the site stormwater management design, including sub-surface cooling trenches, and infiltration-based measures such as LID BMPs.

Aldershot area creeks, as well as Grindstone, Falcon, and Indian Creeks, and the Upper Hager-Rambo Creek system, are all noted to discharge to Hamilton Harbour, which is governed by the Hamilton Harbour Remedial Action Plan. The 1992 report (Hamilton Harbour Remedial Action Plan, Stage 2 Update (2002)) outlines the overall principle of zero discharge, namely, that a "…philosophy be adopted whereas control of inputs of persistent toxic substances shall eventuate to zero discharge". This approach (no net increase in contaminants due to development) would suggest a more stringent target than Level 1 Protection (80% TSS removal) for these areas. The City of Burlington, Conservation Halton and other regulators may require additional water quality treatment in these areas accordingly, such as off-site measures or a cash-in-lieu contribution to support off-site improvements; this should be reviewed at the time of development.

For areas discharging to Hamilton Harbour, proponents are to calculate and compare water quality treatment requirements both using the City's standard approach (providing treatment for the entire site, regardless of its current use), as well as the "no net increase" approach (as per the HHRAP) to determine whether additional off-site measures are required.

Additional water quality controls may also be required for sites expected to generate higher contaminant loads (gas stations, etcetera) or draining to sensitive receivers (endangered species habitat, etcetera).

The City of Burlington may (in consultation with Conservation Halton when appropriate), in its sole discretion, consider a reduced water quality requirement if the proponent is able to clearly demonstrate a rationale. In these cases, the City of Burlington will require proponents to provide a cash-in-lieu contribution, to allow the City to support equivalent measures in other areas.

Where on-site stormwater quality controls are specified, the City of Burlington, Conservation Halton and MECP highly recommend that the "treatment train" approach be employed. This management strategy necessitates that at least two (2) different stormwater quality measures are incorporated as part of the overall stormwater quality strategy, to avoid reliance on a single measure. The City of Burlington will only permit ETV certified quality treatment devices for runoff quality control. Notably Oil Grit Separators (OGS) will only be credited for 50% removal, In general, it is recommended that OGS units be used for pre-treatment purposes, upstream of any proposed secondary infiltrative measures, to reduce the potential for clogging and ease of future maintenance.

3.7 Flow Conveyance

3.7.1 Urban Infrastructure

3.7.1.1 Overview

Urban infrastructure shall be designed to safely convey stormwater runoff from its source location to its receiving system. Typical urban infrastructure consists of major and minor systems.

The minor system in Burlington is designed to convey drainage from smaller, more "minor" storms, with a frequency (return period) of a 5-year storm event. Minor system conveyance is typically via storm sewer systems, and associated drainage features (gutters, catchbasins, swales, etcetera) or roadside ditches. The minor system is typically assumed by the City of Burlington to be at full capacity.

The major system is intended to drain flows in excess of the capacity of the minor system. The major system would include swales and ditches, roadways, walkways and easements, and ultimately natural watercourses.

The major and minor system shall be designed such that impacts to upstream and adjacent properties do not occur. For minor systems, this requires the proponent to complete a hydraulic grade line (HGL) assessment to ensure that water levels do not rise above the street level, and do not negatively impact the buildings with hydraulic connections to the system. For the major system, this typically requires the proponent to ensure that surface ponding and flood depths are limited to maximum depths and restricted to individual properties.

3.7.1.2 Minor System

The minor system shall be designed to convey the 5-year storm event (as per the City of Burlington's currently specified rainfall dataset, and associated intensity-duration-frequency (IDF) values, without surcharging (85% of theoretical full flow capacity). In addition to the sizing of the primary conveyance feature (i.e. storm sewer), all related appurtenances and inlets shall be designed to ensure that an equivalent inlet capacity is provided with an appropriate factor of safety (50% blockage for sag points, as per Section

5.2.5) to account for potential debris blockage. This factor is to be applied for major system capture design only and does not apply to the design of catchbasin spacing.

In areas where a higher design standard has been applied (i.e. the 10-year storm event or greater), the higher design standard shall govern. Consideration should be given to areas where Region of Halton storm sewer systems interact with City of Burlington storm sewer systems as part of this review.

New developments shall be designed such that the maximum 100-year hydraulic gradeline (HGL) is a minimum of 0.30 m below any proposed basement footing. Inlet Control Devices (ICDs) may be required to ensure that inflows for larger storm events are restricted to limit the HGL elevation to the designed level.

In existing areas where an elevated 100-year HGL may exist, the proponent must ensure that the proposed works do not increase surcharge levels (the HGL) beyond existing levels.

Foundation Drain Collectors (FDCs) are dedicated sewer systems for the collection of drainage from building foundations. These systems are generally not permitted within the City of Burlington but may be considered subject to suitable justification (such as water budget/water balance requirements) and specific written approval from the City of Burlington.

3.7.1.3 Major System

The major system shall be designed to convey the 100-year storm event (as per the City of Burlington's currently specified rainfall dataset, and associated IDF values), less the capacity of the minor system. This requirement applies to urban (pluvial) flooding conditions; riverine (fluvial) flooding requirements for ingress/egress should be implemented consistent with Provincial Policy (MNRF) and the requirements of Conservation Halton and the City of Burlington.

Analytical methods which consider the interaction between the minor and major system (and associated inlet capacity) such as dual drainage analysis, are encouraged to confirm expected major system performance such as conveyance depths. Sag points should be minimized to the extent possible, particularly along collectors and arterials. A "saw-tooth" grading profile may be considered in special cases where existing grading does not allow for a reduction in sag points.

For roadways, the maximum permissible major system depths for the 100-year storm event shall be based on the classification of the roadway:

- For local roadways, the maximum permissible depth is 150 mm (0.15 m) above the roadway crown and a maximum depth of 300 mm (0.30 m) at the edge of the pavement.
- For collector and arterial roadways, the maximum permissible depth is 0 mm above the roadway crown (maximum depth of 80 mm (0.08 m) at the inside lane edge, in order to allow for at least one clear lane for travel in either direction)

Consideration should also be given to the specific requirements of Regional Roads, which may differ from City of Burlington criteria.

3.7.2 Open Channels and Watercourses

Open channels conveying overland flows to receiving watercourse systems shall be designed to convey the peak flows directed through the channel. Generally, the maximum storm event to be conveyed through open channels associated with development sites is the 100-year storm event, however conveyance of the Regional Storm may be required in some instances depending on drainage area. Existing and proposed watercourses are generally required to convey the Regulatory Flood flow (i.e. greater of 100 year and Regional Storm peak flows).

Open channels that are within the regulation limits of Conservation Halton are to be designed to meet all applicable Conservation Authority standards. Watercourses, in addition to the Conservation Authority standards, shall be designed to meet all other applicable agency standards (i.e. MNRF). Proponents are required to consult with the City and Agencies with respect to channel and watercourse design requirements.

Armour Stone lined channel design is the preferred method for enhanced erosion protection, however natural channel design best practices should be applied when designing open channels and watercourses, in keeping with the "Adaptive Management of Stream Corridors in Ontario (MNR, 2002), among other design guidelines.

A significant proportion of the watercourses in Burlington's urban areas have been historically modified through diversions, hardening and piping in an attempt to address drainage and flooding issues. Rehabilitation/restoration works on historically altered channels must take into consideration these constraints and conditions; however, natural channel design principles and softer treatments, such as bio-engineering, should be considered to the extent possible.

3.8 Groundwater

Understanding of seasonal groundwater is required to ensure development feasibility, including the application of specific stormwater management measures such as infiltration-based approaches. In general, the City of Burlington does not support single family detached residential development within the expected limits of the seasonal high groundwater table. For high density, multi-story developments with deeper underground facilities, intrusion into the groundwater table is likely, hence proponents must provide detailed groundwater management studies and plans to demonstrate adequate and appropriate mitigation.

Proponents are required to review/assess groundwater conditions within the respective development site (including seasonal variations) through the completion of site specific geotechnical or hydrogeological investigations, including consideration of adjacent groundwater users (e.g. private wells) in order to confirm the long-term impacts on groundwater, and to ensure that the proposed SWM strategy can be implemented as intended by the design.

The proponent must also abide with the regulations of the Ministry of the Environment, Conservation and Parks (MECP) with respect to groundwater takings both during construction and longer-term. The proponent is responsible for obtaining a Permit to Take Water (PTTW) from the MECP or registering in the Environmental Activity and Sector Registry (EASR) where necessary.

3.9 Sediment and Erosion Controls

The City of Burlington requires that an Erosion and Sediment Control (ESC) Plan be developed as part of any proposed construction works and completed to its satisfaction. The ESC plan must be in accordance with the Greater Golden Horseshoe Area Conservation Authorities' "Erosion and Sediment Control Guidelines for Urban Construction" (December 2006). The ESC plan must clearly demonstrate the measures proposed to limit the movement and transportation of sediment on-site. Measures to limit the period of bare (unvegetated) soil are required, including temporary seeding (using crops such as oats or rye) until such time as a permanent vegetative cover can be established. The proponent is responsible for installing, maintaining and monitoring ESC controls throughout the construction phase, revising measures as required, and removing ESCs upon full site stabilization. The proponent shall be held liable for any off-site impacts resulting from improper ESC controls.

3.10 Cash-in-Lieu

Where stormwater management measures are not considered feasible or practical to implement, re-development (infill / intensification) development proponents can provide cash-in-lieu. Cash-in-lieu will be used by the City of Burlington towards off-site SWM infrastructure. In general, the cash-in-lieu practice is less preferred over on-site controls (including source/conveyance controls, which can be more readily implemented in sites with limited areas). The onus is placed upon the proponent to justify the cash-in-lieu approach, however at a minimum, the proponent is required to demonstrate that the implementation of stormwater management measures is not feasible or practical for a re-development site. Potential situations where the cash-in-lieu approach may be considered include:

- Re-developments of single lots fronting on an existing municipal roadway
- Small re-development sites (i.e. less than 0.5 ha)

The cost of the cash-in-lieu is to be determined in consultation with the City of Burlington. Typically, cash-in-lieu should be no less than 100% of the cost of on-site controls, such as the smallest commercially available oil/grit separator unit for water quality treatment. The costs associated with other requirements (erosion, water budget, or quantity control) should be determined in a similar manner.

The proponent should consult with the City regarding the cash-in-lieu approach, as well as cash-in-lieu charges.

3.11 Private Ownership

End of pipe stormwater management facilities (SWMFs) in sub-division developments are typically assumed by the City of Burlington. The City is therefore ultimately responsible for the long-term operations and maintenance for these facilities. Notwithstanding, site specific developments (including infills and re-developments) are normally expected to provide on-site SWM controls, which are owned and operated by the developer/owner (i.e. privately owned). The City of Burlington requires that all SWM controls for the site be listed on the property title, such that these features form part of the property and are transferred along with the property in the event of a change in ownership. The City of Burlington will determine the specific long term inspection, operations and maintenance requirements of such facilities as part of the Site Plan or Grading and Drainage Clearance Certificate (GDCC) approval process, in consultation with the developer, and whether these requirements should also be listed on the property title. The City of Burlington may, in its sole discretion, require an easement be ceded to the City as part of the approval to ensure that the City can access and inspect the approved SWM systems as required. The easement size and orientation shall be determined specific to the development site.

4.0 Analytical Methodology

4.1 Overview

Hydrologic and hydraulic analyses are necessary in order to reasonably assess and design stormwater management infrastructure. This section is intended to outline the requirements and standards of the City of Burlington in this regard. The selection of an appropriate analytical method depends on several different criteria:

- **The type of project** – greenfield development, urban development/re-development, stream rehabilitation/erosion works, retrofit designs, road reconstructions and other types of projects will all have different objectives and modelling requirements.
- **The associated planning stage** – the level of detail required at the various planning stages would be different given the various spatial scales.
- **The complexity of the analysis** – design of storm sewer systems is typically undertaken using standardized desktop methods (e.g., Rational Method peak flow analysis for single design events, and Manning's Equation uniform flow hydraulics), whereas analysis of stream erosion or groundwater recharge conditions requires more complex techniques (e.g., continuous period hydrologic modelling, and three-dimensional groundwater system modelling).

This section is intended to provide guidance to practitioners on the City of Burlington's recommended analytical methodologies, and the specific criteria and parameters associated with the application of specific methodologies. Notwithstanding, it should be acknowledged that analytical methods and modelling tools will continue to evolve over time. Therefore, discussions with the City of Burlington and other review agencies (e.g. Conservation Halton and others) are recommended to confirm the appropriateness of applying alternative analytical methods or models, and to ensure compatibility with broader scale analyses and studies where relevant.

4.2 Hydrology

Hydrology refers to the study of the movement of water. With respect to stormwater management, hydrology, and hydrologic engineering/modelling generally refers to the estimation of the response of various surface water drainage systems to varying rainfall inputs, with a typical focus on the generation of runoff. Numerous hydrologic modelling tools are available for this purpose. Acceptable methods within the City of Burlington, and guidelines with respect to the application and limitation of each method are discussed further within this section.

4.2.1 Rainfall Intensity-Duration-Frequency (IDF) Relationships

Current City of Burlington IDF curves were developed in 1994 using rainfall data from Environment Canada's Royal Botanical Gardens (RBG) rain gauge. The equation to be used to calculate average rainfall intensity for a given duration is as follows:

$$\mathbf{I = A / (t_d + B)^C}$$

Where:

- I is rainfall intensity, defined in mm/hr
- t_d is the time duration, defined in minutes

A, B, and C are empirical curve fitting parameters derived from the various return period storm event curves. Specific parameters for different storm event return periods based on the City of Burlington's approved rainfall data source are included in Appendix B.

In order to ensure that rainfall IDF statistics remain relevant, the City of Burlington may periodically revise and update these values to better reflect currently available data.

4.2.2 Climate Change and Historic Extreme Storm Events

The City of Burlington acknowledges the potential impact that ongoing climate change is expected to have on rainfall patterns. With respect to surface water hydrology, climate change is expected to result in more intense and severe rainfall events, occurring on a more frequent basis.

Climate change science is however acknowledged to not have advanced sufficiently to provide a definitive recommendation with respect to the rainfall data adjustment to be applied. A range of potential future rainfall trends is possible, depending on numerous different factors. Notwithstanding, predictive tools are available which provide a range of potential future outcomes to practitioners.

The City of Burlington has undertaken an assessment of the currently anticipated impacts of climate change on future rainfall characteristics. Full details of this assessment and the associated approved rainfall intensity-duration-frequency (IDF) details are provided in Appendix B.

4.2.3 Rational Method

Proponents should recognize the limitations of the Rational Method (lumped/simplified nature of the approach, inability to account for time varying rainfall and associated flow response, associate inappropriateness for sizing volumetric controls, etcetera) and the availability of more modern and robust hydrologic modelling tools.

The City of Burlington approves the use of the Rational Method based upon the City's IDF curves provided in Appendix B for use in specific drainage system analyses. Return period storm event flows shall be established using the following equation:

$$Q = K * C * I * A$$

Where:

- Q = Return Period Storm Event Flow (m^3/s)
- K = Conversion Factor (0.00278)
- C = Runoff Coefficient
- I = Rainfall Intensity (mm/hr), to be calculated as per the City of Burlington's approved IDF equation
- A = Contributing Drainage Area (ha)

The Rational Method should be limited to the design of flow conveyance features, such as storm sewers and associated overland flow conveyance. The Rational Method is not approved for use in establishing stormwater management criteria (i.e. sizing stormwater management facilities for flood control or erosion control). Further, the application of the Rational Method should be limited to a maximum drainage area of 5 ha due to its conservatism in estimating peak flows.

Storm sewer sizing using the Rational Method shall apply the City of Burlington's currently approved 5-year IDF parameters. Storm sewer design sheets, as per City approved templates shall be used. The currently approved Rational Method Runoff Coefficients are presented in Table 4.1. These values supersede the values recommended in City Standard Drawing S-3D.

Table 4.1: Runoff Coefficients	
Area Type	**Runoff Coefficient (C)**
Where Impervious/Pervious Areas are directly measured:	
Impervious Areas (Asphalt, Concrete, Rooftop, and Water Surfaces)	0.95
Gravel Surfaces	0.80
Permeable Pavement	0.80[1]
Pervious Areas (Grass, Meadow, Forest)	0.25
For Use in Design Without Detailed Site Plans/Plot Plans:	
Parks	0.35
Commercial	0.90
Industrial	0.90
Institutional (Schools and Churches)	0.75
Greenfield Residential:	
Single Family (under 30 ft width)	0.65
Single Family (between 30 and 50 ft width)	0.60
Single Family (greater than 50 ft width	Consult City staff
Semi-Detached	0.70
Row Housing, Town Houses	0.75
Apartments	0.85
Infill Residential	Calculated from proposed plans

1. May vary depending on type of application; to be reviewed and confirmed with City of Burlington.

Where impervious and pervious areas are directly measured, the proponent must also account for proposed amenity areas if not indicated on the drawing (i.e. areas beyond the rooftop – driveway, walkways, patios, etcetera). For detached and semi-detached residential properties (including row houses and townhouses), if no additional information is available, amenity areas shall be calculated as 90% of the rooftop area (including the driveway). The revised combined Runoff Coefficient should however not exceed 0.9.

These Runoff Coefficient values apply for storms up to and including the 10-year event. For storms greater than this return period, an adjustment factor shall be applied to account for expected soil saturation. Runoff Coefficients shall be multiplied by factors of 1.1, 1.2 and 1.25 for the 25, 50- and 100-year return periods respectively, to a maximum runoff coefficient of 1.0.

At the detailed design stage, storm sewer sizing and stormwater management calculations cannot be completed using generic runoff coefficients. Rather, weighted runoff coefficients must be calculated based on the proposed pervious and impervious surfaces. Supporting calculations demonstrating the calculated imperviousness ratio must be provided for all developments. Impervious area should include the roof, driveway, walkways, and an allowance for hard-surfaced patios in the backyard, all to the satisfaction of the Director. A maximum runoff coefficient of 0.9 should apply, notwithstanding the previously noted additional adjustment for storm events greater than the 10-year event (maximum runoff coefficient of 1.0).

The proponent shall provide calculations to demonstrate the expected time of concentration (t_c or t_d) applied for the Rational Method and associated calculation of peak rainfall intensity. A minimum time of concentration of 10 minutes should be applied. The actual expected time of concentration is however to be calculated based on contributing drainage area to the point of interest. An appropriate empirical equation shall be applied, or the value shall be calculated based on the length of storm sewer to the point of interest and an assumed average velocity of 2 m/s, plus an additional inlet time of 10 minutes.

4.2.4 Event-Based Modelling

Event-based (single storm – typically synthetic design storm) hydrologic modelling is applicable for a range of different drainage area scales. Event-based hydrologic models are considered more robust than the Rational Method (particularly in assessing temporal variability of hydrographs and associated volumetric storage requirements), however there are limitations in the accuracy of event-based models due to the synthetic nature of design storms and single event modelling basis.

Approved imperviousness values are presented in Table 4.2 (generally consistent with Rational Method Coefficients as per Table 4.1). Imperviousness values for sites should be directly measured wherever possible to most accurately estimate coverages.

Table 4.2: Imperviousness Values

Area Type	Imperviousness (%)
Where Impervious/Pervious Areas are directly measured:	
Impervious Areas (Asphalt, Concrete, Rooftop, and Water Surfaces)	100
Gravel Surfaces	80
Permeable Pavement	80[1]
Pervious Areas (Grass, Meadow, Forest)	0
For Use in Design Without Detailed Site Plans/Plot Plans:	
Parks	15
Commercial	95
Industrial	95
Institutional (Schools and Churches)	70
Greenfield Residential:	
Single Family (under 30 ft width)	55
Single Family (between 30 and 50 ft width)	50
Single Family (greater than 50 ft width	Consult City Staff
Semi-Detached	65
Row Housing, Town Houses	70
Apartments	85
Infill Residential	Calculated from proposed plans

2. May vary depending on type of application; to be reviewed and confirmed with City of Burlington.

Where impervious and pervious areas are directly measured, the proponent must also account for proposed amenity areas if not indicated on the drawing (i.e. areas beyond the rooftop – driveway, walkways, patios, etcetera). For detached residential properties, if no additional information is available, amenity areas shall be calculated as 90% of the rooftop area (including the driveway). The revised combined Imperviousness should however not exceed 90%.

Infiltration modelling should consider the local surficial soils (based on available on-site geotechnical and/or hydrogeological data) and select appropriate parameters which represent these conditions.

Where available, proponents should select rainfall (design storm) distributions for event-based hydrologic modelling to be compatible and consistent with those which were applied in a SWS, MDP or MESP study encompassing their development site. Where such studies do not exist, proponents must complete a sensitivity analysis to determine the most appropriate rainfall distribution. Acceptable distributions for the City of Burlington include:

- Chicago Design Storm (6, 12, and 24 hour durations)
- SCS Type II Design Storm (6, 12, and 24 hour durations)

The same rainfall distribution should be used for both pre and post-construction conditions as part of the previously noted sensitivity analysis, to determine which is the most critical.

In all cases, the above-noted rainfall distributions should apply the City of Burlington's currently approved rainfall IDF parameters, as per Appendix B. Rainfall hyetographs for the above-noted distributions are also provided in Appendix B. For the simulation of erosion control, where there is an absence of a higher level study, a 4-hour Chicago Design storm distribution, with a total rainfall of 25 mm is to be applied.

Where an event-based model has been applied to calculate volumetric storage requirements, a 24-hour duration storm event shall be included as part of the verification process.

4.2.5 Continuous Simulation Modelling

Continuous simulation is preferred particularly for broader based system analyses, due to its use of actual observed rainfall data. Continuous modelling applies a long term time series of historical meteorological data instead of a single synthetic design storm. Continuous models are typically more complex than event based models, as they generally consider more processes of the hydrologic cycle including soil water movement (infiltration), snowpack accumulation and melt, evapotranspiration, groundwater recharge and groundwater discharge to local watercourses.

Continuous simulation modelling also provides useful data with respect to water balance/budget, erosion (through the use of critical duration analysis), drawdown time for storage facilities (including LID BMPs) and the impact of "back to back" storms, baseflow information, and other useful information. Notwithstanding, continuous simulation modelling requires much more data and effort to apply. Continuous simulation modelling is considered more suitable for larger scale watershed and subwatershed assessments and more natural, rural systems.

Proponents are required to use continuous simulation modelling for SWSs. The City of Burlington may, in its sole discretion (with input from Conservation Halton as required) also require proponents to use continuous simulation modelling for MDPs and MESPs. It is expected that such requirements will be determined as part of the establishment of Terms of Reference at the outset of the study.

Consistent with the City of Burlington's IDF parameters, which are based on Environment Canada's RBG gauge, continuous simulation modelling should also apply the available long-term precipitation dataset from this same station (currently available from 1962-2016, or 55 years; the most currently available dataset should be applied).

4.2.6 Approved Hydrologic Models

Hydrologic models which are currently accepted by the City of Burlington for event-based and/or continuous simulation modelling are listed in Table 4.3 below.

Table 4.3: Currently Approved Hydrologic Models

Model	Application(s)
SWMHYMO	Single Event
VISUAL OTTHYMO	Single Event
GAWSER[1]	Single Event or Continuous
HSP-F	Single Event or Continuous
HEC-HMS	Single Event or Continuous
EPA-SWMM	Single Event or Continuous
PCSWMM	Single Event or Continuous
XP-SWMM	Single Event

1. Generally discouraged for new assessments given the model vintage and supportability.

Where defined, hydrologic analyses should apply the currently approved hydrologic model for the study area, as developed from higher level or parent studies. The models should be refined as required to reflect the study area. Where no higher level hydrologic model is defined or available, proponents should determine the most appropriate modelling platform based on the list of currently approved hydrologic models in discussion with the City of Burlington and other review agencies (such as Conservation Halton), in order to confirm the most appropriate selection.

Notwithstanding the preceding, should proponents propose the use of an alternative hydrologic model (not listed in Table 4.3), the City of Burlington may consider the request, subject to the provision of a suitable technical justification and documentation of the proposed alternative modelling platform.

4.2.7 Hydrologic Modelling Standards

Sound modelling standards of practice should be followed in developing hydrologic models. The following standards of practice are recommended by the City of Burlington for use in municipal studies:

1. All assumptions should be provided with rationale for their selection;
2. Provide the purpose for developing the hydrologic model, such as determining flow rates, runoff volumes, flow routing effects for proposed development, and existing land use conditions;
3. Provide the study objectives and how they relate to the hydrologic modelling;
4. Provide the model selection criteria and how the model matches the criteria;
5. Provide drainage area plans outlining both internal and external catchments, modelling schematics, and tables providing drainage area parameters;
6. Background information on the selection of the drainage area parameters should be provided to assist the reviewer in understanding the assumptions leading to the drainage area parameters;
7. Background data on overland (major) and minor storm systems should be provided with plans clearly presenting and labeling both systems;
8. Data should be provided on routing through natural and man-made storage systems, with detailed plans and calculations outlining how the stage/discharge relationship has been developed;
9. For complex models (i.e. models with several subcatchment parameters, integrated models, complex routing routines) and major studies, a sensitivity analysis should be conducted on key parameters;
10. For complex models and major studies, verification or validation of results should be provided through various methods such as calibration to recorded stream flows, observed water levels, unit flow rates and runoff volume comparison using a technique such as the MTO index method or equivalent. The application of the validation technique (number and type) will depend on the availability of data and the sensitivity of the analysis;
11. All input and output details should be provided in a logical manner, with an explanation for potential errors;
12. A schematic flow diagram of the model must be included. The schematic and information must be consistent with other minor and major system diagrams/drawings provided in the documentation.
13. A digital copy of all models should be provided, with model version clearly identified.

Low Impact Development Best Management Practices (LID BMPs) require special consideration in selection of analytical methods. In early planning stages, criteria for these measures (e.g., infiltration, erosion, etcetera) should be determined, including the most appropriate hydrologic modelling methodology, considering assessment of the performance of the facilities (such as inter-event drawdown time), as well as the ultimate drainage system receivers (e.g. water balance/budget, erosion impacts, etcetera).

4.3 Hydraulics

4.3.1 Manning's Equation

The Manning's Equation may be used in conjunction with the Rational Method to determine design capacity for simplified conveyance systems, such as storm sewers and open channels, within the limitations of the Rational Method noted in Section 4.2.3 (5.0 ha drainage area or less). The City of Burlington's approved Manning's Roughness Coefficients are provided in Table 4.4.

Table 4.4: Roughness Coefficients

Material/surface Type	Manning's 'n'
Concrete Pipe	0.013 – 0.017
Corrugated Metal Pipe	0.024 – 0.026
PVC Pipe	0.013 – 0.015
Roads and Gutters (concrete or asphalt)	0.013 – 0.017
Concrete Channel	0.013 – 0.020
Rip Rap and River Stone	0.035 – 0.045
Maintained Channels	0.03 – 0.08
Unmaintained Channels	0.05 – 0.14
Naturalized Overbank Areas	0.08

Reference is also made to applicable Conservation Halton guidelines. Design capacity requirements for various conveyance systems are outlined in Chapter 5

4.3.2 1-Dimensional Hydraulic Modelling - General

For larger, or more complex hydraulic conveyance elements, 1-dimensional (1D) hydraulic modelling should be applied. 1D hydraulic modelling presumes that flow is conveyed in the same direction as the defined hydraulic element (open channel or closed conduit). Where the flow route is ill-defined and flows spill outside of the primary channel, then 2-dimensional (2D) hydraulic modelling is considered to be more appropriate, as discussed in Section 4.3.4.

Specific guidance for the design of 1D hydraulic elements using hydraulic models is provided in Section 5.

Numerous 1D hydraulic models are available (refer to Section 4.3.4 for approved hydraulic models); the selection of an appropriate model will depend on the type of system being analyzed and purpose of the analysis. Where 1D models are applied, roughness coefficients and other parameters, shall be selected based upon the guidance provided in the User's Manual for the corresponding design conditions. Further guidance may also be found in the MTO Drainage Manual (MTO, 1997), the Highway Drainage Design Standards (MTO, January 2008), the HEC-RAS Hydraulic Reference Manual (USACE, January 2010), and Conservation Halton Guidelines.

4.3.3 1-Dimensional Hydraulic Modelling – Dual Drainage Modelling

For the assessment of urban drainage systems (sewers, roadways, etcetera), the City of Burlington supports the application of dual drainage models. Dual drainage models typically include separate 1D representations of both the minor system (storm sewer) and major system (roadway), although combined 1D-2D dual drainage models are also possible. Dual drainage models provide greater insight into urban drainage system performance, by modelling the linkage and interaction between the minor and major drainage systems. An accurate representation of inlet capacity is a key consideration in estimating overland flow depths, including the differences in inlet capacity of at-grade and sag point catchbasins.

Dual drainage models are useful in estimating the hydraulic grade line (HGL) for storm sewers. Proponents may be required to undertake dual drainage modelling in areas where foundation drains are known to be connected to the storm sewer system, in order to ensure no negative impacts to adjacent areas. A simplified approach (such as an HGL spreadsheet/manual backwater calculation) may be acceptable in smaller areas (up to 2 lots), at the sole discretion of the City of Burlington.

4.3.4 2-Dimensional Hydraulic Modelling

The City of Burlington supports the use of 2-dimensional (2D) hydraulic modelling for the assessment of spills and surface flooding impacts in both riverine and urban drainage systems. 2D modelling should be considered in areas where overland flow routes are poorly defined or restricted or the minor drainage system has known capacity constraints, particularly older development areas which predate requirements for overland flow route designs. The necessity and requirements (Terms of Reference) for 2D hydraulic modelling should be discussed with the City of Burlington and regulatory agencies (such as Conservation Halton).

4.3.5 Approved Hydraulic Models

Hydraulic models which are currently accepted by the City of Burlington for different hydraulic applications are listed in Table 4.5 below.

Table 4.5: Currently Approved Hydraulic Models

Model	Application(s)
CULVERT MASTER	Culvert Structures
FLOWMASTER	Open Channel, Culvert, Pipe
HEC-RAS	Open Channel, Culvert / Bridge Structures / 2D
EPA-SWMM	Open Channel, Culvert, and Urban Storm Drainage System Analysis
PCSWMM	Open Channel, Culvert, and Urban Storm Drainage System Analysis / 2D
XP-SWMM	Urban Storm Drainage System Analysis / 2D

Where feasible and appropriate, the hydraulic modelling analyses should apply the currently approved hydraulic model, as developed from higher level studies. The models should be refined as required to reflect the study area. Where no higher level hydraulic model is defined or available, proponents should determine the most appropriate modelling platform based on the list of currently approved hydraulic models and discussion with the City of Burlington and other review agencies (such as Conservation Halton).

Notwithstanding the preceding, should proponents propose the use of an alternative hydraulic model not listed in Table 4.5, the City of Burlington may consider the request, subject to the provision of a suitable technical justification and documentation of the proposed alternative modelling platform.

4.3.6 Hydraulic Modelling Standards

Sound hydraulic modelling standards of practice should be followed in developing a model. The following standards of practice are recommended for the City of Burlington:

1. All assumptions should be provided with rationale for their selection;
2. Provide the purpose for developing the hydraulic model;
3. Provide the study objectives and how they relate to the hydraulic modelling;
4. Provide the model selection criteria and how the model matches the criteria. This should also include a summary of any and all model limitations;
5. Provide plans clearly presenting the closed and/or open hydraulic system;
6. For open systems – clearly present the cross sections, study limits, land use, crossing details, spill areas, ineffective flow areas, and flooding limits and elevations for the appropriate design event(s). Preparation of the model should be such that it fully contains the modelled flows without exceeding the hydraulic cross-section. Should it not be possible to contain the flows within the defined geometry of the open storm system, the proponent should provide details on the spill characteristics. In the event of a spill, rationale should be provided on whether or not to include a flow loss in the calculation (flow losses are typically not supported for flood hazard mapping preparation; refer to Conservation Halton guidelines as well as applicable Provincial Policy documents);
7. For closed systems (i.e., storm sewers) - clearly present the storm sewer network details including manhole numbers, pipe size, length, study limits, land use, slope, and sewer and ground elevations;
8. For combined hydrologic/hydraulic models - provide plans that not only describe the closed system but also the contributing drainage areas and overland flow system;
9. For all hydraulic models - provide the downstream and, if applicable, the upstream boundary conditions for each storm modelled and the assumptions used to define the boundary conditions. Document the parameters established for hydraulic losses, such as Manning's 'n', inlet and outlet losses and other appropriate losses;
10. Summarize the selection of procedures for determining the computed hydraulic energy grade line and water surface elevations;
11. Document the hydraulic results in summary form for the relevant storm events;
12. Document potential impacts on existing infrastructure and possible mitigation measures;
13. For complex models and major studies, a sensitivity analysis should be conducted on key parameters;
14. If possible, verify hydraulic results for an existing closed/open storm system by documenting historical flood elevations for specific storm events and comparing the hydraulic modelling results to the historic data; calibration of losses should be included, if sufficient data exists;
15. Provide the input and output data in a logical manner with an explanation of the potential error;
16. A schematic flow diagram of the model must be included. The schematic and information must be consistent with other minor and major system diagrams/drawings provided in the report.
17. A digital copy of all models should be provided, with model version clearly identified.

B. STORMWATER DESIGN STANDARDS

5.0 Design Criteria – Conveyance Systems

5.1 Property Drainage Systems

5.1.1 Site Grading

In general, grading shall be completed to safely direct surface water flows towards safe outlets. Safe outlets may consist of surface drainage features (i.e. overland flow routes, storm sewers, etc.) or creek systems.

All developments (excluding single family residential) shall design site grading to provide an overland flow route to an acceptable receiver, generally the roadway right-of-way. All grading and drainage shall consider the City of Burlington By-Law 52-2018 (A by-law to regulate the altering of grades or drainage on Low Density Residential Lands). Reference is also made to City Standards S-118 (Lot Grading Standards, Exclusive of Current Subdivision) and S-119 (Lot Grading Standards for Subdivision Lots). Outside grades shall be a minimum of 0.15 m below the top of the foundation wall.

Site grading is to be completed to facilitate a positive slope away from buildings and other features that may be at risk of damage caused by flooding. Lot grading shall be completed to provide grades between 2% - 5% away from the building foundation for a minimum apron length of 5 m. Reduced lot grades (i.e. less than 2%) may be considered by the City of Burlington as part of an overall stormwater management (SWM) system in order to slow overland flows and promote infiltration. Steeper lot grades may be considered by the City of Burlington where constrained, to a maximum slope of 3H:1V.

Lot grading for development sites shall be self-contained and prevent spills onto adjacent properties, while also blending into existing topography and grades surrounding the site. Where external areas drain through a subject property, the proponent shall be required to design on site grading and drainage systems to safely convey these flows (up to the 100-year post development condition) and prevent ponding or negative impacts to the adjacent properties.

For residential lots, the City of Burlington generally supports both back to front and split drainage. Where split drainage is proposed, rear-yard drainage system must be designed to the satisfaction of the City of Burlington.

There shall be a 0.6 m wide pathway (at a 2% cross fall slope away from the foundation) around one side of the building to allow access to the rear yard area, except where side yard setbacks from lot lines do not permit such a pathway.

Driveways must slope away from the building with positive drainage towards the roadway right-of-way, with slopes of between 1% (minimum) and 5% (maximum). Reverse sloped driveways are strongly discouraged, unless no other feasible grading solution exists. Where a reverse sloped driveway is proposed, a complete hydraulic gradeline (HGL) analysis will be required by a qualified Professional Engineer (P.Eng.) to demonstrate no negative effects for all storm events up to and including the 100-year storm.

Upon completion of the development works, the owner shall supply the City of Burlington with an as-built grading plan, stamped by a qualified Civil Engineer (P.Eng), certifying that the grading conforms to the approved grading plans and that there are no adverse impacts on neighbouring properties.

5.1.2 Roof Leaders

Roof leaders/downspouts shall be directed to concrete splash pads, and then to pervious grassed or landscaped areas for infiltration, or to a storage system for on site re-use. Concrete splash pads or a corrugated downspout extension should be located to discharge water a minimum of 0.6 m away from the building edge and should direct flows away from the building (and away from adjacent buildings) in conjunction with the site grading plan. Roof leaders are not permitted to directly discharge onto impervious surfaces or to be directly connected to the storm sewer system, unless an intermediate stormwater management system is in place to restrict flows to meet the requirements of the City of Burlington.

5.1.3 Foundation Drains

The City of Burlington strongly discourages any foundations that intersect the groundwater table, as identified through a site specific geotechnical/hydro-geologic study or other local information to identify the seasonally high groundwater elevation. Where the proposed development will intersect the seasonally high groundwater table, the proponent shall be required to complete detailed technical analyses to confirm the range of expected pumping rates and volumes, as well as potential groundwater drawdown impacts to adjacent properties and features as well as the overall hydrogeologic setting. Additional on-site controls may be required where the anticipated groundwater pumping rate cannot be accommodated by existing drainage infrastructure.

Foundation drains should either discharge directly to surface (via a sump pump system) or, where permitted, to the storm sewer system via a gravity drain or sump pump and private lateral connection. Discharge to the storm sewer is generally preferred by the City, if it can be demonstrated that the storm sewer has enough capacity and that a functional design can be achieved. Foundation drains connections to the sanitary sewer system are not permitted.

Where a sump pump is proposed, a “goose neck” connection should be provided that ensures the pumped flows are pumped to an elevation of at least 0.15 m above final ground elevation prior to discharge either to surface or to a private foundation drain lateral. A backflow valve must be implemented.

Where a sump pump line discharges to surface, flows shall be directed to concrete splash pads, and then to pervious grassed or landscaped areas for infiltration. Discharge points should be located a minimum of 0.6 m away from the building edge (with concrete splash pads) and should direct flows away from the building (and away from adjacent buildings) in conjunction with the site grading plan. Sump pump discharges should be separated by a minimum of 1.8 m from roof leader/downspout discharges and should not discharge to the side yard between the houses. Where sump pump drainage is to be collected by a private lateral, a surface overflow shall be provided. Sump discharges cannot be in a residential side yard.

Foundation drain laterals, where required, shall have a minimum diameter of 150 mm. Foundation drain laterals shall have a minimum slope of 2%.

Where a foundation drain is proposed to have a gravity drain connection to the storm sewer system, the proponent shall be required to provide a hydraulic gradeline (HGL) analysis for the 100-year storm event, using an approved hydraulic modelling methodology as described in Section 4. This analysis shall be required to demonstrate that the proposed basement footing is a minimum of 0.3 m above the 100-year HGL, and a minimum of 1.0 m above the storm sewer obvert.

5.1.4 Rear-Yard Catchbasins

Rear yard catchbasins shall be limited to the extent possible by providing positive drainage from rear yard areas toward the municipal right-of-way (i.e. back to front drainage). Where positive drainage cannot be provided, rear yard catchbasins shall be implemented. Rear yard catchbasins shall not service more than four (4) to six (6) lots,a maximum drainage area of 0.36 ha, or a maximum swale length of 50 m.

Where a RYCB services a single lot, the RYCB shall be considered private. Where a RYCB services more than one lot or drains external areas, a municipal easement will be required at the owner’s expense.

Rear yard catchbasins and leads shall be entirely located within one lot and shall be spatially positioned to maximize functionality of the lot. All rear-yard catchbasins shall be private (single lot – property owner), unless they collect external drainage from other areas, or as determined by the City of Burlington. Rear yard catchbasins shall be sumpless. Rear yard catchbasins shall be offset 1.0 m from all lot lines. Rear yard catchbasin leads shall run adjacent to lot lines (offset a minimum of 1.0 m from the building edge) and have a minimum diameter of 250 mm and have bedding/cover as per the applicable OPSD. OPSD bedding/cover shall be substituted with concrete encasement where leads are located within private property limits. A minimum slope of 2% should be implemented. Where site grading necessitates a shallower slope, discussion with City of Burlington staff is required.

Where rear-yard catchbasins are required but a municipal storm sewer service is not available, the City of Burlington may consider the implementation of on-site infiltration pits, designed to hold a minimum of the 5-year storm event, with a drawdown of between 24 and 48 hours. Discussion with the City of Burlington is required in these cases.

Where rear-yard catchbasins are proposed, the proponent will be responsible to complete a hydraulic gradeline (HGL) analysis for the 100-year storm event (by a qualified Professional Engineer) to demonstrate that rear-yard areas will not be impacted by surcharge/backwater from the receiving storm sewer system. The methodologies discussed in Section 4.3.3 shall apply.

Emergency overland flow routes may be required accordingly. Details regarding proposed rear-yard catchbasins, including inverts, lengths and grades should be provided as part of the proponent's submission.

Lots containing rear-yard catchbasins shall have the final security release withheld until the pipe has passed a closed circuit television (CCTV) inspection to the satisfaction of the City of Burlington. Long-term operations and maintenance of private RYCBs and RYCB leads is at the sole expense of the owner.

5.1.5 Swales and Ditches

Private swales and ditches shall be constructed to convey private surface drainage towards safe, appropriate outlets as approved by the City of Burlington, in conjunction with the overall provision of overland flow routes.

Private swales shall be constructed at the lot level to direct discharge from roof leaders away from buildings and toward the municipal right-of-way or a rear yard catchbasin. Longitudinal grading of swales should follow the lot grading (i.e. minimum of 2%, maximum of 5%). Side slopes shall be a maximum of 3 horizontal to 1 vertical. Swale depth shall be a minimum of 150 mm and a maximum of 300 mm. The base of the swale must be a minimum 0.2 m below the outside grade of the adjacent foundation, as per City Standard S-119.

In instances where a swale grade must be less than 2%, a sub-drain must be constructed along the entire length of the swale and must be connected to an adjacent storm sewer, LID feature or onto the surface where grades permit. The subdrain must be located 300 mm beneath the invert of the swale and have a minimum diameter of 150 mm. Subdrains should be wrapped in filter cloth and surrounded by a minimum of 300 mm deep, 25 mm diameter crusher run clearstone, to prevent clogging due to fine particulate matter.

Lot level swales conveying drainage from abutting lots shall not service more than four (4) to six (6) lots, or a maximum drainage area of 0.36 ha, or swale length of 50 m. The number of lots draining into a rear yard swale and catchbasin will be contingent upon the capacity of the swale and the catchbasin.

5.2 Storm Sewers

5.2.1 Design Principles

Storm sewers shall be designed to convey the City's currently approved 5-year storm, to a maximum capacity of 85%. Storm sewers shall be sized using approved analytical methods, as per Section 4. Regardless of the analytical methodology applied, a summary of the proposed storm sewer sizing shall be provided using the City of Burlington's standard storm sewer design sheet.

Storm sewer systems shall be designed to limit surcharging during the 100-year storm event to a maximum of 0.3 m below ground surface. An exception may be granted for rear-yard catchbasins, provided that a Hydraulic Grade Line (HGL) analysis is completed (as per Section 4.3.3 and 5.1.4) and it demonstrates no adverse effects to adjacent properties.

Where gravity foundation drains are directly connected to the storm sewer, hydraulic grade line analyses shall be completed to demonstrate that the elevation of the basement floor is at least 1.0 m above the elevation of the storm sewer obvert and at least 0.3 m above the 100-year HGL at that point. Inlet control devices (ICDs) may be required to limit storm sewer inflows, in conjunction with the required assessment of the capacity of the major overland flow system.

The minimum flow velocity within a storm sewer shall be 0.75 m/s to ensure that the sewers are self cleaning, and the maximum velocity shall be 4.5 m/s to ensure that scouring of the pipe does not occur. The pipe slope shall be selected to accommodate design requirements. The City of Burlington generally discourages pipe slopes less than 0.5%, unless it can be demonstrated that a slope of 0.5% or greater cannot practically be achieved. The City of Burlington considers an absolute minimum pipe slope of 0.3%.

5.2.2 Size and Material

The minimum diameter of a storm sewer shall be 300 mm. Where changes in pipe size are required to accommodate design flows, obverts of the upstream and downstream storm sewer pipes shall match. Decreases in pipe size from upstream to downstream are not permitted, except under circumstances where approved SWM controls permit. Proponents will be required to demonstrate that a decrease in pipe size is acceptable in such cases, to the satisfaction of the City of Burlington.

. For storm sewer sizes 450 mm in diameter or greater, concrete shall be used. The City of Burlington may, in its sole discretion, consider the application of alternative pipe materials (such as HDPE or large diameter PVC) on a case by case basis.

For trunk storm sewers (675 mm diameter or greater), the maximum permissible pipe bend is 45 degrees. Additional maintenance hholes will be required to reduce the pipe angles where the overall direction changes by more than 45 degrees.

Bedding and cover materials shall comply with OPSS 1010.05.03.

5.2.3 Depth and Location

The depth of cover for storm sewers is dependent on the storm sewer outlet elevation. Unless specified in the Functional Servicing Report (FSR), the minimum depth of cover shall be 2.5 m. Reference is also made to the City of Burlington's standard drawing details for storm sewers.

In areas where it can be demonstrated that greater depths cannot be reasonably achieved, a minimum permissible depth of cover for storm sewers is 1.2 m in order to account for loading and frost protection. In all cases, depth of cover is to be measured from the top of the pipe to the ground surface. Maximum depth of cover shall be in accordance with OPSD 806.060, 807.010 and 807.030.

Storm sewers within rights-of-way shall be located in accordance with the City of Burlington's Standard Drawings. Storm sewers shall be aligned in a straight direction between manholes. The City of Burlington, may, in its sole discretion, accept radius pipe in special circumstances if the proponent can reasonably demonstrate that it is required.

The minimum horizontal and vertical separation between storm sewers and other underground services/utilities is 0.5 m measured from the outside of the storm sewer pipe to the outside the conduit of the respective service/utility.

The minimum horizontal speration between a sewer and watermain is 2.5 metres. In cases where it is not practical to maintain sperate trenches or the recommended horizontal seperation cannot be achieved a deviation may be allowed.

5.2.4 Maintenance Holes

Maintenance holes shall be constructed along the storm sewer system at the downstream and upstream ends, as well as at a maximum spacing as per Table 5.1.

Table 5.1: Maximum Maintenance Hole Spacing

Sewer Diameter	Distance
Up to 600 mm	100 m
Greater than 600 mm	150 m

Maintenance holes are also to be constructed to facilitate changes in sewer direction, sewer elevation, pipe size, and sewer grade. Sizes shall be selected to accommodate the storm sewer pipe size(s). Maintenance holes may be pre-cast or cast-in place and shall correspond with applicable OPSD details.

Maintenance holes exceeding 5.0 m in depth shall include safety platforms in accordance with OPSD 404.020 or 404.022.

Maintenance hole frames and grates shall correspond with OPSD 401.010. Where Type B (Open Cover) is proposed, the proponent must account for the additional inlet capacity as part of the assessment of the minor and major systems.

Maintenance hole adjustment units shall correspond with OPSD 704.010.

Maintenance hole benching shall correspond with OPSD 701.021. Benching details for non-standard maintenance holes shall be provided on Engineering Drawings.

Calculations of energy losses resulting from drops across maintenance holes shall be provided with storm sewer design calculations. Sufficient drops shall be provided across maintenance holes to offset the energy losses, to the extent possible. Drops across maintenance holes shall be measured from the invert of the upstream pipe to the invert of the downstream pipe. A minimum drop of 0.03 m should be applied for all maintenance holes. Unless calculated, the allowance for hydraulic losses will be a minimum of 0.03 m for angles up to 45 degrees and 0.06 m for angles between 45 and 90 degrees. For drops of 1.2 m or greater, drop structures shall be provided in accordance with OPSD 1003.020.

5.2.5 Inlets and Catchbasins

Catchbasins shall be constructed along the storm sewer system to capture surface drainage. Catchbasins shall be provided within roadways having urban cross-sections, located at the curb and gutter. The minimum spacing of catchbasins shall be confirmed by the designer as required to capture the design flow (5-year storm event). The maximum catchbasin spacing shall be as per Table 5.2.

Table 5.2: Maximum Catchbasin Spacing		
Road Grade	Distance	
	Two Lane	Four Lane
0.5% to 3%	100 m	70 m
3% to 5%	70 m	40 m

Catchbasins should not be located within 1.0 m of intersections, pedestrian crossings, and driveways/entrances. Double catchbasins are required at all low (sag) points within urban cross-sections. All catchbasins should incorporate a minimum 0.6 m sump. Goss traps may be required to be incorporated into the catchbasin design, at the discretion of the City of Burlington.

Catchbasin shall be precast with sump and correspond with OPSD 705.010 (single) and 705.020 (double). Catchbasin adjustment units shall correspond with OPSD 704.010. Catchbasin frames and grates shall correspond with OPSD 400.090 (herring bone style). For landscaped areas, a "beehive" type frame and cover shall be used, as per City Standard S-176.

Side inlet catchbasins on roadways may be considered for construction by the City, subject to suitable justification. Where side inlet catchbasins are proposed, an inlet capacity assessment must be completed to demonstrate that the proposed inlet capacity is sufficient and comparable to the standard bottom inlet type.

Ditch inlets shall be implemented along the storm sewer system to capture surface drainage within ditches. Ditch inlets shall be provided within roadways having semi-urban and rural cross-sections, located at the downstream end of the ditch. Ditch-inlets shall be sized as per section 5.1.5. Ditch inlets shall correspond with OPSD 705.030 and 705.040. Ditch inlet frames and grates shall correspond with OPSD 403.010. Ditch inlet adjustment units shall correspond with OPSD 704.010.

Catchbasin and ditch inlet leads shall be designed based on expected flow rates for the 5-year storm event. The minimum size and slope of catchbasin and ditch inlet leads shall be as follows:

Table 5.3: Catchbasin Lead Sized and Slopes		
Catchbasin Type	Minimum Lead Diameter	Minimum Slope
Single	250 mm	1.0%
Twin-Inlet	300 mm	1.0%
Rear-Yard	250 mm	0.5%
Ditch-Inlet	375 mm	1.0%

In order to reduce surcharging of the storm sewers or to control sewer flows for Stormwater Management (SWM) purposes, inlet control devices (ICD) may be installed in catchbasins, building drain pipes, storm sewers or SWM Pond outlets. The City of Burlington approves the use of orifice pipes for this purpose to eliminate the possibility of the ICD being physically removed. Where the diameter of the orifice pipe is determined to be too small and could result in debris blockage, other devices may be considered at the discretion of the City. ICDs should incorporate a sump draw design (inlet below water level) to prevent debris blockage and promote retention of floatables and oils. Consultation with the City of Burlington is recommended to ensure that an appropriate ICD is selected.

For the purposes of calculating required surface inlet capacity, all surface inlets located at depressions and sag points shall be assessed assuming 50% blocked conditions.

5.2.6 Storm Sewer Outfalls

Storm sewer outfalls are locations where storm sewers discharge to open watercourses or waterbodies. When designing a storm sewer outfall, it is important to consider the potential for erosion due to the concentrated discharge and the flow characteristics of an urbanized system (steeper slopes, smooth surfaces, rapidly peaked flows/velocities, etc.).

Storm sewer outfalls (including SWM outlets) should be designed to mitigate impacts accordingly. Designers should confirm the expected velocity of flows at outfalls and ensure appropriate mitigation measures to slow (disperse) the velocity to avoid negative impacts to the receiving channel. This could include chute blocks, aggregate or vegetative protection, etc. in the vicinity of the outfall but outside of the normal high-water level of the channel or waterbody. The alignment of proposed outfalls should also consider the primary direction of flows and attempt to match the direction of flow accordingly to the extent possible. The erodibility of the existing watercourse or waterbody should be considered accordingly, including input from a qualified fluvial geomorphologist where warranted.

5.2.7 Requirements Prior to Assumption

Prior to transferring ownership of storm sewers to the City of Burlington, the requirements for assumption shall be addressed in accordance with the City of Burlington's assumption requirements. Elements to be addressed in assumption requirements include:

1. CCTV Inspection (a full CCTV inspection is to be provided to the City of Burlington to confirm that no defects exist)
2. Mandrel testing/pipe deflection (a mandrel shall be pulled for all flexible (PVC and HDPE) piping as per OPSS 410; deflections shall not exceed a maximum of 5% of the pipe diameter).
3. As-built drawings signed and stamped by a qualified professional (P.Eng.).

Following receipt of the above-noted information, the storm sewer infrastructure is placed on a one (1) year maintenance period. Following the one (1) year maintenance period, a second round of CCTV inspection and mandrel testing is required. Following City acceptance of these works, the storm sewer infrastructure shall be removed from the maintenance period, and appropriate securities released to the owner. If the preceding are not acceptable, the owner is responsible to correct any identified defects at their sole expense.

5.3 Major Systems and Roadway Conveyance

5.3.1 Roadway Conveyance

Roadways shall be designed to accommodate the major system flow (i.e. overland flow in excess of the storm sewer capacity) for the 100-year storm event. Roadway conveyance capacity shall be determined using the approved methods presented in Section 4. Analyses must consider both the minor and major system, and the interaction between the two (i.e. inlet capacity).

Reverse crowned roadways for private roadways are strongly discouraged.

Depth of flooding within roadways shall be limited in order to provide public safety and protect adjacent properties. Depth of flooding within City of Burlington roadways shall be as follows with respect to urban (pluvial) flooding conditions:

Table 5.4: Maximum Depth of Flooding for Roadways	
Road Classification	**Maximum Depth of Flooding**
Urban Arterial, Emergency Routes	One lane open in either direction (0 mm at crown)
Rural Arterial, Collector	One lane open (0 mm at crown)
Local	150 mm above crown and 300 mm at the edge of pavement

Depth of flooding within roadways shall also be limited to the of the right-of-way limits so as not to impact adjacent properties. Roadways shall be positively graded to continuously convey overland flow to suitable outlets or other overland flow routes.

The requirements outlined herein shall apply both to roadways with urban servicing (curb and gutter) and rural servicing (ditches).

Flooding depths on roadways due to riverine (fluvial) conditions for the Regional Storm Event (Hurricane Hazel) should also be determined based on providing access and egress in accordance with the Ontario Ministry of Natural Resources River and Stream Systems: Flooding Hazard Limit Technical Guidelines (2002 or latest revision).

Consideration should also be given to the specific requirements of Regional Roads, which may differ from City of Burlington criteria.

5.3.2 Overland Flow Routes

Overland flow routes are commonly used to provide a linkage of overland flow conveyance between roadways and stormwater management facilities, channels/watercourses, or other suitable storm drainage outlets. Overland flow routes shall be appropriately sized to convey the peak flows which they capture and intercept, up to and including the 100-year storm event (and the Regional Storm, in those locations where the Regional Storm may exceed the 100-year storm event). Depth of flooding within overland flow routes shall be limited to 300 mm to protect public safety,

5.4 Watercourses, Bridges and Culverts

Proposed works in the vicinity of watercourses, wetlands, valleys, and shorelines may lie within areas regulated by Conservation Halton. The proponent is required to assess approval requirements based on Approximate Regulation Limit mapping and consultation with Conservation Halton. Additional requirements may also apply from other agencies, including, but not limited to the Ministry of the Environment, Conservation and Parks (MECP), the Ministry of Natural Resources and Forestry (MNRF), the Department of Fisheries and Oceans (DFO), the Niagara Escarpment Commission (NEC), and the Ontario Ministry of Tourism, Culture and Recreation where heritage features may be present.

Roadway crossings shall be sized in accordance with MTO Directive B-100, at a minimum. Consideration for Regional Storm (Hurricane Hazel) conveyance shall be given, and if feasible, shall be the target for the design conveyance capacity. Freeboard and clearance measurements for crossings shall meet the requirements of the MTO Highway Drainage Design Standards (MTO, 2008). These policies shall also be applied for railway crossings.

Corrugated steel pipe (CSP) is not acceptable to the City of Burlington for culverts less than 1200 mm in diameter (including roadway and drivewway crossings), unless suitable additional measures are implemented to prevent crushing, including (but not limited to) headwall/endwall treatment. Additional measures may also be required to prevent corrosion, including aluminized steel or polymer-laminate coatings. Acceptable alternative pipe materials include concrete and HDPE.

For larger watercourse systems (contributing drainage areas generally > 50 ha), the City of Burlington supports the construction of naturalized substrate within bridges/culverts to support aquatic habitat. Open bottom structures with natural substrate should be implemented where feasible. Pre-cast and manufactured culvert units with bottom members should be embedded, and end baffles should be constructed to contain substrate material without impeding fish passage. Substrate material should be sized based on conveyance and erosion requirements. In all cases, the hydraulic design of the culvert opening should consider the presence of the proposed substrate.

Where channel reconstruction is identified, channel works must consider erosion requirements to ensure the long-term stability of the channel. Velocity and shear stress calculations should be undertaken to determine suitable materials for channel bed and banks to minimize future erosion, while also considering requirements for natural channel design and associated ecological function and aesthetics. Discussion with the City of Burlington and CH is recommended in such cases to determine the most appropriate measures.

6.0 Design Criteria – Stormwater Management

6.1 Site Level Controls

Site Level Controls refer to Stormwater Management (SWM) measures for smaller or individual sites addressed through the Site Plan or Grading and Drainage Clearance Certificate (GDCC) process. These types of developments typically involve different types of SWM controls as compared to larger plans of subdivision, which would more typically involve an end of pipe SWM Facility (as discussed further in Section 6.2).

Notwithstanding the preceding, the site level controls outlined within this section would also be expected to apply to works within the municipal right-of-way, including roadway reconstructions.

While the general principles of SWM (as per previous sections) remain the same in both cases, the specific criteria and forms of SWM differ. This section is intended to specifically focus on site level controls, which are typically applied for infills and re-development projects, as well as roadway reconstructions.

Where site controls are proposed on private lands, the City of Burlington may require an easement to allow for periodic access to confirm the controls are being operated and maintained by the owner. At a minimum, a site access agreement will be required. Site level controls are preferred to be in proximity to the property line to facilitate such access. Ultimately, operation and maintenance of all private SWM control are the responsibility of the private property owner.

6.1.1 Flood Control

6.1.1.1 Design Criteria

Proponents are required to provide flood control in accordance with the specified level of control outlined within a governing Subwatershed Study (SWS), Master Drainage Plan (MDP), or Master Environmental Servicing Plan (MESP) that encompasses the proponent's site.

Where a SWS, MDP, or MESP does not exist, the following flood control is typically required as a minimum:

- Where a site discharges to a watercourse system: post-development to pre-development peak flow control for the 2 through 100-year return periods;
- Where a site discharges to a storm sewer: 100-year return period post-development to allotted capacity of storm sewer;
  - Where the allotted capacity of storm sewer is unknown: 100-year return period post-development to 5-year return period pre-development peak flow control (where pre-development conditions are as per the definition in this section).
- Regional Storm Controls (i.e. Hurricane Hazel) may also be required at the discretion of the City of Burlington and its partners (i.e. Conservation Halton)

The City in consultation with Conservation Halton may exempt specific sites from flood control requirements where the site discharges directly to Lake Ontario; or under special circumstances where these controls are ineffective due to timing, etc.

Proponents are required to consult with the City and Agencies (including Conservation Halton) regarding the acceptable level of flood controls to be applied to the proponent's site, including special cases (receivers with limited capacity, lack of overland flow route, etcetera).

For re-developments of individual lots, the City of Burlington requires that the 5-year storm event be controlled on site, and that a suitable overland flow route be implemented to convey flows greater than the

5-year storm event, up to the 100-year storm event. This type of re-development is the only type of situation where the City of Burlington will accept the discharge of uncontrolled overland flows.

Return period peak flows are to be established through hydrologic simulation tools based on the City of Burlington's currently specified rainfall dataset and associated IDF values. When establishing pre-development return period peak flows, proponents are required to complete hydrologic simulation based on actual impervious percentages. However, where a site discharges to a storm sewer, the following criteria apply:

- For greenfield development sites: a maximum imperviousness of 25% (i.e. runoff coefficient C = 0.43) may be applied;
- For re-development sites: a maximum imperviousness of 36% may be applied (i.e. runoff coefficient C = 0.50).

When establishing post-development return period peak flows, proponents are also required to complete hydrologic simulation based on proposed impervious coverage (i.e. standard runoff coefficients and impervious percentages based on development type cannot be applied) as outlined in Section 5. Consideration should be given for the ultimate (full) build-out of the site and include potential amenity areas beyond the building structure and roadway accesses.

Flood control systems (quantity control systems in addition to extended detention/erosion control systems) discharging to a storm sewer must have a maximum drawdown of forty-eight (48) hours, unless the proponent can reasonably demonstrate that this is not practically achievable. In these cases, the drawdown time shall be discussed with the City of Burlington.

A minimum orifice diameter of 75 mm is allowable for flow restrictors, to prevent clogging. In cases where a smaller diameter orifice is required, the City of Burlington will require the use of a vortex type valve to ensure adequate flow conveyance. The City of Burlington requires the use of orifice tubes as opposed to orifice plates, to prevent removal in the future. Orifices tubes should be located on the downstream side of control structures.

6.1.1.2 Sub-Surface Storage

Subsurface stormwater quantity control facilities, consisting of pre-manufactured units or cast-in-place structures, can reduce peak flow rates by providing storage of stormwater underground. Generally, underground storage facilities are used for smaller development sites or areas of intensified urban development which lack enough space to construct typical surface-based stormwater detention facilities.

Acceptable on-site locations for using subsurface stormwater storage facilities are to be established in consultation with City staff and justified to the satisfaction of the City. Consideration for surficial soils (types and layers of soils, depth to bedrock), depth to groundwater, locations of sub-surface utilities, and future maintenance access shall be considered in the selection of the on-site location.

Subsurface stormwater quantity control facilities shall be designed in accordance with manufacturer's specifications and supporting documentation from the manufacturer shall be included as part of the Stormwater Management Design Brief.

The City of Burlington generally recommends that water quality controls and pre-treatment measures be located upstream of the quantity control storage to prevent clogging and sedimentation.

Underground storage systems shall include an emergency overflow system consisting of a surface overflow/relief path sited and sized to convey the uncontrolled flow for the 100-year storm in the event that the subsurface storage facility becomes clogged or inoperable. The proponent should consider measures to address these considerations as part of the design process, as well as undertake regular inspections of system post-construction to minimize the risk of clogging or blockage. Notwithstanding the preceding, the storage system shall be designed to ensure that flows from the 100-year storm event and below can be safely directed to the storage system for capture and treatment.

6.1.1.3 Parking Lot and Surface Storage

Parking lot and surface storage (vegetated areas of the site) are acceptable for use in the City of Burlington for commercial and industrial sites only; surface storage is not acceptable for residential sites given safety concerns. Parking lot storage shall not be used for storm events with a 5-year return period or less to prevent nuisance flooding, and the depth of ponding shall be limited to a maximum of 300 mm during the 100-year storm event. Overflow relief shall be provided, consisting of a surface overflow path sited and sized to convey the uncontrolled flow for the 100-year storm in the event that the controls become clogged or inoperable.

Underground parking ramps shall be designed to ensure a minimum of 0.3 m freeboard between the maximum ponding elevation and the spill point elevation, to limit the potential for overflow flooding.

6.1.1.4 Rooftop Storage

Rooftop storage is generally not acceptable for use in the City of Burlington, given the inability to prevent modification to rooftop controls post-construction. The City of Burlington may consider the acceptability of rooftop storage where the proposed approach would involve either "blue roofs" (rooftop storage via separate modular trays attached to the roof) or "green roofs" (rooftops which incorporate a membrane, drainage/filter layer and a layer with planting medium and plants).

Rooftop detention must be designed to meet the requirements of the Ontario Building Code (OBC). Structural design calculations, signed and stamped by a qualified professional Structural Engineer, shall be provided to confirm the loading capacity.

Rooftop drain controls shall be designed in such a manner to prevent removal or tampering with the controls, such as restrictive downspouts or sub-surface orifice tubes. The City of Burlington, in its sole discretion, may require the controls to be listed on the title of the property, as well as a long-term agreement with respect to operations and maintenance.

6.1.2 Erosion Control

Proponents are required to provide erosion control in accordance with the specified level of control outlined within a SWS, MDP, or MESP that encompasses the proponent's site.

Where a SWS, MDP, or MESP does not exist, proponents should provide extended detention control (detention of the runoff generated from the developed site for a 4-hour, 25 mm storm event over at least 24 hours, with a preference for 48 hours). Proponents are required to consult with the City and Agencies (including Conservation Halton) regarding the acceptable level of erosion controls to be applied to the proponent's site prior to initiating the requisite studies.

Alternatively, the proponent should manage the retention of the 90th percentile rainfall (27 mm for the City of Burlington) as per the pending potential Provincial Policy, subject to review and discussion with the City of Burlington and Conservation Halton.

Where the proponent can demonstrate that the preceding is not practically feasible, the City of Burlington in consultation with Conservation Halton may consider a "best efforts" approach for on-site controls; a "cash-in-lieu" policy may be required to account for the balance of the erosion control requirements not provided. Such conditions may include sites where the required storage volume cannot be practically accommodated, single lots fronting on a municipal roadway, or sites below a certain size/area threshold.

6.1.3 Water Budget

A water budget is a general accounting for the amount of rainfall input which becomes runoff, is infiltrated, or is lost through evapotranspiration for a subject area. A water budget analysis ensures that other considerations beyond peak flow control are considered as part of a stormwater management (SWM) system, in particular that the overall water budget is generally maintained, including that pre-development infiltration and runoff volumes are generally maintained.

Proponents are required to maintain the site infiltration-based water budget in accordance with the specified level of control outlined within a SWS, MDP, or MESP that encompasses the proponent's site. Reference is also made to Conservation Halton's applicable guidelines on feature-based water balance.

Where a SWS, MDP, or MESP does not exist, proponents are required to ensure that pre-development (defined as per Section 6.1.1.1) infiltration volumes calculated on a site basis are maintained under post-development conditions. Consistent with pending potential Provincial guidelines, the proponent may achieve this requirement by managing the retention of the 90th percentile rainfall (27 mm for the City of Burlington). The City of Burlington supports the application of Green Infrastructure (GI) and Low Impact Development Best Management Practices (LID BMPs) to achieve these requirements, however it does not credit its benefit with respect to quantity control requirements. At a minimum, the City of Burlington recommends that the proponent ensure that the first 5 mm of rainfall which lands on the site is retained and infiltrated on site (i.e. zero runoff for the first 5 mm of rainfall).

The City of Burlington may (in consultation with Conservation Halton where appropriate), in its sole discretion, consider a reduced infiltration and water budget requirement if the proponent is able to clearly demonstrate that meeting the preceding is not feasible on the site, due to physical constraints such as an elevated groundwater condition, bedrock or other system constraints.

6.1.4 Quality Control

6.1.4.1 Treatment Train Approach and Design Criteria

The City of Burlington, consistent with the Province of Ontario, requires the application of the "treatment train" approach for water quality treatment. This approach requires that at least two (2) separate forms of water quality treatment are provided in series in order to achieve the City's required target of 80% average annual removal of Total Suspended Solids (TSS) – i.e. the Ministry of the Environment, Conservation and Park's (MECP) "Enhanced" criteria.

The proponent is to provide TSS removal calculations for each proposed form of water quality treatment as well as the combined removal in order to verify that this minimum requirement is met. Treatment from engineered systems such as oil/grit separators shall be credited at 50% only. For other accepted water quality treatment measures, a blanket treatment rate of 60% average annual TSS removal shall be credited unless the proponent can supply other calculations/justifications. Availble tools, such as the Sustainable Technologies Evaluation Program (STEP) Treatment Train Tool (TTT) may be considered.

More stringent criteria may be applied in special cases, including areas draining to Hamilton Harbour (Burlington Bay), or where an existing higher level study (i.e. SWS, MDP or MESP) or other applicable study (EIS or EIA) have been completed. This may include (but is not limited to) areas of known concern with respect to salt, as well as thermal impacts. The proponent is to consult with the City of Burlington accordingly.

For re-development applications, the City of Burlington requires that proponents provide treatment for the entire redevelopment site, regardless of its current use or the proportion being re-developed.

Rooftop areas may be considered as "clean" impervious area for the purposes of calculating water quality treatment requirements (removed from the calculations), provided the flows are separated from runoff from other non-roof areas.

In all cases, as part of the supporting design material for the proposed stormwater quality control measures, consideration of long-term operations and maintenance requirements, including clean-out frequency and associated methods shall be clearly outlined in an "Operations and Maintenance Manual". Where the proposed quality control measures are to be privately held, an agreement with the City of Burlington is required to ensure that the proponent continues to adequately maintain and operate the infrastructure.

6.1.4.2 Oil/Grit Separators

Oil/Grit Separators (OGS) may be implemented as part of the treatment train for stormwater quality control in urban areas where land use constraints prohibit the use of other BMPs. They are typically used for small sites or infill development (typically 5 ha or less), where a water quality control pond/wetland is not feasible. OGS units can also be used for spill control or as a pre-treatment device, as part of a multi-component system (treatment train) to achieve the requisite water quality control criteria. Based on current studies, OGS units have minimal benefits in reducing/managing nutrients and organic matters and do not effectively remove dissolved or emulsified oils and pollutants like a traditional SWM facility. Where an OGS is proposed, as part of the treatment train approach, it is generally recommended that the OGS unit be placed upstream of another water quality treatment methodology more suited to removing other types of pollutants, particularly filtration-based approaches. Owners are requested to provide maintenance, inspection and clean-out logs annually.

OGS units shall be approved as per the CA-ETV program (http://etvcanada.ca/home/verify-your-technology/current-verified-technologies/).

In accordance with the most current MECP SWM manual (2003), for "enhanced" level water quality protection (80% TSS removal), OGS units shall be sized to capture and treat a minimum of 90% of the runoff volume that occurs for a site on a long-term average basis.

6.1.4.3 Catchbasin and Maintenance Hole Inserts

Manufactured catchbasin devices are designed to promote retention to avoid re-suspension of suspended sediments in catchbasin sumps. Maintenance hole inserts are perforated barriers installed perpendicular to the direction of flow in combination with a deeper sump. They similarly promote settling of suspended solids.

These devices are acceptable to the City of Burlington as part of the treatment train approach and should only be employed as a pre-treatment to another downstream system, given their typical focus on larger suspended solid particles. Where available, the treatment capacity of these systems shall be determined as per the manufacturer's sizing program, using the CA-ETV PSD.

6.1.4.4 Filtration Based Technologies

Filtration based technologies refer to proprietary manufactured technologies which rely on filtration of stormwater to remove pollutants, rather than sedimentation or hydrodynamic separation of suspended particulate matter only. Filtration typically removes a larger portion of contaminants and provides removal of additional parameters (such as nutrients) which are not addressed by other approaches. The City of Burlington supports filtration-based technologies as part of the treatment train approach; it is suggested that methodologies which remove coarser suspended material be placed upstream of filtration-based technologies to prevent clogging.

Filtration units shall be sized using the Canadian Environmental Technology Verification (ETV) particle size distribution (PSD) to determine the manufacturer determined TSS removal rate. Filtration units shall be approved as per the CA-ETV program (http://etvcanada.ca/home/verify-your-technology/current-verified-technologies/).

6.1.4.5 Low Impact Development Best Management Practices (LID BMPs)

The City of Burlington encourages proponents to implement LID BMPs wherever practical to address the requisite water quality control criteria for their site as well as complementary benefits for water balance and erosion control. Potential LID BMPs which are supported by the City include (but are not limited to):

- Bioretention areas and bioswales
- Vegetated filter strips
- Enhanced grassed swales
- Permeable pavements (asphalt, concrete, and paving stones)
- Soakaway pits and infiltration chambers
- Exfiltration pipes
- Pre-fabricated modules (including soil retention cells) and tree pits
- Green Roofs

Designers should reference available resources through the Credit Valley Conservation (CVC) and Toronto Region Conservation Authority (TRCA) and others, including:

- CVC Low Impact Development Guidance Documents (https://cvc.ca/low-impact-development/low-impact-development-support/stormwater-management-lid-guidance-documents/)
- Low Impact Development Stormwater Management Planning and Design Guide Wiki (https://wiki.sustainabletechnologies.ca/wiki/Main_Page)

The selection and design of LID BMPs must consider site characteristics, including but not limited to:

- Local groundwater table elevation (seasonal maximum)
- Subsurface soil type(s) and associated permeability/infiltration capacity (minimum soil infiltration rate of 15mm/hr).
- Depth to bedrock
- Sub-surface utility conflicts
- Existing zoning and land use, including legacy contamination sites
- Existing groundwater use including downgradient groundwater receptors (e.g. private wells, wetlands, sourcewater protection areas, etcetera)
- Long term Operations and Maintenance requirements

LID BMPs are also supported by the City of Burlington to address erosion control and water balance retention requirements. Acceptable on-site locations for LID BMPs are to be established in consultation with City staff based on the preceding site characteristics and justified to the satisfaction of the City. Where sub-surface LID BMPs are proposed, it is recommended that an additional water quality treatment measure be placed upstream, to prevent clogging and improve long term functionality.

6.1.4.6 Assessment of New Technologies

To foster innovation in stormwater management, the City of Burlington encourages proponents to propose the use of new products and emerging technologies. For new products that have received New Jersey Department of Environmental Protection (NJDEP) and/or Canadian Environmental Technology Verification (CA-ETV) approval, a formal assessment is not required, however the City of Burlington may request the proponent provide background information for the subject product.

For products and technologies that have not received NJDEP and/or CA-ETV certification, or if the certification is pending, new technologies will be assessed based on the following process and requirements:

1. A thorough review of existing background information by a third-party reviewer, as selected by the City of Burlington and paid for by the land owner/developer or technology manufacturer/ provider.
2. A pilot study to test the technology under laboratory conditions performed by, or at a minimum verified by, a third party. Current existing pilot studies deemed acceptable by the City of Burlington may eliminate this requirement. Pilot studies are to be paid for by the land owner/developer or technology manufacturer/provider.
3. A full-scale field demonstration test to obtain performance data. The demonstration is to be performed by, or at a minimum verified by, a third party. The results of any and all field tests are to be reviewed by the City of Burlington as per requirement 1. Field demonstration tests are to be paid for by the land owner/developer or technology manufacturer/provider.
4. Performance verification tests of the technology's ability to meet performance standards at the site where it will be deployed. Only existing start-up/compliance tests that are within a reasonable proximity to the eventual site where it will ultimately be deployed will be accepted. 'Reasonable proximity' is at the discretion of the City of Burlington. Start-up/compliance tests are to be paid for by the land owner/developer or technology manufacturer/provider.

Note that process steps 3 and 4 can be combined based on the location selected.

The results from all the preceding process requirements will be examined by a peer-review committee selected by the City of Burlington and based on recommendations from the peer-review, the City of Burlington may accept the product for application within the City. Costs associated with the peer-review process are to be paid by the land owner/developer or technology manufacturer/provider.

6.2 Stormwater Management Facilities (SWMFs)

6.2.1 General

End of pipe Stormwater Management Facilities (SWMFs) refers to those systems with open ponding areas used for quantity, erosion and/or quality control to mitigate the impacts of development. An end of pipe SWMF may refer to a dry pond, wet pond, wetland, or hybrid design. End of pipe SWMFs are typically only applicable for drainage areas of 5 ha or greater in order to support a permanent pool component.

Where a SWMF is required and proposed by the proponent, it shall be designed in accordance with the City of Burlington's design guidelines, and the Province of Ontario's (Ministry of the Environment's) 2003 Stormwater Management Planning and Design Manual, or any subsequent updated versions. The SWMF shall also meet guidelines and criteria set forth by CH (including its recommendations with respect to acceptable landscaping) and other agencies (i.e. MTO, MNRF, etc.), as applicable.

Siting of SWMFs shall be established in consultation with City staff, account for other Agency requirements, and be justified to the satisfaction of the City. Siting shall be based on site specific conditions and an appropriate analysis of environmental, technical (safety, maintenance and operations), economic and social considerations.

Consideration shall be explicitly given in the supporting design materials to long term operations and maintenance requirements for the proposed SWMF, with particular attention to the required frequency of inspection and monitoring, as well as the design of operations and maintenance amenities (such as sediment decanting zones, access roadways and safety considerations), and the expected frequency of sediment removal in the case of wet ponds, wetlands, and hybrid systems.

6.2.2 Requirements Prior to Assumption

SWMFs to be assumed by the City are to be designed and constructed to the satisfaction of City staff, and ownership shall be conveyed to the City free of charge and encumbrance. Private SWMFs will require a long-term agreement with the City with respect to inspections, operation and maintenance, to ensure that the SWMFs continue to function and operate as originally designed and approved. All public SWMFs should include a designated access roadway to provide safe and direct access to public roadways.

Requirements prior to assumption include:

- Facility clean-out completed to design elevations and grades; a bathymetric survey registered to an approved benchmark shall be provided to confirm that the facility has been cleaned and graded to the required elevations.
- The as-constructed drawing set is to confirm that key elevations of inlets, outlets, spillways and other features have been constructed to the design elevations.
- An engineering certification letter from the proponent confirming that all components of the SWMF have been inspected and are in good repair (i.e. in working condition) and constructed to design values. A summary table comparing design values to constructed values shall be provided, including an updated and confirmed stage-storage-discharge relationship for the SWMF. This is to also include a map (drainage plan) depicting the contributing drainage area. Any discrepancies shall be noted and assessed for significance.
- A copy of the Ministry of the Environment, Conservation and Parks (MECP) Environmental Compliance Approval (ECA), as well as any other related permits or approvals.
- All plantings, landscaping features, and restoration works completed as per approved SWMF design.
- An Operations and Maintenance Manual.

All the preceding materials shall be signed and stamped by a qualified Professional Engineer licensed to practice in the Province of Ontario. The preceding items may be required earlier in the process, potentially at the subdivision registration stage. The specific requirements should be discussed with the City of Burlington.

7.0 Erosion and Sediment Control (ESC) Design Criteria

7.1 General

Erosion and sediment controls are required by the City of Burlington for any proposed development or site alterations to ensure that sediment is kept on site, and that it does not negatively impact adjacent roadways, properties, infrastructure, watercourses, and waterbodies.

Prior to the commencement of any on-site work activities, proponents must implement an Erosion and Sediment Control (ESC) Plan that includes ESC measures designed to effectively reduce on-site erosion and minimize off-site transport of sediment, either through overland flows, municipal sewer systems or via wind transport. ESC measures shall conform to the erosion and sediment control methods as outlined in the "Greater Golden Horseshoe Area Conservation Authorities Erosion and Sediment Control Guidelines for Urban Construction" (2006), in addition to the City of Burlington requirements. Reference is also made to CAN/CSA-W202-18 (Erosion and Sediment Control Inspection and Monitoring).

Details of the ESC Plan/drawings shall be prepared by a licensed professional engineer and be included with the appropriate submission(s) for approval by the City of Burlington, and other relevant agencies (i.e. CH, MNRF, etc.), as required. Preference is given to those professionals with the Certified Professional in Erosion and Sediment Control (CPESC) designation from the Erosion Sediment Control Association of Canada.

Acceptable erosion and sediment control practices and requirements for submission(s) to the City of Burlington are provided herein.

7.2 ESC Plan Requirements

7.2.1 General

ESC Plans shall be prepared to show a plan view of the construction site and/or construction phase. Plans must be drawn at a minimum scale of 1:500. Lines and symbols shall be used to represent ESC measures.

ESC Plans shall include details demonstrating/indicating how ESC measures are to be constructed and maintained. Details shall be enough so the ESC measure can be properly installed. Plan enlargements may be required to show additional details in sensitive and/or special site areas.

Notes shall be included to outline site monitoring/remediation requirements for ESC measures, construction staging procedures, construction timing windows and restrictions, and any other key information.

Disturbance to site areas should be minimized, where possible, to reduce the potential for erosion and sediment transport. Proponents should consider a staged approach to construction works, such that disturbance to site areas occurs only as necessary for construction activities.

ESCs may require modification throughout the construction phase to address current site conditions. ESC controls (and all accumulated sediment) should be removed off-site once site conditions have suitably stabilized.

7.2.2 Construction Phase

ESC Plans shall be prepared to address all phases of construction. Phases of construction are dependent on the nature of the construction activity; however typical phases of construction are as follows:

- Topsoil Stripping/Site Clearing;
- Earthworks/Rough grading;
- Site Servicing and Road Construction; and

- House/Building Construction
- Demolition

Proponents are required to tailor the ESC measures to their construction site, based on the requirements of the site characteristics and anticipated staging. Depending on the complexity of the construction activities, multiple ESC Plans may be required to address the various construction phases.

All ESC measures are to be inspected by the Design Engineer or a CISEC (Certified Inspector of Sediment and Erosion Controls) Certified Inspector a minimum of twice per week during the active construction period and after significant rainfall events (>10 mm) to ensure ESC measures remain in good working condition. An inspection report is to be prepared by the site inspector immediately following each inspection. Inspection reports must outline the conditions of the ESC measures, including any deficiencies noted and a timeline to address such deficiencies. Reference is made to the “Erosion and Sediment Control Inspection Guide” (Greater Golden Horseshoe Area Conservation Authorities, 2008). The City of Burlington is to be provided a copy of each inspection report in a timely manner following each inspection (i.e. within 1 week).

Independent inspections may be completed by the City of Burlington staff in order to verify that the ESC measures implemented on the site follow the approved plan and in working order. Written notice will be provided as required, outlining any deficiencies noted and providing a timeline to address.

The proponent is responsible for addressing any deficiencies noted in the erosion and sediment controls implemented on the site. If the deficiencies are not addressed within the specified timeframe, the City of Burlington may use the Letter of Credit to finance any required remedial works.

7.3 Permissible ESC Measures

7.3.1 Erosion Controls

Permissible erosion controls for site alterations include, but are not limited to, the following practices.

Surface Roughening (Scarification)

Scarification is a process of roughening exposed slopes perpendicular to the slope/drainage direction. Typically, scarification can be useful for sites with steep slopes up to 2H:1V. Scarification reduces drainage velocity, quantity and erosion potential.

Seeding

Vegetative cover is established by seeding a disturbed area. Typically, seeding of disturbed areas is conducted following final grading or for site areas where no further construction is scheduled for 30 days. Seed application typically occurs with straw mulching, hydraulic mulching and erosion control blankets. Seeding using hydroseeding or terraseeding techniques is encouraged to support the more rapid growth of vegetation. Sodding may be required in site areas where instant ground cover is required or where seed is difficult to establish (e.g. swale inverts due to concentrated flows).

Mulching

Freshly seeded soils can be protected by applying man-made or natural materials such as mulching. Mulching reduces drainage velocity and therefore the erosion potential of seeded soils. Manufacturer’s specifications should be followed for mulch application.

Polymers and Tackifiers

Polymers and tackifiers are substances which can be used in conjunction with seeding and mulching activities to bind material together (increase cohesion) to limit erosion. Such materials must be confirmed to be environmentally benign. Supporting material is required where such substances are proposed prior to approval and application.

Erosion Control Blankets, Netting and Matting

Erosion control blankets, netting and matting should be fully biodegradable materials which are placed on relatively steep surfaces to prevent erosion and promote seed growth. This type of mechanical stabilization is also required in areas of exposed soils if construction is proceeding outside the growing season (i.e. late October to early April). Manufacturer's guidelines should be followed in the use of erosion control blankets.

Vegetative Buffer Strips

Erosion control can be provided through the use of existing or proposed vegetation adjacent to the feature to be protected.

7.3.2 Sediment Controls

Permissible sediment controls for proposed developments or site alterations include but are not limited to the following practices. In all cases, the City of Burlington encourages re-vegetation of exposed surfaces as quickly as possible following grading works.

Vehicle Tracking Control

The City of Burlington requires that a vehicle tracking control mat (i.e. "mud mat") be implemented where vehicles access and leave a construction site via a municipal road. A mud mat is comprised of both 150 mm diameter aggregate (first 10 m) and 50 mm diameter aggregate (last 10 m) placed on a geotextile, 300 mm deep, with a minimum width of 5 m and a minimum total length of 20 m. Mud mats should be located at each site entrance/exit. Mud mats require regular maintenance to ensure sustained performance. Where the mud mats fail to perform, and where sediment is conveyed to the road, the proponent will be required to clean the road at its sole expense. Should the City of Burlington inspect the road and determine that maintenance is not adequate, the proponent shall be responsible to address the identified deficiencies. Other less common forms of vehicle tracking control, such as wash-pads, are also acceptable for use. There may be instances where the City requires proponents to implement multiple forms of vehicle tracking control.

Dust Management

Dust management is a key consideration during dryer periods (summer, etc.) and is most notable whilst soils are not yet stabilized on site. Efforts must be made to ensure appropriate mitigation measures are available and in place on site, such that concerns can be avoided and/or otherwise managed within a timely manner should they arise.

Sediment transport via wind can be reduced by implementing dust control measures on site. Dust control measures can include but are not limited to: soil wetting via water truck, placement of calcium chloride, anionic polymers, and vegetation of disturbed areas.

Temporary Grading Diversions

Diversion of drainage from steep slopes and disturbed areas through the use of diversion swales should be considered depending on site conditions. Drainage should be directed to appropriate sediment control measures.

Check Dams

Check dams (most typically rock check dams, however other types of materials are available) involve the placement of granular material either in a swale, ditch or watercourse to facilitate settling of sediment. Site specific design of check dams shall consider the depth of the swale (i.e. the height of check dams shall be smaller than the depth of the swale). Check dams shall be constructed such that flows do not by-pass the check dam.

Temporary Slope Drains

To prevent slope erosion, concentrated drainage may be conveyed down a slope via a temporary slope drain comprising a flexible conduit or ditch liner. Slope drains should employ adequate inlet and outlet protection and should not discharge directly to creeks.

Sediment Control Fences

Sediment control fences act as a barrier to sediment migration and drainage, creating ponding and therefore settling of sediment, rather than relying on filtering of the runoff. In order to function properly and effectively, sediment control fence must be properly installed and maintained, including ensuring an appropriate depth of burying/anchoring. In areas of environmental concerns, or sensitive discharge locations, a double row of silt fence may be required. Sediment Control fence should not be used in areas of concentrated flows; other more appropriate measures should be used in those areas, including check dams and compost berms.

Compost Berms

Compost berms may in some locations be used in place of sediment control fences. The Compost berms should be designed according to manufacturer's guidelines. Unlike sediment control fence, compost berms are able to filter sediment from drainage and do not obstruct flow paths. Compost berms are easily spread out on-site after construction completion instead of being required to be removed like sediment control fence.

Compost Socks

Compost socks provide a similar function to compost berms, however on steep or paved surfaces, manufacturer's guidelines should be used in both design and placement of the compost sock. Compost socks can also be used in place of rock check dams and catchbasin sediment traps.

Sediment Traps

The design and construction of sediment traps should incorporate guidelines outlined in the Greater Golden Horseshoe Conservation Authorities Erosion and Sediment Control Guidelines (2006). Typically, drainage areas to sediment traps are less than 2 ha. The location of sediment traps should be outside of regulated floodplain limits whenever possible.

Sediment Control Ponds/Basins

Similar to sediment traps, sediment control ponds/basins should incorporate guidelines outlined in the GGHCA ESC Guidelines. Typically, sediment control ponds/basins are sized to provide a permanent pool volume, as well as an active storage volume with a minimum drawdown time for drainage areas of 2 ha or greater. Sediment control ponds/basins should be located outside of areas regulated by Conservation Halton unless approved through their permitting process.

Catchbasin Sediment Traps

Catchbasin sediment traps are devices positioned inside catchbasins and are intended to prevent sediment build-up and clogging of the storm sewers by trapping sediment laden runoff. Catchbasin sediment traps are required on all catchbasins potentially subject to sediment laden runoff, including those outside of the construction site. Catchbasin sediment traps should be cleaned as per manufacturers specifications.

Polymer Flocculation

Anionic polymers can be used in combination with many of the sediment control measures noted previously to create larger particles which more easily settle out. Polymers can be used for dewatering and bypass applications, including creating treatment ditches or pipes that contain polymer blocks or contact surfaces to promote flocculation and minimize sediment loading to downstream receivers.

7.3.3 Drainage Protection

Permissible drainage protection for site alterations include, but are not limited to, the following practices.

Temporary Creek Crossings

Temporary creek crossings typically span a watercourse feature for the purpose of construction access. For regulated watercourses, CH, MNRF, and possibly DFO will have individual requirements that should be fulfilled related to location, capacity and form.

Where watercourses are not regulated by other agencies, concrete or corrugated metal pipes may be used to provide temporary crossings during construction. Notionally, the crossings would be required to convey a frequent event (i.e. 2-year storm event +/-) design flow, depending upon the duration of crossing, time of year, and any site-specific constraint; the capacity is to be established in consultation with the City of Burlington.

Temporary Drainage Diversions

Temporary diversions of non-regulated drainage features should be conducted only when necessary to reduce impacts on the social or natural environment and are supported by a comprehensive evaluation of potential impacts. Diversions should be designed according to drainage function and form and may require natural channel design principles. Watercourse diversions must account for other Agency requirements.

Temporary Storm Drain Inlet Protection

Storm drain inlet protection may consist of a sediment control barrier, granular material, geotextile and/or ponding area. Specific applications will require different inlet protection designs.

Temporary Storm Drain Outfall Protection

Outfall protection should be designed according to both the outfall flow velocities and the receiving watercourse flow dynamics.

Temporary Flow Bypass and Dewatering

Temporary cofferdams are used to allow dewatering of a construction area to permit work in dry conditions. Sediment laden water should be pumped to a sediment bag (or equivalent) within a vegetated area a minimum of 30 m away from features to be protected. Design considerations and installation and maintenance considerations are provided within the GGHCA ESC Guidelines.

7.3.4 Soil and Fill Management

General References

Fill management and excess soil management should follow applicable guidelines, including the Province of Ontario’s “Management of Excess Soil – a Guide for Best Management Practices”.

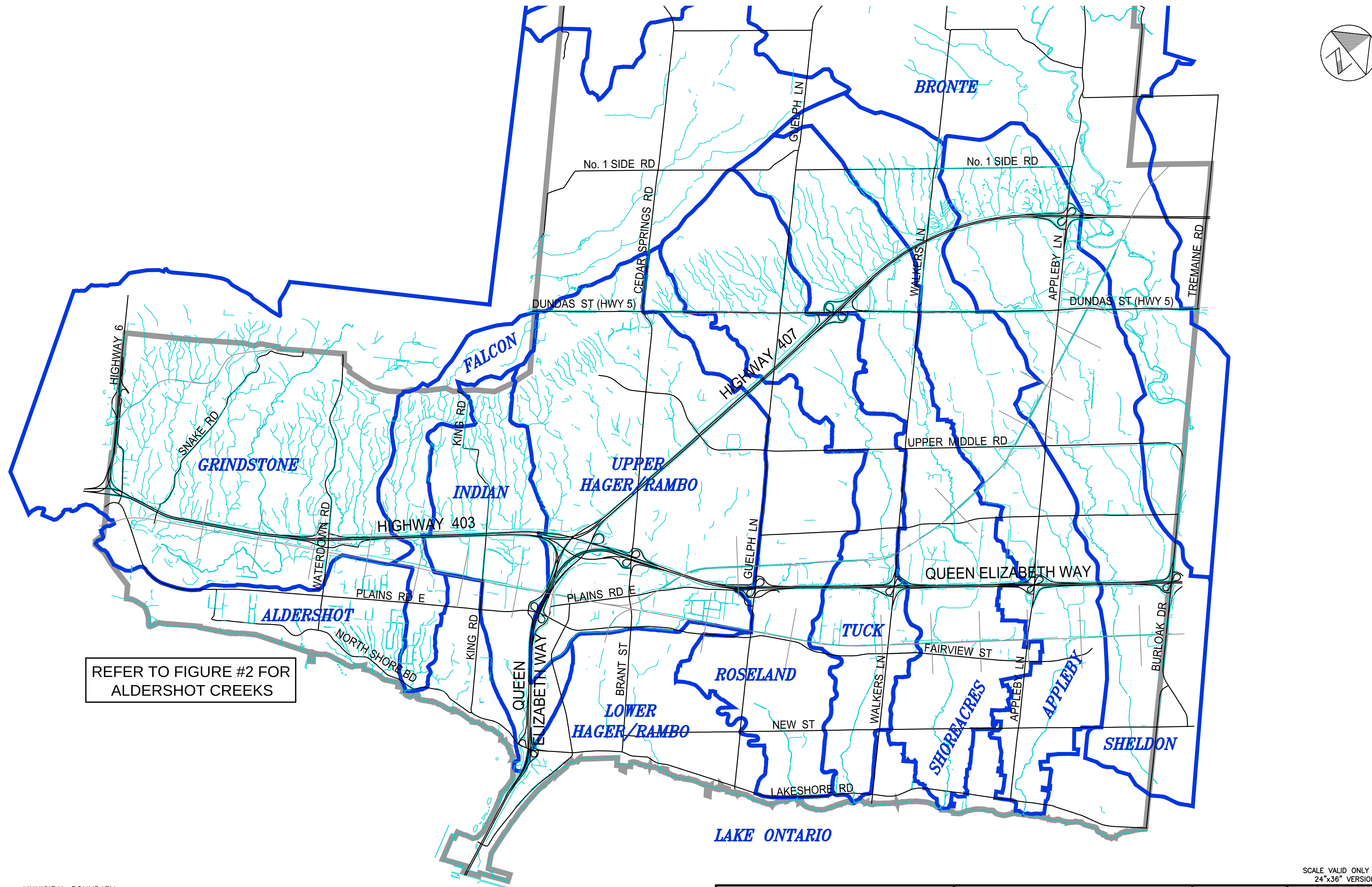
Fill and Topsoil Stockpiles

Fill and Topsoil stockpiles shall be limited to a height of 3 m and must have side slopes not exceeding 3H:1V. Sediment fences are to be installed around the perimeter of the stockpile to control sediment laden runoff. For larger material stockpiles (>100m^3) an additional setback at the toe of the stockpile (not less than 2 m) shall be included. Stockpiles to be undisturbed for 30 days or more must be vegetated to prevent sediment transport, typically by seeding.

8.0 Future Evolution of SWM Design Guidelines

While these Stormwater Management Design Guidelines have been prepared based upon current best practices and approaches, it is recognized that stormwater management is a field that has consistently evolved over time and will continue to do so in the future. These guidelines will necessarily be regularly reviewed and updated by the City of Burlington to reflect current design practices, updated regulations and legislation, guidance from partner agencies and other levels of government, and new technologies. The practitioner should contact the City of Burlington for the most current design guidelines.

In addition to the preceding overall review of design principles and methodologies, the City of Burlington will review rainfall intensity-duration-frequency (IDF) data on a 5-year cycle to ensure that the applied values continue to be reasonable and appropriate, including the potential effects of climate change. Where appropriate, the currently approved IDF data provided in Appendix B of this document may be updated accordingly.



UPDATE TO STORMWATER MANAGEMENT DESIGN GUIDELINES CITY OF BURLINGTON	CITY OF BURLINGTON WATERSHEDS	wood.	Scale 1:27500 (0 250 500 1000) Consultant File No. TPB188002 Drawing No. 1

LEGEND

- MUNICIPAL BOUNDARY
- WATERCOURSE
- ROADWAY
- WATERSHED BOUNDARY

SCALE VALID ONLY FOR 24"x36" VERSION

UPDATE TO STORMWATER MANAGEMENT DESIGN GUIDELINES CITY OF BURLINGTON	CITY OF BURLINGTON WATERSHEDS ALDERSHOT CREEKS	wood.	Scale 1:5000 (0 50 100 200) Consultant File No. TPB188002 Drawing No. 2

Path: P:\2018\Projects\TPB188002 – Update To SWM Design Guidelines\06_DES-ENG\01_CAD\02_DWGS\05_WR\2018-09\Fig2 AldershotCreeks.dwg

Plotted By: richard.bartolo
Last Saved By: richard.bartolo
Plotted: 2018-09-20
Last Saved: 2018-09-19

Appendix A

Glossary of Terms and Acronyms

LIST OF ACRONYMS

ANSI:	Area of Natural or Scientific Interest
CB:	Catchbasin
CCTV:	Closed Circuit Television
CH:	Conservation Halton
CSP:	Corrugated Steel Pipe
DI:	Ditch Inlet
ECA:	Environmental Compliance Approval
EIS:	Environmental Impact Study
ESC:	Erosion and Sediment Control
ETV:	Environmental Testing Verification
FDC:	Foundation Drain Collector
FSR:	Functional Servicing Report
GDCC:	Grading and Drainage Clearance Certificate
GI:	Green Infrastructure
HDPE:	High Density Polyethylene
HGL:	Hydraulic Grade Line
HHRAP:	Hamilton Harbour Remedial Action Plan
ICD:	Inlet Control Device
IDF:	Intensity-Duration-Frequency
LA:	Landscape Architect
LID BMP:	Low Impact Development Best Management Practices
MDP:	Master Drainage Plan
MECP:	Ministry of Environment, Conservation and Parks
MESP:	Master Environmental Servicing Plan
MH:	Maintenance Hole
MNRF:	Ministry of Natural Resources and Forestry
MOECC:	Ministry of the Environment and Climate Change
MTO:	Ministry of Transportation Ontario
OBC:	Ontario Building Code
OGS:	Oil/Grit Separator
OLS:	Ontario Land Surveyor
OP:	Official Plan
OPA:	Official Plan Amendment
OPSD:	Ontario Provincial Standard Drawing
OPSS:	Ontario Provincial Standard Specification
PSD:	Particle Size Distribution
PVC:	Polyvinyl Chloride
RYCB:	Rear-yard Catchbasin
SAR:	Species at Risk
SWM:	Stormwater Management
SWMF:	Stormwater Management Facility
TSS:	Total Suspended Solids
TTT:	Treatment Train Tool

GLOSSARY OF TERMS

Blue Roof: Rooftop storage via separate modular trays attached to the roof to achieve stormwater management

Catchbasin: A manufactured inlet structure used to provide drainage from roadways and other hard surfaces into a sub-surface storm sewer system.

Conservation Authority: Watershed-based regulatory agencies which are responsible for flood management and overall ecological matters within the watershed

Continuous Simulation: Hydrologic modelling which considers a long-term precipitation data series (typically 10 years or more), and accounts for other components of the hydrologic cycle, including evapotranspiration, snowfall/snowmelt, groundwater, and other components.

Design Storm: A synthetic rainfall event distribution used to estimate stormwater flows under specified return periods.

Dual Drainage: An approach for urban hydraulics that considers both the sub-surface (i.e storm sewer) and surface (roadways) systems.

Erosion: The loss of soil or other material due to the action of water (including watercourses and waves) in particular.

Event-Based Simulation: Hydrologic simulation which considers a single event only, typically through the application of design storms.

Floodplain: The area along a watercourse expected to be inundated by floodwater for a given storm event or return period.

Fluvial Geomorphology: The study and design of watercourses, including erosion and sediment transport

Grading: The design of topography for a site or area, including elevation changes and slopes.

Greenfield: An undeveloped area or site currently in a natural condition (i.e. not previously developed).

Green Infrastructure: Generally used synonymously with LID BMPs, GI refers to stormwater management measures which generally mimic natural water cycle features, with a focus on infiltration.

Green Roof: Rooftops which incorporate a membrane, drainage/filter layer and a layer with planting medium and plants to achieve stormwater management.

Hydrogeology: The study of groundwater and related considerations

Hydrology: The study of hydrologic processes, including the estimation of flow rates and runoff amounts in response to rainfall inputs.

Hydraulics: The study of the conveyance of water, including capacity of closed (i.e. storm sewer) and open (i.e. creeks and channels) systems.

Imperviousness: The proportion of an area that is hardscaped (i.e. paved) and does not permit infiltration of stormwater.

Infiltration: The seepage/percolation of water into the sub-surface through permeable soils and other materials.

Inlet Control Device: A mechanical structure used to restrict inflow, either to a storm sewer system, a stormwater management facility, or other feature.

Low Impact Development: A broad suite of SWM measures which focus on the at-source control of stormwater, with a focus on filtration and infiltration-based approaches

Major System: Overland flow in excess of the minor system; typically refers to roadway flow in urban areas.

Minor System: A drainage system intended to convey smaller, more frequent storm events such as a storm sewer system.

Oil/Grit Separator: A manufactured device which uses gravity or hydrodynamic means to settle out suspended solids (i.e. grit) and floatable materials (i.e. oil) to provide stormwater quality treatment from storm sewer inflows.

Runoff: Excess stormwater flows which is not infiltrated or evaporated and “runs off” over the surface.

Storm Sewer: A subsurface pipe used to convey a portion of stormwater runoff towards an appropriate receiver.

Stormwater Management: Broadly refers to the process of how water, stemming from precipitation (rain and/or snowmelt events) is managed and controlled.

Stormwater Management Facility: Typically a dedicated area to treat and control stormwater runoff prior to release to a suitable receiver. Includes dry ponds (generally for quantity control only; no permanent pool of water) and wet ponds (quality and quantity control, include a permanent pool of water).

Subwatershed: A sub-area of land that drains to a common receiver; typically a smaller watercourse system which drains into a larger watercourse (i.e. a component of a larger watershed)

Swale: A minor surface-based water conveyance feature, such as a ditch.

Water Budget: A general calculation of the division of water cycle components for a given storm event, including the proportion of precipitation that becomes surface runoff, infiltration, and evapotranspiration.

Watershed: The area of land that drains to a common receiver, normally a creek or river.

Burlington

Appendix B

Current Rainfall IDF Curves

Appendix B: Climate Change and Intensity-Duration-Frequency Relationships

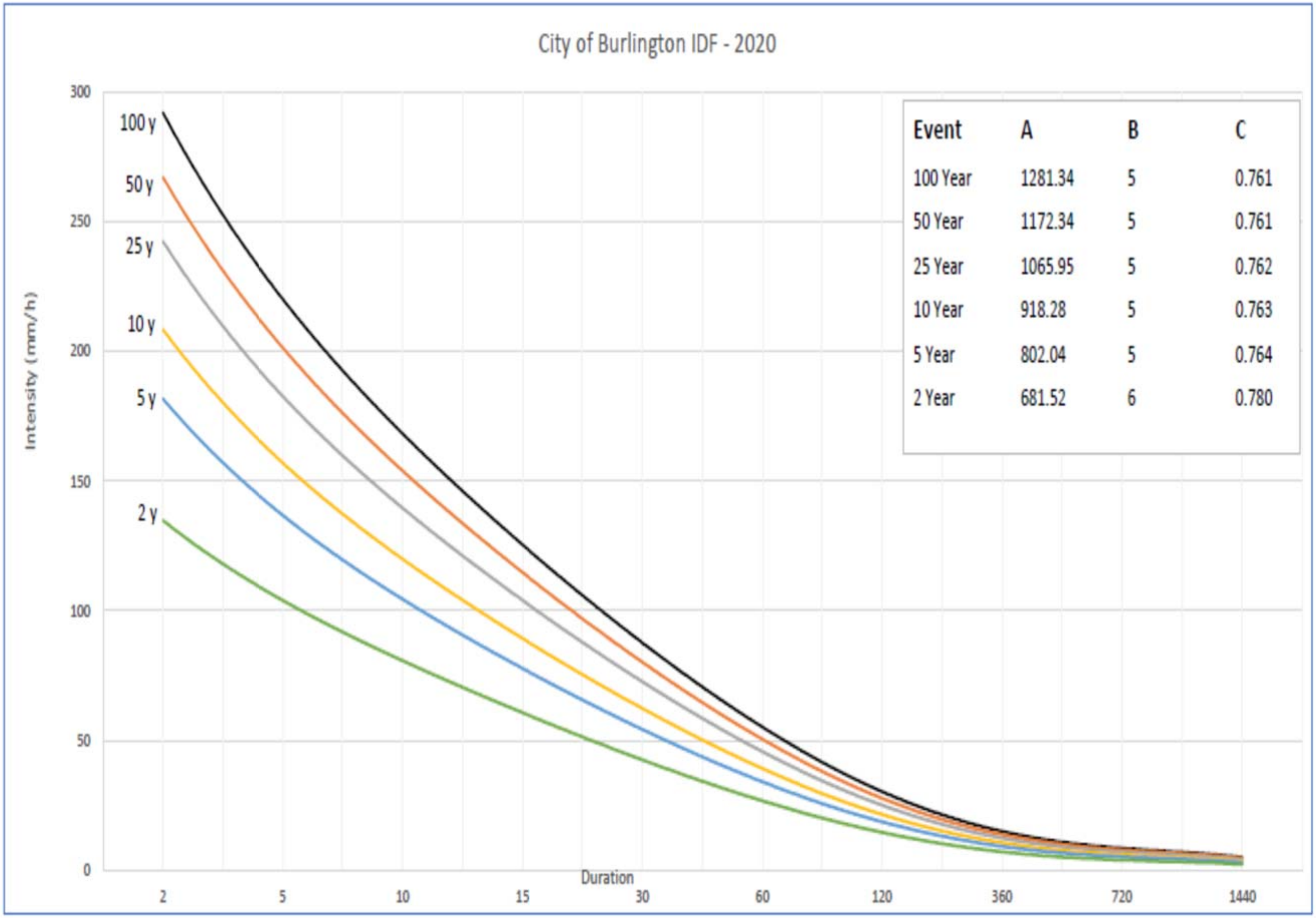
The University of Western Ontario has developed a "Computerized Tool for the Development of Intensity-Duration-Frequency Curves under a Changing Climate" (available at http://www.idf-cc-uwo.ca/). This computerized web-based IDF tool integrates a user interface with a Geographic Information System (GIS). By creating or selecting a station the user is able to carry out statistical analysis on historical data, as well as generate and verify possible future change based on a methodology using a combination of global climate modelling outputs and locally observed weather data.

There are currently a total of twenty-four (24) different Global Circulation Models (GCM's) available in the tool. The Representative Concentration Pathways (RCP's) (as defined in the Fifth Assessment Report (AR5, IPCC, 2013) represent various future greenhouse gas concentrations scenarios. Three (3) different RCP scenarios are available in the tool. RCP 2.6 represents a low greenhouse gas concentration scenario, followed by RCP 4.5 as an intermediate scenario and RCP 8.5 as a high concentration scenario.

The City used the University of Western Ontario Intensity-Duration-Frequency Climate Change (IDFCC) tool to generate local IDF curves utilizing 54 years of historical rainfall data from RBG meteorological station. The IDFCC tool was used to also produce projected rainfall intensities to the year 2100 for each of the three RCP scenarios. The table below shows the results for 5 and 100-year events:

Table B1: 5-year event					
	Existing	Historic*	RCP 2.6	RCP 4.5	RCP 8.5
Intensity (mm/h)	88.09	88.2	95.01	97.20	102.37
% Increase compared to Existing	N/A	0.12	7.85	10.34	16.21
Table B2: 100-year event					
	Existing	Historic	RCP 2.6	RCP 4.5	RCP 8.5
Intensity (mm/h)	141.89	141.11	151.92	153.82	163.11
% Increase compared to Existing	N/A	-0.88	10.56	8.4	14.85

The increase in intensities for the three scenarios ranges from 8 to 16%. Based on these results, the City will update the current IDF relationships by applying a 15% increase. The revised IDF relationships are shown in the figure below, which will now become the new standard for the City's stormwater infrastructure designs.


City of Burlington IDF - 2020
Intensity (mm/h)
300
250
200
150
100
50
0
Duration
2
5
10
15
30
60
120
360
720
1440
100 y
50 y
25 y
10 y
5 y
2 y
Event A B C
100 Year 1281.34 5 0.761
50 Year 1172.34 5 0.761
25 Year 1065.95 5 0.762
10 Year 918.28 5 0.763
5 Year 802.04 5 0.764
2 Year 681.52 6 0.780