City of Guelph

Stormwater Management Master Plan

Appendix F – Stormwater Design Criteria and Targets

December 2022

Prepared for:
The City of Guelph

Stormwater Management Master Plan

Appendix F: Stormwater Design Criteria and Targets

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Reference #: 66636
December 2022
Final Report

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1 Purpose

The purpose of this document is to review the City's existing stormwater management criteria and to recommend new criteria for implementation as part of the City of Guelph Stormwater Management Master Plan (SWM-MP) for new development, redevelopment, infill and intensification as well as linear projects (eg. linear infrastructure and transportation infrastructure).

The following shall be read in conjunction with the **Stormwater Infiltration Policy Recommendations (November 2022, as amended from time to time)** as prepared for the SWM-MP.

The specified minimum targets contained within this document do not preclude the proponent from achieving the required stormwater quantity, quality, erosion control and water balance requirements as identified through watershed, subwatershed, master drainage plans, Environmental Impact Statement (EIS), Provincial Policy and Guidelines or other area specific studies; nor does it preclude the proponent from the requirement to prepare appropriate pollution prevention plans per the Canadian Environmental Protection Act, or other documents per City of Guelph requirements. Where an implementation strategy has been developed through a Subwatershed Study, Master Drainage Plan, Secondary Plan or other planning study, the criteria contained within these detailed studies will supersede the SWM-MP criteria.

The application of the specified stormwater targets contained herein shall be effective once the City's CLI ECA is approved or the SWM-MP comes into effect, whichever is earlier.

2 Key Definitions

Throughout this document the following terminology shall be applied:

Criteria is defined as numerical targets or management principles given to practitioners for stormwater control to be defined and outlined in local by-laws set by the City of Guelph.

Development[1] means:

a) The creation of a new lot, a change in land use, or the construction of buildings and structures requiring approval under the Planning Act;
b) Site alteration activities such as fill, grading and excavation that would change the landform and natural vegetative characteristics of a site; and
c) Various forms of intensification, infill development and redevelopment.

Evapotranspiration is the combination of evaporation and transpiration of water into the atmosphere from living plants, the water surface and soil.

Infill Development[1]: a form of development within an older established area of the city on land that has not previously been built on.

Infiltration is the downward entry of water into the surface of the soil, as contrasted with percolation which is movement of water through soil layers. Infiltration shall be defined as the temporary storage in

[1] Definition taken from City of Guelph Official Plan (2018 Consolidation)

the upper soil layers prior to evapotranspiration; or water that percolates down to local aquifers (shallow and deep aquifers).

Intensification[1]: the development of a property, site or area at a higher density than currently exists through:

a) redevelopment, including the reuse of brownfield sites;
b) the development of vacant and/or underutilized lots within previously developed areas;
c) infill development; and
d) the expansion or conversion of existing buildings.

Linear Infrastructure[1]: corridors that include infrastructure such as the pipes necessary for the transmission and distribution of sewage (including stormwater) and water, communication, hydro, oil, and gas lines, but does not include transportation infrastructure.

Low Impact Development[1] is a stormwater management strategy that seeks to mitigate the impacts of increased runoff and stormwater pollution by managing runoff as close to its source as possible. LID comprises a set of site design strategies that minimize runoff and distributed, small scale structural practices that mimic natural or pre-development hydrology through the processes of infiltration, evapotranspiration, harvesting, filtration and detention of stormwater. These practices can effectively remove nutrients, pathogens and metals from runoff, and they reduce the volume and intensity of stormwater flows.

Pre-Development Conditions are defined as current conditions present in the field the date the application is made or the least urbanized condition (i.e. lowest total impervious percentage for the site) prior to the date the of application, whichever is most stringent.

Residential Intensification[1]: intensification of a property, site or area which results in a net increase in residential units or accommodation and includes:

a) redevelopment, including the redevelopment of brownfield sites;
b) the development of vacant or underutilized lots within previously developed areas;
a) infill development;
c) the conversion or expansion of existing industrial, commercial and institutional buildings for residential use; and
d) the conversion or expansion of existing residential buildings to create new residential units or accommodation, including accessory apartments, second dwelling units and rooming houses.

Redevelopment[1]: the creation of new units, uses or lots on previously developed land in existing communities, including brownfield and greyfield sites. In spite of the above definition, for the lands within the Special Policy Area Floodplain of this Plan, redevelopment shall include an addition which is larger than 50 per cent of the total ground floor area of the original or existing building or structure.

- Brownfields are undeveloped or previously developed properties that may be contaminated; and
- Greyfields are previously developed sites that are not contaminated.

Re-use includes storing stormwater runoff and then using it as a source of water for internal and external uses. Re-use is also referred to as rainwater harvesting.

Stormwater refers to rainwater and melted snow that flows over roads, parking lots, lawn and other sites in rural and urban areas.

Stormwater Management refers to practices which help to minimize the impact of polluted runoff flowing into receivers (eg. wetland, watercourse, etc.), control the rate at which, or prevent, flooding from occurring and reduces the strain that stormwater places on municipal infrastructure and the natural heritage system.

Volume Retention Criteria has been described as "volume reduction", "permanent interception", "zero discharge" and/or an "infiltration target". For the purpose of the City of Guelph, the Stormwater Volume Criteria and Target shall be described as a Volume Retention Target. The retained volume shall be ultimately infiltrated, evapotranspired or re-used, such that the specified volume shall not later be discharged to the municipal sewer networks or surface waters and does not therefore become runoff.

3 Existing Criteria

The City's existing SWM criteria are generally described in the Development Engineering Manual (2019, as amended from time to time). Numerous site-specific studies have been completed throughout the City which are not included in the manual. The criteria arising from these studies have therefore been summarized below in **Table 3.1** and **Figure 3.1,** including the existing City-wide criteria arising from the Development Engineering Manual (DEM). Any future studies completed beyond the date of this report should be considered when reviewing all figures and tables within this report.

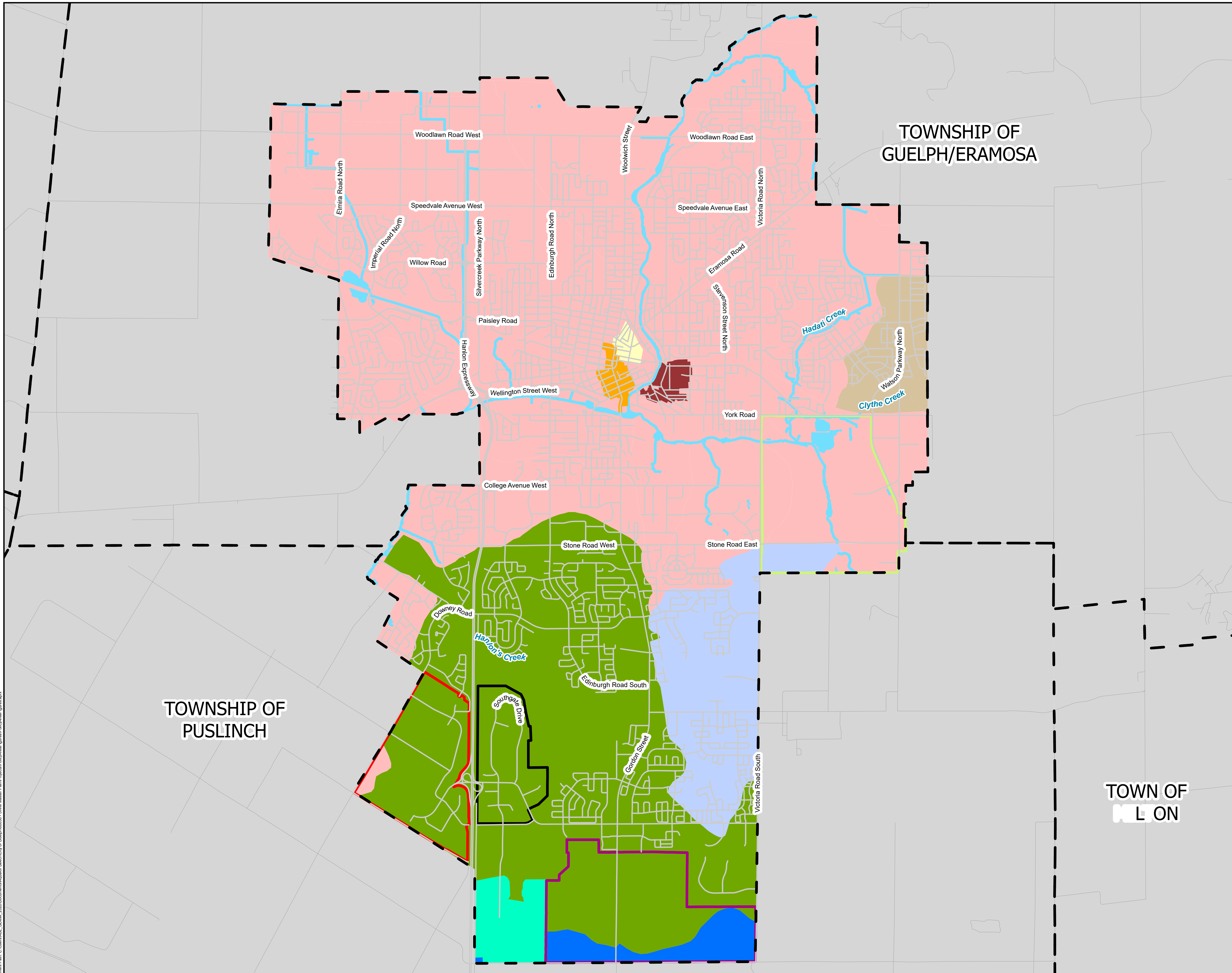
Table 3.1: Existing City Criteria

	Location	Infiltration / Water Balance	Quality	Quantity	Erosion	Additional Information
1	Hanlon Industrial Business Park	Recharge† Volume (acre feet) = 5-year peak flow (ft^3/s) x 0.035	• Minimum acceptable is 70% TSS removal • Limit sediment pond discharge to 0.015 ft^3/s per square foot of pond surface area	• Storm outlet rate is: 0.014 m^3/s – 100yr Hanlon Design Storm	Not specified	Appendix A1
2	HCBP Pond 1	Block-by-block recharge rates to be met	Enhanced level of quality treatment	Control up to and including 100-year design storm	Not specified	Appendix A2
3	HCBP Pond 2 & 4	Block-by-block recharge rates to be met	Enhanced level of quality treatment	• Control up to and including 100-year design storm • 100-year design storm runoff limited to 180 L/s/ha through on-site controls	Not specified	Appendix A3
4	Hanlon Creek Subwatershed	• No urban drainage permitted to the headwaters of Tributary E or F, except lands that have positive drainage outlet, unless a pilot scale demonstrates effectiveness over five years. • Areas adjacent to Clair Road can drain into greenway system of Upper Hanlon area subject to the same design criteria. • Areas south of Clair Road but isolated from direct outlet must rely on infiltration/evaporation. • Remainder designed to current City standards	• Implement thermal preventive and mitigation measures to maintain cold water fish habitat • Achieve specified water chemistry targets	• See infiltration requirements	Not specified	Appendix A4
5	Torrance Creek Subwatershed	• Zone 1: Zero runoff requirement (1:100 year volume captured, all water infiltrates) • Zone 2 & 3: Infiltration target of between 100 and 150mm/yr	Enhanced level of water quality treatment	• Control peak flow post to pre for all design events (2-100 year) • 1:100 year flow controlled to pre-development levels in Zones 2 and 3 • If no positive outlet, must provide on-site storage for twice the 5-year design storm runoff volume • Commercial, industrial, and high density residential: store excess runoff for 2-year storm underground or on rooftops	24 hour extended detention for 25mm rainfall event, if necessary (given infiltration levels and water quality requirements)	Appendix A5
6	Guelph Downtown - The Ward	No infiltration BMPs* permitted	Follow City-Wide criteria.	Control post-development flows up to the 100-year event to the 2-year pre-development flows	Per City's DEM	Appendix A6
7	Guelph Innovation District	27mm capture in infiltrative LID BMPs	• Enhanced level of water quality treatment • Recommended retrofit of SWMF 38	• 27 mm volume control on-site • Unitary storage and discharge rates for 25-year and 100-year events (refer to GID SWM Report for details)	Additional controls not required due to infiltration volume	Appendix A7
8	Clair-Maltby	20 mm captured within LID BMPs	• 20mm capture within LID BMPs • 100mm capture in Community Park	• 20 mm captured within LID BMPs with remaining drainage conveyed to designated surface water capture areas sized to capture Regional Storm • Small developments (<5ha) draining to Maltby Road: capture and control Regional Storm • Community Park: LID BMPs to capture 100-year storm	Not specified	Appendix A8

	Location	Infiltration / Water Balance	Quality	Quantity	Erosion	Additional Information
9A	Guelph Downtown – Dublin/Gordon	No infiltration BMPs permitted	Enhanced level of water quality treatment	Overcontrol stormwater to a 5-year pre-development condition for major and minor flows	Per City's DEM	Appendix A6
9B	Guelph Downtown – Quebec/ Macdonell	No infiltration BMPs permitted	Enhanced level of water quality treatment	Limit post-development peak runoff to the 25-year pre-development peak flow	Per City's DEM	Appendix A6
10	Clythe Creek Subwatershed	Maintain pre-development water balance	Thermal preventive and mitigation measures for coldwater habitat	Control peak flow post to pre for all design events (2-100 year)	Not specified	Appendix A9
11	Mill Creek Subwatershed	Maintain existing recharge and discharge characteristics	• Thermal preventive and mitigation measures for coldwater habitat • Implement appropriate water quality controls that promote infiltration and/or sedimentation	Maintain/reduce runoff peaks and volumes	Maintain/reduce existing erosion rates	Appendix A10
12	Southgate and Irish Creek Subwatershed	• Minimum groundwater recharge target of 300 mm/year • Quantity and proportion of runoff to Wetlands B and E should be maintained • Runoff quantities to Wetlands A-H should be maintained	Enhanced level of water quality treatment	Retain and infiltrate up to Regional Storm Event	Not specified	Appendix A11
13	City-Wide	Maintain predevelopment recharge rate, volume and hydroperiods at post-development conditions	Enhanced level of water quality treatment	Control peak flow post to pre for all design events (2-100 year)	Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A12

† It has been assumed that recharge, a term typically used in older reports, is equivalent to infiltration.

* BMP = best management practice



City of Guelph
Making a Difference

Legend

- Municipal Boundary
- Rivers
- Road Centreline

Policy Area:

- Policy Area 1: Hanlon Industrial Business Park
- Policy Area 2 & 3: Hanlon Creek Business Park Ponds 1, 2 & 4
- Policy Area 4: Hanlon Creek Subwatershed
- Policy Area 5: Torrance Creek Subwatershed
- Policy Area 6: The Ward
- Policy Area 7: Guelph Innovation District
- Policy Area 8: Clair-Maltby
- Policy Area 9A: Guelph Downtown - Dublin/Gordon
- Policy Area 9B: Guelph Downtown - Quebec/ Macdonell
- Policy Area 10: Clythe Creek Subwatershed
- Policy Area 11: Mill Creek Subwatershed
- Policy Area 12: Southgate and Irish Creek Subwatershed
- Policy Area 13: City-Wide

LOCATOR MAP

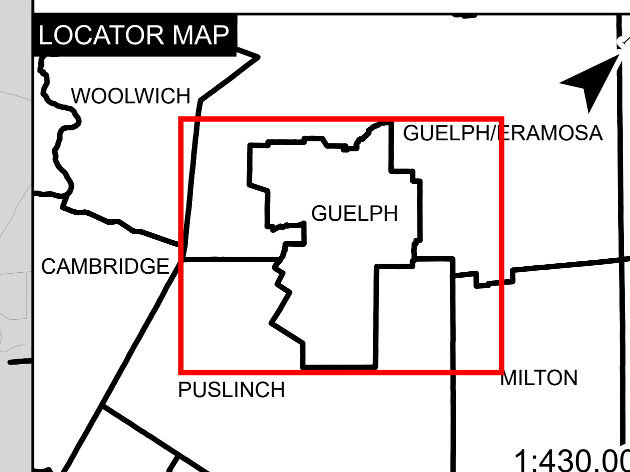


Figure 3.1

Existing City Criteria

Date: 2022-11-09
Projection: NAD83_UTM_Zone_17N
Data Source: City of Guelph, GRCA, Natural Resource Solutions
Created by: A.V.

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Aquafor Beech Limited

4 City of Guelph Stormwater Criteria

4.1 Stormwater Volume Retention Targets

4.1.1 Volume Target Rationale

The general rationale for the development of the Volume Retention Criteria and targets includes, but is not limited to:

- Pollutant loads to receivers are reduced through infiltration, evapotranspiration and re-use. Additional water quality benefits result from treatment process of filtration, adsorption and sedimentation;
- Reduced impacts (eg. erosion, sedimentation, etc.) to receivers;
- Urban flood prevention of the municipal sewer network through increased sewer capacity by reduced volume and peak flows, as well as delayed time-to-peak, especially in the context of climate change;
- Maintenance of pre-development groundwater recharge or hydrologic cycle preservation through infiltration and evaporation;
- Contribution to stream baseflow and mitigation of thermal impacts to urban streams; and
- Preservation of groundwater quantity and levels.

4.1.2 Provincial Direction

4.1.2.1 2015 Interpretation Bulletin

The Ministry of the Environment, Conservation and Parks (MECP) released in February 2015 an Interpretation Bulletin—Expectations Re: Stormwater Management which detailed the Ministry's position, specifically that:

- "The natural hydrologic cycle should be maintained to the greatest extent possible."
- "Too often, preservation of the natural hydrologic cycle is not sufficiently addressed in stormwater management plans submitted to the Ministry for an Environmental Compliance Approval (ECA)."
- "Low Impact Development (LID) is relevant for all forms of development, including urban intensification and retrofit."
- "LID can be less costly than conventional stormwater practices."
- "Going forward the Ministry expects that stormwater management plans will reflect the findings of the watershed, subwatershed, and environmental management plans, and will employ LID in order to maintain the natural hydrologic cycle to the greatest extent possible. "

4.1.2.2 Low Impact Development Planning and Design Guide

The Interpretation Bulletin was a precursor to the release of the pending Low Impact Development Planning and Design Guide. This Guide is expected to prescribe volumetric control targets of the 90th percentile rainfall event, and require the use of LID approaches for new development, infill and redevelopment as well as linear (ROW) projects.

4.1.2.3 Consolidated Linear Infrastructure Environmental Compliance Approval

In order to comply with the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI ECA), the proposed stormwater treatment train must comply with the requirements outlined in

Appendix A of the CLI ECA application. These requirements arose from the pending LID Planning and Design Guide.

A key component of the CLI ECA (2021 version provided in **Appendix B)** is the control of stormwater, as described below:

> Stormwater volumes generated from the geographically specific 90th percentile rainfall event on an annual average basis from all surfaces on the entire site are targeted for control. Control is in the following hierarchical order, with each step exhausted before proceeding to the next:
>
> 1) retention (infiltration, reuse or evapotranspiration),
> 2) LID filtration, and
> 3) conventional stormwater management.
>
> Step 3, conventional stormwater management, should proceed only once Maximum Extent Possible has been attained for Steps 1 and 2 for retention and filtration.

While the CLI ECA allows for site-specific studies to achieve water balance, erosion control, water quantity, and flood control criteria, water quality treatment of suspended solids requires control (as outlined above) of the 90th percentile storm event; and if conventional methods are necessary, then 80 per cent, 70 per cent or 60 per cent suspended solids removal (based on the receiver) as per the full ETV Canada particle size distribution.

4.1.3 Need within Existing Areas

The **Major/Minor System Hydrologic and Hydraulic Analysis (Current Draft, November 2022)** was prepared for the SWM-MP, and outlines the results of the City-wide model under various scenarios. This study found that under existing conditions, 195km of storm sewers were surcharged during the 1:5-year event, representing 41 per cent of the City's storm sewers. This increased to 280km (59 per cent) under the future growth and climate change scenario. By applying 5mm of volume control across the City, the total length of surcharged storm sewers decreased to 89km (19 per cent) while assuming future growth and climate change conditions, a reduction of 68 per cent. This illustrates the effectiveness of volume control to mitigate the effects of a changing climate and denser population.

4.1.4 Volume Retention Target

In light of the pending MECP LID Volume control targets, the identified issues relating to increases in impervious surfaces and drainage area contributing to existing stormwater facilities, conveyance capacity of the stormwater piping systems and in light of predicted climate change impacts, for the purposes of the City of Guelph SWM-MP, an interim minimum Volume Retention Target of **5mm** has been established. However, if a site-specific water balance indicates pre-development infiltration is greater than 5mm, the higher target will apply.

The volume target is to be applied as a minimum target. This minimum target, like all other noted targets for water quantity, quality, erosion control and water balance shall be superseded by varying targets as developed by the MECP or through future Watershed Studies, Subwatershed Studies, Master Drainage Plans, Environmental Impact Statement (EIS) and/or other area specific studies, including those related to the GRCA Wetland Policy.

This interim target will ensure that the implementation mechanisms and policies within the SWM-MP are in place while not pre-supposing the pending targets from the MECP.

Any works that results in site disturbance or create new impervious surface must meet all of the following stormwater performance goals, while **Section 6** provides additional implementation details.

4.1.4.1 'New' Development Volume Control

For new nonlinear development without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site for runoff that is generated from the first 5mm of rainfall from all surfaces on the entire site. A centralized tracking system is recommended for establishment as part of the overall LID Program Implementation. Once established, volume control measures will be tracked using this mechanism. Development applications will be required to provide appropriate details to support inclusion of the infrastructure in the system.

4.1.4.2 Redevelopment, Infill, Intensification and Adaptive Re-Use Volume Control

For redevelopment, infill development, intensification, or adaptive re-use without restrictions, stormwater runoff volumes will be controlled and the post-construction runoff volume shall be retained on site for runoff that is generated from the first 5mm of rainfall from all surfaces on the entire site. The subject site shall be entered into centralized tracking system to be developed and implemented by the City.

4.1.4.3 Linear Development Volume Control

a) New linear projects without restrictions and subject to the **Stormwater Infiltration Policy Recommendations (November 2022, as amended from time to time)**, that create 0.25 or greater hectares of new and/or fully reconstructed impervious surfaces, shall capture and retain the larger of the following:

   I. The first 5mm of runoff from the new and fully reconstructed impervious surfaces on the site;
   II. The first 5mm of runoff from the net increase in impervious area on the site.

b) Roadway resurfacing, mill and overlay and other resurfacing activities are not considered new linear projects and shall achieve volume reduction to the maximum extent possible (MEP) subject to the **Stormwater Infiltration Policy Recommendations (November 2022, as amended from time to time)**.

4.1.4.4 Sites with Restrictions

For all sites regardless of perceived constraints, the proponent shall be required to fully comply with the appropriate volume control targets described above. Should pre-consultation with City of Guelph engineering staff and/or pre-design investigation by the proponent and reviewed by the City identify that volume targets are not achievable; the proponent must consider and present the merits of relocating project elements to address varying soil conditions and other constraints. Site restrictions which may result in the City permitting alternatives to the above prescribed volume targets include:

a) Shallow bedrock[†],
b) High groundwater[†],
c) Contaminated soils (e.g. Brownfields)

Per the **Stormwater Infiltration Policy Recommendations (November 2022, as amended from time to time):**

d) High Risk Site Activities: See **Appendix C**

e) Restrictions*:
    a. WHPA Vulnerability Score 10 (Private and Municipal Property)**
    b. WHPA Vulnerability Score greater than or equal to 2 (Municipal Roads)**

† May limit infiltration capabilities if within 1m of the proposed facility invert per "Site Considerations" table the LID Stormwater Planning and Design Guide (wiki.sustainabletechnologies.ca). Detailed assessment or studies are required to demonstrate infiltration effects within 1.0m and results may permit relaxation of the minimum offset as approved by City of Guelph Engineering.

** Infiltration may be permitted within these areas, depending on the existing conditions, as outlined in the **Stormwater Infiltration Policy Recommendations** report.*

*** While Chloride isn't currently identified as an ICA within Guelph's boundaries, salt concentration has been increasing across the City, so the City is taking a conservative approach to restricting infiltration of salt-laden water.*

4.1.4.5 Maximum Extent Possible (MEP)

In cases where the City of Guelph Engineering has confirmed that site constraints exist which cannot be overcome, the proponent shall be required to implement volume controls to the MEP or "maximum extent possible". Note that this does not exempt the proponent from implementing all other required SWM controls. City of Guelph Engineering shall define the MEP based on techniques outlined in the CVC LID Planning and Design Guide (V1.0, 2010 and https://wiki.sustainabletechnologies.ca/wiki/Main_Page as amended from time to time).

4.1.4.6 Cash-in-Lieu

It is recommended that the City explore a cash-in-lieu program for sites where the proponent cannot implement the required volume control to the MEP or "maximum extent possible" as confirmed by the City of Guelph Engineering. If/once established, the proponent would be required to contribute to the cash-in-lieu program corresponding to all uncontrolled areas at the current per hectare rate as defined by the City of Guelph as amended from time to time.

Note that in areas where a capacity related constraint exists, development must demonstrate no negative impacts. As such, MEP or cash-in-leu would not be permitted and pre to post criteria must be strictly enforced.

4.2 Water Balance

If completion of a water balance is required, the Thornthwaite-Mather approach is supported by the City, as is described in the DEM. This approach is a practical method that is familiar to most practitioners and City staff. At the City's discretion, a continuous model may also be used to develop a water balance using a model supported by the DEM, provided sufficient data is available to complete the modelling, as described by the MECP 2003 SWM Planning and Design Manual.

To ensure consistency, all proponents completing a Thornthwaite-Mather analysis shall use the temperature and precipitation data summarized in **Table 4.1**. The precipitation analysis was completed as part of the Rainfall and IDF Curve Analysis (October 2021) completed as part of this SWM-MP. The average monthly temperatures were estimated from the following weather stations:

- Guelph OAC (1954-1973);
- Guelph Arboretum (1975-1997);
- Guelph Turfgrass CS (1997-2004); and
- Guelph Turfgrass (2006-2020).

Table 4.1: Guelph Monthly Temperature and Precipitation (1954-2020)

	Mean Monthly Temperature (°C)	Mean Monthly Precipitation (mm)
January	-7.4	57.7
February	-6.5	50.9
March	-1.7	61.8
April	5.6	73.4
May	12.0	75.0
June	17.1	75.2
July	19.6	80.4
August	18.7	80.5
September	14.6	75.4
October	8.5	71.0
November	2.5	76.2
December	-3.7	66.8

4.3 Water Quality Requirements

Where site-specific targets, as described in **Table 4.2** do not apply, stormwater quality strategies shall control pollutant loadings in accordance with current MECP guidelines to 'Enhanced-Level 1' protection as defined in the 2003 Stormwater Management Planning and Design Manual, as amended from time to time.

Enhanced-Level 1 protection is the reduction of average long-term annual load of suspended sediment by 80 per cent or greater. Per the MECP manual "any stormwater management practice that can be demonstrated to approval agencies to meet the required long-term suspended solids removal for the selected levels under the conditions of the site is acceptable for water quality objectives." For LIDs implemented in Ontario, the industry standard to achieve an Enhanced-Level 1 protection is to design for runoff resulting from the 90th percentile rain event (28-29 mm rainfall depth in Guelph) (MECP, 2020). Treating the runoff from one hundred percent of rainfall events of 28-29 mm or less and the first 28-29 mm of all events larger than 28-29 mm provides a high level of pollutant load reduction, which equates to roughly a 90 per cent reduction in the long-term annual load of suspended sediment. Enforcing volume targets will reduce the loading of pollutants into stormwater management facilities, watercourses, ecological restoration areas, and the natural heritage system.

Where proponents of development, redevelopment, infill or intensification projects are able to achieve the volume targets described above, this pollutant load reduction will be acknowledged during the review of a stormwater management plan. The complete control of runoff that is generated from the first 5mm of rainfall from all surfaces on the entire site through a combination of reuse, evapotranspiration and infiltration practices will be considered by the City of Guelph to be achieving 17.5 percent of the site's required Enhanced-Level 1 water quality treatment.

As such, in order to achieve the prescribed water quality target of 28-29 mm (Enhanced-Level 1 protection) the proponent may design other onsite stormwater quality best management practices (source, conveyance, end-of-pipe, or proprietary water quality devices) to treat the remaining runoff (23-24 mm) or may be required to contribute to the cash-in-lieu program. City of Guelph Engineering will determine through the requirements of existing and future Watershed Studies, Subwatershed Studies, Master Drainage Plans, Environmental Impact Statement (EIS), Provincial SWM Policy and/or other area specific studies, including those related to the GRCA Wetland Policy and/or site condition the means and methods by which the remainder of the 28-29 mm (Enhanced-Level 1 protection) will be achieved, such as through on-site control or via the cash-in-lieu program.

For sites which are within the catchment of a stormwater management facility that has been determined by the City of Guelph to be deficient in water quality control for the prescribed drainage area or impervious cover, the proponent shall be required to provide on-site water quality control equivalent to 'Enhanced-Level 1' control. Deficient stormwater management facility catchments have been defined through the SWM-MP, and will be included in the Implementation Plan.

4.3.1 Thermal Mitigation

Thermal preventive and mitigation measures are important components of water quality treatment. Source and conveyance controls (eg. bioretention, infiltration trenches) are typically the most effective measures for to prevent and mitigate the discharge of warm water (Van Seters et al., 2019), but the City accepts all measures identified by Credit Valley Conservation (2011), including, but not limited to:

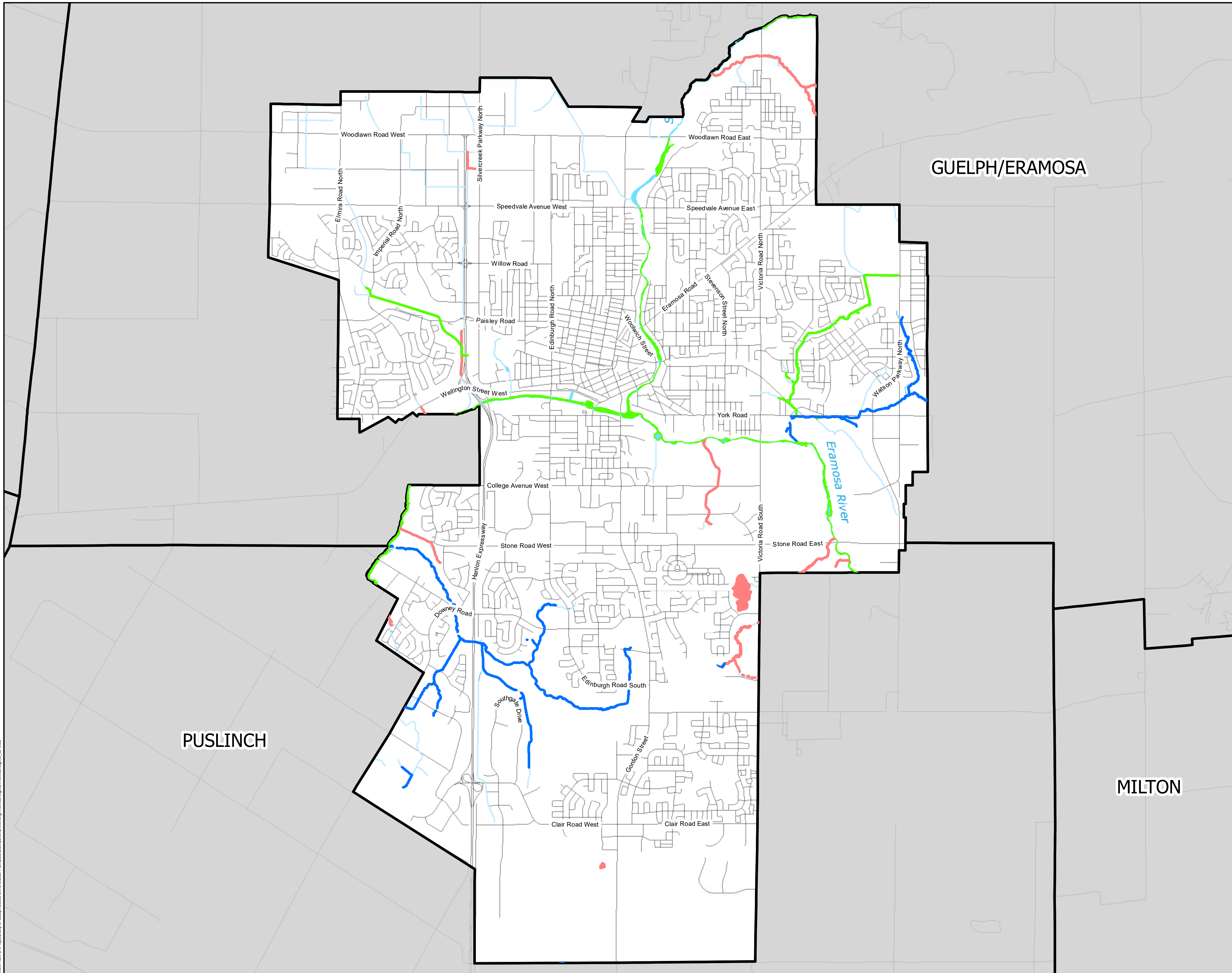
- Bottom draw outlets in stormwater management ponds;
- Cooling trenches installed in stormwater management ponds;
- Subsurface trench outlets;
- Automated controls on pond outlets to allow stormwater to be discharged at night when it's cooler;
- Shading of the pond's permanent pool, outfall channel, and paved surfaces in the catchment area;
- Improved stormwater pond design (e.g. selecting location and orientation to minimize sun exposure, increasing length-to-width ratio, and application of planted berms within ponds); and
- Application of stormwater management facilities without a permanent pool (e.g. infiltration facilities, dry extended detention ponds).

Hanlon Creek, Clythe Creek, and Mill Creek have been mapped as having a cold water regime, while Hadati Creek, Speed River, Eramosa River, and portions of the Willow West Drain have been classified as having a cool water regime. Therefore, within these subwatersheds, the following criteria should be applied:

1. Developments should, at a minimum, maintain the pre-development water balance;
2. Where possible, infiltration and filtration measures should be maximized, considering site-specific restrictions and in compliance with the City's Infiltration Policy; and
3. All end-of-pipe SWM facilities should be designed to implement the appropriate thermal mitigation measures listed above.

Some water bodies within the City do not have a thermal regime mapped, primarily those within the northwest. If these water bodies discharge into a cool or cold water stream, and have a comparable channel type as the receiver, then the receiver thermal regime should be applied until the water body

can be assessed. Therefore, the above Criteria #1-3 should also be applied to the following subwatersheds: Speed Urban Catchment 7 and the remainder of Willow West Drain.



Legend

- Municipal Boundary
- Road Centreline

Thermal Regime:

- Cold Water Temperature
- Cool Water Temperature
- Warm Water Temperature
- Unknown Water Temperature

*Note: Thermal regime for Speed and Eramosa Rivers obtain from data published in Offical Plan (Schedule 4B)

LOCATOR MAP

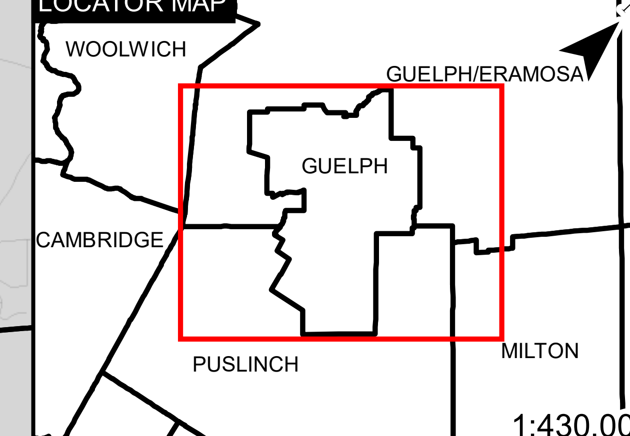


Figure 4.1

Thermal Regime

Date: 2021-03-23
Projection: NAD83_UTM_Zone_17N
Data Source: City of Guelph, GRCA
Created by: J.R.

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4.4 Water Quantity Requirements

Different areas of the City of Guelph have different water quantity criteria based on the sensitivity of the watershed and the receiver, as directed through MECP and GRCA approved studies. Unless otherwise specified in **Table 4.2** and **Figure 4.2,** every site in the City is at a minimum required to meet post-to-pre development runoff rates for the 2-to-100 year storm events, as per the City's DEM. In addition, if no positive outlet is present, each site must store twice the 5-year design storm runoff volume on site.

Volume targets may also help to achieve stormwater quantity control improvements. Water quantity targets including the restriction of post-development peak flows to pre-development peak flows as well as area-weighted flow values as prescribed in appropriate planning documents (Subwatershed Plan, Master Drainage Plan, etc.) shall remain in effect.

However, peak flow reductions that are achieved as a result of achieving the specified volume control targets will contribute to the site's water quantity requirements. The proponent shall demonstrate through calculations or hydrologic modelling the peak flow reductions associated with incorporating the required volume controls into a development, redevelopment, infill or intensification project, and shall ensure the LID facility is in an accessible location for City inspection.

For sites which are within the catchment of a stormwater facility that has been determined by the City of Guelph to be deficient in flood control for the prescribed drainage area or impervious cover, the proponent shall be required to provide on-site pre-to post volume control as directed by the City of Guelph Engineering, unless explicitly agreed to contribute to facility upgrade costs. Deficient stormwater management facility catchments have been defined through the SWM-MP (Stormwater Management Facilities, OGS and Catchments Report – October 2022), and will be included in the Implementation Plan.

Table 4.2: Proposed Stormwater Criteria

Policy Area	Location†	Infiltration / Water Balance	Quality	Quantity	Erosion	Additional Information
1	Hanlon Industrial Business Park	Recharge Volume (acre feet) = 5-year peak flow (ft^3/s) x 0.035	• Limit sediment pond discharge to 0.015 ft^3/s per square foot of pond surface area • Enhanced level of quality treatment*	• Storm outlet rate is: 0.014 m^3/s – 100yr Hanlon Design Storm • Control peak flow post to pre for all design events (2 through 50 year)	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A1
2	HCBP Pond 1	Block-by-block recharge rates to be met	Enhanced level of quality treatment*	Control peak flow post to pre for all design events (2-100 year)	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A2
3	HCBP Pond 2 & 4	Block-by-block recharge rates to be met	Enhanced level of quality treatment*	• Control peak flow post to pre for all design events (2-100 year) • 100-year design storm runoff limited to 180 L/s/ha through on-site controls	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A3
4	Hanlon Creek Subwatershed	• No urban drainage permitted to the headwaters of Tributary E or F, except lands that have positive drainage outlet, unless a pilot scale demonstrates effectiveness over five years. • Areas adjacent to Clair Road can drain into greenway system of Upper Hanlon area subject to the same design criteria. • Areas south of Clair Road but isolated from direct outlet must rely on infiltration/evaporation. • Remaining areas per Policy Area 12 (City-Wide)	• Implement thermal preventive and mitigation measures to maintain cold water fish habitat • Achieve specified water chemistry targets • Enhanced level of quality treatment*	• See infiltration requirements • Control peak flow post to pre for all design events (2-100 year) after achieving infiltration requirements	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A4
5	Torrance Creek Subwatershed	• Zone 1: Zero runoff requirement (1:100 year volume captured, all water infiltrates) • Zone 2 & 3: Infiltration target of between 100 and 150mm/yr	Enhanced level of water quality treatment*	• Control peak flow post to pre for all design events (2-100 year) • 1:100 year flow controlled to pre-development levels in Zones 2 and 3 • If no positive outlet, must provide on-site storage for twice the 5-year design storm runoff volume • Commercial, industrial, and high density residential: store excess runoff for 2-year storm underground or on rooftops	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A5
6	Guelph Downtown - The Ward	Per Policy Area 13 (City-Wide)	• Implement thermal preventive and mitigation measures to maintain cool water fish habitat • Enhanced level of water quality treatment*	Control post-development flows up to the 100-year event to the 2-year pre-development flows	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A6
7	Guelph Innovation District	27mm capture in infiltrative LID BMPs	• Implement thermal preventive and mitigation measures to maintain cool water fish habitat	• 27 mm volume control on-site • Unitary storage and discharge rates for 25-year and 100-year events	Additional controls not required due to infiltration volume	Appendix A7

			• Enhanced level of water quality treatment* • Recommended retrofit of SWMF 38			
8	Clair-Maltby	20 mm captured within LID BMPs	• Implement thermal preventive and mitigation measures to maintain cool or coldwater fish habitat (per study criteria) • 20mm capture within LID BMPs • 100mm capture in Community Park	• 20 mm captured within LID BMPs with remaining drainage conveyed to designated surface water capture areas sized to capture Regional Storm • Small developments (<5ha) draining to Maltby Road: capture and control Regional Storm • Community Park: LID BMPs to capture 100-year storm	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A8
9A	Guelph Downtown – Dublin/Gordon	Per Policy Area 13 (City-Wide)	• Implement thermal preventive and mitigation measures to maintain cool water fish habitat • Enhanced level of water quality treatment*	Overcontrol stormwater to a 5-year pre-development condition for major and minor flows	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A6
9B	Guelph Downtown – Quebec/ Macdonell	Per Policy Area 13 (City-Wide)	• Implement thermal preventive and mitigation measures to maintain cool water fish habitat • Enhanced level of water quality treatment*	Limit post-development peak runoff to the 25-year pre-development peak flow	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A6
10	Clythe Creek Subwatershed	Per Policy Area 13 (City-Wide) or as updated per the forthcoming Clythe Creek Subwatershed Update (pending)	• Thermal preventive and mitigation measures for coldwater habitat • Enhanced level of water quality treatment*	Control peak flow post to pre for all design events (2-100 year)	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A9
11	Mill Creek Subwatershed	Maintain existing recharge and discharge characteristics	• Thermal preventive and mitigation measures for coldwater habitat • Enhanced level of water quality treatment*	Control peak flow and volumes post to pre for all design events (2-100 year)	Maintain/reduce existing erosion rates or Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A10
12	Southgate and Irish Creek Subwatershed	• Minimum groundwater recharge target of 300 mm/year • Quantity and proportion of runoff to Wetlands B and E should be maintained • Runoff quantities to Wetlands A-H should be maintained	• Enhanced level of water quality treatment	Retain and infiltrate up to Regional Storm Event	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A11
13	City-Wide (all areas where site-specific studies have not been completed)	• Maintain predevelopment recharge rate, volume and hydroperiods at post-development conditions • Provide a minimum of 5mm of volume control	• Thermal preventive and mitigation measures for cool water habitat per Figure 4.1 • Enhanced level of water quality treatment*	Control peak flow post to pre for all design events (2-100 year)	Control 90th percentile event or Extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours	Appendix A12

* Each appendix contains added detail from what is included in the table. Proponents and City staff are directed to refer to the appropriate appendix for full description of requirements.

TOWNSHIP OF GUELPH/ERAMOSA

TOWNSHIP OF PUSLINCH

TOWN OF MILTON

Woodlawn Road West
Woodlawn Road East
Woolwich Street
Elmira Road North
Speedvale Avenue West
Speedvale Avenue East
Victoria Road North
Imperial Road North
Silvercreek Parkway North
Edinburgh Road North
Willow Road
Eramosa Road
Stevenson Street North
Hadati Creek
Paisley Road
Hanlon Expressway
Watson Parkway North
Wellington Street West
Clythe Creek
York Road
College Avenue West
Stone Road West
Stone Road East
Downey Road
Hanlon Creek
Edinburgh Road South
Southgate Drive
Gordon Street
Victoria Road South

Legend

- Municipal Boundary
- Rivers
- Road Centreline

Policy Area:

- Policy Area 1: Hanlon Industrial Business Park
- Policy Area 2 & 3: Hanlon Creek Business Park Ponds 1, 2 & 4
- Policy Area 4: Hanlon Creek Subwatershed
- Policy Area 5: Torrance Creek Subwatershed
- Policy Area 6: The Ward
- Policy Area 7: Guelph Innovation District
- Policy Area 8: Clair-Maltby
- Policy Area 9A: Guelph Downtown - Dublin/Gordon
- Policy Area 9B: Guelph Downtown - Quebec/ Macdonell
- Policy Area 10: Clythe Creek Subwatershed
- Policy Area 11: Mill Creek Subwatershed
- Policy Area 12: Southgate and Irish Creek Subwatershed
- Policy Area 13: City-Wide

LOCATOR MAP

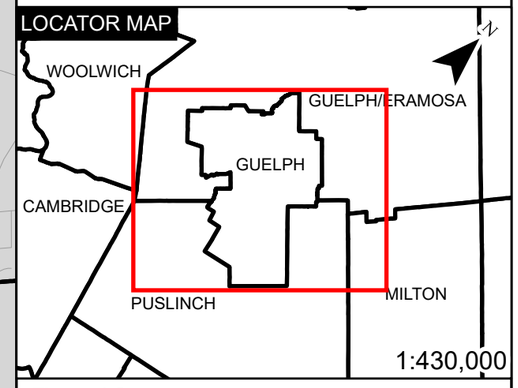

Figure 4.2

Stormwater Control Criteria

Date: 2022-11-09
Projection: NAD83_UTM_Zone_17N
Data Source: City of Guelph, GRCA, Natural Resource Solutions
Created by: A.V.

0 1 2
Kilometres

Aquafor Beech Limited

4.5 Direct Discharge of Stormwater to Surface Receivers

Sites located in close proximity to surface receivers (eg. watercourse, wetland, etc.) present unique challenges for stormwater practitioners. The reduction of pollutant loads is essential before stormwater is discharged to these features in order to preserve or enhance ecological habitat.

Sites that discharge via private or municipal conveyance systems to a surface receiver that is **within 1,000m of the site**: The proponent will ensure the site achieves complete water quality control of runoff that is generated from all surfaces on the entire site by:

> Achieving Enhanced-Level 1 protection by designing for the treatment of the runoff resulting from a 28-29 mm rainfall depth event (See **Section 4.2)**, including the adherence to the volume targets as described in **Section 4.1**.

For sites that discharge via private or municipal conveyance systems to a surface receiver that is **within 1,000m of the site** contribution to the cash-in-lieu program will not be considered as the minimum criteria must be met.

For sites where discharge is greater than 1000m, refer to **Sections 4.1 to 4.4.**

4.6 Linear Targets

The targets outlined in **Sections 4.1** through **4.5** will apply to all roads and properties within the City.

Storm sewers will be designed per the criteria outlined in the DEM. It is recommended that storm sewer designs include a sensitivity analysis using a climate IDF curve (RCP 4.5 or equivalent) following the Four Step Climate Change Adaptation Process for Stormwater Management, outlined in Section 6.8 of the Draft LID Stormwater Management Guidance Manual (2022, as amended from time to time).

5 Future Considerations

The following mechanisms could be considered by the City after further study outside of the Stormwater Management Master Plan Update project:

5.1 Aggregated or Shared BMPs

The City of Guelph may choose in the future to establish a system or policy to permit the sharing of BMPs amongst multiple properties of the same owner. Projects can thus achieve on-site retention with a "Aggregated or Shared BMP" that is off-site if:

- the proponent is the owner of both subject properties;
- both properties are tracked within the City's LID tracking system; and
- the facilities are registered on title with appropriate operations and maintenance conditions to the satisfaction of the City of Guelph.

5.2 Credit Trading Program

The City of Guelph currently operates a Stormwater Rebate and Credit Program. This program was approved in 2017, implemented in 2018, and currently includes the following components:

- Industrial, commercial, institutional, and multi-residential (≥6 units) are eligible for up to 50 per cent off their Stormwater Service Fees. At credit renewal, proof of maintenance (and potential inspection) is required by the City.
- Rain garden rebate (up to $2000, based on volume held by rain garden).
- Rainwater harvesting rebate (up to $2000, based on volume held by rainwater harvesting tank).

The City of Guelph may choose in the future to establish a Stormwater Volume Retention Credit (SVRC) trading program. Through this future program, development projects can implement "over control" (Over control is a method of balancing the amount of water retained in multiple areas) to retain more than the required 5mm of runoff volume in one area and less in another. Projects which can demonstrate "over control" to the satisfaction of the City could qualify for the credits.

Future studies are recommended in this regard.

5.3 Maximum Extent Possible

In cases where the City of Guelph Engineering has confirmed that site constraints exist which cannot be overcome, the proponent shall be required to implement volume controls to the MEP or "maximum extent possible". Note that this does not exempt the proponent from implementing all other required SWM controls. City of Guelph Engineering shall define the MEP based on techniques outlined in the CVC LID Planning and Design Guide (V1.0, 2010 and https://wiki.sustainabletechnologies.ca/wiki/Main_Page as amended from time to time).

5.4 Cash-in-Lieu

It is recommended that the City explore a cash-in-lieu program for sites where the proponent cannot implement the required volume control to the MEP or "maximum extent possible" as confirmed by the City of Guelph Engineering. If/once established, the proponent would be required to contribute to the cash-in-lieu program corresponding to all uncontrolled areas at the current per hectare rate as defined by the City of Guelph as amended from time to time.

Note that in areas where a capacity related constraint exists, development must demonstrate no negative impacts. As such, MEP or cash-in-leu would not be permitted and pre to post criteria must be strictly enforced.

6 Implementation of the Volume Targets

In order for the City of Guelph to implement the stormwater criteria and targets specified herein for development or redevelopment, infill and intensification, the review process will need to be integrated into existing planning processes.

The SWM criteria established in this report must be demonstrated to be achieved by any proposed development or retrofit project through Stormwater Management Reports and other related submissions within the DEM.

The specified stormwater criteria and targets will be enforced through the following planning application processes:

A. Plan of Subdivision
B. Site Plan Control
C. Plan of Condominium

D. Zoning By-Law Amendments
E. Official Plan Amendments

For all sites a Pollution Prevention Plans and/or Risk Management Plans shall be required to be submitted as part of SWM Reports, where a SWM report would be required by the DEM.

In the cases of a Committee of Adjustment development or infill development only requiring a building permit, the requirement for providing 5mm of volume control may be waived at the City's discretion. Key considerations for waiving this requirement, which will be considered by City staff, include, but are not limited to:

- Site size;
- Changes to imperviousness;
- Whether the site is located in the catchment of a SWM facility;
- Whether the SWM facility is deficient in water quality or quantity control; and
- Whether there are identified capacity issues in the downstream storm sewers.

The following planning application process does not directly result in the construction or reconstruction of impervious surfaces on a site. As such the specified stormwater criteria and targets will not be enforced during this process. Instead, it is recommended that where new lots are created, the monthly property charges billed by the City through the Stormwater Service Fee are to be updated periodically to reflect runoff conditions of the subject property.

A. **Part-Lot Control:** This type of application is undertaken to subdivide a residential lot or a block fronting an existing or dedicated road for the purpose of selling, conveying, leasing or mortgaging.

6.1 Ensuring Ongoing Compliance

It is recommended that the subject site be entered into a centralized tracking system to be developed and implemented by the City. This system should track the location of stormwater BMPs and LID measures and require regular renewal . This renewal process helps to ensure that the facilities have been properly maintained and are still functional.

Through the City's Property Standards By-Law, namely Section 3.1 (reproduced below), the City already has the necessary requirements in place to enforce maintenance compliance:

> **3.13 -** Every storm water disposal system shall be maintained in the condition for which it was designed and shall not be blocked, altered, filled or obstructed.

7 Recommendations

The following recommendations are noted:

1) In light of increases in impervious surfaces arising from intensification and in an effort to address conveyance system capacity constraints and potential climate change impacts, and to align the City's policies with the CLI ECA, it is recommended that the City require a minimum of 5mm of volume control, or that the post-development water balance match existing, whichever is higher, to mitigate and manage the impacts noted above.

2) That the City update their SWM criteria per **Table 4.2.**

3) That the proponent will ensure a site within 1,000m of a surface water receiver achieves complete water quality control of runoff that is generated from all surfaces on the entire site by achieving Enhanced-Level 1 protection.

4) That the City consider and subsequently evaluate a cash-in-lieu program to allow proponents to pay a fee per at a rate per hectare where the SWM criteria have not been met, after designing to the Maximum Extent Possible.

5) When the DEM is next updated, it is recommended that the City refer to the Low Impact Development design guidelines per the Low Impact Development Stormwater Planning and Design Guide (Volume 1.0, or wiki.sustainabletechnologies.ca,as amended from time to time).

6) It is recommended that the City direct proponents of development, redevelopment, infill and intensification to the LID reference documents listed in **Appendix D** for industry-accepted standards and specifications.

7) It is recommended that the criteria outlined above come into effect once the City's CLI ECA is approved or the SWM-MP comes into effect, whichever is earlier.

8) It is recommended that the City establish the LID implementation program being outlined the LID Implementation Strategy report (draft in progress) being completed as part of the SWM-MP.

8 References

City of Guelph, 2019. Development Engineering Manual. Version 2.0.

CVC, 2011. Thermal Impacts of Urbanization including Preventive and Mitigation Techniques.

MECP, 2020. Low Impact Development Stormwater Management Guidance Manual. Draft Working Document.

Van Seters, T., Graham, C., Dougherty, J., Jacob-Okor, C., David, Y. 2019. Data Synthesis and Design Considerations for Stormwater Thermal Mitigation Measures. Sustainable Technologies Evaluation Program. Ontario.

Appendix A: Stormwater Criteria References

The following documents are provided, in part or in whole:

	Location	References
1	Hanlon Industrial Business Park	**Appendix A1:** City of Guelph (2020). Hanlon Industrial Business Park SWM Criteria. Knox, Martin, Kretch Limited (1979). Hanlon Industrial Park: Guelph. Report on Grading and Storm Drainage.
2	HCBP Pond 1	**Appendix A2:** City of Guelph (2020). Stormwater Criteria: XXXXX Hanlon Creek Blvd (Part of Block XXX, 61M-169 – HCBP Phase 1 – Pond 1) [± XXXX ha or ± XXXX ac] Banks Groundwater Engineering Limited (2008). Hanlon Creek Business Park Environmental Implementation Report - Hydrogeology.
3	HCBP Pond 2 & 4	**Appendix A3:** City of Guelph (2020). Stormwater Criteria: XXXXX Hanlon Creek Blvd (Part of Block XXX, 61M-169 – HCBP Phase 1 – Pond 2) [± XXXX ha or ± XXXX ac] City of Guelph (2020). Stormwater Criteria: HCBP Phase 2 – Pond 4 – Blocks XXXXX, 61M-176 (± XXXXX ha) Banks Groundwater Engineering Limited (2008). Hanlon Creek Business Park Environmental Implementation Report - Hydrogeology.
4	Hanlon Creek Subwatershed	**Appendix A4:** Peil Planning and Engineering Initiatives (2004). Hanlon Creek State-of-the-Watershed Study. Marshall Macklin Monaghan Limted (1993). Hanlon Creek Watershed Plan.
5	Torrance Creek Subwatershed	**Appendix A5:** City of Guelph (2020). SWM Criteria: Address (± 000 ha). [Torrance Creek] Totten Sims Hubicki (1998). Torrance Creek Subwatershed Study summary.
6	The Ward	**Appendix A6:** Cole Engineering (2021). Downtown Servicing Study.
7	Guelph Innovation District	**Appendix A7:** Wood Environment and Infrastructure Solutions (2020). Stormwater Management Study – Guelph Innovation District.

	Location	References
8	Clair-Maltby	**Appendix A8:** Wood Environment and Infrastructure Solutions (2021). Clair-Maltby Secondary Plan and Master Environmental Servicing Plan (CMSP / MESP) Comprehensive Environmental Impact Study (CEIS).
9A	Guelph Downtown – Dublin/Gordon	**Appendix A6:** Cole Engineering (2021). Downtown Servicing Study.
9B	Guelph Downtown – Quebec/ Macdonell	**Appendix A6:** Cole Engineering (2021). Downtown Servicing Study.
10	Clythe Creek Subwatershed	**Appendix A9:** Clythe Creek Subwatershed Overview Report.
11	Mill Creek Subwatershed	**Appendix A10:** CH2M Gore & Storrie Ltd (1996). Mill Creek Subwatershed Plan.
12	Southgate and Irish Creek Subwatershed	**Appendix A11:** City of Guelph (2018). SWM Criteria for 995 Southgate Dr. (5.6 Ha.) City of Guelph (2018). SWM Criteria for 1080 Southgate Dr. (9.5 Ha.) Natural Resource Solutions Inc. (2012). Southgate Business Park 23T-06503 Environmental Implementation Report. IBI Group (2012). Grading, Servicing, and Stormwater Management Report, Southgate Business Park, City of Guelph.
13	City-Wide	**Appendix A12:** City of Guelph (2019). Development Engineering Manual (As amended from time to time). City of Guelph (2020). Stormwater Criteria: (± XXX ha)

Appendix A1: Hanlon Industrial Business Park

DATE

TO
COMPANY
EMAIL

FROM
DIVISION IDE
DEPARTMENT ETS

EMAIL
PHONE 519-837-5604
X **XXXX**
FAX 519-822-6194

SUBJECT Hanlon Industrial Business Park SWM Criteria: (± XXX ha)

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site.*

- The City of Guelph's allowable storm outlet rate is: 0.014 m^3/s – *100yr Hanlon Design Storm.*
- Sites that do not have a positive outlet must be designed to provide storage on site for twice the five year design storm runoff volume.
- On site control and storage (roof top/parking lot/ponds/superpipes) may be required to attenuate flows.
- For commercial, institutional and high density residential developments, excess runoff for the two year design storm is to be stored underground or on roof tops.
- Excess runoff from the five year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3m.
- Major storms are to be routed overland to the City's R.O.W. without exceeding a maximum parking lot pond depth of 0.3m. Sites which cannot meet these criteria are required to provide storage on the site for twice the five year design storm runoff volume.
- Clean runoff (roof water) should be directed to pervious areas for infiltration to encourage ground water recharge (Low Impact Development).
- If on-site infiltration is to be incorporated into the design, permeameter tests needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- Any proposed infiltration on-site is to be designed in accordance with the MOE SWM Planning and Design Manual – March 2003.
- For infiltration system design and drawdown calculations, a safety factor should be determined using the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (Appendix C). This rate should be applied to the percolation rate as infiltration systems tend to clog-up over time. The design percolation rate should note exceed 75mm/hr.
- Evaluate infiltration potential on site as it relates to the existing water budget, and recommend measures to meet the goal of maintaining or enhancing groundwater recharge.
- Quality control facilities are required to remove suspended solids (oil and grit) from areas draining driveways and parking lots (i.e. oil/grit interceptors, catch basins, and vegetative buffer strips or a combination thereof). Please note that Goss traps are not acceptable for areas larger than $250m^2$.
- The minimum acceptable water quality level for discharge to the municipal collection system is 70% TSS removal.
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.
- SWM requirements for the Hanlon Industrial Business Park are governed by a specific set of guidelines developed by Knox, Martin, Kretch Limited in 1979 *(based upon the 100yr Hanlon Design Storm 1 m^3/min/ha)*. A copy of these guidelines is available upon request.
- Stormwater management designs for industrial sites may require the Ministry of the Environment, Conservation and Parks (MECP) approval. *The applicant is to contact the MECP directly to determine the Ministry's requirements for the site.*
- Any end-of-pipe stormwater management facility design must conform to the City of Guelph design guidelines.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the SWM facility.

We require that the SWM modelling be submitted in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5 year and 100 year design storms and must include scale drawings showing drainage catchment areas, delineated pond limits for the 5yr and 100yr design storms (where applicable) and a schematic diagram reflecting the model (complex models).

City of Guelph design storm hyetographs and Miduss stormwater modelling parameters for the design storms and Miduss Guelph design storm electronic files are available upon request. Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheet.

2.1 HANLON CREEK ECOLOGICAL STUDY - continued ....

To carry out sedimentation and recharge of storm runoff the Study provided guidelines for calculating land requirements as follows:

1. Sediment Pond Surface Area Requirements

It will be required to limit storm water discharge from sediment ponds to approximately 0.015 c.f.s. per sq. ft. of pond surface area to assure that efficiency of sediment removal will be reasonably high.
Sediment Pond Surface Area (S.F.) = Peak Flow (cfs) ÷ 0.015

2. Recharge of Storm Runoff Volume Requirements

The volume of storm runoff caused by a peak storm discharge of 1 c.f.s. is estimated to be 0.035 acre feet per acre of tributary area.
Recharge Volume (Acre Feet) = Peak Flow (c.f.s.) x 0.035

3. Peak Flow

Peak flow to be calculated using 5 year design storm.

Appendix A2: HCBP Pond 1

DATE

TO	FROM
COMPANY	DIVISION IDE
EMAIL	DEPARTMENT ETS
	EMAIL
	PHONE 519-837-5604 X XXXX
	FAX 519-822-6194

CC

SUBJECT Stormwater Criteria: XXXXX Hanlon Creek Blvd (Part of Block XXX, 61M-169 -- HCBP Phase 1 – Pond 1) [± XXXX ha or ± XXXX ac]

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies (including MOECC and MTO) to determine the requirements which pertain to a specific site.*

Quantity Control

- Municipal Ponds & stormwater conveyance channels are designed up to and including the 100 year design storm. HCBP storm sewers within the right-of-way have been designed with a Runoff Co-efficient C=0.75 – 5_{yr} Guelph design storm. *The required recharge rate target for aforementioned block **(±0.XXXX** ha**)** is: **XXXX** mm/yr **or XXXX** m^3/yr.*
- Additional stormwater management design information is available in the following documents: *Hanlon Creek Business Park Stormwater Management Design Report (January 2009), Hanlon Creek Business Park Environmental Implementation Report (February 2009), and supplemental documentation to the EIR dated 9th July 2010 and Geotech Report HCBP Ph1 dated 29th January 2008.* Electronic copies of these documents are available from the City web page.

- Standard Requirements for HCBP
- On site control and storage (roof top/subsurface/storm chambers) may be required to meet infiltration targets.
- Excess runoff for the 2 year design storm is to be stored underground or on roof tops.
- Excess runoff from the 5 year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3 metres.
- Major storms are to be routed overland to the stormwater conveyance system and/or City right-of-way (depending upon block location) without exceeding a maximum parking lot pond depth of 0.3 metres.
- The majority of the Blocks will have a split lot grading design *(with exception of Block 4 which is graded to flow rear to front)* so that the direction of the stormwater runoff from the fronts of the lots is to the road network while the back portion of the lots is drained toward the rear lot swales. The flow is then directed to the storm sewer system or channel conveyance system which outlet to the proposed SWM facilities[1].

Water Balance & Quality Control

- Post to pre-development water balance must be maintained as per the site specific "Block by Block recharge rate targets" (mm/yr) as presented on Figure 17 of Appendix XII, *Environmental Implementation Report (February 2009)*. The Developer's engineer must demonstrate that recharge targets will be met at site plan approval.
- Any proposed infiltration on-site is to be designed in accordance with the MOECC Stormwater Management Planning and Design Manual – March 2003.
- Existing on-site interim infiltration galleries to be properly abandoned during site development as appropriate.
- Roof runoff must be directed to infiltration systems (i.e. infiltration galleries, bio-retention basins, rain gardens, grassed swales, vegetated filter strips, etc.) to encourage groundwater recharge and to meet recharge targets. Parking lot areas shall not be infiltrated as per MOECC SWM guidelines.
- Infiltration devices are acceptable in soils with percolation rates of at least 15 mm/hr for the drainage of grassed and roofed areas. For less permeable soils, an overflow and/or under-drain connection to the storm conveyance system must be provided.
- Infiltration devices must be designed to fully infiltrate within a 24-48 hour period.
- Municipal SWM Ponds are designed to provide an enhanced level of water quality treatment.

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[1] AECOM Canada Ltd. – City of Guelph. Hanlon Creek Business Park Stormwater Management Report – Ponds 1, 2, 3 and 4, January 2009.

- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.

Design Requirements

- A Geotechnical Investigation Report(s) must be provided along with the design of infiltration systems, indicating soil percolation rates (in mm/hr) and grain size distributions established from boreholes or testing sites within the vicinity of the proposed infiltration systems.
- For on-site infiltration, a permeameter test needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- A minimum separation distance of 1.0 metre must be provided between the bottom of the infiltration system and the seasonally high groundwater table elevation.
- For infiltration system design and drawdown calculations, a safety factor should be determined using the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (Appendix C). This rate should be applied to the percolation rate as infiltration systems tend to clog-up over time. The design percolation rate should note exceed 75mm/hr.
- Infiltration systems should be located at a minimum of 4.0 metres from any building foundation and 2.0 metres away from any property line.
- Stormwater management designs for industrial sites may require the Ministry of the Environment, Conservation and Parks (MECP) approval. *The applicant is to contact the MECP directly to determine the Ministry's requirements for the site.*
- SWM modelling must be submitted to the City in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5 year and 100 year design storms and must include scale drawings showing drainage catchment areas, delineated ponding limits for the 5 year and 100 year design storms (where applicable), overland flow routes, and a schematic diagram reflecting the model (complex models).
- City of Guelph design storm hyetographs and Miduss stormwater modelling parameters for the design storms and Miduss Guelph design storm electronic files are available upon request.
- Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheets.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the on-site SWM facilities.

Hanlon Creek Business Park

City of Guelph

Environmental Implementation Report

Hydrogeology

Banks Groundwater Engineering Limited

Legend

- Expressway
- Primary Road
- Secondary Road
- Surface Water
- Wetland
- Project Boundary
- Development Block
- Block 32 — Development Block Number
- (283) — Recharge Rate Target (mm/yr)

Disclaimer: This Figure is for illustrative purposes only and is to be considered in conjunction with the Hydrogeology Report.

Digital Mapping Source: Airphoto (2006) used under license from the Corporation of the City of Guelph.

Map Projection: UTM Zone 17, NAD83

Block Development layer provided by Totten Sims Hubicki (TSH) November 21, 2007 (X-prlegal.dwg)

May, 2008

Scale: 1:10,000 (@ 11x17")

0 100 200 300 400 500 Meters

Figure 17

Block-By-Block Recharge Rate Targets

562000 562500 563000 563500 564000 564500

4816500 4816000 4815500 4815000 4814500

Teal Dr.
Downey Rd.
Laird Rd.
McWilliams Rd.
Hanlon Expressway / Hwy. 6
Phelan Dr.
Forestell Rd.

Block 1 (380)
Block 2 (37)
Block 3 (341)
Block 4 (76)
Block 5 (150)
Block 6 (270)
Block 7 (87)
Block 8 (250)
Block 9 (353)
Block 10 (380)
Block 11 (360)
Block 12 (332)
Block 13 (187)
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Block 33 (253)
Block 34 (230)
Block 35 (229)
Block 36 (287)
Block 37 (283)
Block 38 (255)
Block 39 (278)
Block 40 (193)

N

NRSI_0726P_Fig13_BlockRechargeRateTargets_10K_30Nov07_NJB

Table 4: Block-By-Block Recharge Rate Targets

Block No.	Net Recharge (m^3/year)	Total Area of Block & Road Allowance (ha)	Recharge Target (mm/year)
1	2,150	0.57	380
2	912	2.48	37
3	12,263	3.60	341
4	1,305	1.72	76
5	9,266	6.19	150
6	6,939	2.57	270
7	1,345	1.55	87
8	5,403	2.16	250
9	13,937	3.95	353
10	13,016	3.43	380
11	21,171	5.88	360
12	33,614	10.13	332
13	3,331	1.78	187
14	9,696	3.99	243
15	5,040	4.06	124
16	662	0.17	380
17	17,290	6.01	288
18	1,162	0.65	179
20	41,385	12.28	337
21	1,957	0.96	203
22	1,364	0.77	178
23	246	0.48	51
24	238	0.68	35
25	15,508	6.01	258
26	2,379	1.11	214
27	1,631	0.83	197
28	4,015	3.49	115
29	1,354	1.06	127
30	2,655	1.33	200
31	11,677	4.73	247
32	36,462	13.54	269
33	23,745	9.38	253
34	8,902	3.86	230
35	18,522	8.09	229
36	16,736	5.83	287
37	63,543	22.44	283
38	16,967	6.66	255
39	6,400	2.30	278
40	11,837	6.12	193

Appendix A3: HCBP Pond 2 & 4

DATE

TO	FROM
COMPANY	DIVISION IDE
EMAIL	DEPARTMENT ETS
	EMAIL
	PHONE 519-837-5604 X XXXX
	FAX 519-822-6194

CC

SUBJECT Stormwater Criteria: XXXXX Hanlon Creek Blvd (Part of Block XXX, 61M-169 -- HCBP Phase 1 – Pond 2) [± XXXX ha or ± XXXX ac]

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies (including MOECC and MTO) to determine the requirements which pertain to a specific site.*

Quantity Control

- Municipal Ponds & stormwater conveyance channels are designed up to and including the 100 year design storm. HCBP storm sewers within the right-of-way have been designed with a Runoff Co-efficient C=0.75 – 5_{yr} Guelph design storm. Development Block drainage areas tributary to Pond 2 (Except Blocks 2, 3 and 5) will provide on-site quantity controls to limit the 100yr design storm runoff to: 180 l/s/ha x **XXX** ha = **XXX** l/s or **XXX** *m^3/s. The required recharge rate target for aforementioned block* ***(±XXX*** *ha**)*** *is:* ***XXX*** *mm/yr* ***or XXX*** *m^3/yr.*
- Additional stormwater management design information is available in the following documents: *Hanlon Creek Business Park Stormwater Management Design Report (January 2009), Hanlon Creek Business Park Environmental Implementation Report (February 2009), and supplemental documentation to the EIR dated 9th July 2010 and Geotech Report HCBP Ph1 dated 29th January 2008.* Electronic copies of these documents are available from the City web page.

- Standard Requirements for HCBP
- On site control and storage (roof top/subsurface/storm chambers) may be required to meet infiltration targets.
- Excess runoff for the 2 year design storm is to be stored underground or on roof tops.
- Excess runoff from the 5 year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3 metres.
- Major storms are to be routed overland to the stormwater conveyance system and/or City right-of-way (depending upon block location) without exceeding a maximum parking lot pond depth of 0.3 metres.
- The majority of the Blocks will have a split lot grading design *(with exception of Block 4 which is graded to flow rear to front)* so that the direction of the stormwater runoff from the fronts of the lots is to the road network while the back portion of the lots is drained toward the rear lot swales. The flow is then directed to the storm sewer system or channel conveyance system which outlet to the proposed SWM facilities[1].

Water Balance & Quality Control

- Post to pre-development water balance must be maintained as per the site specific "Block by Block recharge rate targets" (mm/yr) as presented on Figure 17 of Appendix XII, *Environmental Implementation Report (February 2009)*. The Developer's engineer must demonstrate that recharge targets will be met at site plan approval.
- Any proposed infiltration on-site is to be designed in accordance with the MOECC Stormwater Management Planning and Design Manual – March 2003.
- Existing on-site interim infiltration galleries to be properly abandoned during site development as appropriate.
- Roof runoff must be directed to infiltration systems (i.e. infiltration galleries, bio-retention basins, rain gardens, grassed swales, vegetated filter strips, etc.) to encourage groundwater recharge and to meet recharge targets. Parking lot areas shall not be infiltrated as per MOECC SWM guidelines.
- Infiltration devices are acceptable in soils with percolation rates of at least 15 mm/hr for the drainage of grassed and roofed areas. For less permeable soils, an overflow and/or under-drain connection to the storm conveyance system must be provided.

---

[1] AECOM Canada Ltd. – City of Guelph. Hanlon Creek Business Park Stormwater Management Report – Ponds 1, 2, 3 and 4, January 2009.

- Infiltration devices must be designed to fully infiltrate within a 24-48 hour period.
- Municipal SWM Ponds are designed to provide an enhanced level of water quality treatment.
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.

Design Requirements

- A Geotechnical Investigation Report(s) must be provided along with the design of infiltration systems, indicating soil percolation rates (in mm/hr) and grain size distributions established from boreholes or testing sites within the vicinity of the proposed infiltration systems.
- For on-site infiltration, a permeameter test needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- A minimum separation distance of 1.0 metre must be provided between the bottom of the infiltration system and the seasonally high groundwater table elevation.
- For infiltration system design and drawdown calculations, a safety factor should be determined using the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (Appendix C). This rate should be applied to the percolation rate as infiltration systems tend to clog-up over time. The design percolation rate should note exceed 75mm/hr.
- Infiltration systems should be located at a minimum of 4.0 metres from any building foundation and 2.0 metres away from any property line.
- Stormwater management designs for industrial sites may require the Ministry of the Environment, Conservation and Parks (MECP) approval. *The applicant is to contact the MECP directly to determine the Ministry's requirements for the site.*
- SWM modelling must be submitted to the City in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5 year and 100 year design storms and must include scale drawings showing drainage catchment areas, delineated ponding limits for the 5 year and 100 year design storms (where applicable), overland flow routes, and a schematic diagram reflecting the model (complex models).
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- A Professional Engineer must certify the design and construction of the on-site SWM facilities.

DATE

TO	FROM	
COMPANY	DIVISION	Development Services
EMAIL	DEPARTMENT	Engineering
	EMAIL	
	PHONE	519-837-5604 X XXXXX
	FAX	519-822-6194

CC

SUBJECT Stormwater Criteria: HCBP Phase 2 – Pond 4 – Blocks **XXXXX**, 61M-176 (± **XXXXX** ha)

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site.*

Quantity Control

- The City's allowable outlet rate is (for lands within Pond 4 drainage area): 180 l/s/ha x **XXXX** ha **= XXXX** l/s **or XXXX** m^3/s (100 yr Guelph Design Storm).
- Municipal Ponds & stormwater conveyance channels are designed up to and including the 100 year design storm. *The required recharge target for aforementioned blocks (±**XXXX** ha) is: **XXXX** mm/yr or **XXXX** m^3/yr.*
- Additional stormwater management design information is available in the following documents: *Hanlon Creek Business Park Stormwater Management Design Report (January 2009), Hanlon Creek Business Park Environmental Implementation Report (February 2009) and supplemental documentation to the EIR dated 9th July 2010.* Electronic copies of these documents are available from the City web page.

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Hanlon Creek Business Park

City of Guelph

Environmental Implementation Report

Hydrogeology

Banks Groundwater Engineering Limited

Legend

- Expressway
- Primary Road
- Secondary Road
- Surface Water
- Wetland
- Project Boundary
- Development Block
- Block 32 — Development Block Number
- (283) — Recharge Rate Target (mm/yr)

Disclaimer: This Figure is for illustrative purposes only and is to be considered in conjunction with the Hydrogeology Report.

Digital Mapping Source: Airphoto (2006) used under license from the Corporation of the City of Guelph.

Map Projection: UTM Zone 17, NAD83

Block Development layer provided by Totten Sims Hubicki (TSH) November 21, 2007 (X-prlegal.dwg)

May, 2008

Scale: 1:10,000 (@ 11x17")

0 100 200 300 400 500 Meters

Figure 17

Block-By-Block Recharge Rate Targets

562000 562500 563000 563500 564000 564500

4816500 4816000 4815500 4815000 4814500

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Downey Rd.
Laird Rd.
McWilliams Rd.
Hanlon Expressway / Hwy. 6
Phelan Dr.
Forestell Rd.

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Block 34 (230)
Block 35 (229)
Block 36 (287)
Block 37 (283)
Block 38 (255)
Block 39 (278)
Block 40 (193)

N

NRSI_0726P_Fig13_BlockRechargeRateTargets_10K_30Nov07_NJB

Table 4: Block-By-Block Recharge Rate Targets

Block No.	Net Recharge (m^3/year)	Total Area of Block & Road Allowance (ha)	Recharge Target (mm/year)
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6	6,939	2.57	270
7	1,345	1.55	87
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9	13,937	3.95	353
10	13,016	3.43	380
11	21,171	5.88	360
12	33,614	10.13	332
13	3,331	1.78	187
14	9,696	3.99	243
15	5,040	4.06	124
16	662	0.17	380
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27	1,631	0.83	197
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34	8,902	3.86	230
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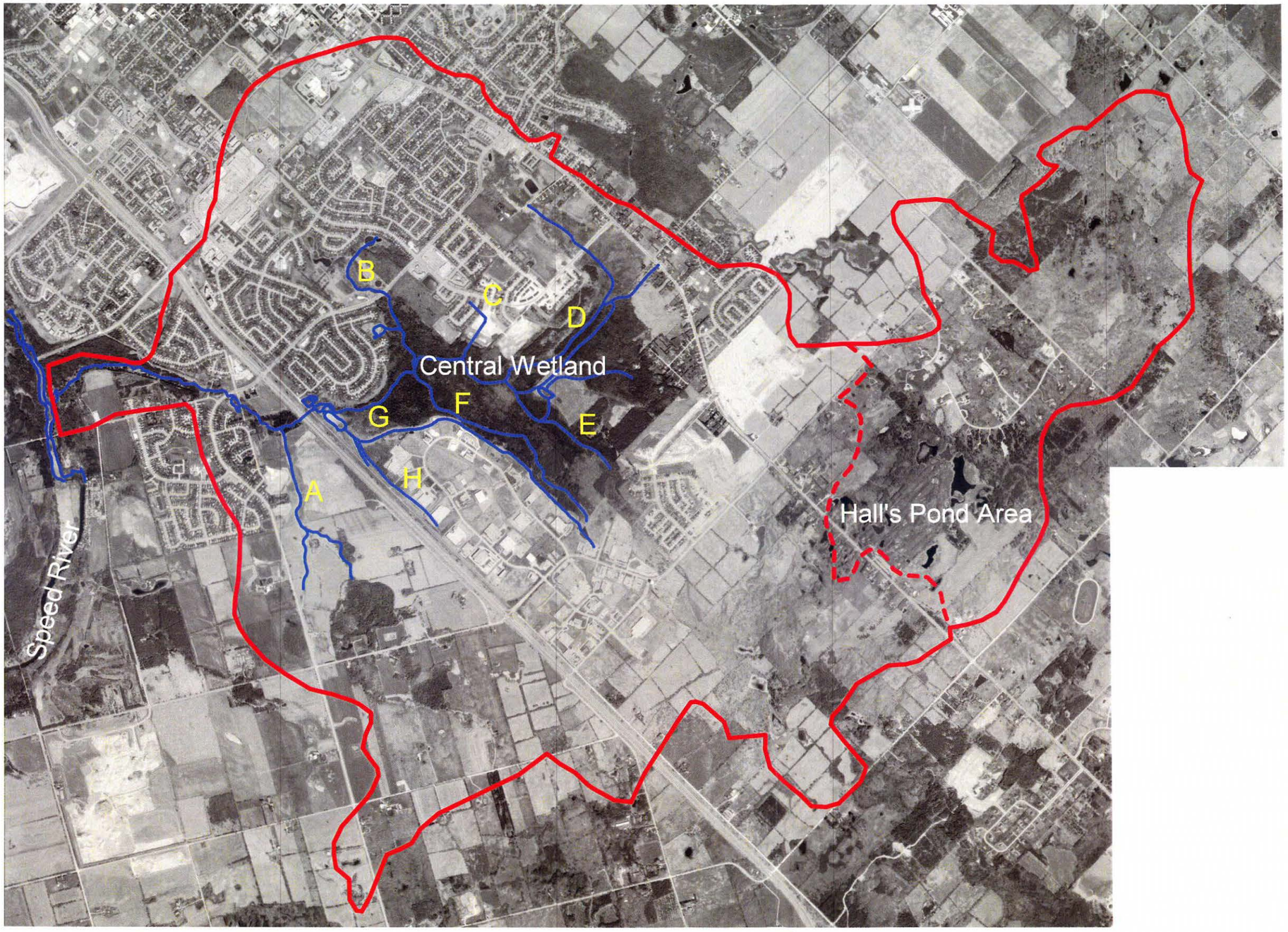
37	63,543	22.44	283
38	16,967	6.66	255
39	6,400	2.30	278
40	11,837	6.12	193

Appendix A4: Hanlon Creek Subwatershed



Hanlon Creek State of the Watershed Study

N
W E
S

Legend

- Hanlon Creek Watershed Boundary
- Limit of Direct Surfacewater Runoff
- Hanlon Creek
- E — Tributary E

379 Queen Street South,
Kitchener, Ontario, N2G 1W6
Tel. (519) 745-9455
Fax: (519) 745-7647
e-mail: kitchener@peil.net
www.peil.net
HAMILTON KITCHENER TORONTO
PEIL PLANNING & ENGINEERING INITIATIVES LTD.

In association with:

Dougan and Associates
C. Portt and Associates
Naylor Engineering Associates
Peter Chisholm

Hanlon Creek Watershed

Scale : 1 : 30 000	Date: March 2004
Project No.: K1178	Figure: A1.1

Revegetation of Corridors and Linkages

As an adjunct to the development of the Trail Plan discussed above, a revegetation plan will be developed. Where woody vegetation already exists in linkage corridors, every effort should be made to preserve it, and to incorporate it into the final design. Where the original vegetation has been cleared or damaged, a mixture of native species which will quickly reestablish the functions of the linkage corridor should be planted. Where the linkage corridor consists of predominantly non-woody plants, the introduction of tree and shrub species should be considered to provide food and cover for wildlife, and shade to any streams. Where shade and terrestrial food is an important consideration for fish streams, trees and shrubs that overhang the bank should be considered.

Generally, native species indigenous to the area are preferred for planting. When choosing the species to be planted in a linkage corridor, consideration must be given to the functions of the corridor, and to the requirements of the animal species that will be using the corridor. Along waterways, or in steep areas, plants with deep or widespread rooting systems should be used to bind soil and reduce erosion. If a primary importance of the vegetation is to provide a screen from human disturbance along the corridor, then species with dense top growth should be chosen, and consideration should be given to the use of thorny or prickly shrubs and trees such as raspberries and hawthorns. For wetland areas and along watercourses, trees and shrubs with high tolerance to flooding and sediment inundations should be chosen.

4.3.5 Development Criteria

In areas where development is permitted (eg. non constraint areas), certain criteria should be applied to ensure that the impacts are within the bounds permissible for sustainable watershed management within the plan. The criteria applicable vary depending upon the location of the proposed development within the basin. They can be summarized as follows:

Expected Near Term Development

The developments known as Kortright IV and South Creek/Hartsland can proceed at the densities and with the type of development proposed, within the modified boundaries indicated on Figure 3.4.2. Stormwater management proposals associated with the developments are generally appropriate in controlling flow impacts. In the case of the South Creek/Hartsland subdivisions

it will be necessary to re-evaluate the number, size and location of the facilities required to account for the reduced area of development and potential impact on Tributary D. However, the criteria established are appropriate. It will be necessary to avoid encroaching into core sensitive natural areas in the siting of the facilities but they can be placed in the buffer zones defined in this plan. In the case of Kortright IV, the stormwater facility previously proposed was a constructed wetland at the outlet of Tributary A. This may be appropriate if incorporated into the revegetated buffer/linkage proposed to connect the headwater wetland area to the lower Hanlon Creek valley. The most important factor will be to ensure that water temperatures are not elevated since this would be incompatible with remediation efforts proposed downstream of Tributary A (Management Options 19 and 21). No other tributaries are directly affected by the near term development scenario.

Upper Hanlon Creek Development

The potential impacts of the Upper Hanlon Creek development have been extensively investigated as reported in Section 3.9. The primary recommendation is that no urban drainage will be permitted to the headwaters of Tributary E or F, except for lands which currently have a positive drainage outlet, unless a pilot scale (15 - 20 ha.) development demonstrates the effectiveness of the proposed infiltration system over a five year period. This implies that all stormwater generated from the area must either infiltrate into the ground or evaporate. Under the assumptions made in the GAWSER/MODFLOW modelling, it was indicated that about 50 percent of the runoff from the development would infiltrate or evaporate with the greenway system proposed. The remainder would discharge into Tributary E under the proposed scheme. Hence in order to infiltrate all runoff about twice the area currently proposed would be required as infiltration areas. Alternatively, the intensity of development could be reduced such that its imperviousness is about half of that currently proposed by either using larger lot sizes or by clustering development so as to reduce its overall impervious 'footprint'. This would reduce the volume of runoff to that which the proposed greenway system would be expected to infiltrate over the long term (The above would apply unless the developers opt to create a pilot development project designed to prove the long term performance of the currently proposed system, as discussed in Section 3.9.4). Relying upon a drainage system with no surface drainage outlet will require careful attention to servicing, lot grading and basement elevations. Innovative methods of recycling stormwater should be considered. This would have the potential benefit of reducung domestic water use as well as creating additional distributed infiltration. It will be necessary to position first floor elevations above the Regional Storm level in the system. It may

be necessary to use weeping tiles connected to sump pumps discharging to the surface (swale) drainage system. No other tributaries are impacted by this development.

Full Development - Recommended Linkages, Buffers and Core Areas Preserved

Lands which lie beyond the boundaries of those discussed above have no specific development plans at this time. However, in preparing a watershed plan it was necessary to examine the possibility of ultimate development of these areas. This included lands south of Clair Road east of Hanlon Parkway and lands west of Hanlon Parkway in the headwaters of Tributary A. In both areas, large tracts of land are recommended for protection as either core natural areas, buffers or linkages. Of the remaining lands, three areas can be distinguished:

i) areas adjacent to Clair Road - these areas could drain into the greenway system in the Upper Hanlon area (if that system was ultimately proven to function successfully) subject to the same design criteria for that area. Alternatively, the lands would have to rely upon self-contained infiltration/evaporation. This would imply the same low impervious footprint as in the Upper Hanlon area.

ii) areas south of Clair Road but isolated by the 'hummocky' topography from any direct drainage outlet - these areas would have to rely upon internal drainage by means of infiltration/evaporation. This would imply a very low level of imperviousness (of the order of 10 percent based upon D3 scenario simulations) which may only be suitable for rural residential type of development or clustered development forms with very large pervious infiltration buffers around them. Whether such dispersed development is economically or environmentally sustainable from other viewpoints should be carefully evaluated before proceeding.

iii) areas in the upper part of Tributary A - these areas currently drain to Tributary A and could continue to do so if developed. It was demonstrated that a combination of extensive buffer/linkage corridors, revegetation of the lower reaches and a system of stormwater control facilities designed according to current City of Guelph standards (Hanlon Creek drainage criteria) could protect and enhance this tributary. The type and density of development assumed was relatively standard single family residential with an aggregate imperviousness of 45 percent. Any development must be located above the ultimate Regulatory floodline.

4.3.6 Resource Protection Targets

The recommended actions contained in preceding sections provide a strategy which will provide protection and enhancement of the important natural areas while allowing sustainable levels of urban development in other areas. It is important that the overall results of the Watershed Plan be monitored so that adjustments can be made if it becomes clear that a problem is developing.

A monitoring strategy has been formulated (Section 4.5) and is to be carried out as part of the implementation of the Watershed Plan. In order to provide a context for the results of the monitoring program, resource protection targets have been established. These targets represent in-stream conditions which may be influenced by a variety of factors. They should not therefore be used as "end-of -pipe" standards. The targets which are recommended include:

Water Chemistry

In general, the Provincial Water Quality Objectives (PWQO) should be used as the in-stream targets for water chemistry. In all cases the ultimate goal should be to reduce concentrations to these levels. For the purposes of evaluating the effectiveness of the Watershed Plan and the need for possible adjustments however, the PWQO are not always appropriate. Based on a knowledge of the background conditions on the watershed, combined with an understanding of the resources to be protected, alternate guidelines have been established for chloride, zinc, total phosphorus, nitrate, and dissolved oxygen:

Chloride: all tributaries should be maintained below an average level of 100 mg/l during normal (non runoff) conditions. Individual tributaries should be maintained within 10 mg/l of their current average value.

Zinc: elevated zinc levels have been observed throughout the watershed and are believed to originate from natural sources. A guideline of 0.07 mg/l is therefore established for all tributaries. If average dry weather levels rise above this target, additional investigations may be required.

Phosphorus: total phosphorus levels currently exceed the Province's guideline (no objective exists) of 0.03 mg/l. A value of 0.10 mg/l (average, under dry weather

conditions) is established as a guideline for all tributaries. Based on existing data it is expected that this value will be exceeded on Tributaries A, B, D and G.

Trend analysis should indicate no consistent increase in total phosphorus levels on any tributary.

Nitrate: nitrate levels on the watershed are above commonly used fisheries guidelines (2.0 mg/l) and maximum concentrations recorded on Tributaries A and E approach the Drinking Water Objective of 10 mg/l. For the purposes of the Watershed Plan, trend analysis should show a decrease in nitrate levels within five years. A level of 5 mg/l is established as a guideline for Tributaries A and E. A guideline of 3 mg/l is established for other tributaries.

Dissolved Oxygen: A dissolved oxygen value of 6.0 mg/l is established as a guideline for all tributaries except B and G. These tributaries are not currently viable fish habitats, have limited potential in that regard and are not slated for rehabilitation.

Stream Temperature

Brook Trout have been selected as an "indicator species" for this watershed. Therefore, target stream water temperatures should be those appropriate for a cold-water fisheries stream. We therefore recommend that the target for the maximum water temperature be 22°C in all reaches of the main branch of Hanlon Creek (Tributary E), Tributary A, Tributary F, and Reach 3 of Tributary D (Figure 3.1.7). It is recognized that this target in Tributary A may not be met for some time. Higher maximum temperatures are acceptable in Tributary B, so long as they are not resulting in unacceptable temperature impacts on the main branch of the creek, and in Reaches 1 and 2 of Tributary D, so long as Reach 3 of Tributary D is not adversely affected. Temperature targets are not appropriate for Tributaries G and C, as these are drainage ditches with intermittent flow.

Baseflow

To attain the temperature targets described above, it will be necessary to maintain a proportion of groundwater baseflow to total flow, similar to present conditions. Therefore, by attaining temperature targets, baseflow targets will be met.

Groundwater Levels

Because the natural variability in groundwater levels is not well documented, it is not appropriate to set specific target levels for groundwater levels at this time. Monitoring results should be analyzed in a manner that is able to separate time trends from natural variability caused by fluctuations in climatic conditions. Conclusions from this analysis should be reported every five years in the "State-of-the-Watershed" Report.

Streambank Erosion

The existing stream channel system shows little sign of stress from erosion. The generally moderated flow rates appear to be in equilibrium with the current channel configuration. The target for streambank erosion should be to maintain this existing equilibrium condition. The erosion monitoring stations established in the project, and any subsequent stations established, should show no rapid and major change in channel cross-section. If such change does occur, flow monitoring should be undertaken to determine whether there has been a change in flow characteristics.

Trend analysis of annual recession rates at the erosion monitoring stations should show no acceleration subsequent to upstream land use change.

Terrestrial Resources

Annual reconnaissance, and examination of recent aerial photographs, should reveal no encroachments and no emerging problems with vegetation. A numerical target is not appropriate.

The results of bird surveys, conducted every 5 years, should be compared with results of previous surveys (including the results presented in the Interim Report) by a qualified

ornithologist to examine any possible changes in abundance and diversity since the previous surveys. Significant changes in these attributes should be treated as "flags", warning of a loss in ecosystem integrity.

Fisheries

Annual reconnaissance should show no emerging problems related to fish habitat on Hanlon Creek or any of its tributaries. In the "State-of-the-Watershed" Report, analyses of data on the composition of the fish community should reveal no significant changes in its structure. As rehabilitation and enhancement options (revegetation of stream banks; restructuring of Tributary A; removal of in-line ponds; channel reshaping to provide small pool refugia; removal of woody debris barriers) are implemented, the summer distribution of Brook Trout should increase. Biomass of Brook Trout should not decrease below present levels, and should increase to some degree as rehabilitation and enhancement options are implemented.

4.4 Implementation Strategy

The Watershed Plan recommended for the Hanlon Creek watershed consists of a series of policies and specific actions which should accompany the future development of the basin in order to protect and enhance its natural resources and provide for public safety, health and aesthetic enjoyment. In order to ensure the Plan's orderly implementation, the responsibilities, mechanisms and timing associated with each component have been identified to assist both regulatory agencies and potential developers in administering and meeting its requirements. In addition, an important element of implementation will be monitoring the success of the Plan in meeting the goals originally established for it. Hence, a monitoring strategy has been prepared which should commence immediately and continue throughout the development and subsequent stabilization of the watershed. The monitoring strategy is presented in detail in Section 4.5.

Before discussing the implementation aspects of each component of the Plan, a number of guiding principles have been identified, as follows:

i) Once the Watershed Plan has been endorsed and accepted by the agencies which participated in its development through the Steering Committee, it should be recognized as having precedence over all other generic guidelines and policies generally applicable

Appendix A5: Torrance Creek Subwatershed

DATE

TO
COMPANY
EMAIL

FROM
DIVISION IDE
DEPARTMENT ETS

EMAIL
PHONE 519-837-5604

FAX 519-822-6194

CC
SUBJECT SWM Criteria: Address (± 000 ha)

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site. The proposed development is situated within the Torrance Creek Subwatershed. The stormwater design must reflect SWM criteria set forth in the "Torrance Creek Subwatershed Study Management Strategy – Revised January 1999" concerning quantity, quality and water balance objectives. "The primary objective of quantity control is to maintain hydrologic functions (flow conditions) for existing conditions with both surface and subsurface flows."* [1]

- Control peak flow for all design events (Post to Pre 2_{yr} to 100_{yr} events) – Guelph Design Storms.
- Sites that do not have a positive outlet must be designed to provide storage on site for twice the five year design storm runoff volume.
- On site control and storage (roof top/parking lot/ponds/superpipes) may be required to attenuate flows
- For commercial, institutional and high density residential developments, excess runoff for the two year design storm is to be stored underground or on roof tops.
- Excess runoff from the five year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3m.
- Major storms are to be routed overland to the City's R.O.W. without exceeding a maximum parking lot pond depth of 0.3m. Sites which cannot meet these criteria are required to provide storage on the site for twice the five year design storm runoff volume.
- Clean runoff (roof water) should be directed to pervious areas for infiltration to encourage ground water recharge (Low Impact Development).
- If on-site infiltration is to be incorporated into the design, permeameter tests needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- Any proposed infiltration on-site is to be designed in accordance with the MOE SWM Planning and Design Manual – March 2003.
- For infiltration system design and drawdown calculations, a safety factor should be determined using the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (Appendix C). This rate should be applied to the percolation rate as infiltration systems tend to clog-up over time. The design percolation rate should note exceed 75mm/hr.
- Evaluate infiltration potential on site as it relates to the existing water budget, and recommend measures to meet the goal of maintaining or enhancing pre-development groundwater recharge.
- Quality control facilities are required to remove suspended solids (oil and grit) from areas draining driveways and parking lots (i.e. oil/grit interceptors, catch basins, and vegetative buffer strips or a combination thereof).
- Control water quality to an Enhanced Protection Level (80% TSS removal).
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.
- Stormwater management designs for industrial sites may require the Ministry of the Environment, Conservation and Parks (MECP) approval. *The applicant is to contact the MECP directly to determine the Ministry's requirements for the site.*
- Any end-of-pipe stormwater management facility design must conform to the City of Guelph design guidelines.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the SWM facility.

We require that the SWM modelling be submitted in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 2 year and 100 year design storms and must include scale drawings showing drainage catchment areas, delineated pond limits for the 5yr and 100yr design storms (where applicable) and a schematic diagram reflecting the model (complex models). City of Guelph design storm hyetographs & Miduss stormwater modelling parameters (Guelph design storms) files are available upon request.

Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheet.

Engineering and Transportation Services
Infrastructure, Development and Enterprise

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[1] TSH, Ecological Services Group, Ray Blackport, Mark L. Dorfman Planner Inc., Shroeter & Associates, GRCA – City of Guelph. Torrance Creek Subwatershed Study Management Strategy, Page 131, Revised January 1999.

Torrance Creek Subwatershed Study (Totten Sims Hubicki, 1998)

Zone 1

Catchments 101, 130, 132, 135, 145, 140, 150, 160

- Zero runoff requirement
- 1:100 year volume captured, all water infiltrates
- Peak flow control for all design events (post to pre, 2 to 100 year event)
- 24 hour extended detention for 25mm rainfall event, if necessary (given infiltration levels and water quality requirements)

Zone 2

Catchments 102-120, 124, 126

- Infiltration target of between 100 and 150mm/yr
- Baseflow enhancement close to creek encouraged
- 1:100 year flow controlled to pre-development levels
- Peak flow control for all design events (post to pre, 2 to 100 year event)
- 24 hour extended detention for 25mm rainfall event, if necessary (given infiltration levels and water quality requirements)

Zone 3

Catchments 162, 165, 170, 175 and 180

- Infiltration targets of between 100 and 150 mm/yr
- Baseflow enhancements encouraged
- 1:100 year flows controlled to pre-development levels
- Peak flow control for all design events (post to pre, 2 to 100 year event)
- 24 hour extended detention for 25mm rainfall event, if necessary (given infiltration levels and water quality requirements)

Table 5.4.5 (also in Table 6.2.1)
Stormwater Management Volumes for Torrance Creek (1:100 Year Controls)

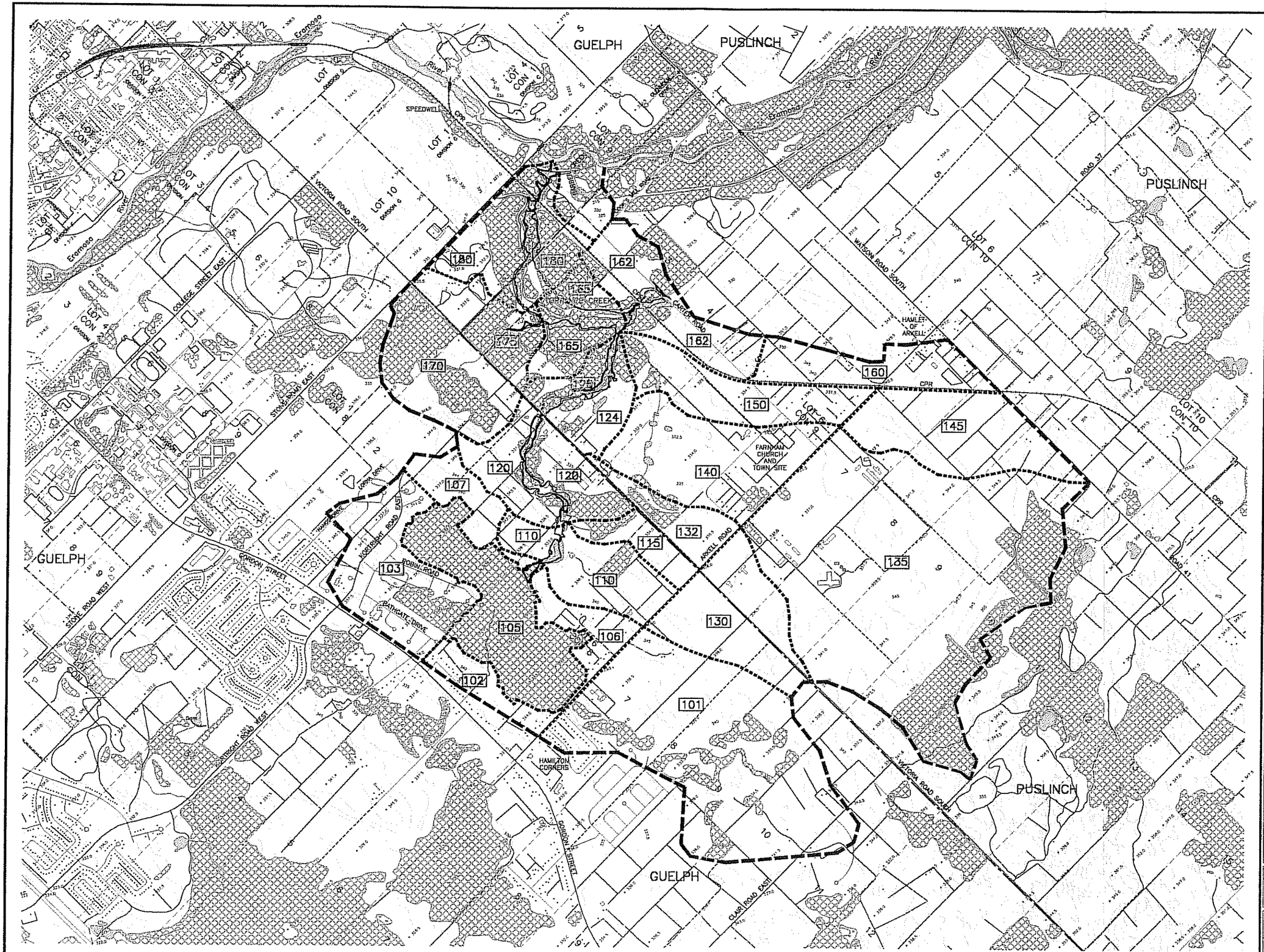
Zone	Catchment	1:100 Year Volumes (m^3/ha)
1	101	710
1	130	710
2	106	780
2	107	820
2	110	730
2	115	620
2	120	620
3	170	500
3	175	480
3	180	600

Table 6.2.3 Infiltration Targets

South of Arkell Road	25 cm/yr
Arkell to Torrance Creek	15 cm/yr
Torrance Creek to Stone Road	10 cm/yr

Section 6.2.3 Water Quality

- 80% TSS removal
- Level 1 (Enhanced) protection
- Water Quality parameters (nutrients, temperature, etc.) provided in section 6.2.3



NORTH

LEGEND:

- WOODED AREA
- MARSH
- WATERSHED BOUNDARY
- SUBWATERSHED DRAINAGE BOUNDARY
- 145 SUBWATERSHED DRAINAGE NUMBER
- 330 CONTOUR (5m INTERVAL)
- CITY OF GUELPH – TOWNSHIP OF PUSLINCH BOUNDARY
- 345 SPOT ELEVATION

Study Team:

Totten Sims Hubicki Associates
Ecological Services Group
Mark L. Dorfman, Planner Inc.
Stanley Consulting
Donald G. Weatherbe Associates
Schroeter & Associates

THE CITY OF **Guelph**

TORRANCE CREEK SUBWATERSHED

GUELPH ONTARIO

Grand River Conservation Authority

SUBWATERSHED DRAINAGE BOUNDARIES

DRAWN BY	DESIGNED BY –	DATE SEPT. 1998
CHECKED BY	APPROVED BY –	PROJECT No.
SCALE HORIZ. N.T.S. VERT. –	DRAWING No.	FIGURE 4.6.1

Appendix A6: The Ward, Guelph Downtown – Dublin/Gordon, and Guelph Downtown – Quebec/Macdonell

6.4.5 Downtown Stormwater Criteria

As redevelopment progresses in the downtown area there is an opportunity to introduce stormwater management features and controls consistent with today's standards. The following section discusses the approach to stormwater quantity management, quality management, erosion control and water balance in the downtown area.

Water Quantity:
Water quantity control will be required at the site level as there is no identifiable opportunities for centralized water quantity controls in the downtown area.

Water quantity control will be based on post-development flows not exceeding existing pre-development flows for storm events from 2-year to the 100-year. This is consistent with the City Development Engineering Manual (January 2019).

For existing systems, the following peak flow criteria are recommended for quantity control in the existing downtown area:

- Stormwater discharge from new developments must improve downstream surcharge conditions, or at least maintain existing conditions;
- No surcharge during the 5-year design storm event;
- Maintain a freeboard of greater than 1.8m during the 100-year design storm
  - If there are no local storm service connection, more surcharging may be permissible.
  - The presence of downstream service connections should be evaluated on an individual site bases to determine freeboard requirements.
- Overland flows must be contained within the municipal Right-of-Way for all events (flow depth less than 300mm).

From the storm system assessment, achieving the above criteria is not possible in all areas. The following is a summary of post-development flow controls assuming local improvements are completed:

- Dublin Street/Gordon Street: 5-year pre-development flow control to bring HGL below grade.
- Quebec Street: Post-development not to exceed pre-development for 2- through 100-year.
- The Ward: 5-year pre-development flow control.

If the improvements are not implemented over-control will be required to the 5-year pre-development level in the Dublin Street area; 25-year in the Quebec Street area; and 2-year in The Ward all based on 50% imperviousness.

Water Quality:
Water quality control to current stormwater standards is not practical in the downtown area. Improving stormwater quality by installing OGS on site or part of a central OGS facility is recommended as a means to improve water quality supported by best practices, such as regular street cleaning and catchbasin cleaning.

It is recommended that OGS specifications and salt management plans be part of all site plan applications.

LID:
LID features, such as green roofs, rainwater harvesting, and rain gardens integrated into redevelopments present an opportunity to reduce the stormwater quantity as well as providing some water quality benefits.

As discussed previously, infiltration LIDs should be avoided because of wellhead protection.

Other Criteria (Erosion Control, Water Balance):
Other stormwater criteria contained in the City Development Engineering Manual (January 2019) will need to be followed for any new development in the downtown area related to erosion control and water balance where practical. Applicants will need to demonstrate they have addressed City requirements and if they cannot be met, applicants need to ensure they have not worsened conditions.

6.4.6 Stormwater Improvements Summary

The storm services in the downtown area were never designed using current standards and therefore should not be expected to meet current stormwater guidelines. However, through redevelopment the post-redevelopment flows must not worsen pre-redevelopment conditions and if possible, improve quantity control and look at opportunities to introduce quality control where feasible.

In the context of the downtown area, the development of stormwater system improvements started with the 2012 Stormwater Master Plan. The development of projects for this report involved reviewing projects recommended in the Master Plan with the following objectives:

- Mitigate surcharge and flooding conditions in the minor system during the 5-year storm event;
- Alleviate the depth of flooding during the 100-year storm event; and
- Control the 100-year freeboard to greater than 1.8m, where feasible.

Furthermore, opportunities in the downtown area to incorporate LID and water quality controls were investigated. Finally, stormwater criteria are discussed recognizing it is generally difficult to effectively retrofit/implement traditional stormwater management techniques for quantity and/or quality control as part of infill/intensification involving individual land parcels in an established downtown area.

The following summarizes the stormwater recommendations:

- **Dublin Street / Gordon Street**
  - Investigate overland flow drainage at Dublin Street and Wellington Street West.
  - Upgrade the local storm sewer on Dublin Street from Fountain Street to Wellington Street (ST-13: 137m of 750mm). This improvement is not considered critical and should be coordinated with other water or road improvements.
  - In the Dublin Street /Gordon Street area, limit post-development flows to a 5-year pre-development flow levels to improve hydraulic performance and minimize surcharge.
- **Quebec Street / Macdonell Street**
  - Implement local upgrades to provide a consistent level of performance with no surcharging under the 5-year event; freeboard greater than 1.8m for the 100-year event; and, ponding less than 300mm for the 100-year event in the downtown area.
  - Alternatively, without improvements, limit post-development flow to 25-year pre-development level.

- **The Ward**
  - The Ward currently has a <2-year level of service. Two alternatives are available, to control post development flow to 2-year level, or, implement improvements which will allow post development control to increase to 5-year.
  - It is recommended the City consider the local improvements (Alternative 2) and implement a 5-year control.
  - Upstream storm flows contribute to existing issues. As such, more restrictive stormwater controls should be considered for the upstream area outside of the downtown area.
- **LID-Controls -** Non-infiltration LIDs, such as green roofs, rainwater harvesting may be viable in the downtown area and should be promoted as part of redevelopment. Infiltration type LIDs are not recommended because of source water protection.
- **Water Quality -** There are limited opportunities to retrofit water quality controls. OGS located at three locations should be investigated as centralized facilities for the downtown area. LIDs will also contribute to improving water quality.
- **Stormwater Criteria -** Criteria have been proposed to guide the City in the process of reviewing proposals as they come forward. The criteria vary for different downtown areas given current performance.

6.4.7 Stormwater Opinion of Probable Cost and Phasing

Figure 6-10 showed the proposed stormwater system improvements (ST-1 through ST-13). In total, there are 13 improvement projects identified. A summary of the project phasing, costing, and rational is provided **Table 6.4**. Detailed project sheets for each location are provided in **Appendix F**.

Figure 6-12and **Figure 6-13** show the hydraulic performance (minor system) for 2031 conditions under the 5-year and 100-year events, respectively, with stormwater infrastructure improvements only. Similarly, **Figure 6-14** and **Figure 6-15**show the same hydraulic performance for the 5- and 100-year events with peak flow control criteria: Dublin Street, 25-year; Quebec Street, 100-Year; and, The Ward, 5-year. **Figure 6-16**shows the 100-year overland performance with improvements and stormwater criteria.

An Opinion of Probable Cost (OPC) were developed based on storm pipe construction costs prepared by COLE using tender values from the Greater Toronto Area (GTA) and approved by the City of Guelph. Unit costs for storm sewers, maintenance hole, and services were applied based on length, depth and diameter. The unit costs were classified as being either independent or in conjunction with road programs to account for the added cost of road removals and restoration efforts. If there is another system improvement (water or wastewater) along the same road segment, the unit cost for the stormwater project would be reduced to be in conjunction with a road program to avoid duplication of costs.

Estimating percentages were applied to account for contingency (25%), engineering (15%) and other general items (5%). **Table 6.4** summarizes the project details and OPCs for all stormwater servicing alternatives.

Appendix A7: Guelph Innovation District

7.0 Conclusions and Recommendations

7.1 Conclusions

The following conclusions have been developed:

i. A full background review of the GID drainage features, patterns and existing stormwater management has been conducted.
ii. Stormwater management objectives and policies have been established to mitigate the impacts of the proposed GID development and redevelopment.
iii. GID stormwater management will need to meet all City of Guelph policies including NHS and SWPP policies.
iv. Preliminary locations for stormwater management facilities have been determined.
v. Low Impact Development BMPs will be required to meet the GID water balance objectives and policies.
vi. Clythe Creek will be realigned and improved to facilitate the proposed York Road improvements.

7.2 Recommendations

The following recommendations have been made:

i. Preliminary locations for stormwater management facilities should be assessed within the Block Plan stage, using all relevant City policies and GRCA and provincial requirements.
ii. Opportunities to improve the water quality from the existing Watson Industrial stormwater management facility (facility No. 38) should be investigated. The existing facility does not have permanent pool and a permanent pool could be created within part or all of the facility. This would require further assessment within the update to the Stormwater Management Master Plan.
iii. Enhanced Level of water quality treatment (80% average annual TSS removal) within the GID should be provided using a treatment train approach consisting of pre-treatment measures and various LID BMPs that provide 27 mm capture, followed by end of pipe treatment as required.
iv. Annual water balance within the GID should be maintained (or improved in existing developed areas) through implementing 27 mm capture in infiltrative LID BMPs.
v. Stormwater quantity controls would include 27 mm of capture within LID BMPs and end of pipe stormwater quantity control facilities with recommended unitary storage volumes and release rates.
vi. Salt management measures would include temporary bypasses of infiltrative LID BMPs and lining and/or bypasses of quantity control facilities. Other broader City programs to better manage the application of road salt are beyond the scope of the current study.
vii. The City should consider easements for access, operation and maintenance of privately owned LID BMPs.

Respectfully submitted,

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Per: Steve Chipps, P.Eng.
Senior Engineer

Per: Matt Senior, M.A.Sc., P.Eng.
Project Engineer

SC/kf

Appendix A8: Clair-Maltby

4. Phase 3 Impact Assessment and Management Plan (Second Iteration)

This report summarizes the results and recommendations from the comprehensive assessment of the May 2019 updated Preferred Community Structure (ref. Figure EX.6) and the supplemental analyses related to the Halls Pond catchment and the confirmed Community Park location (Final PCS) (March 2020) (ref. Figure EX.7) which was completed to assess the potential impacts of the future planned development to the local and neighbouring environmental systems and features, and to establish management (including monitoring) strategies appropriate for this study area at the Secondary Plan scale (ref. Appendix H).

a. Hydrology (Surface Water)

The hydrologic model (PCSWMM) was used to assess the hydrologic impacts from the updated Preferred Community Structure and from the Final Preferred Community Structure. Typical impacts from urbanization include additional runoff, less infiltration and higher peak flows. As noted, the Clair-Maltby SPA is characterized by a significant number of depressional features, with certain features providing over 300 mm capture of runoff, which is greater than the Regional Storm (Hurricane Hazel) at 285 mm of precipitation.

To mimic the existing depressional features, a distributed approach was adopted by using low impact development (LID) best management practices (BMPs) capturing 20 mm runoff (reduced from 27 mm in the first impact assessment, to determine recharge sensitivity to capture amount and to improve feasibility and reduce cost of implementing LID BMPs) and designated stormwater capture areas (SWCAs), for capturing and infiltrating the balance of the drainage not captured by the LID BMPs at source.

Hydrologic modelling comparing existing and post-development conditions indicated that peak flows (external to the SPA) within Hanlon Creek and Mill Creek and along Maltby Road will be maintained at pre-development levels. In addition, the amount of water available for infiltration will largely match existing drainage conditions on a subwatershed basis. Furthermore, the supplemental analyses completed over the fall of 2020, provided an approach to maintain wetland water balances for the three largest ponds / wetland areas in the PSA (i.e., Neumanns Pond, Halls Pond and Halligan's Pond) under post-development conditions (ref. Appendix H). Based on the hydrologic modelling, stormwater management has been summarized as the following:

1. To provide stormwater management for the Clair-Maltby SPA, it is recommended that distributed low impact development best management measures capturing 20 mm runoff be provided within both public and private lands, with the remaining drainage being conveyed to stormwater capture areas, sized to capture the Regional Storm. Stormwater capture areas are to have an overflow to existing depression areas, should the stormwater capture area storage capacity be fully used.

2. For small development areas (typically less than 5 ha), unless draining to Maltby Road, 20 mm capture will be required to provide water quality treatment
3. For small development areas (typically less than 5 ha), draining to Maltby Road, Regional Storm (285 mm) capture and control will be required, to mitigate impacts to properties located south of Maltby Road. Water quality controls will be required as per all of the development within Clair-Maltby.
4. For the Community Park, located adjacent to Halls Pond, distributed LID BMPs are to capture the 100 year storm event. The distributed LID BMPs are to replace a 100 year stormwater capture area, which would have been required for the park draining to Halls Pond. The rationale for using LID BMPs versus a SWCA is to prevent groundwater mounding and increases in the average Halls Pond water level.
5. The SWCA's for Subcatchments SW-42 and SW-61 should be located as per the recommendations of the Halls Pond Assessment (ref. Appendix H).
6. Infiltrative low impact development best management measures that receive runoff from paved surfaces will require pretreatment to protect groundwater quality.
7. A treatment train approach should be used to protect the stormwater capture areas' function of infiltration and to protect groundwater quality.
8. Surface and groundwater quality monitoring as discussed in this report, will be required to protect existing surface water and groundwater resources.
9. The City of Guelph should consider salt reduction and management measures recommended in the MESP and herein.
10. Phasing of stormwater management servicing as per the MESP recommendations.

b. Hydrogeology

The conceptual understanding of groundwater flow conditions within the SPA and PSA was used to inform the location of future land use types found in the initial and updated community structure. This understanding also informed the development of a Stormwater Management (SWM) plan and associated low impact development best management practice (LID BMP) recommendations tailored to the unique biophysical context of the CMSP SPA and to the Final Preferred Community Structure land use plan.

The unique SWM plan developed for this SPA takes advantage of the high infiltration capacity of the soils and thick unsaturated zone to replicate the function of existing depressional features in the landscape which, outside of the protected NHS, are expected to be altered through grading for development. Additional depression storage depth has been incorporated into the development areas, outside of the NHS, to meet the established capture/infiltration targets and support an overall study area water balance. The SWCAs have been sized and located to

receive excess runoff and infiltrate additional runoff during larger precipitation events, in excess of 20 mm, within the development area.

The future conditions scenario was simulated using the integrated surface water – groundwater model MIKE SHE model developed as part of the Phase 1 and 2 Existing Conditions Characterization. Future conditions were represented in the model for each iteration of the impact assessment to represent Initial, Updated and Final PCS land use and the SWM management approaches. In addition, MIKESHE was used to inform the more area-specific analyses undertaken for the Halls Pond catchment area associated with the Final Preferred Community Structure with the confirmed Community Park location. The representation of the development area was updated to reflect changes in topography, imperviousness, changes in vegetation cover and proposed stormwater management practices. Additional depression storage was incorporated to all development areas. Source control LID capture of 20 mm was determined to be effective in the Final PCS, but values of 5 to 35 mm were simulated and assessed in the Final PCS simulations. Alternative source control capture volumes were evaluated but ultimately 20 mm was found to offer the best balance of impact mitigation and constructability. Stormwater volumes in excess of local depression storage were simulated to be routed to the centralized SWCAs consistent with the proposed SWM plan.

The impacts of the future conditions scenario and effectiveness of the LID BMPs and SWM measures were assessed by comparison to the existing conditions for the period of 2003-2017 for the updated and Final Preferred Community Structure (May 2019). The 15-year simulation period employed in iteration 2 and 3 (updated and final PCS) provided additional insight on long term impacts compared to the shorter simulation used in iteration 1 (based on the initial Preferred Community Structure, May 2018).

The impacts of the future land use change associated with the updated and Final Preferred Community Structure were evaluated based on simulated changes to:

- Water budgets in the SPA, PSA and key NHS features in, and adjacent to, the SPA,
- Groundwater flow directions and depth to water table,
- Recharge to the water table, shallow and deep bedrock aquifers,
- Groundwater discharge to streams and wetlands,
- Average annual ponded water elevation in wetlands.

Overall, the modelling predicted that under the final Preferred Community and the recommended LID BMPs and SWCAs, recharge is maintained with slight increases in recharge within the SPA. While localized increases and decreases in groundwater recharge to the water table are predicted within the SPA, the distributed detention storage in development areas and the additional capture capacity provided by the SWCAs are predicted to maintain or slightly increase recharge and maintain overall groundwater flow directions and recharge to shallow and deep bedrock aquifers by infiltrating water as close to source as possible. By maintaining groundwater flow, gradients and linkages between groundwater recharge and discharge areas are expected to be sustained under the updated and final Preferred Community

Structure plan and the groundwater function is simulated to be maintained across the study area.

c. Surface Water Quality

The updated Preferred Community Structure land use plan (May 2019) includes a mix of densities of different land uses including residential, commercial, institutional (schools) and parks, as compared to the existing predominant agricultural land uses and golf course. As such, contaminant loadings typically associated with agriculture and golf courses are expected to be reduced, while contaminants associated with urbanization (e.g., from road runoff in particular) are expected to increase.

To help manage the water quality impacts of the urbanized land uses, drainage will be conveyed through a series of LID BMPs, with the overflow being directed towards SWCAs that will infiltrate the balance of the captured drainage. The foregoing approach is described in the following:

i. Apply a distributed approach for 20 mm capture within LID BMPs, 100 mm for Community Park.

ii. Separate 'clean' water (rooftop and landscaped areas runoff) from dirty water, with dirty water typically resulting from roadways and parking areas

iii. Apply water quality measures in series to protect the SWCA's function of infiltration

iv. LID BMP selection and locations to be determined based on land ownership, land use, development form and grading (public and private realm)

v. Reduce the use of salt through the City of Guelph Salt Management Plan; and through implementation of the recommendations provided by the Wood Team to the City for reducing infiltration of salt laden runoff, and

vi. LID BMPs and other stormwater quality management measures would need to be reviewed and refined through the planning process.

d. Natural Heritage

The refined NHS confirmed through the CMSP study process is a well-connected system that occupies more than 45 per centper cent of the land base in the Clair-Maltby SPA. "Environment first" strategies that influenced the development of the initial Preferred Community Structure (May 2018) have been carried forward into the updated Preferred Community Structure and land use plan including:

- Respecting the limits of the NHS by excluding all residential, commercial, institutional and industrial development from identified Significant Natural Areas, and their applicable minimum or established buffers;
- Keeping new municipal roads from crossing Significant Wetlands and Significant Woodlands, and generally limiting new road crossings of the NHS to the extent possible;

Appendix A9: Clythe Creek Subwatershed

Recommendation #5 - Groundwater

a) *Groundwater inputs to the creeks must be maintained to preserve the aquatic habitat in this system*

b) *The emulation of existing groundwater recharge is recommended throughout the watershed, particularly within the potentially sensitive areas.*

c) *Groundwater withdrawals need to be reviewed from the perspective of reductions in water levels within the groundwater flow system providing discharge water to the creeks and wetlands. An assessment of this linkage, for existing and future groundwater takings, is necessary to maintain the aquatic and terrestrial function.*

d) *Groundwater quality degradation from road salting, fertilizer, septic systems, spills etc. is more likely within the sensitive groundwater areas and is to be controlled.*

Appendix A10: Mill Creek Subwatershed

Table 7.1
Subwatershed Plan Goals, Objectives, and Management Approaches Pg 1 of 2

Goal	Objectives	Management Options
To restore, protect, and enhance water quality and associated aquatic resources and water supplies.	Maintain existing recharge and discharge characteristics.	• Limit impervious cover. • Protect greenspace system functions/ features. • Promote innovative subdivision/site designs. • Promote infiltration BMPs.
	Control sediment discharges and provide erosion control during development.	• Ensure BMPs consistent with municipal, MNR, GRCA policies.
	Ensure appropriate post-development water quality control measures.	• Implement appropriate water quality control BMPs that promote infiltration and/or sedimentation and maintain/reduce runoff peaks and volumes. • Limit impervious cover. • Protect greenspace system functions/ features.
	Maintain/reduce existing erosion rates following development.	• Implement appropriate BMPs that maintain/reduce runoff peaks and volumes. • Limit impervious cover. • Protect greenspace system functions/ features.
	Maintain/enhance cold-water fisheries potential as subwatershed creeks.	• Maintain/improve riparian conditions along selected stream reaches. • Remove in-stream obstructions. • Rehabilitate, retrofit, or remove online ponds. • Mitigate temperature impacts of stormwater management pond discharges. • Limit impervious cover. • Protect greenspace system functions/ features.
To conserve, protect, and restore natural land, water, forest, and wildlife resources.	Protect natural area functions/features from development.	• Delineate and protect integrated greenspace system. • Undertake Site EIS reports to guide adjacent developments. • Limit impervious cover. • Promote innovative subdivision/site designs. • Promote infiltration BMPs. • Minimize transportation/service crossings of sensitive areas.
	Enhance natural area features and functions in long term.	• Develop post-extractive land management plan that enhances existing greenspace features and functions.

Table 7.1
Subwatershed Plan Goals, Objectives, and Management Approaches Pg 2 of 2

Goal	Objectives	Management Options
To protect, restore, and enhance groundwater quantity and quality.	Maintain infiltration, baseflow, and discharge to natural features.	• Limit impervious cover. • Protect greenspace system functions and features. • Promote innovative subdivision/site designs. • Promote infiltration BMPs that do not threaten water quality. • Promote water conservation.
	Ensure continued aggregate extraction does not impair existing groundwater quantity or quality.	• Promote appropriate limits, setbacks, and rates of extraction. • Ensure onsite BMPs are set forth and followed. • Develop post-extractive land management plan that enhances existing greenspace features and functions.
To minimize the threat to life and the destruction of property and natural resources from flooding and erosion, and preserve natural flood plain hydrologic functions.	Minimize risk to life and property with future development.	• Promote levels of development and runoff peak and volume control that maintain regulatory flood lines.
	Control development in the floodplain.	• Manage floodplain as integrated whole within greenspace system.

Appendix A11: Southgate and Irish Creek Subwatershed

DATE **4 September, 2018**

TO	Jurgen Koehler, P. Eng.	FROM	Mario Martinez, B.Sc.CE
COMPANY	C. F. Crozier & Associates	DIVISION	Development Services
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		EMAIL	mario.martinez@guelph.ca
		PHONE	519-822-1260 Ext.2671
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SUBJECT: **SWM Criteria for 995 Southgate Dr. (5.6 Ha.)**

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site. This criteria is based upon the South Guelph Secondary Plan Area Scoped EIS, November 1998 (ID#2284)/ Grading, Servicing & SWM Report – Southgate Business Park, Final Revised, January 2012 (ID# 2513)/ Southgate Business Park – Hydrogeological Report August 2006 (ID #2282).*

- The City of Guelph's stormwater criteria is: SWM facilities must be sized to retain and infiltrate up to the Regional Storm event. On-site storage/ retention using infiltration ponds/ grassed swales/dry ponds is required since no overland outlet from the site exists.
- On site control and storage (roof top/parking lot/ponds/superpipes) may be required to attenuate flows.
- For commercial, institutional and high density residential developments, excess runoff for the two year design storm is to be stored underground or on roof tops.
- Excess runoff from the five year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3m.
- Major storms are to be routed overland to the City's R.O.W. without exceeding a maximum parking lot pond depth of 0.3m. Sites which cannot meet these criteria are required to provide storage on the site for twice the five year design storm runoff volume.
- Any proposed infiltration on-site is to be designed in accordance with the MOE Stormwater Management Planning and Design Manual – March 2003. The minimum percolation rate for infiltration ponds is 60 mm/hour.
- Roof runoff must be directed to infiltration systems (i.e. infiltration galleries, bio-retention basins, rain gardens, grassed swales, vegetated filter strips, etc.) to encourage groundwater recharge. Parking lot areas shall not be infiltrated as per MOE SWM guidelines.
- For on-site infiltration, a permeameter test needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- Quality control facilities are required to remove suspended solids (oil and grit) from areas draining driveways and parking lots (i.e. oil/grit interceptors [for areas < 5 ha], constructed wetlands, catch basins and vegetative buffer strips or a combination thereof). Please note that Goss traps are not acceptable for areas larger than 250m^2.
- Enhanced Protection Level water quality treatment should be provided to the site stormwater, prior to discharge to the on-site infiltration facility and/ or off-site kettle and wetland areas to minimize the introduction of urban pollutants (80% TSS removal).
- The design of the stormwater management facility must include a water balance analysis.
- Storm water management designs for industrial sites must pass through the Ontario Ministry of the Environment's approval process. The applicant is to contact the MOE directly to determine the Ministry's requirements for the site.
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the SWM facility.

We require that the SWM modelling be submitted in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5yr, 100yr and Regional design storms and must include scale drawings showing drainage catchment areas, delineated pond limits for the 5yr, 100yr and Regional design storms (where applicable) and a schematic diagram reflecting the model (complex models).
Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheets. City of Guelph design storm hyetographs and Miduss stormwater modelling parameters for the design storms and Miduss Guelph design storm electronic files are available upon request.

DATE **8 March 2018**

TO	Glenn Anderson, CET	FROM	Mario Martinez, B.Sc.CE, C.Tech.
COMPANY	GM BluePlan Engineering Ltd.	DIVISION	Development Services
EMAIL	glenn.anderson@gmblueplan.ca	DEPARTMENT	Engineering
		EMAIL	mario.martinez@guelph.ca
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SUBJECT: **SWM Criteria for 1080 Southgate Dr. (9.5 Ha.)**

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site.*

- The City of Guelph's stormwater criteria will be based upon the ***South Guelph Secondary Plan Area Scoped EIS - dated November 1998, LGL Project TA2166*** and ***Grading, Servicing and Stormwater Management Report for Southgate Business Park, IBI Ref.# 19312(1743).*** On-site storage and retention using infiltration ponds is required and must be sized to retain and infiltrate up to Regional Storm Event.
- On site control and storage (roof top/parking lot/ponds/superpipes) may be required to attenuate flows.
- For commercial, institutional and high density residential developments, excess runoff for the two year design storm is to be stored underground or on roof tops.
- Excess runoff from the five year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3m.
- Major storms are to be routed overland to the City's R.O.W. without exceeding a maximum parking lot pond depth of 0.3m. Sites which cannot meet these criteria are required to provide storage on the site for twice the five year design storm runoff volume.
- Any proposed infiltration on-site is to be designed in accordance with the MOECC Stormwater Management Planning and Design Manual – March 2003. The minimum percolation rate for infiltration ponds is 60 mm/hr.
- Roof runoff must be directed to infiltration systems (i.e. infiltration galleries, bio-retention basins, rain gardens, grassed swales, vegetated filter strips, etc.) to encourage groundwater recharge.
- Parking lot areas shall not be infiltrated as per MOECC SWM guidelines.
- For on-site infiltration, a permeameter test needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- Quality control facilities are required to remove suspended solids (oil and grit) from areas draining driveways and parking lots (i.e. oil/grit interceptors [for areas < 5 ha], constructed wetlands, catch basins and vegetative buffer strips or a combination thereof). Please note that Goss traps are not acceptable for areas larger than 250m2.
- Enhanced Protection Level water quality treatment should be provided to the site stormwater, prior to discharge to the on-site infiltration facility and/ or off-site kettle and wetland areas to minimize the introduction of urban pollutants (80% TSS removal).
- The design of the stormwater management facility must include a water balance analysis.
- Storm water management designs for industrial sites must pass through the Ontario Ministry of the Environment's approval process. The applicant is to contact the MOE directly to determine the Ministry's requirements for the site.
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the SWM facility.

We require that the SWM modelling be submitted in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5yr, 100yr and Regional design storms and must include scale drawings showing drainage catchment areas, delineated pond limits for the 5yr, 100yr and Regional design storms (where applicable) and a schematic diagram reflecting the model (complex models).
Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheets.
City of Guelph design storm hyetographs and Miduss stormwater modelling parameters for the design storms and Miduss Guelph design storm electronic files are available upon request.

11.0 Stormwater Management

11.1 Overview of Stormwater Management

The following description of the stormwater management for the SBP is based on the December 20, 2011 report (revised January 16, 2012) entitled "Grading, Servicing and Stormwater Management Report" prepared by IBI Group (Appendix X). Detailed site drainage and grading plans, and sediment and erosion control plans are included in Appendix X and included in the engineering drawing set.

The groundwater table lies relatively deep beneath the property, owing to the extensive presence of well-drained permeable granular deposits both at surface and at depth. The Geotechnical Investigation prepared by Peto MacCallum Ltd. (July 25, 2006) indicated that the soils on the property (silty gravels, gravel sand-silt mixtures) have an infiltration rate of 60 mm/hr which is suitable for stormwater infiltration.

Based on grading constraints on site (no overland outlet), it is required that all runoff generated up to the Regional Storm (Hurricane Hazel) be retained and infiltrated on-site for all future developing sites. The area is characterized by closed drainage, with surface runoff discharging to low-lying depressions and wetlands throughout the site, with no runoff flowing off-site. A stormwater management infiltration pond is proposed to retain runoff generated from the right-of-way of the proposed Southgate Drive extension, from the proposed Street "A" to the east, and from a portion of Maltby Road. The total drainage area controlled by the pond is approximately 3.85ha of road. Additional privately owned infiltration facilities will be required to retain and infiltrate surface runoff from the developing sites.

A detailed water balance assessment for the subject property has been completed in the Hydrogeological Assessment for the Environmental Implementation Report (Anderson GeoLogic Ltd. 2010) (Appendix IX). The strategy for stormwater management will include the following components, as recommended in the water balance analysis completed in the Hydrogeological Assessment:

- the overall average groundwater recharge target should be a minimum of 300 mm/year (0.3 m/yr) in order to maintain the regional groundwater flow system,
- the precise location(s) of where post-development SWM recharge facilities are located is not critical to the maintenance of the regional flow system, since there is already a broad

distribution of 'natural' recharge points (wetlands) across the width of the property perpendicular to the groundwater flow direction,

- wetlands B and E are sustained, in part, by up-gradient groundwater recharge from the northeast, some of which occurs in Development Block 1. This recharge should be maintained, both in respect to quantity and proportion contributing to Wetland B and. E,
- all eight wetlands (A through H) are sustained to varying degrees by local surface water runoff within the individual wetland catchments. These runoff quantities should be maintained, as ultimately this surface water is important both for the wetlands themselves and for regional groundwater recharge.

Each developing site must therefore provide the appropriate quantity and distribution of infiltration and surface runoff to meet the above strategy. Each site must also provide stormwater quality control to an Enhanced Protection Level as per MOE guidelines prior to any infiltration or discharge of surface runoff. This can be achieved by using constructed wetland/wet pond facilities, or by using devices such as OGS units. The municipal road areas will be treated using OGS units, the surface runoff from Southgate Drive will sustain the required surface water flow to Wetland 'G'. A Monitoring Program (typically for a minimum of two years) will be required for effluent chemistry for stormwater quality features, and for groundwater chemistry. The design of stormwater management facilities and subsequent monitoring is to address the recommendations from the Grading, Servicing and Stormwater Management Report (IBI 2012) (Appendix X).

The infiltration and stormwater techniques outlined in the Grading, Servicing and Stormwater Management Report prepared by IBI (2012) conform to Low Impact Development Techniques. As previously noted, based on site constraints, all runoff must be retained on site and infiltrated. Measures for on-site design include:

- direct infiltration of roof runoff (to prevent mixing with surface runoff),
- grass surface infiltration ponds, which will limit the overall impervious cover on-site,
- routing treated surface runoff (using oil/grit separator units) through grass/vegetated swales to provide additional treatment, and
- maintenance of treated surface flow to the wetland areas, ensuring that the water balance for each feature is maintained.

11. STORMWATER MANAGEMENT

The following are the applicable stormwater management control criteria established for this development:

- On-site storage and retention using infiltration ponds is required given that no overland outlet from the site exists;
- Facilities must be sized to retain and infiltrate up to the Regional Storm event;
- The minimum percolation rate for infiltration ponds is 60 mm/hour. This has been confirmed by the Geotechnical Investigation by Peto MacCallum Ltd. (2006);
- A water balance calculation must be completed for any developing lands impacting an environmental feature (i.e. wetlands) that must be retained and protected; and
- Water quality control for the surface drainage is to be provided on-site for Enhanced protection level prior to water being infiltrated (80 percent TSS removal for 90 percent of annual flows for OGS units).

11.1 Water Balance Requirements

There are a total of 8 wetland features on the site that rely on surface water drainage. Each developing parcel must maintain the required level of surface flow to any wetland feature whose drainage area (in whole or in part) is contained with the site.

The strategy for stormwater management should include the following components, as recommended in the water balance analysis completed in the Hydrogeological Assessment:

- The overall average groundwater recharge target should be a minimum of 300 mm/year (0.3 m/yr) in order to maintain the regional groundwater flow system.
- The precise location(s) of where post-development SWM recharge facilities are located is not critical to the maintenance of the regional flow system, since there is already a broad distribution of 'natural' recharge points (wetlands) across the width of the property perpendicular to the groundwater flow direction.
- Wetlands B and E are sustained, in part, by up-gradient groundwater recharge from the northeast, some of which occurs in Development Block 1. This recharge should be maintained, both in respect to quantity and proportion contributing to Wetland B and E.
- All eight wetlands (A through H) are sustained to varying degrees by local surface water runoff within the individual wetland catchments. These runoff quantities should be maintained, as ultimately this surface water is important both for the wetlands themselves and for regional groundwater recharge.

To guide stormwater management design, the pre-development runoff and recharge contributions to each of the eight individual wetlands have been calculated and summarized in Table 1 of the Hydrogeological Report (table included in Appendix A).

The following is a list of stormwater management strategies and responsibilities for individual future landowners, specific to the individual development blocks and/or portions of development blocks:

Block 1 & Wetlands B-C-E-F. Block 1 is planned as an individual lot under a single ownership. Specifically, this owner is responsible for meeting the following targets:

- a recharge quantity calculated from the overall minimum recharge target of 0.3 m/yr multiplied by the size of Block 1, of which proportional amounts are recharged hydraulically upgradient from Wetland B and Wetland E in accordance with Table 1, and
- runoff quantities to each of Wetlands B, C, E and F, calculated in accordance with the Table 1 wetland runoff targets and proportioned according to the percent that an individual wetland catchment area lies within Block 1.

Block 2, Southgate Drive SWM & Wetlands A-D-E-G. Block 2 (northeast of Southgate Drive) is likely to be split into two or more lots, with individual owners responsible for meeting the following targets:

- a recharge quantity calculated from the overall minimum recharge target of 0.3 m/yr multiplied by the size of the individual lot,
- the municipally-owned Southgate Drive SWM (southwest of Wetland G at the corner of Street A and Southgate Drive) to be designed to achieve (or exceed) the proportional recharge quantity (based on the SWM catchment area) and with an outlet devise directing the entire Wetland G runoff target (from Table 1) into Wetland G [Note: no other runoff to G from other land owners to be permitted], and
- runoff quantities to each of Wetlands A, D and E, calculated in accordance with the Table 1 wetland runoff targets and proportioned according to the percent that an individual wetland catchment area lies within an individual lot.

Block 3, CMP2 & Wetland H. Block 3 (southwest of Southgate Drive) may be a single lot or be split into individual lots, with individual owner(s) responsible for meeting the following targets:

- individual lot recharge quantities calculated from the overall minimum recharge target of 0.3 m/yr multiplied by the size of the individual lot,
- the runoff quantity to Wetland H, calculated in accordance with the Table 1 wetland runoff target and proportioned according to the percent of the individual wetland catchment area within an individual lot in Block 3, and
- the owner of the land directly southwest of Southgate Drive and northwest of Maltby Road to be responsible for managing the off-site runoff through CMP2 and from the southern limit of Southgate Drive.

Any surplus runoff should be directed to the SWM facilities for enhanced recharge. Stormwater quality control is discussed in Section 11.2 below.

11.2 Stormwater Quantity Control

For each developing site, all runoff up to the Regional Storm event must be retained and infiltrated on site. Infiltration facilities can include surface ponds, or underground storage structures. Low Impact Development (LID) options should be explored at the Site Plan stage to achieve the stormwater and infiltration targets.

The industrial developable lands on either side of Southgate Drive will generally drain away from Southgate Drive with Southgate Drive generally forming a "ridge" between the eastern and western lands (refer to grading plans drawing 2 through 5). Each private parcel of land, or site, will be responsible for its own stormwater management; it is intended that there would be no municipally owned ponds with the exception of Pond A for the municipal road runoff.

Tertiary treatment could also be provided within grass swales in the ponds. Water quality control would be required to an Enhanced Protection Level as defined in the Stormwater Management Planning and Design Manual, Ontario Ministry of the Environment, March 2003 (MOE 2003).

Stormwater would then be stored in each site's SWM pond sized to accommodate the Regional Storm. This water would infiltrate into the ground via the pond bottom and/or side slopes and via an infiltration gallery (perforated pipe system) generally placed beneath the SWM pond bottom. The infiltration gallery would be sized to store the first 5 to 10mm of rainfall so that the pond would be dry during frequent rainfall events. The gallery would also ensure that there is a route to infiltrate storm water when the ground is frozen. This design concept was used for the TDL site to the northeast of the subject lands with success. Note, as there is expected to be large rooftop areas, it is recommended that the clean roof drainage bypass the quality control infrastructure and be infiltrated without treatment as this avoids oversized quality control facilities.

All infiltration ponds should be designed to drain down within approximately 48 hours and calculations supporting this should be included with the SWM Report for each developed parcel. An infiltration rate of 60mm/hour should be achieved, which is the minimum infiltration rate recommended in Section 4.6.6 of MOE (2003) for infiltration ponds. Site-specific Geotechnical Investigations should be prepared for each proposed pond location to demonstrate that this minimum infiltration rate can be met. Where a pond bottom contacts a less permeable soil layer or if a less permeable soil layer exists within 1.0m of the bottom, the soil must be removed and replaced with permeable material (to be confirmed on-site by Geotechnical Engineer during construction). Based on the Geotechnical and Hydrogeological work completed to date, the developing lands can provide the required infiltration rate.

As required by the MOE, monitoring will be required for effluent from OGS units and/or constructed wetlands, and for groundwater adjacent to each SWM pond. Refer to Section 7 for a preliminary discussion of monitoring programs. The Monitoring Program for each site will be developed and finalized at the detailed design stage.

Under proposed conditions, surface drainage must continue be directed to any feature that abuts the developing site as outlined above in Section 5.1. Each developing parcel must maintain the required level of surface flow to any wetland feature whose drainage area (in whole or in part) is contained with the site. Supporting water balance calculations must be included in the Stormwater Management Report.

The locations and layout of the site property lines is unknown at this time. A situation may arise where a developing site may prevent access of an adjacent developing site from contributing surface flows to an environmental feature. If this occurs, the site under development must

contribute an additional amount of surface runoff to a feature that would normally have been contributed by the adjacent area, or through a drainage easement or other solution agreed upon by the landowners.

11.2.1 MUNICIPAL POND

It is proposed that stormwater runoff from Southgate Drive and Street A will be directed to roadside ditches as is typical of the City's southern industrial lands. External drainage from the roads' adjacent lands to the road allowances would be minimized. The roadside ditches will be relatively flat and grass lined conforming to MOE design guidelines. As such the ditches and oil/grit separators will provide stormwater quality control of storm runoff from the relatively small road drainage area. The ditches north of approximate Sta 1+710 will drain northerly and connect to the existing Southgate Drive ditches. Ditches south of approximate Sta 1+710 and a north portion of Maltby Road will drain toward the proposed stormwater management facility. Therefore, the facility (Pond A) will control runoff from the Southgate Drive extension, Street A, and a portion of Maltby Road (refer to Figure 1 for drainage areas and pond location).

Future Pond A sizing is based on 3.852 ha of Municipal right-of-way drainage area, requiring a total storage volume of 4,388 m^3 to retain and infiltrate the Regional Storm. The pond grading has been completed so that the pond bottom remains above the groundwater table to allow for infiltration. MIDUSS modelling for the drainage areas and pond is included in Appendix B.

The stormwater management for this development is described in further detail as follows.

The proposed hydrologic conditions were modelled using the MIDUSS stormwater management computer model using Horton's infiltration method and SWMM routing in accordance with City of Guelph guidelines. Key variables for proposed conditions are summarized in **Table 1.**

Table 1 – MIDUSS Modeling Variables

Parameters		Southgate Drive	Street A	Pond Block	Maltby Road
		201	202	203	204
Catchment	Area (ha)	2.619	0.487	0.751	0.746
Impervious	Area (m^2)	1.3095	0.2435	0	
	Flow Length (m)	15	15	10	15
	Gradient (%)	1.0	1.0	20	1.0
	Manning "n" Paved	0.013	0.013	0.013	0.013
	Maximum Infiltration Rate (mm/hr)	0	0	0	0
	Minimum Infiltration Rate (mm/hr)	0	0	0	0
Pervious	Area (m^2)	1.3095	0.2435	0.751	0.373
	Flow Length (m)	15	15	30	15
	Gradient (%)	1.0	1.0	20	1.0
	Impervious (%)	50	50	0	50
	Manning "n" Grass	0.250	0.250	0.250	0.250
	Maximum * Infiltration Rate (mm/hr)	60	60	60	60
	Minimum Infiltration Rate (mm/hr)	25	25	25	25
	Lag Constant (hr)	0.5	0.5	0.5	0.5

** Based on Geotechnical Investigation for the development*

The 100 year Hanlon Design Storm provided by the City of Guelph was used for the hydrologic modelling. The 25mm, 2 year, and 5 year storms, based on City of Guelph IDF parameters, were also modelled. The Regional Storm was also modelled. The MIDUSS model output is provided in Appendix B. Infiltration has been accounted for using the pond side areas only. The total drainage area to the pond is indicated on Figure 1, and the design and details of the pond and storm sewer system are shown on the engineering drawings.

The Geotechnical Investigation (Peto MacCallum Ltd. 2006) indicates that the soils underlying the location of Pond A consist primarily of silty sand and gravel, which has a percolation rate of 60 mm/hour. A longevity factor of 0.75 has been applied to Pond A based on Table 4.12 of MOE (2003) which results in a long-term percolation rate of 45 mm/hour. Pond A will be underlain by a perforated pipe system to enhance the infiltration capacity of the pond and convey the small storm events (5 mm to 10 mm) underground (trench sizing calculations included in Appendix A). This is beneficial if the ground is frozen, since there is still an infiltration route, and will also eliminate frequent nuisance ponding. Based on the field work, no groundwater was encountered within the Pond A area to a depth of at least 5 m below existing grade (335.0m). Therefore, the use of an infiltration gallery is feasible at this location. Investigations also indicated that the wetland adjacent to the proposed pond receives a lower component of groundwater influx compared to other depression areas, and is

mainly sustained by surface water inflow. The design of the pond inlet makes provisions for a portion of the stored water to be routed directly to the wetland via surface flow, with the remainder being infiltrated to depth in the pond block. This will provide the required surface water inputs to the wetland, to duplicate the pre-development conditions.

Referring to Figure 1, runoff from area 201 and 202 includes asphalt areas and grass areas from Southgate Drive and Street A. Runoff from area 203 includes the pond block area. Runoff from area 204 includes a north portion of Maltby Road and its intersection with the Southgate Drive extension. Stage-storage-discharge calculations for Pond A are included in Appendix A. As the MIDUSS modelling indicates, the entire 100 year Hanlon Design Storm and the Regional Storm will be stored and infiltrated, with no surface flow discharging off-site. Table 2 provides a summary of infiltration flows prior to and after routing through the pond. The ponding characteristics within Pond A are summarized in Table 3. As the modelling and calculations indicate, the pond will drain down within approximately 24 hours. Pond details are provided on the engineering drawings (drawing sheets 18 and 20).

Table 2 – Peak Flows

Return Event	Proposed Conditions	
	Discharge Prior to Routing (m^3/s)	Discharge After Routing* (m^3/s)
25 mm Storm	0.324	0.007
2 Year Storm	0.478	0.008
5 Year Storm	0.694	0.011
100 Year Hanlon Design Storm	2.413	0.023
Regional Storm	0.492	0.029

* All discharge as infiltration.

Table 3 – Ponding Characteristics				
Return Event	**Storage (m^3)**	**Elevation (m)**	**Depth (m)**	**Detention Time (hours)**
Pond Invert = 333.00m				
25 mm Storm	384	333.20	0.20	7
2 Year Storm	615	333.31	0.31	10
5 Year Storm	1,043	333.50	0.50	12
100 Year Hanlon Design Storm	3,147	334.24	1.24	21
Regional Storm	4,388	334.59	1.59	24

Water Balance Wetland 'G'

Based on the water balance calculations provided in the Hydrogeological Assessment, the existing surface water flow volume to Wetland 'G' is 6,728 m^3/year. In order to maintain the water balance for Wetland 'G', treated flow downstream of the OGS unit for Street 'A' will flow to the wetland. A vegetated spreader at the outlet of the OGS will provide additional stormwater treatment by settling finer particles before they enter the wetland. Given that 25mm storm events and smaller represent approximately 90 percent of annual rainfall, a flow rate of 0.09 m^3/s (which represents the MIDUSS 5 year storm pipe-full capacity prior to overflow to the stormwater management pond) will provide the required surface water volume to the wetland. The water balance calculations also account for runoff from the 1.975 ha woodlot area to the north of Street 'A', which will also discharge to the wetland.

Therefore, minor runoff from Street 'A' and all runoff from the woodlot area will provide a total of 6,770 m^3/year, which matches the existing annual surface water volume to Wetland 'G'. Refer to Appendix A for volume, flow, and hydraulic pipe sizing calculations. Details of the flow splitter and vegetated spreader are shown on the engineering drawings.

Note that no additional surface flow from adjacent development lands may be directed toward Wetland 'G'. The only exception would be drainage from relatively small sloped grass areas that may be required to match property line grades.

11.3 Stormwater Quality Control

Each developing site must provide stormwater quality control to an Enhanced Protection Level as per MOE guidelines. This can be achieved by using constructed wetland/wet pond facilities, or by using devices such as OGS units. It is proposed that the best option for water quality control for developing areas would be using constructed wet facilities, based on the relatively large drainage areas. Where drainage areas are less than 5 ha, the use of OGS

units should be considered. It is recommended that rooftop areas are routed directly to infiltration facilities since this runoff is considered to be clean.

11.3.1 MUNICIPAL POND

The municipal road areas will be treated using an OGS unit. Referring to Figure 1, runoff from area 201, 202, and 204 include asphalt areas and grass areas, and will drain to an infiltration pond and will therefore require treatment.

Water quality control for the road drainage is to be provided for an Enhanced Protection Level prior to water being infiltrated (80 percent TSS removal for OGS units). All runoff from road right-of-way areas will be routed via ditches to OGS units prior to discharging to the infiltration pond. The road areas are less than 5 ha, and would likely not support a constructed wetland for water quality control. The OGS units have been sized to provide Enhanced Protection Level for long-term suspended sediment removal. This will prevent untreated runoff from entering the groundwater, and will also prevent sediment from clogging the infiltrating pond bottom areas. Tertiary treatment will be provided within grass swales in the ponds and in the roadside ditches. The Stormceptor drainage areas are as indicated on Figure 1, and sizing calculations are provided in Appendix C.

A Stormceptor OGS unit (STC 6000) will be installed to provide water quality control for flows entering Pond A from areas 201 and 204 on Figure 1. The total drainage area to this OGS is 3.365 ha (50 percent impervious). Based on output from the Stormceptor CD Sizing Program software, an STC 6000 unit will provide a TSS removal efficiency of 81 percent for 94 percent of annual flows generated by lands tributary to the unit.

A Stormceptor OGS unit (STC 750) will be installed to provide water quality control for flows entering Pond A from area 202 on Figure 1. The total drainage area to this OGS is 0.487 ha (50 percent impervious). Based on output from the Stormceptor CD Sizing Program software, an STC 750 unit will provide a TSS removal efficiency of 85 percent for 97 percent of annual flows generated by lands tributary to the unit. As noted above, additional treatment will be provided in a vegetated spreader prior to flows discharging to Wetland ‘G’.

Both units meet the Enhanced Protection Level requirements (80 percent TSS removal efficiency). The units should be inspected and cleaned once per year as per the manufacturer’s specifications.

Finally, conventional stormwater quality control measures will not remove salt from runoff, it is therefore recommended that the use of salt be minimized to as great an extent as possible in compliance with any City of Guelph policies and regulations.

12. MONITORING PROGRAMS

Typically, a minimum of two years of monitoring is required for effluent chemistry for water quality features, and for groundwater chemistry as outlined in a preliminary fashion below. After the two-year period, the results of the program will be reviewed to determine if further monitoring is required. If the stormwater management facilities are functioning as per the design, no additional monitoring will be required. **Specific monitoring requirements should be confirmed with the MOE at the Site Plan stage.**

Appendix A12: City-Wide

DATE

TO
COMPANY
EMAIL

FROM
DIVISION IDE
DEPARTMENT ETS

EMAIL
PHONE 519-837-5604
X **XXXX**
FAX 519-822-6194

SUBJECT Stormwater Criteria: (± XXX ha)

NOTE: *The following information is supplied to aid in the engineering or design of a project and is not all-inclusive. The applicant is advised to contact all relevant Departments and Agencies to determine the requirements which pertain to a specific site. All Oil and Grit Separators (OGS) shall be verified by the Canadian Environmental Technology Verification (ETV) program.*

- The City of Guelph's allowable storm outlet rate is: XXXX m^3/s – Guelph Design Storms.
- Sites that do not have a positive outlet must be designed to provide storage on site for twice the five year design storm runoff volume.
- On site control and storage (roof top/parking lot/ponds/superpipes) may be required to attenuate flows.
- For commercial, institutional and high density residential developments, excess runoff for the two year design storm is to be stored underground or on roof tops.
- Excess runoff from the five year design storm may pond in parking areas of least anticipated use to a maximum depth of 0.3m.
- Major storms are to be routed overland to the City's R.O.W. without exceeding a maximum parking lot pond depth of 0.3m. Sites which cannot meet these criteria are required to provide storage on the site for twice the five year design storm runoff volume.
- Clean runoff (roof water) should be directed to pervious areas for infiltration to encourage ground water recharge (Low Impact Development).
- If on-site infiltration is to be incorporated into the design, permeameter tests needs to be conducted in the field (in-situ) using the following methods: Constant Head Double-ring Infiltrometer Method or Guelph Permeameter Method. Refer City Development Engineering Manual (DEM) - Pg. 41 or CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide – Appendix C.
- Any proposed infiltration on-site is to be designed in accordance with the MOE SWM Planning and Design Manual – March 2003.
- For infiltration system design and drawdown calculations, a safety factor should be determined using the CVC/TRCA Low Impact Development Stormwater Management Planning and Design Guide (Appendix C). This rate should be applied to the percolation rate as infiltration systems tend to clog-up over time. The design percolation rate should note exceed 75mm/hr.
- Evaluate infiltration potential on site as it relates to the existing water budget, and recommend measures to meet the goal of maintaining or enhancing groundwater recharge.
- Quality control facilities are required to remove suspended solids (oil and grit) from areas draining driveways and parking lots (i.e. oil/grit interceptors, catch basins, and vegetative buffer strips or a combination thereof). Please note that Goss traps are not acceptable for areas larger than $250m^2$.
- The minimum acceptable water quality level for discharge to the municipal collection system is **70% TSS removal or an enhanced level 80% TSS removal – depending on receiving water course.**
- The SWM report must include an erosion and sedimentation control plan to be employed during construction of the project.
- Stormwater management designs for sites may require the Ministry of the Environment, Conservation and Parks (MECP) approval. *The applicant is to contact the MECP directly to determine the Ministry's requirements for the site.*
- Any end-of-pipe stormwater management facility design must conform to the City of Guelph design guidelines.
- Existing overland drainage patterns from adjoining properties must be maintained and shown on the submitted drawing.
- A Professional Engineer must certify the design and construction of the SWM facility.

We require that the SWM modelling be submitted in Miduss format using the Horton Equation as this enables our office to complete our review in a timely fashion. The SWM Report is to show system performance for the 5 year and 100 year design storms and must include scale drawings showing drainage catchment areas, delineated pond limits for the 5yr and 100yr design storms (where applicable) and a schematic diagram reflecting the model (complex models).

City of Guelph design storm hyetographs and Miduss stormwater modelling parameters for the design storms and Miduss Guelph design storm electronic files are available upon request.

Should Miduss software not be available, the City of Guelph will permit the stormwater design to be submitted using the Rational Method clearly demonstrating all work and including storm sewer design sheet.

Apartments – 295 u/ha	7 L/s/ha
High Density Apartments (Re-development Area)	7 L/s/ha

Some site specific factors may require additional calculations as directed by City staff.

2. Minimum sanitary sewer diameter is 200 mm.
3. A roughness coefficient of 0.013 to be used for all pipe sizes and types.
4. Unless otherwise specified in the Official Plan, all development applications must receive sanitary services via City infrastructure (i.e., no private services such as septic are allowed).
5. Designs must be completed in a manner that eliminates any potential surcharging in the sanitary system.
6. Sanitary calculations to be made on City Design Sheets and submitted so that each sheet may be filed separately, with the subdivision name in the upper right hand corner of each sheet.
7. All developments shall be designed such that any new building is constructed at such an elevation that the lowest level of the new building can be serviced with a gravity connection to the sanitary sewer.

5.7 Stormwater Management

Stormwater management is generally comprised of lot level source control, conveyance control and end-of-pipe control. The City encourages at-source lot level control using low impact development (LID) best management practices, where appropriate.

The minor flow (i.e. 5 year return period) stormwater management system comprising street gutters, catchbasins and storm sewers is discussed in Section 5.5.

The major flow is overland flow in excess of the minor system capacity during periods of surcharging or higher intensity events. The major system overland flow route to the stormwater management (SWM) facilities shall be designed to safely convey the 100 year storm and Hurricane Hazel overland flow. The major system inherently comprises the minor system, as well as the overland route followed by runoff not captured by the minor system.

In practice, streets act as components of the major system during severe floods since they transport the runoff in excess of the storm sewer capacity.

5.7.1 Water Quantity Control Criteria:

Under circumstances where watershed water quantity control criteria exist, the proposed development will be required to comply with their recommendations. For properties where there is no watershed study quantity control criterion available, post-development peak flows shall be controlled to pre-development (existing) levels for the 2 year through 100 year storm events.

5.7.2 Water Quality Control Criteria

All developments shall provide as a minimum the Enhanced level of protection (i.e. 80% TSS removal)

5.7.3 Oil and Grit Separators

All Oil and Grit Separators (OGS) shall be verified by the Canadian Environmental Technology Verification (ETV) program.

All stormwater management facilities (i.e. dry pond, wet pond, and wetland) require a forebay for quality control, OGS products are only permitted as a pre-treatment device. For small development sites ≤ 2ha where a water quality control pond/wetland is not feasible OGS units are permitted as part of a treatment train approach, OGS units operating alone will be considered as capable of achieving a TSS removal efficiency of 50%.

5.7.4 Erosion Control Criteria

For all development sites the minimum erosion control requirement is extended detention of the 4 hour, 25mm Chicago distribution rainfall event for 24 hours.

5.7.5 Thermal Impacts

Assessing, preventing and mitigating thermal impacts on the receiving Stormwater system shall be considered as an integral part of stormwater management. The Hanlon Creek Subwatershed and the Clythe Creek Subwatershed support cold water fish habitat therefore developments in these subwatersheds are required to assess the thermal impact and implement thermal preventive and mitigation measures.

Preventive measures include reduction of runoff and increase infiltration at lot level, use of thermal conductive pipe material (i.e. concrete pipes) for better heat exchange between subsoil and storm runoff, and minimize direct sun exposure to

the stormwater management pond, with pond orientation, pond shape, planting, shading trees etc.

Mitigation measures should be implemented in conjunction with the preventive measures. Examples of mitigation include mid draw outlets and cooling trenches. A mid draw outlet can be effective for deeper stormwater management ponds (i.e. greater than 3m deep). A mid draw outlet could help by releasing cooler water, and avoid releasing potential high concentrations of chlorides at the bottom of the pond.

Cooling trench:

- Buried in the ground with deep cover (approximately 2m) to provide cooling during and between events by allowing the flow to mix with cooler groundwater.
- Large surface areas of solid media and/or long contact times are required as transfer of heat to ground and groundwater is slow.
- Trench should be installed perpendicular to the groundwater flow.
- Outlet invert must be designed above the seasonal high groundwater to continue natural flow path of groundwater towards the receiving water bodies.
- Trench sizing should provide approximately the same volume as the runoff being treated to capture the heat in the 25mm runoff event.

5.7.6 Water Balance Criteria

Water balance analysis is required for all developments to maintain predevelopment recharge rate, volume and hydroperiods at post development conditions.

A site-specific monthly water balance analysis shall be conducted based on available local meteorological data such as, precipitation, temperature and sunshine hours, etc., to estimate changes in evapotranspiration, recharge and runoff volume caused by the alteration made in canopy cover, percent impervious, depression storage, and rate of runoff at post-development conditions.

Site-specific monthly water balance calculations shall be completed using the water balance method developed by Thornthwaite and Mather (1956) as documented in the MECP Stormwater Management Planning and Design Manual (2003), as updated from time to time.

Low Impact Development (LID) best management practices (BMP) shall be used to mitigate the development's impact on the water balance and mimic pre-development recharge.

5.7.7 Infiltration Testing

Infiltration tests are to be conducted in the field (in-situ). Laboratory tests or grain size analysis are not an acceptable alternative to infiltration field testing

It is recommended that soil evaluation and investigation be conducted following development of a concept plan or early in the development of a preliminary plan to identify suitable areas for infiltration. The approximate location of the BMPs should be shown on the proposed development plan and serve as the basis for the location and number of tests to be performed onsite. If a later proposed site layout plan causes potential BMP locations to be eliminated or relocated, the designer must revisit the proposed layout and grading plan and adjust the development plan as necessary.

The use of soil borings as a substitute for test pits is strongly discouraged, as visual observation is narrowly limited in a soil boring and the soil horizons cannot be observed in-situ, but must be observed from the excavated borings. Test pits should provide information related to conditions at least 1.5m below proposed bottom elevation of the infiltration BMP.

A minimum of one on-site infiltration test shall be conducted at the proposed bottom elevation of each infiltration BMP. In addition, one on-site infiltration test shall be conducted at every other soil horizon encountered within 1.5 meters below the proposed bottom elevation.

One of the following methods are to be used to determine the field saturated hydraulic conductivity (Ks):

a. Guelph Permeameter method (Constant head well permeameter method); and

b. Constant head double-ring infiltrometer method.

For further details please see the multi-step infiltration testing protocol as documented in the Credit Valley Conservation (CVC) Authority Low Impact Development Stormwater Management Planning and Design Guide, "APPENDIX C-SITE EVALUATION AND SOIL TESTING PROTOCOL FOR STORMWATER INFILTRATION CREDIT VALLEY CONSERVATION (CVC) AUTHORITY STORMWATER MANAGEMENT CRITERIA".

Appendix B: Draft Consolidated Linear Environmental Compliance Approval Stormwater Management Criteria (September 22, 2021)

Applicability of Criteria

1.1 The criteria listed under Table A1 of the Appendix applies to all drainage areas greater than 0.1 ha, with the construction erosion and sediment control criteria applying also to sites <0.1 ha;

1.2 Despite condition 1.1 of Appendix A, if some or all of the criteria listed under Table A1 of the Appendix have been assessed for and addressed in other adjacent developed lands to the project site through a subwatershed plan or equivalent study, then those criteria may not be applicable to the project site.

Table A1. Performance Criteria

Water Balance [1]	**FOR DEVELOPMENT SCENARIOS** [2] **Assessment Studies:** i) Control [3] as per the criteria identified in the water balance assessment completed in one or more of the following studies, if undertaken: a watershed/subwatershed plan; s*ource protection plan* (Assessment Report component); Master Stormwater Management Plan, Master Environmental Servicing Plan; Class EA or similar approach that transparently considers social, environmental and financial impacts; or local site study including natural heritage, Ecologically significant Groundwater Recharge Areas (EGRA), inflow and infiltration strategies. The assessment should include sufficient detail to be used at a local site level and consistent with the various level of studies; OR **IF Assessment Studies in i) NOT completed:** ii) Control [3] the recharge [4] to meet pre-development [5] conditions on property; **OR** iii) Control [3] the runoff from the 90th percentile storm event. **Lake Simcoe Watershed Municipalities:** iv) Control [3] as per the evaluation of anticipated changes in water balance between pre-development and post-development assessed through a stormwater management plan in support of an application for Major Development [6]. The assessment should include sufficient detail to be used at a local site level. If it is demonstrated, using the approved water balance estimation methods [7], that the site's post to pre-development water balance cannot be met, and Maximum Extent Possible [8] has been attained, the proponent may use Lake Simcoe and Region Conservation Authority's (LSRCA) Recharge Compensation Program [9]. **FOR RETROFIT SCENARIOS** [10]

	Assessment Studies: i) Control as per criteria identified in the water balance assessment completed in one or more of the following studies: a watershed/subwatershed plan, s*ource protection plan* (Assessment Report component), Master Stormwater Management Plan, Master Environmental Servicing Plan, Class EA, or local site study including natural heritage, EGRA, inflow and infiltration strategies, if undertaken. The assessment should include sufficient detail to be used at a local site level and consistent with the various level of studies; **OR** ii) If constraints [11] identified in i), then control [3] as per Maximum Extent Possible [8] based on environmental site feasibility studies. **IF Assessment Studies in i) NOT completed:** iii) Control [3] the recharge [4] to meet pre-development [5] conditions on property; **OR** iv) Control [3] the runoff from the 90th percentile storm event.
Water Quality [1]	**FOR DEVELOPMENT SCENARIOS** [2] **General:** i) Characterize the water quality to be protected and *stormwater* contaminants (e.g. suspended solids, nutrients, bacteria, water temperature) for potential impact on the *natural environment*, and control as necessary, **OR** ii) As per the watershed/subwatershed plan, similar area-wide stormwater study or stormwater management plan to minimize, or, where possible, prevent increases in contaminant loads and impacts to receiving waters. **Suspended Solids:** v) Control [3] 90th percentile storm event and if conventional methods are necessary, then 80%, 70% or 60% suspended solids removal (based on the receiver) as per the full ETV Canada particle size distribution. (Not to be confused with USEPA ETV program) **Phosphorus:** i) Minimize existing phosphorus loadings to Lake Erie and its tributaries, as compared to 2018 or conditions prior to the proposed development, **OR** ii) Minimize phosphorus loadings to Lake Simcoe and its tributaries. Proponents with development sites located in the Lake Simcoe watershed shall evaluate anticipated changes in phosphorus loadings between pre-development and post-development through a stormwater management plan in support of an application for Major Development [6]. The assessment should include sufficient detail to be used at a local site level. If, using the approved phosphorus budget tool [12], it is demonstrated that the site's post to pre-development phosphorus budget cannot be met, and Maximum Extent Possible [8] has been attained, the proponent may use LSRCA's Phosphorus Offsetting Policy [9].

	FOR RETROFIT SCENARIOS [10] i) Improve the level of water quality control currently provided on site; **AND** ii) As per the 'Development' criteria for Suspended Solids **OR** iii) **If 'Development' criteria for Suspended Solids cannot be met**, *Works* are designed as a multi-year retrofit project, in accordance with a rehabilitation study or similar area-wide stormwater study, such that the completed treatment train will achieve the 'Development' criteria for Suspended Solids, within ten (10) years; **OR** iv) If constraints [11] identified in ii) and iii), then control [3] as per Maximum Extent Possible [8] based on environmental site feasibility studies. vi)
Erosion Control (Watershed) [1]	**FOR DEVELOPMENT SCENARIOS** [8] i) As per erosion assessment completed in watershed/subwatershed plan, Master Stormwater Management Plan, Master Environmental Servicing Plan, Drainage Plan, Class EA, local site study, geomorphologic study or erosion analysis; **OR** ii) As per the Detailed Design Approach or Simplified Design Approach methods described in the MECP 2003 SWM Manual: a. The Detailed Design Approach may be selected by the proponent for any development regardless of size and location within the watershed provided technical specialists are available for the completion of the technical assessments; or considered more appropriate than the simplified approach given the size and location of the development within the watershed and the sensitivity of the receiving waters in terms of morphology and habitat function. b. The Simplified Design Approach may be adopted for watersheds whose development area is generally less than twenty hectares AND either one of the following two conditions apply: 1) The catchment area of the receiving channel at the point-of-entry of *stormwater* drainage from the development is equal to or greater than twenty-five square kilometres; or 2) Meets the following conditions: • The channel bankfull depth is less than three quarters of a metre; • The channel is a headwater stream; • The receiving channel is not designated as an Environmentally Sensitive Area (ESA) or Area of Natural or Scientific Interest (ANSI) and does not provide habitat for a sensitive aquatic species; • The channel is stable to transitional; and • The channel is slightly entrenched; **OR** iii) In the absence of a guiding study, detain at minimum, the runoff volume generated from a 25 mm storm event over 24 to 48 hours. **FOR RETROFIT SCENARIOS** [10]

	vii) If approaches i-iii) under 'Development Scenarios' are not feasible as per identified constraints [11], then improve the level of erosion control [3] currently provided on site to Maximum Extent Possible [8] based on environmental site feasibility studies.
Water Quantity (Minor and Major System) [1]	viii) As per municipal standards, Master Stormwater Management Plan, Class EA, Individual EA and/or ECA, as appropriate for the type of project [13]
Flood Control (Watershed Hydrology) [1]	**FOR DEVELOPMENT SCENARIOS** [2] ix) Manage peak flow control as per watershed/subwatershed plans, municipal criteria being a minimum 100 year return storm (except for site-specific considerations and proximity to receiving water bodies), municipal guidelines and standards, Individual/Class EA, *ECA*, Master Plan, as appropriate for the type of project [13]. **FOR RETROFIT SCENARIOS** [10] x) If approaches i) under 'Development Scenarios' are not feasible as per identified constraints [11], then improve the level of flood control [3] currently provided on site to Maximum Extent Possible [8] based on environmental site feasibility studies.
Construction Erosion and Sediment Control	i) Manage construction erosion and sediment control through development and implementation of an erosion and sediment control (ESC) plan. The ESC plan shall: a. Have regard to Canadian Standards Association (CSA) Erosion and Sediment Control Inspection and Monitoring Standard (as amended); OR b. Have regard to Erosion and Sediment Control Guideline for Urban Construction 2019 by TRCA (as amended). ii) Be prepared by a *QP* for sites with drainage areas greater than 5 ha or lower as specified by the owner. iii) Installation and maintenance of the ESC measures specified in the ESC plan shall have regard to CSA W208:20 Erosion and Sediment Control Installation and Maintenance (as amended). iv) For sites with drainage areas greater than 5 ha, a *QP* shall inspect the construction ESC measures, as specified in the ESC plan.
Footnote	1. Where the opportunity exists on your project site or the same subwatershed, reallocation of development elements may be optimal for management as described in footnote [3]. 2. Development includes new development, redevelopment, infill development, or conversion of a rural cross-section into an urban cross-section 3. *Stormwater* volumes generated from the geographically specific 90th percentile rainfall event on an annual average basis from all surfaces on the entire site are targeted for control. Control is in the following hierarchical order, with each step exhausted before proceeding to the next: 1) retention (infiltration, reuse or evapotranspiration), 2) *LID* filtration, and 3) conventional stormwater management. Step 3, conventional stormwater management, should proceed only once Maximum Extent Possible [8] has been attained for Steps 1 and 2 for retention and filtration.

	4. Recharge is the infiltration and movement of surface water into the soil, past the vegetation root zone, to the zone of saturation or water table. 5. Pre-development is defined as the more stringent of the two following scenarios: 1) a site's existing condition, or 2) as defined by the local municipality. 6. Major Development has the same meaning as in the Lake Simcoe Protection Plan, 2009. 7. Currently, the approved tool by LSRCA for calculating the water balance is the Thornthwaite-Mather Method. Other tools agreed upon by relevant approval agencies (e.g. LSRCA, municipality or *Ministry*) may also be acceptable, subject to written acceptance by the Director 8. Maximum Extent Possible means maximum achievable stormwater volume control through retention and *LID* filtration engineered/landscaped/technical stormwater practices, given the site constraints [11]. 9. See MECP Guide for ECA Application for more background information. 10. Retrofit means: 1) a modification to the management of the existing infrastructure, 2) changes to major and minor systems, or 3) adding *stormwater* infrastructure, in an existing area on municipal right-of-way, municipal block or easement. It does not include conversion of a rural cross-section into an urban cross-section. 11. Site constraints must be documented. A list of site constraints can be found in Table A2. 12. Tools for calculating phosphorus budgets may include the *Ministry*'s Phosphorus Tool, the Low Impact Development Treatment Train Tool developed in partnership by TRCA, LSRCA and Credit Valley Conservation (CVC), or other tools agreed upon by the LSRCA and other relevant approval agencies including the municipality. 13. Possible to look at combined grey infrastructure and *LID* system capacity jointly.

Table A2. Stormwater Management Practices Site Constraints

Site Constraints	
a)	Shallow bedrock [1], areas of blasted bedrock [2], and Karst;
b)	High groundwater [1] or areas where increased infiltration will result in elevated groundwater levels which can be shown through an appropriate area specific study to impact critical utilities or property (e.g., susceptible to flooding);
c)	Swelling clays [3] or unstable sub-soils;
d)	Contaminated soils (e.g. brownfields);
e)	High Risk Site Activities including spill prone areas;
f)	Prohibitions and or restrictions per the approved source protection plans and where impacts to private drinking water wells and /or Vulnerable Domestic Well Supply Areas cannot be appropriately mitigated;
g)	Flood risk prone areas or structures and/ or areas of high inflow and infiltration (I/I) where wastewater systems (storm and sanitary) have been shown through technical studies to be sensitive to groundwater conditions that contribute to extraneous flow rates that cause property flooding / sewer back-ups and where LID Best Management Practices have been found to be ineffective;
h)	For existing municipal rights-of-way infrastructure (e.g. roads, sidewalks, utility corridor, sewers, LID, trails) where reconstruction is proposed and where surface and subsurface areas are not available based on a site-specific assessment completed by a QP.
i)	For developments within partially separated wastewater systems where reconstruction is proposed and where based on a site-specific assessment completed by a QP can be shown to: i Increase private property flood risk liabilities that cannot be mitigated through design; ii Impact pumping and treatment cost that cannot be mitigated through design; or iii Increase risks of structural collapse of sewer and ground systems due to infiltration and the loss of pipe and/or pavement support that cannot be mitigated through design.
j)	Surface water dominated or dependent features including but not limited to marshes and/or riparian forest wetlands which derive all or a majority of their water from surface water, including streams, runoff, and overbank flooding. Surface water dominated or dependent features which are identified through approved site specific hydrologic or hydrogeologic studies, and/or Environmental Impact Statements (EIS) may be considered for a reduced volume control target. Pre-consultation with the MECP and local agencies is encouraged;
k)	Existing urban areas where risk to water distribution systems has been identified through assessments to meet applicable drinking water requirements, including Procedures F-6 and F-6-1, and substantiated by a QP through an appropriate area specific study and where the risk cannot be reasonably mitigated per the relevant design guidelines;
l)	Existing urban areas where risk to life, human health, property or infrastructure has been is identified and substantiated by a QP through an appropriate area specific study and where the risk cannot be reasonably mitigated per the relevant design guidelines;

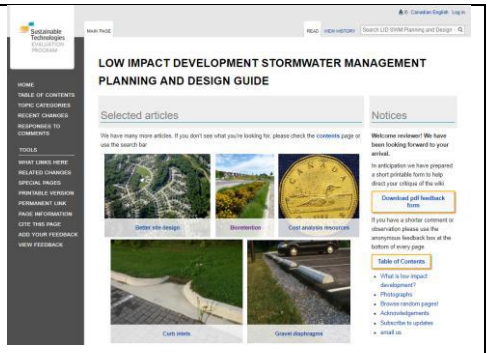
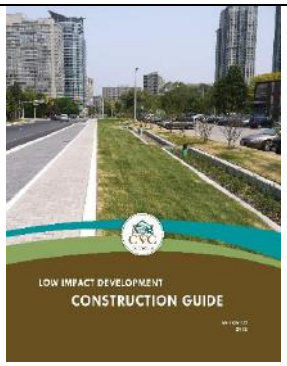
m) Water reuse feasibility study has been completed to determine non-potable reuse of stormwater for onsite or shared use.
n) Economic considerations set by infrastructure feasibility and prioritization studies undertaken at either the local/site or municipal/system level [4]
Footnote: 1. May limit infiltration capabilities if bedrock and groundwater is within 1m of the proposed facility invert per Table 3.4.1 of the LID Stormwater Planning and Design Guide (2010, V1.0 or most recent by TRCA/CVC). Detailed assessment or studies are required to demonstrate infiltration effects and results may permit relaxation of the minimum 1m offset. 2. Where blasting is more localized, this constraint may not be an issue elsewhere on the property. While infiltration-based practices may be limited in blasted rock areas, other forms of LID, such as filtration, evapotranspiration, etc., are still viable options that should be pursued. 3. Swelling clays are clay soils that is prone to large volume changes (swelling and shrinking) that are directly related to changes in water content. 4. Infrastructure feasibility and prioritization studies should comprehensively assess stormwater site opportunities and constraints to improve cost effectiveness, environmental performance and overall benefit to the receivers and the community. The studies include assessing and prioritizing municipal infrastructure for upgrades in a prudent and economically feasible manner.

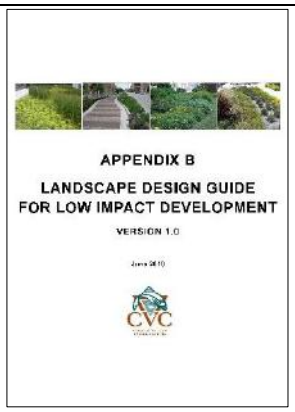
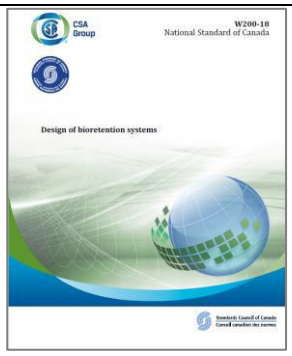
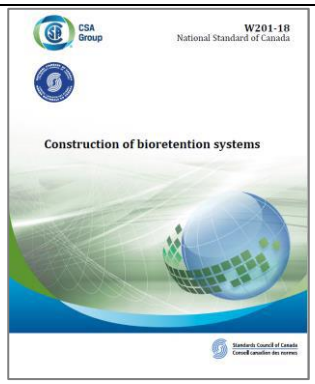
Appendix C: High Risk Site Activities

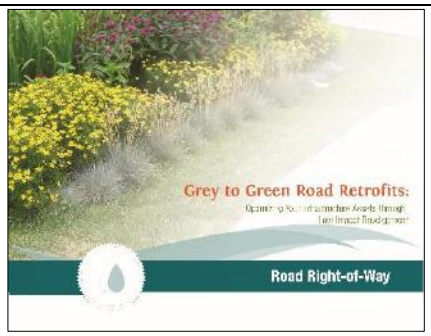
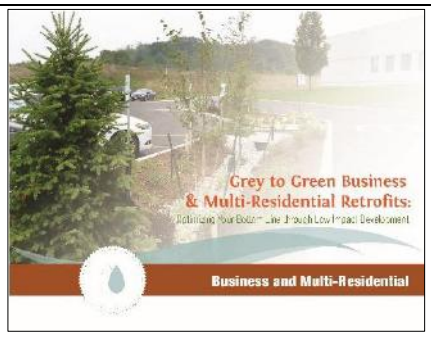
High Risk Site Activities

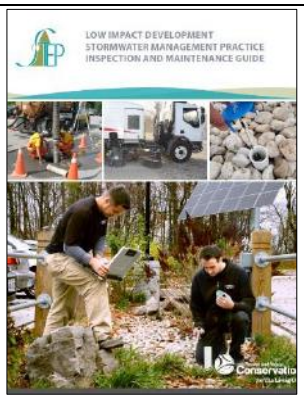
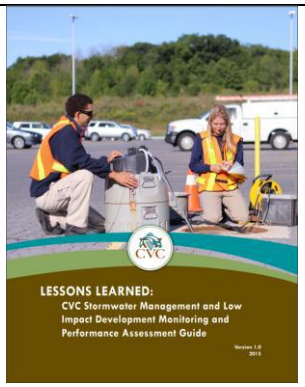
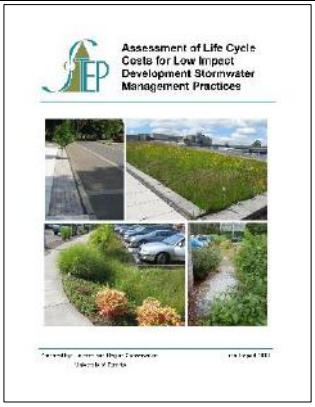
Potentially Contaminating Activities (O.Reg. 153/04 Table 2)		
• Acid and Alkali Manufacturing, Processing and Bulk Storage • Adhesives and Resins Manufacturing, Processing and Bulk Storage • Airstrips and Hangars Operation • Antifreeze and De-icing Manufacturing and Bulk Storage • Asphalt and Bitumen Manufacturing • Battery Manufacturing, Recycling and Bulk Storage • Boat Manufacturing • Chemical Manufacturing, Processing and Bulk Storage • Coal Gasification • Commercial Autobody Shops • Commercial Trucking and Container Terminals • Concrete, Cement and Lime Manufacturing • Cosmetics Manufacturing, Processing and Bulk Storage • Crude Oil Refining, Processing and Bulk Storage • Discharge of Brine related to oil and gas production • Drum and Barrel and Tank Reconditioning and Recycling • Dye Manufacturing, Processing and Bulk Storage • Electricity Generation, Transformation and Power Stations • Electronic and Computer Equipment Manufacturing • Explosives and Ammunition Manufacturing, Production and Bulk Storage • Explosives and Firing Range • Fertilizer Manufacturing, Processing and Bulk Storage	• Fire Retardant Manufacturing, Processing and Bulk Storage • Fire Training • Flocculants Manufacturing, Processing and Bulk Storage • Foam and Expanded Foam Manufacturing and Processing • Garages and Maintenance and Repair of Railcars, Marine Vehicles and Aviation Vehicles • Gasoline and Associated Products Storage in Fixed Tanks • Glass Manufacturing • Importation of Fill Material of Unknown Quality • Ink Manufacturing, Processing and Bulk Storage • Iron and Steel Manufacturing and Processing • Metal Treatment, Coating, Plating and Finishing • Metal Fabrication • Mining, Smelting and Refining; Ore Processing; Tailings Storage • Oil Production • Operation of Dry-Cleaning Equipment (where chemicals are used) • Ordnance Use • Paints Manufacturing, Processing and Bulk Storage • Pesticides (including Herbicides, Fungicides and Anti-Fouling Agents) Manufacturing, Processing, Bulk Storage and Large-Scale Applications • Petroleum-derived Gas Refining, Manufacturing, Processing and Bulk Storage • Pharmaceutical Manufacturing and Processing	• Plastics (including Fibreglass) Manufacturing and Processing • Port Activities, including Operation and Maintenance of Wharves and Docks • Pulp, Paper and Paperboard Manufacturing and Processing • Rail Yards, Tracks and Spurs • Rubber Manufacturing and Processing • Salt Manufacturing, Processing and Bulk Storage • Salvage Yard, including automobile wrecking • Soap and Detergent Manufacturing, Processing and Bulk Storage • Solvent Manufacturing, Processing and Bulk Storage • Storage, maintenance, fuelling and repair of equipment, vehicles, and material used to maintain transportation systems • Tannery • Textile Manufacturing and Processing • Transformer Manufacturing, Processing and Use • Sewage Treatment and Sewage Holding Facilities • Vehicles and Associated Parts Manufacturing • Waste Disposal and Waste Management, including thermal treatment, landfilling and transfer of waste, other than use of biosoils as soil conditioners • Wood Treating and Preservative Facility and Bulk Storage of Treated and Preserved Wood Products
Prescribed Drinking Water Threats (O.Reg. 287/07)		
• The establishment, operation or maintenance of a waste disposal site within the meaning of Part V of the Environmental Protection Act. • The establishment, operation or maintenance of a system that collects, stores, transmits, treats or disposes of sewage. • The application of agricultural source material to land. • The storage of agricultural source material. • The management of agricultural source material. • The application of non-agricultural source material to land. • The handling and storage of non-agricultural source material.	• The application of commercial fertilizer to land. • The handling and storage of commercial fertilizer. • The application of pesticide to land. • The handling and storage of pesticide. • The application of road salt. • The handling and storage of road salt. • The storage of snow. • The handling and storage of fuel. • The handling and storage of a dense non-aqueous phase liquid. • The handling and storage of an organic solvent.	• The management of runoff that contains chemicals used in the de-icing of aircraft. • An activity that takes water from an aquifer or a surface water body without returning the water taken to the same aquifer or surface water body. • An activity that reduces the recharge of an aquifer. • The use of land as livestock grazing or pasturing land, an outdoor confinement area or a farm-animal yard. • The establishment and operation of a liquid hydrocarbon pipeline. O. Reg. 385/08, s. 3; O. Reg. 206/18, s. 1.
Other Threats		
• Anthropogenically contaminated soils that have not been fully remediated		
Uses within the site boundaries which would preclude infiltration for the identified catchment where the High-Risk use is taking place. Infiltration of roof water is not limited by high-risk site use.		

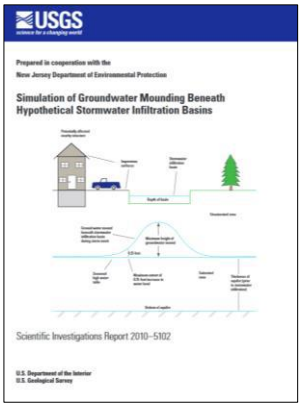
Appendix D: Stormwater, Pollution Prevention and Low Impact Development Resources

Planning and Design Guide	**Low Impact Development Stormwater Management Planning and Design Guide (Sustainable Technologies Evaluation Program)** Wiki Version: https://wiki.sustainabletechnologies.ca Version 1.0 (2010): https://sustainabletechnologies.ca/app/uploads/2013/01/LID-SWM-Guide-v1.0_2010_1_no-appendices.pdf	
Planning Guide	**Grey to Green Enhanced Stormwater Management Master Planning: Guide to Optimizing Municipal Infrastructure Assets and Reducing Risk (CVC)** https://cvc.ca/document/grey-to-green-enhanced-stormwater-management-master-planning-guide-to-optimizing-municipal-infrastructure-assets-and-reducing-risk/	
Planning & Design Fact Sheets	**Low Impact Development Stormwater Management Planning and Design Guide, including Fact Sheets:** https://sustainabletechnologies.ca/app/uploads/2013/02/LID-SWM-Guide-v1.0_2010_Appendix-A.pdf	
Construction Guide	**Construction Guide for Low Impact Development (CVC, 2012, Version 1.0)** https://cvc.ca/document/construction-guide-for-low-impact-development/	

Landscape Design Guide	**Landscape Design Guide for Low Impact Development (CVC – Version 1.0)** https://sustainabletechnologies.ca/app/uploads/2013/02/LID-SWM-Guide-v1.0_2010_3_Appendix-B_Landscape-Design-Guide-for-LID.pdf	
Permeable Interlocking Concrete Pavement Standard	**ASCE/ T&DI/ ICPS 68-18 Permeable Interlocking Concrete Pavement (North American Standard) (2018)** https://ascelibrary.org/doi/book/10.1061/9780784415009	
CSA Standard – Bioretention Design	**NSC/CSA W200 Design of Bioretention Systems – Canadian Standards Association (2018)** https://www.csagroup.org/store/product/W200-18/	
CSA Standard – Bioretention Construction	**NSC/CSA W201 Construction of Bioretention Systems - Canadian Standards Association (CSA) (2018)** https://www.csagroup.org/store/product/W201-18/	

Roads Retrofit Design Guide	**Low Impact Development Road Retrofits: Optimizing Your Infrastructure Assets through Low Impact Development (CVC)** https://cvc.ca/wp-content/uploads//2021/07/Grey-to-Green-Road-ROW-Retrofits-Complete_1.pdf	
Business & Multi- Res. Retrofit Design Guide	**Grey to Green Business & Multi- Residential Retrofits: Optimizing Your Infrastructure through Low Impact Development (CVC)** https://cvc.ca/wp-content/uploads//2021/07/SWI-Grey-to-Green-Business-Multires-Retrofits-Complete1.pdf	
Residential Retrofit Design Guide	**Low Impact Development Residential Retrofits: Engaging Residents to Adopt Low Impact Development in their Properties (CVC)** https://cvc.ca/wp-content/uploads//2021/07/Grey-to-Green-Residential-Guide1.pdf	
Public Lands Retrofit Design Guide	**Grey to Green Public Lands Retrofits: Optimizing Parks, Public Buildings, Schools and Places of Worship through Low Impact Development (CVC)** https://cvc.ca/wp-content/uploads//2021/07/Grey-to-Green-Public-Lands-Retrofits-Complete_3.pdf	

Inspection and Maintenance Guide	**Low Impact Development Stormwater Management Practice Inspection and Maintenance Guide (TRCA/ STEP, 2016, Version 1.0)** https://sustainabletechnologies.ca/home/urban-runoff-green-infrastructure/low-impact-development/low-impact-development-stormwater-practice-inspection-and-maintenance-guide/	
Monitoring and Performance Assessment Guide	**Stormwater Management and Low Impact Development Monitoring and Performance Assessment Guide – Version 1.0 – 2015** https://cvc.ca/wp-content/uploads/2021/08/Monitoring_Guide_Final.pdf	
LID Treatment Train Tool	**Low Impact Development Treatment Train Tool** https://sustainabletechnologies.ca/low-impact-development-treatment-train-tool/	
Life Cycle Costs Report	**Assessment of Life Cycle Costs for Low Impact Development Stormwater Management Practices (TRCA, UofT, 2013)** https://sustainabletechnologies.ca/app/uploads/2013/06/LID-LCC-final-2013.pdf	

Costing Tool	**Low Impact Development Life Cycle Costing Tool (STEP)** http://www.sustainabletechnologies.ca/wp/home/urban-runoff-green-infrastructure/low-impact-development/low-impact-development-life-cycle-costs/	
Groundwater Mounding Analysis	Simulation of Groundwater Mounding Beneath Hypothetical Stormwater Infiltration Basins https://pubs.usgs.gov/sir/2010/5102/ https://pubs.usgs.gov/sir/2010/5102/support/Hantush_USGS_SIR_2010-5102-1110.xlsm	
LID Performance Resources	**Sustainable Technologies Evaluation Program available** http://www.sustainabletechnologies.ca/wp/publications/ **LID BMP monitoring plans, technical reports and case studies** https://sustainabletechnologies.ca/home/urban-runoff-green-infrastructure/ **International Stormwater BMP Database** https://bmpdatabase.org/home	
Other Resources and Reports		

	Sustainable Technologies Evaluation Program (STEP): www.sustainabletechnologies.ca/ **Resources, Studies and Reports** 1. Green Infrastructure Map 2. Stormwater Infiltration in Cold Climates Review (2009) 3. Stormwater Management and Watercourse Impacts: The Need for a Water Balance Approach 4. Preserving and Restoring Healthy Soil: Best Practices for Urban Construction 5. LID Discussion Paper 6. Urban Water Balance 7. LID "Barrier Buster" fact sheet series **Features Studies and Resources:** 1. Bioretention and Rain Gardens 2. Green Roofs 3. Soakaways, Infiltration Trenches and Chambers 4. Permeable Pavement 5. Swales and Roadside Ditches 6. Perforated Pipe Systems 7. Rainwater Harvesting 8. Residential Stormwater Landscaping 9. Water Balance for the Protection of Natural Features