Submitted to:
Municipality of Clarington

Robinson Creek and Tooley Creek Subwatershed Study

Phase 2 and 3 Report

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1 Introduction

The Robinson Creek and Tooley Creek watersheds are located within the Regional Municipality of Durham, in the Municipality of Clarington (**Figure 1.1**). The Robinson Creek and Tooley Creek watersheds are two of the smallest subwatersheds located within the Municipality of Clarington with areas of approximately 570 ha and 1050 ha, respectively. Both watersheds are especially vulnerable to the effects of land use and the impacts of development due to their small size.

This document constitutes **Phases 2 and 3 of the Robinson Creek and Tooley Creek Subwatershed Study (SWS)**, which updates the hydrologic and floodplain models; finalizes constraints mapping; identifies protective measures to protect, enhance or restore environmental features and functions; formulates alternative subwatershed management strategies; evaluates these strategies based on a range of environmental, social and cost considerations, together with stakeholder input; and selects a recommended subwatershed strategy from among the alternatives.

The Municipality of Clarington is a rapidly growing population center located on the shores of Lake Ontario on the eastern side of the Greater Toronto Area (GTA). With a 2016 census population of 92,013, growth is expected to push the population to 124,685 by 2031 (Municipality of Clarington Official Plan, 2018). This represents a growth of 32,687 people, or an increase in the population of 35.5%. While this growth represents an opportunity, it also has the potential to cause significant impact to the local environment which has already been greatly influenced by agricultural cultivation and expanding urban development.

In 2010, the Municipality of Clarington retained AECOM to prepare an Existing Conditions Study and Watershed Management Study for the Robinson Creek and Tooley Creek Subwatersheds. The Watershed Management Study, published in 2011 by AECOM, was the basis of a Courtice Employment Lands Secondary Plan, as part of the Clarington Official Plan Review. Since the preparation of these documents, Clarington Council has adopted a new land use policy framework through Amendment No. 107 to the Clarington Official Plan and the consolidation of the plan. As part of the Secondary Planning process for the detailed land uses of these watersheds, a Subwatershed Study is required.

The Subwatershed Study will take an environment-first approach, fulfill the requirements of the Clarington Official Plan (OP) and also inform the preparation of the following Secondary Plans by guiding development in a manner that respects the local natural heritage system, natural hazards and supports long-term environmental sustainability:

- Southeast Courtice Secondary Plan
- Courtice Employment Lands Secondary Plan
- Southwest Courtice Secondary Plan

1.1 Study Area and Land Uses

1.1.1 Subwatershed Study Area

Land use within the Robinson Creek and Tooley Creek Subwatersheds is mainly a mix of active agriculture (row crops and animal pasturage) and expanding urban development progressing from the west and north. The new Highway 418 corridor extends along the eastern edge of the Tooley Creek Subwatershed between Highway 401 to the south and Highway 407 to the north. Lake Ontario is found at the southernmost boundary of both watersheds.

The study area for this subwatershed study includes the full extent of both the Robinson Creek and Tooley Creek watersheds. However, efforts have been focused on the portions of the watersheds that fall within the Courtice Urban Area, shown outlined in red on **Figure 1.1**. Field studies conducted as part of the subwatershed study were limited to the Courtice Urban Area, while information regarding the broader extent of the watersheds and landscape-level analysis was compiled through review of background and desktop information sources.

1.1.2 Robinson Creek Subwatershed

The Robinson Creek watershed, as illustrated in **Figure 1.1**, is one of the smallest watersheds within the Municipality of Clarington, with an approximate area of 570 ha. The headwaters of Robinson Creek originate north of Bloor Street. The Robinson Creek Subwatershed ultimately drains into Lake Ontario, through the Provincially Significant McLaughlin Bay Wetland Complex and Darlington Provincial Park (AECOM, 2010).

Historically, land use throughout this subwatershed was predominately agricultural and urban residential, with small portions of natural and naturalized cover (AECOM, 2011). With the growing community of Courtice within the northern and western limits of the subwatershed, as well as development along the Highway 401 corridor, this subwatershed is becoming increasingly urbanized. Presently, the Robinson Creek Subwatershed is predominately located within the Urban Area of Courtice, and the main land use designations in the subwatershed are for Employment or Residential purposes.

1.1.3 Tooley Creek Subwatershed

As illustrated in **Figure 1.1**, the Tooley Creek Subwatershed is a relatively small subwatershed located within the Municipality of Clarington, with an approximate area of 1050 ha. The Tooley Creek Subwatershed originates near the Lake Iroquois Shoreline at Nash Road (AECOM, 2011). The uppermost headwaters of the Tooley Creek Subwatershed, north of Highway 2, are located within the Provincial Greenbelt and the Provincially Significant Maple Grove Wetland Complex (AECOM, 2010). The Tooley Creek Subwatershed ultimately drains into Lake Ontario through the Tooley Creek Coastal Marsh.

Figure: 1.1

Study Area:
Robinson Creek & Tooley Creek Subwatersheds

Date: July 2019
Datum:NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

Historically, the land use within the Tooley Creek Subwatershed was predominately agricultural with some rural residential land use (AECOM, 2011). Presently, the north and south portions of the subwatershed are located within the Courtice Urban Area, and are designated primarily for Residential and Employment purposes, respectively.

1.1.4 Provincially Designated Areas

Four provincially designated areas are present within or nearby the study area, as shown in **Figure 1.1**. They include:

- **Darlington Provincial Park** – located along the Lake Ontario shore, overlapping the Robinson Creek Subwatershed at the southernmost extent.
- **McLaughlin Bay Coastal Wetland Complex** – Provincially Significant Wetland (PSW) located where Robinson Creek meets Lake Ontario, inside of Darlington Provincial Park. The PSW is located partially within the Robinson Creek Subwatershed but also extends west along the shoreline into McLaughlin Bay.
- **Maple Grove Wetland Complex** – PSW located within the headwaters of the Tooley Creek Subwatershed, north of Hwy 2, and east of the newly constructed Highway that lies between Hancock Road and Solina Road, fully outside of the Urban Boundary.
- **Tooley Creek Coastal Marsh** – an evaluated wetland that does not meet the criteria for a PSW, associated with the riparian zone of Tooley Creek where it meets Lake Ontario.

The provincial Greenbelt also overlaps the Tooley Creek Subwatershed at its northern extent.

1.2 Subwatershed Study Goals, Objectives, and Phasing

The overall goal of this Subwatershed Study may be defined as follows:

> "**Development of a management plan that allows sustainable urban growth, while ensuring maximum benefits to the natural and human environments on a watershed basis.**" – Watershed Planning in Ontario

The Subwatershed Study is undertaken in three phases. The objectives of this study are summarized below, according to the three study phases. **This report has been prepared to present the results for Phases 2 and 3 of the process.**

Phase 1: Subwatershed Characterization

- Identify and evaluate the location, extent, significance, and sensitivity of the existing natural features of the study area, together with their potential interrelationship with other natural features;
- Identify sensitive areas and natural hazard lands, together with recommend buffers, and select preliminary management practices for these lands; and
- Develop preliminary constraints and opportunities mapping to identify developable and non- developable lands which will inform the development and update of Secondary Plans within the Study Area.

Phase 2: Subwatershed Management Strategies

- Identify potential land use impacts to natural features and functions (Impact Assessment);
- Identify protective measures (best management practices, or BMPs) that, when implemented, will protect, enhance or restore environmental features and functions;
- Formulate alternative subwatershed management strategies;
- Evaluate each strategy, based on a range of environmental, social and cost considerations, together with stakeholder input; and
- Select from among the alternatives a recommended subwatershed strategy (or plan).

Phase 3: Implementation and Monitoring Plans

- Develop an Implementation Plan to ensure the long-term integrity of the Recommended Plan, including the identification of issues and areas where further detailed studies may be required at the draft plan of subdivision stage of the planning process;
- Identify any future recommended monitoring studies or contingency plans; and
- Integrate the Subwatershed Study findings with Municipal Official Plan Policy and ongoing Secondary Plans.

1.3 Class Environmental Assessment (EA) Process

This Subwatershed Study is being conducted in the spirit of a Municipal Class Environmental Assessment (Class EA). One public meeting was held at the end of the Phase 1 Subwatershed Study, the other will be held at the end of Phase 3.

The relationship between the components of the Subwatershed Study process and the Class EA process is depicted in **Figure 1.2**.

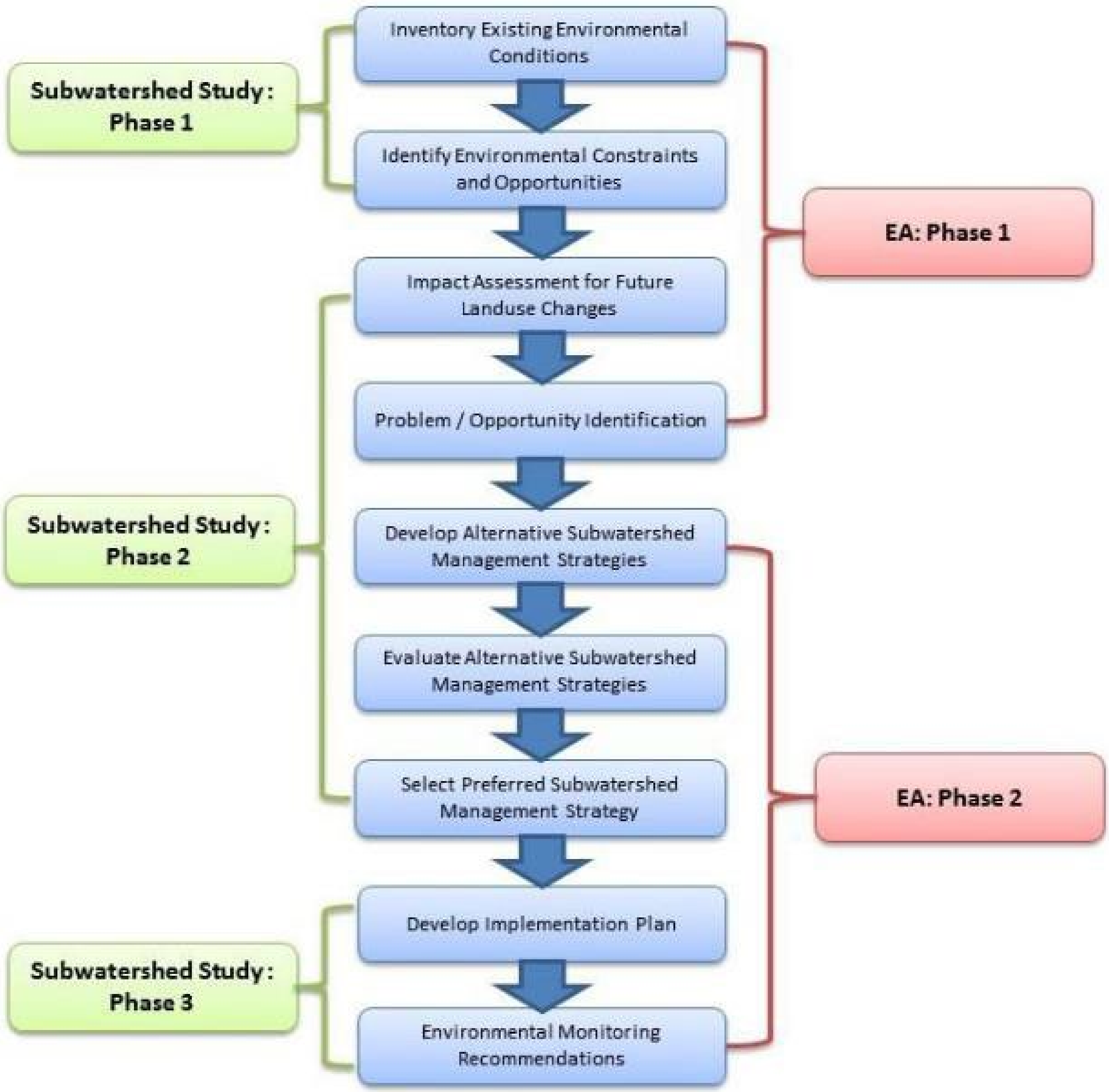

Figure 1.2: Subwatershed Study & Environmental Assessment Study Process

1.4 Secondary Planning within the Robinson and Tooley Subwatersheds

Secondary Plans are land use planning tools that formally address specific opportunities and constraints related to land use in certain defined geographic areas. They are typically undertaken in areas where detailed direction is needed for matters beyond the general framework provided by the Official Plan. Secondary Plans play an important role in the Municipality of Clarington's Official Plan. The preparation or amendment of a Secondary Plan follows the same procedures as an Official Plan Amendment under the Planning Act. This includes the preparation of supporting technical studies, public engagement, notice and holding of public meetings and adoption procedures.

The Clarington Official Plan (Consolidated June 2018), requires that new residential areas greater than 20 ha are to be planned by means of Secondary Plans. This neighbourhood scale planning allows for a more detailed analysis of land use and transportation issues and specific ways to achieve the objectives of the Clarington Official Plan, including meeting density and infill targets.

The preparation of any Secondary Plan requires input from supporting technical studies. The collective recommendations (opportunities and constraints) from these technical studies will influence the developable area of the Secondary Plan, influence the mix and location for the various land uses, as well as recommend design and development parameters. Subwatershed studies are important supporting technical documents to the Secondary Planning process because they establish the base environmental parameters for neighbourhood planning, including not only the natural heritage and hydrological systems but also establish high-level drainage planning for the Secondary Plan Areas. Subwatershed studies include strategies to support the Municipality's Official Plan and identify the responsible management strategies for subwatershed areas with the primary focus of protecting natural ecosystem functions, flooding and erosion. Subwatershed studies analyse the cumulative effects of changes in land use, identify areas of risk, and make recommendations on areas for enhancement to allow for a protected and connected Natural Heritage System.

The Robinson Creek and Tooley Creek Subwatershed Study will primarily inform the preparation of three Secondary Plans. The Secondary Plans are identified in **Figure 1.3**. These secondary plans are:

1) The **Southeast Courtice Secondary Plan** area is partially located in both Robinson Subwatershed and Tooley Subwatershed. This secondary planned area includes two distinct areas that need to be planned comprehensively - the Bloor Street and Courtice Road Regional Corridors and the surrounding residential neighbourhood. The surrounding residential neighbourhoods include the undeveloped portions of the Emily Stowe and Avondale Neighbourhoods and the Ebenezer Neighbourhood located on the east side of Courtice Road between Bloor Street and Highway 2. The total land in this Secondary Plan area is approximately 289 hectares.
2) The **Courtice Transit Oriented Community (CTOC)** was previously known as **Courtice Employment Lands (CEL) Secondary Plan**. For the purposes of this Subwatershed Study, this Secondary Plan will be referred to as the Courtice Employment Lands (CEL). This area is partially located in both Robinson Subwatershed and Tooley Subwatershed. The Courtice Employment Lands is a collection of properties that have all been designated in the Clarington Official Plan for various forms of employment use. This area is situated to take full advantage of the tremendous advances in technology and changes in industry that will shape employment patterns in the coming years. The proposed secondary plan will create a blueprint to guide how this area of Courtice will grow as it transforms into the major employment and innovation centre for Clarington and Durham Region. At the centre of this area is the Courtice Transportation Hub. As a major transit station area, this stop along the GO rail line will be the focal point for the greatest density within the Secondary Plan.

3) The **Southwest Courtice Secondary Plan** area is located northwest of the Courtice Employment Area and south of Bloor Street, extending from the western Robinson Subwatershed boundary to the border of the Courtice Employment Area and the Mid-Courtice Secondary Plan area. The northern portion of this Secondary Plan Area has already been urbanized with residential development but the plan must go through an update to conform with the new Municipality of Clarington Official Plan.

The Clarington Energy Business Park Secondary Plan area is located south of Highway 401 at the southeastern extent of the Tooley Creek Subwatershed, adjacent to the Darlington Nuclear Generating Station. This Secondary Plan, which was adopted in 2006, has recently become the subject of a review and update in order to review current and future usage and update the policy framework applying to the area, however has not been included as a primary focus of the current Subwatershed Study.

Clarington

- Watercourse
- Urban Boundary
- Secondary Plan
- Subwatershed Boundary

Figure: 1.3

Secondary Plan Areas

0 0.25 0.5 1
Kilometers

Date: July 2019
Datum:NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

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2 Subwatershed Planning – Master Plan

The process of Subwatershed Planning has evolved over the last 20-30 years (**Figure 2.1**). The typical Subwatershed Plan of the 1980s, which was commonly termed "Master Drainage Plan", was primarily concerned with two issues; flooding and erosion. In the latter part of the 1980s, the plan evolved and typically dealt with the above issues as well as water quality and occasionally aquatic resources.

Subwatershed Plans have continued to evolve and now deal with numerous inter-related environmental issues including:

- surface water flooding, erosion, and water quality;
- groundwater quantity and quality;
- water budget (groundwater recharge, baseflows and peak flows);
- terrestrial and aquatic habitat;
- wetlands and woodlands, including woodlots and forests;
- Species at Risk;
- environmentally sensitive areas; and
- recreation and aesthetics.

Furthermore, the plans are ecosystem-based, with the potential interaction between each of the environmental features being strongly considered.

Integration of the Land Use Planning Process with Water Resource Management Planning has also evolved over the last 20-30 years. Whereas the historic practice in the mid-eighties involved the development of Official, Secondary and Draft Plans with nominal consideration of environmental consequences; present practice considers the two planning processes in unison.

As a result of ongoing updated policies, this Subwatershed-wide Master Plan becomes an integral part of the overall planning process to provide a solid foundation related to the environmental features that will be protected, enhanced, or restored under present conditions, and as land use changes occur.

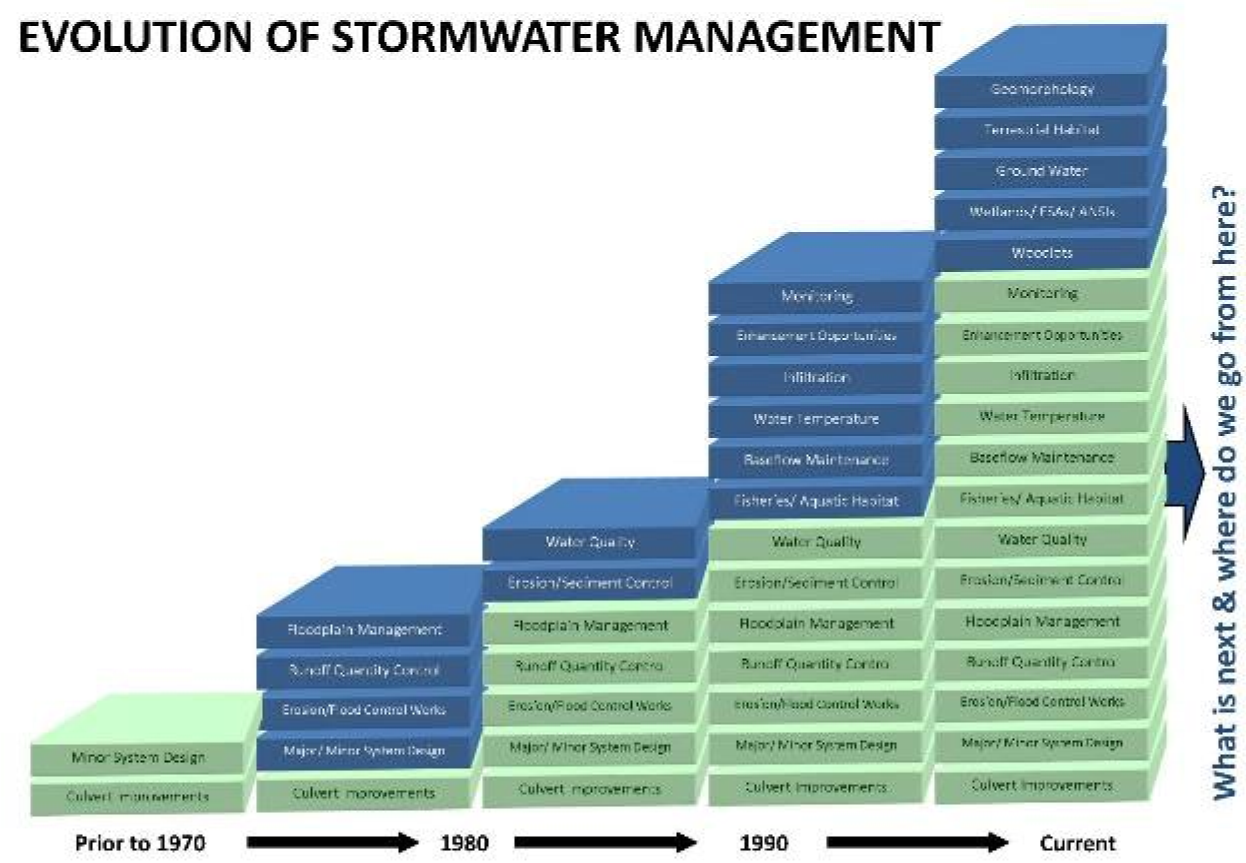


Figure 2.1: The Evolution of Stormwater Management in Ontario (adapted from MECP, 1993)

2.1 Provincial Stormwater Guidance Manuals

The “state-of-the-art” in stormwater management has been evolving rapidly. The MECP’s 2003 Stormwater Management Planning and Design Manual (SWMPDM) provides an integrated approach to stormwater management that has been utilized across the province since its publication. The SWMPDM incorporates water quantity and erosion considerations. The SWMPDM provides technical and procedural guidance for the planning, design, and review of stormwater management practices. The focus of the manual was broadened to incorporate the current multi-objective approach to stormwater facility planning to address targets related to hazards, water quality, fish habitat and recreation. Fundamental stormwater management objectives which are included in the 2003 SWMPDM include:

- Groundwater and baseflow characteristics are preserved;
- Water quality will be protected;
- Watercourses will not undergo undesirable and costly geomorphic change;
- There will not be any increase in flood damage potential; and ultimately,
- That an appropriate diversity of aquatic life and opportunities for human uses will be maintained.

A central theme of the SWMPDM is the application of a "treatment train", a term that is used to describe the combination of controls – source, conveyance and end-of-pipe controls - usually required in an overall stormwater management strategy to ensure that objectives are achieved. The SWMPDM states that:

> "the recommended strategy for stormwater management is to provide an integrated **treatment train approach** to water management that is premised on providing control at the lot level and in conveyance (to the extent feasible) followed by end-of-pipe controls. This combination of controls is the only means of **meeting the multiple criteria for water balance, water quality, erosion control and water quantity**."

The 2003 SWMPDM remains the go-to reference material for end-of-pipe stormwater management criteria and design requirements for wet ponds, constructed wetlands, hybrid wet pond/wetland systems, dry ponds and centralized infiltration facilities.

Since the publication of the 2003 SWMPDM, advancements have been made in the approaches used to manage stormwater and the technologies available to the stormwater practitioner. It is now understood that to effectively mitigate the impacts from urbanization, stormwater strategies must include a means to **reduce runoff volume** with the objective of maintaining the pre-development water balance. To meet the multiple objectives of stormwater management on a broad-scale, it is expected that a combination of source, conveyance and end of pipe controls will be required within Ontario's stormwater systems, an approach that has been supported by CLOCA and the Municipality. To encourage stormwater solutions that treat stormwater as a resource and provide a high level of stormwater quality control, the MECP is in the process of finalizing a LID Stormwater Management Guidance Manual. The draft manual outlines a Runoff Volume Control Target (RVC_T) to be used for new development; similar targets have since been implemented in the Consolidated Linear Infrastructure Environmental Compliance Approval (CLI ECA).

3 Subwatershed Planning and the Secondary Plan Process

The Robinson Creek and Tooley Creek Subwatershed Study was undertaken through an integrated approach with **the Southeast Courtice Secondary Plan** and the **Southwest Courtice Secondary Plan**. The Phase 1 subwatershed characterization report provided a detailed summary of existing conditions associated with subwatershed health and defined constraints to development associated with natural heritage features and natural hazards. The subwatershed characterization report also provided direction for policy development related to natural heritage features, natural hazards, headwater drainage features, and provided recommendations for water balance requirements.

The secondary plan teams used the constraints mapping identified through Phase 1 characterization to define a land use plan that would simultaneously meet the community development goals as outlined in the Municipality of Clarington's Official Plan and the Durham Region Official Plan, while respecting constraints associated with natural heritage features, natural hazards, headwater drainage features, and associated setbacks. Within these land use plans, the following details essential to the development of this Robinson Creek and Tooley Creek Subwatershed Study Phase 2 and 3 Report were identified:

- Land use types and intensities
- Parks and green spaces
- Road networks
- Stormwater management facilities

The land use plans are used in this study to define the hydrologic and hydraulic impact of development on Robinson Creek and Tooley Creek and finally to determine the approach to stormwater management that will be used to mitigate the impact of development on the local water balance, water quality, erosion and flooding.

3.1 Secondary Plans

There are three (3) secondary plans being considered as part of this Robinson Creek and Tooley Creek Subwatershed Study. These secondary plans are the Southeast Courtice Secondary Plan, the Southwest Courtice Secondary Plan, and the Courtice Employment Lands Secondary Plan (CEL), as discussed in **Section 1.4**. The Secondary Plans for Southeast Courtice and Southwest Courtice have advanced to land use planning (**Figure 3.1** and **Figure 3.2**), but the CEL Secondary Plan has not yet reached this stage. Land use for the CEL as evaluated in the hydrologic model (**Section 6**) was therefore based on high-level land uses outlined in the Municipality of Clarington's Official Plan (**Figure 3.3**). Should land use be revised within the CEL through the secondary planning process, the associated impacts must be investigated through updates to hydrologic modelling, hydraulic modelling and a refined stormwater strategy.

Through discussion with the Municipality of Clarington and the Southwest Courtice Secondary Plan team, assumptions were made to ensure a long-term approach for environmental resources for

Southwest Courtice, specifically that specific lands within the CEL immediately south of Southwest Courtice (as identified by diagonal hatching on **Figure 3.2**) be converted to residential through a Regional Municipal Comprehensive Review.

Figure 3.1 identifies the land use plan for the Southeast Courtice Secondary Plan Area. **Figure 3.2** identifies the land use plan for the Southwest Courtice Secondary Plan Area. **Figure 3.3** identifies the land use for the Courtice Employment Lands as identified in the Municipality of Clarington's Official Plan.

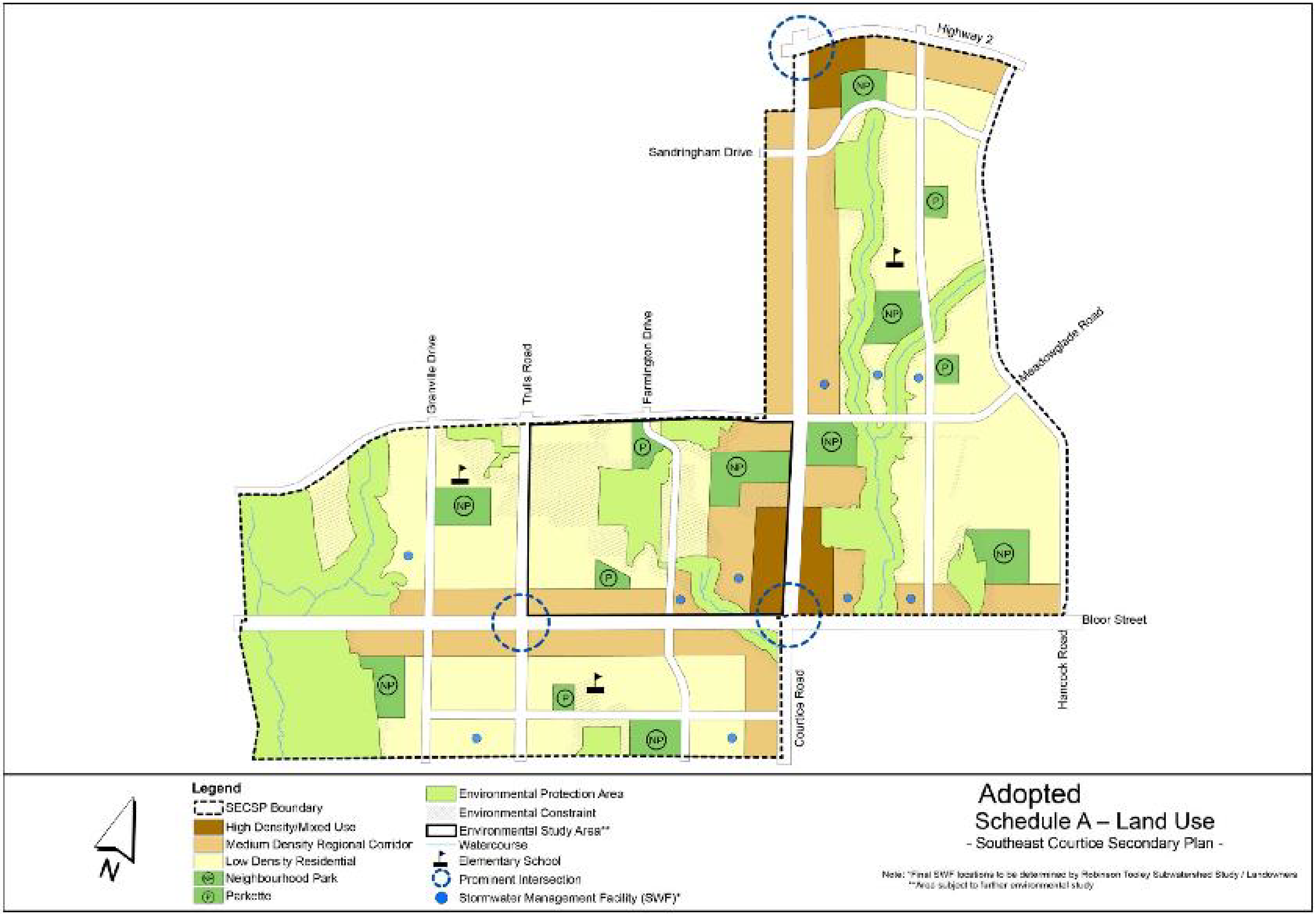


Figure 3.1: Southeast Courtice Secondary Plan – Adopted Land Use Plan

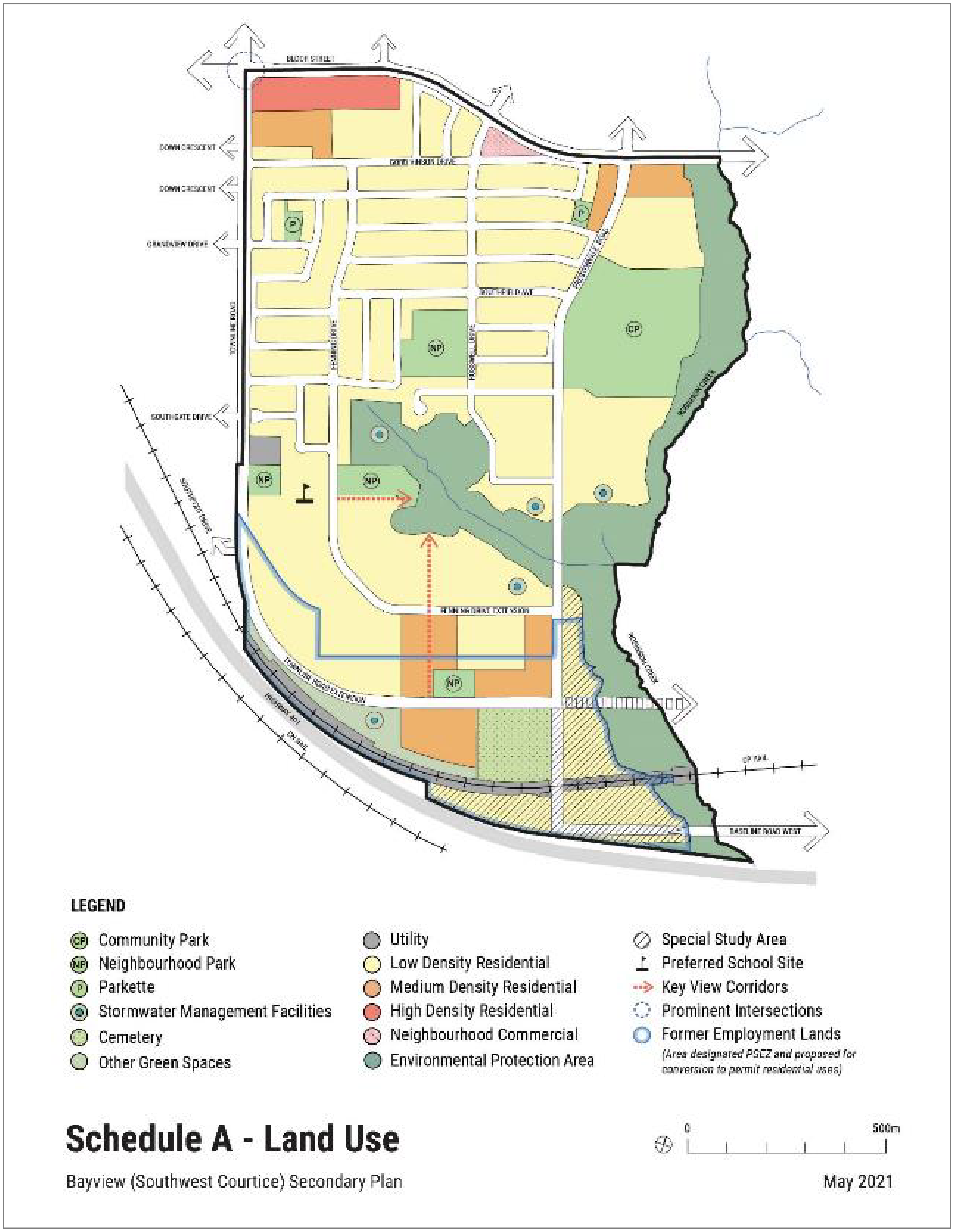
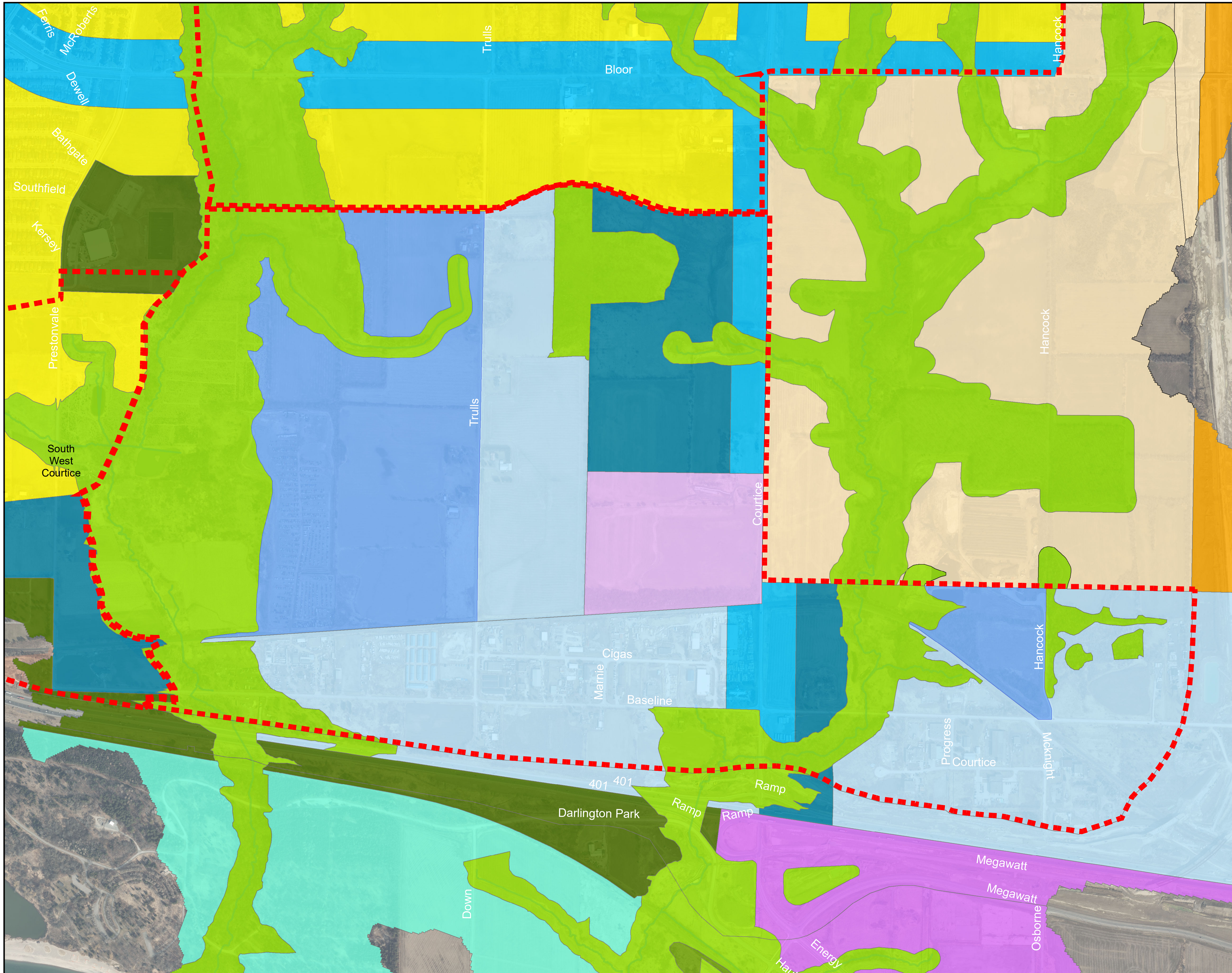


Figure 3.2: Southwest Courtice Secondary Plan – Adopted Land Use Plan

Clarington



Legend

Official Plan

- Business Park
- Community Park
- Environmental Protection
- General Industrial
- Green Space
- Light Industrial
- Municipal Park
- Prestige Employment
- Prime Agriculture
- Regional Corridor
- Rural
- Transportation Hub
- Urban Centre
- Urban Residential
- Utility
- Waterfront Greenway
- SWC Catchments with SWMF

Figure 3.3

Robinson & Tooley
Official Plan with CEL Border

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.125 0.25 0.5
Kilometers

N

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4 Future Subwatershed Conditions

Both Robinson Creek and Tooley Creek Subwatersheds were characterized by CLOCA for existing and future conditions in “Hydrologic and Hydraulic Modeling for Robinson Creek” (CLOCA, 2010) and “Hydrologic and Hydraulic Modeling for Tooley Creek” (CLOCA, 2008). For the Robinson Creek Subwatershed, existing conditions were based on land use from 1980 when the Courtice Heights Neighbourhood was the only urban development in the subwatershed. For the Tooley Creek Subwatershed, existing conditions were based on land use from 2005. For both subwatersheds, the future conditions model was forecast based on the Municipality of Clarington’s 2007 Official Plan. Minor modifications were made to the subwatershed boundaries to account for drainage diversions between Robinson Creek and Tooley Creek subwatersheds in catchments SEC8, SEC10, and SWC2. These diversions were based on the Secondary Plans, and are subject to CLOCA’s approval during future submissions.

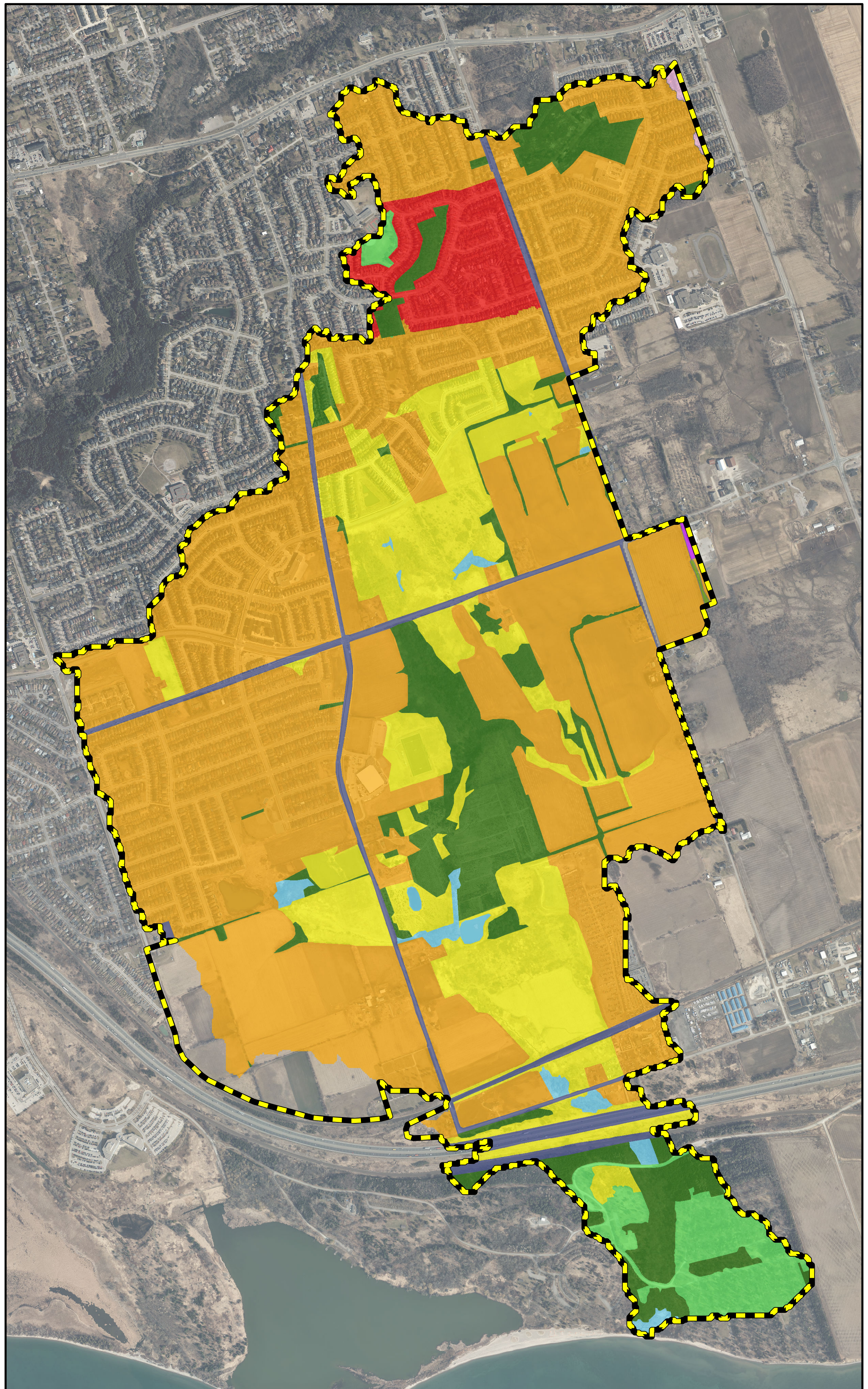
As part of the present Subwatershed Study, the existing conditions land use was reviewed and updated, as required, to 2018, which was the most recent orthophotography available for analysis. No changes were required for land use within Tooley Creek Subwatershed, whereas the land use in Robinson Creek Subwatershed required updating, especially in the northern and western reaches of the subwatershed. Orthophotography from 2018, the most recent year available, was used to update the Robinson Creek land use. In addition to the existing conditions model, a future conditions scenario was considered based on the three Secondary Plans. Existing and future conditions are described below, along with the potential impacts that can be associated with the future land use conditions.

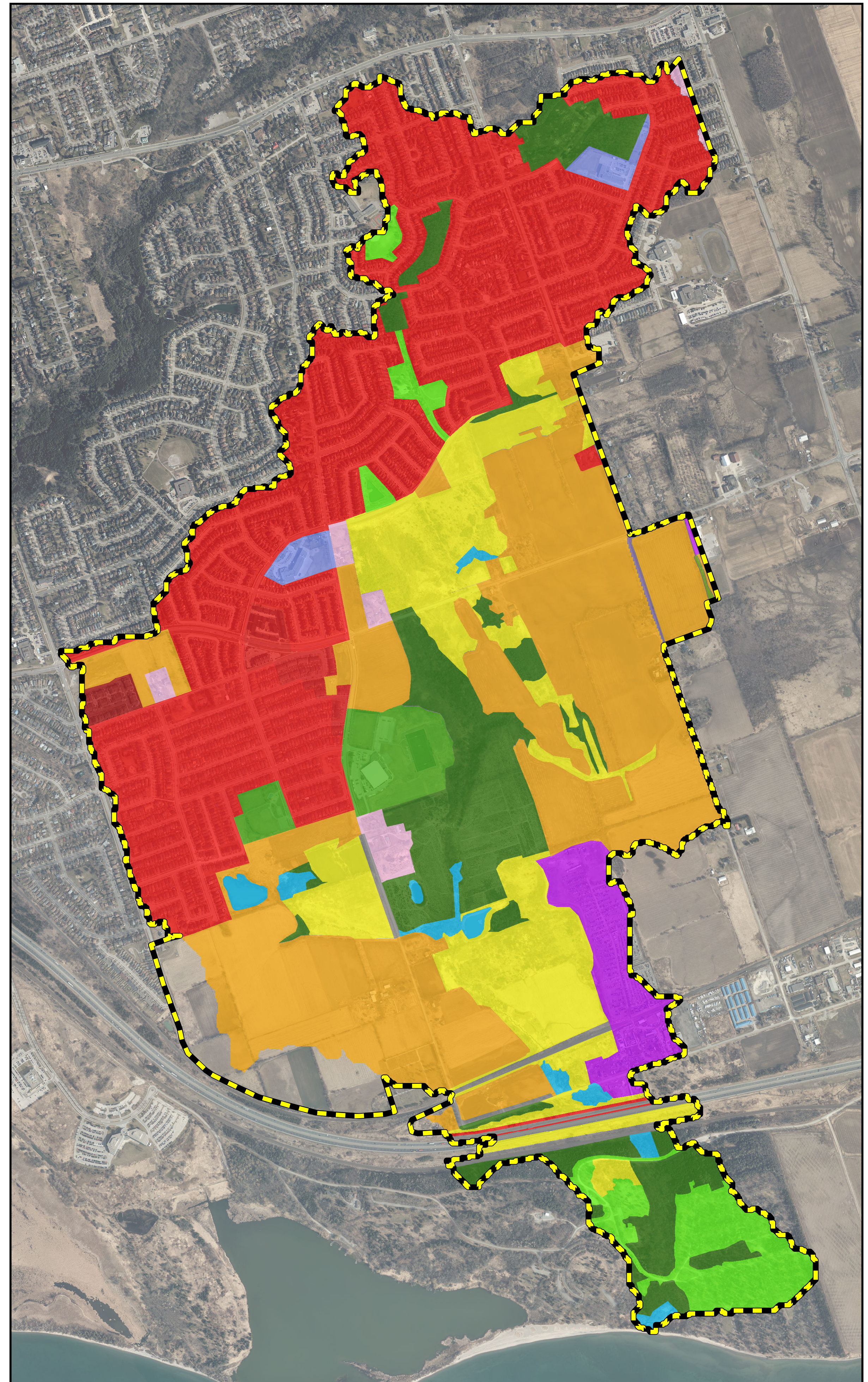
4.1 Existing and Future Conditions

4.1.1 Existing Conditions

Existing land use for Robinson Creek and Tooley Creek Subwatersheds was delineated based on 2018 orthophotography. **Figure 4.1** presents the existing land use within Robinson Creek Subwatershed in 1980 and 2018 and **Figure 4.2** presents the existing land use in 2018 within Tooley Creek Subwatershed, where the only change from 2005 was the construction of Highway 418.

Completed in 2019, Highway 418 connects Highways 401 and 407 and generally runs along the eastern side of Tooley Creek Subwatershed. A number of SWM ponds were constructed to control runoff from the highway. Details regarding these ponds have been requested from the MTO but not received, so the model was created and run without them.





Clarington

Legend

Robinson Existing Landuse (1980)

- Crop & Improved
- Lakes and Wetlands
- Manicured Greenspace
- Pastures & Unimproved
- Transportation & Utility
- Urban Residential
- Woodlots & Forest

Robinson Existing Landuse (2018) ABL

- Crop & Improved
- Industrial & Commercial
- Lakes and Wetlands
- Manicured Greenspace
- Parks
- Pasture & UnImproved
- Rural Residential
- Schools
- Semi Detached
- Townhouses
- Single Family
- Transportation & Utility
- Woodlots & Forest

Figure 4.1

Robinson Existing Land Uses
(Left: 1980; Right: 2018)

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

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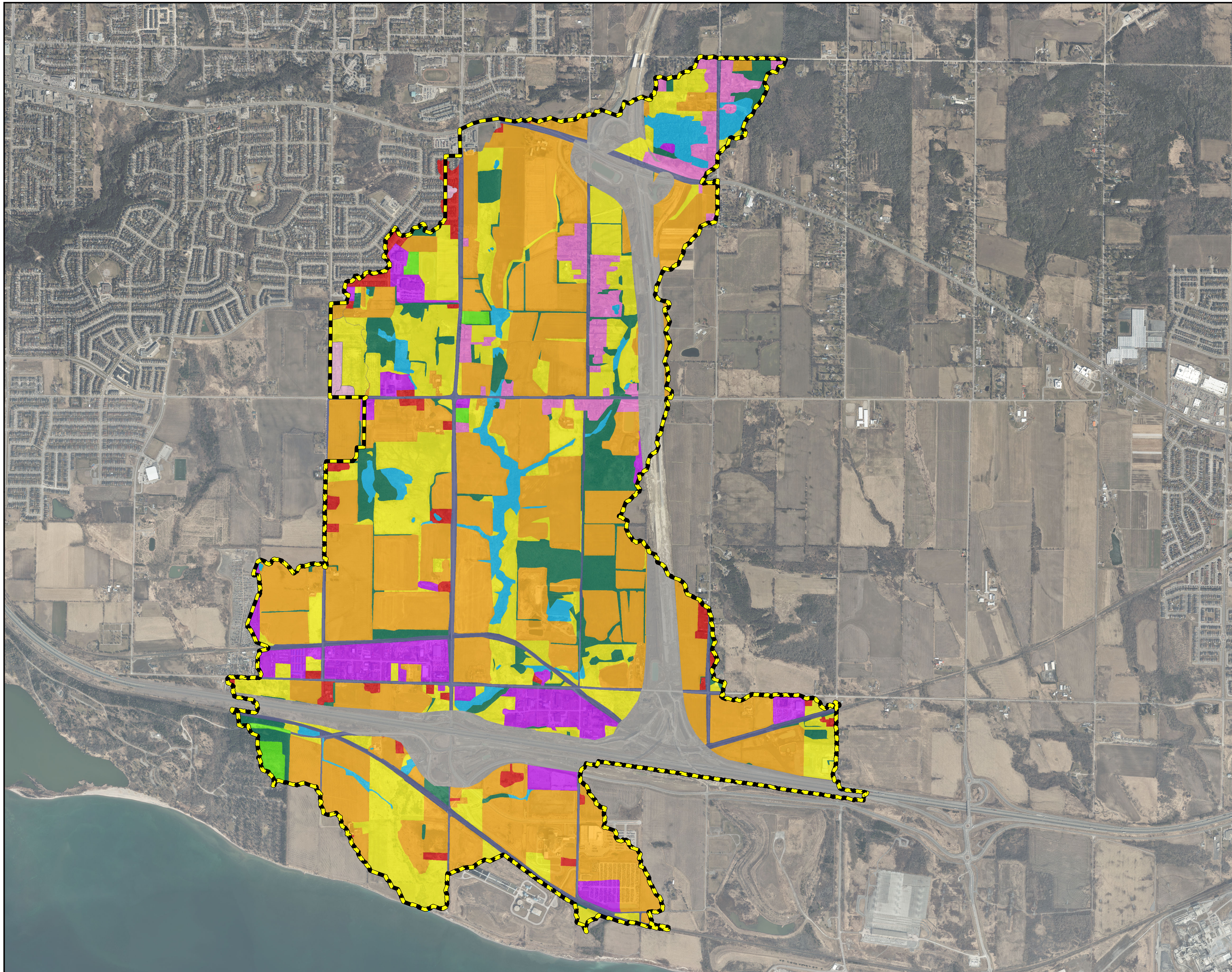

Clarington

Legend

Tooley Existing (2018)

Landuse

- Crop & Improved
- Highway
- Industrial & Commercial
- Lakes and Wetlands
- Manicured Greenspace
- Pasture & UnImproved
- Rural Residential
- Transportation & Utility
- Urban Residential
- Woodlots & Forest

Figure 4.2

Tooley Existing Land Uses
(2018)

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.275 0.55 1.1
Kilometers

N

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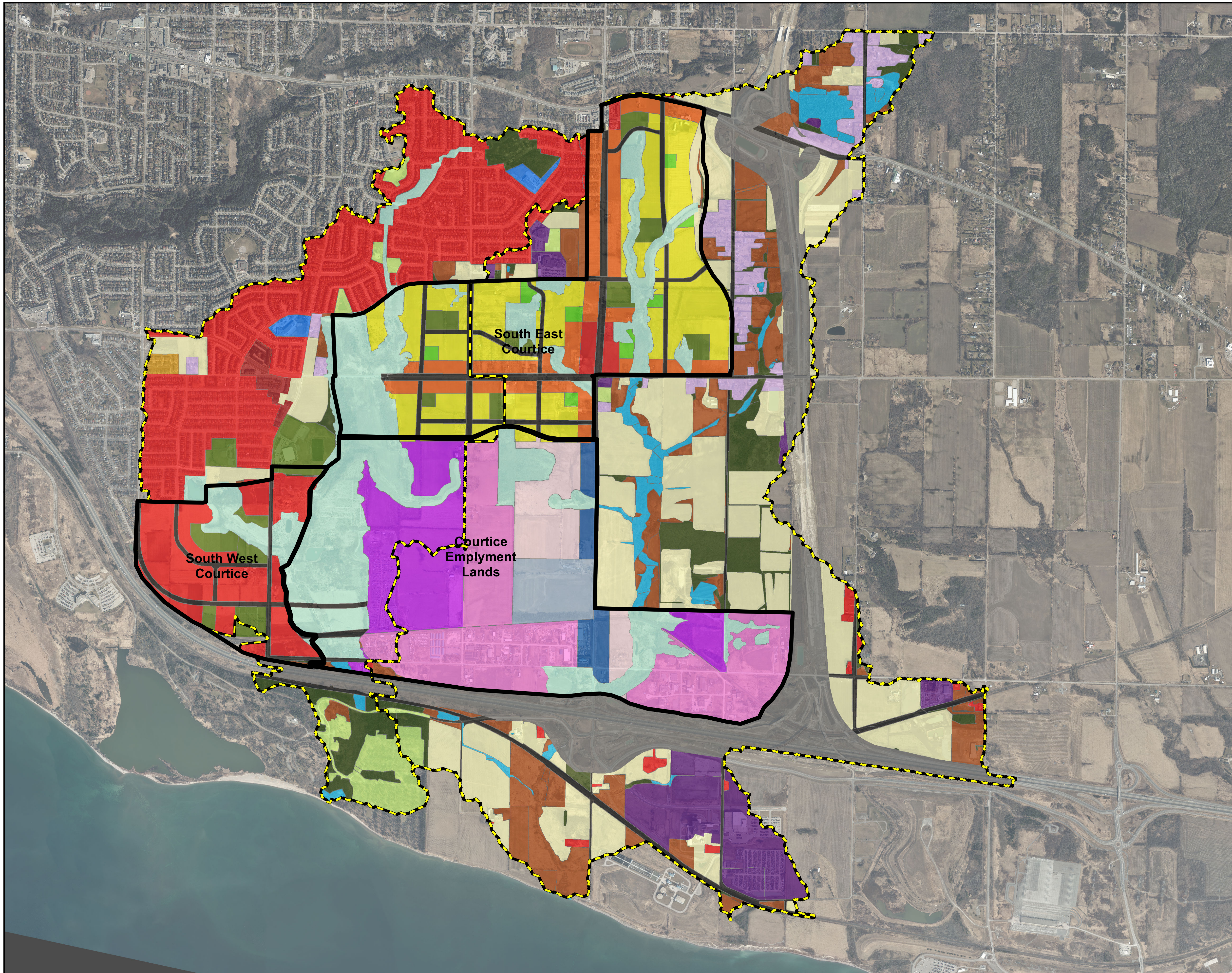
4.1.2 Future Conditions

The proposed land use map has been developed through the Secondary Plan processes. Land use plans are available for the Southwest Courtice and Southeast Courtice Secondary Plans, and the Official Plan land use is available for the Courtice Employment Lands. **Figure 4.3** presents the future land uses as proposed within the Secondary Plans and Official Plan as of 2020. Any subsequent changes in the Secondary Plan land uses were not included in this study. **Section 8.4** identifies how the change between this land use plan and the approved land use plan discrepancies are to be addressed.

Southwest Courtice lands are proposed to be developed mainly as urban residential, while Southeast Courtice lands are proposed to be developed as a mix of High Density/Mixed Use, Mid Density Residential, and Low Density Residential. The Courtice Employment Lands are proposed to be developed as General Industrial, Light Industrial, and Prestige Employment, and also include a Transportation Hub.

Locations of future stormwater management facilities were identified in the Southwest Courtice and Southeast Courtice Secondary Plans, and include four facilities in Southwest Courtice and ten facilities in Southeast Courtice. These facility locations were carried forward through the Subwatershed Study. Both Secondary Plans have policy that allows for changes to pond locations, if required in the future.



Legend

Future Landuse

- Crop & Improved
- Environmental Constraint
- General Industrial
- High Density /Mixed Use (R.C.)
- Highway
- Industrial & Commercial
- Lakes and Wetlands
- Light Industrial
- Low Density Residential
- Manicured Greenspace
- Mid Density Residential (R.C.)
- Parkette
- Parks
- Pasture & UnImproved
- Prestige Employment
- Regional Corridor
- Rural Residential
- Schools
- Semi Detached
- Townhouses
- Transportation & Utility
- Transportation Hub
- Urban Residential
- Woodlots & Forest

Figure 4.3

Robinson & Tooley
Subdivided Subcatchments

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.275 0.55 1.1
Kilometers

N

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4.2 Potential Impacts Associated with Land Use Changes

Existing and proposed land uses within Robinson Creek and Tooley Creek Subwatersheds were reviewed in **Section 4.1**. As noted, Southeast Courtice and Southwest Courtice will be developed with a mix of residential land uses and associated neighbourhood amenities, while the CEL will be developed primarily with industrial / employment land uses.

4.2.1 Potential Stormwater Impacts

This section provides a brief overview of the general stormwater impacts which are directly associated with changes to the hydrologic regime due to urban development. This includes impacts to:

- the overall hydrologic cycle or water balance;
- water quality;
- stream erosion; and
- flooding.

Note that, in addition to the direct impacts noted above, stormwater impacts from urban development can also have a significant effect on many other natural resources including aquatic and terrestrial communities and their habitat.

4.2.1.1 Potential Impact to Groundwater and Water Balance

High Volume Recharge Areas (HVRA) located within the Robinson Creek and Tooley Creek Subwatersheds tend to correspond to the location of surficial sand and gravel deposits. In addition, Significant Groundwater Recharge Areas (SGRAs) exist in the upper reaches of Tooley Creek. Post- development, maintaining the existing groundwater recharge volumes and minimizing changes to the overall site (and feature-based) water budgets are required.

Without controls, the impervious surfaces associated with future urban development will reduce the capacity of the site to infiltrate rainfall events into the groundwater system, creating an increase in the volume of surface water runoff instead (**Figure 4.4**). This alteration to the water budget, in turn, can contribute to increased rates of flooding, erosion, and pollutant loadings, having a negative impact to the surrounding natural heritage features. The corresponding reduction in groundwater levels can also result in reduced supplies of clean, cool baseflows to area streams, thereby negatively impacting downstream aquatic communities. As such, mitigating the impacts to the overall site and feature-based water balances is a requirement of development approval.

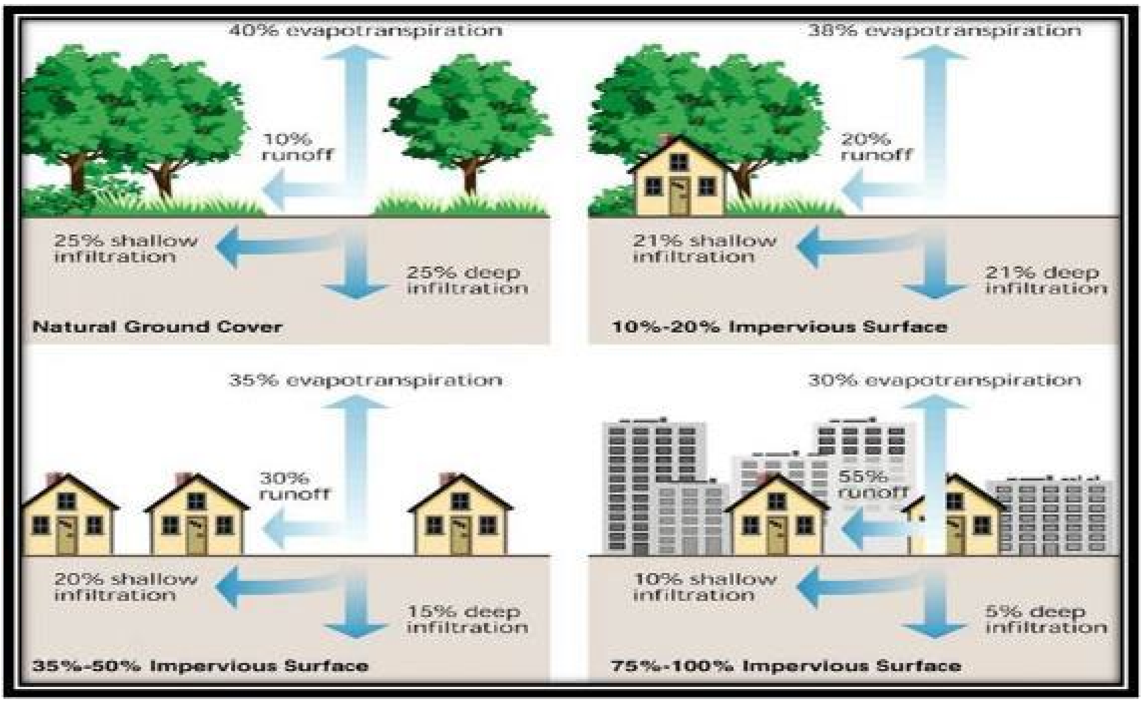


Figure 4.4: **Example of General Water Budget Impacts Due to Development**

4.2.1.2 Potential Impact to Water Quality

The protection of surface water quality within the study area is a key objective. Water quality has a strong influence on the health of fish and other aquatic communities, and also determines the suitability of water for drinking, recreation, fishing, wildlife and general aesthetics.

Stormwater runoff from urban sources typically contains elevated levels of contaminants such as sediment (ie. suspended solids), nutrients (eg. phosphorous, etc.), metals (eg. copper, lead, zinc, etc.), and bacteria. Therefore, without controls, future urban development will result in increased pollutant loadings to the area streams. This, in turn, can contribute to degraded aquatic habitat and increased health risks associated with various recreation activities (**Figure 4.5**).

Figure 4.5: **Water Quality Impacts**

4.2.1.3 Flood and Erosion Impacts

With urbanization there is a typical hydrologic response from the developed land. This generally involves an increase in peak flow rates and runoff volumes, and a decrease in the time-to-peak flow. These effects commonly occur with increased impervious surface areas and improved stormwater drainage systems which are typical of the change from rural to urban land use. The increased runoff volumes and flow rates can result in increased rates of erosion and flooding (**Figure 4.6**).

Figure 4.6: **Examples of Flooding and Erosion Impacts**

4.2.2 Potential Terrestrial and Aquatic Ecological Impacts

This section provides a preliminary discussion of impacts to the natural environment resulting from land use changes and urban development. Additional discussion specific to the study area has been provided in later sections of this report.

Natural heritage features within the study area were identified and discussed in detail in the Robinson-Tooley Subwatershed Study Phase 1 report. Potential impacts to the identified ecological features and functions may be generally attributed to two categories: direct loss of features or functions due to removal of vegetation, channelization or piping of watercourses, etc.; and fragmentation or isolation of natural areas due to the creation of barriers (e.g., roads). There is also the potential for positive impacts to occur in locations where naturalization or restoration efforts are carried out.

Preservation of natural cover on the landscape is crucial for maintaining the health and functionality of a watershed, as natural cover provides wildlife habitat, supports water quality and flood control, and contributes to air quality and carbon sequestration. Both the Robinson Creek and Tooley Creek subwatersheds are located largely within the urban boundary; they have already experienced a high degree of clearing/development with additional intensive development proposed throughout. Phase 1 of the SWS identified features and areas which met the criteria for inclusion in the municipal Natural Heritage System; these features have been carried forward as environmental constraints and must have an appropriate Vegetation Protection Zone (VPZ) applied in keeping with the requirements of the Municipality of Clarington's OP and any additional applicable requirements (e.g., recommendations of this

SWS). Features which did not meet the minimum requirement for inclusion in the NHS are not protected features per existing policies and regulations, but their removal would still represent a loss of natural heritage on the landscape which, in a subwatershed that has already experienced a high loss of natural cover, should be discouraged. Retention of these features in parklands, stormwater management blocks, or other similar features is recommended. If these features/areas are proposed for removal, ecological offsetting is strongly recommended at the site plan or similar stage of proposed development to ensure no net loss of natural cover, and may be required as a condition of site plan approval where impacts to or removal of natural features or areas are proposed.

Land use changes can create barriers to ecological processes (e.g., wildlife movement, seed dispersal) where previously such barriers did not exist. Roads, in particular, act as barriers to wildlife movement and often result in wildlife mortality due to collisions with vehicles. Where new roads are proposed in the study area, it is first and preferentially recommended that these be sited such that they do not encroach on natural heritage features. Where siting of roads cannot avoid impacting natural areas or potential linkages, it is recommended that measures are incorporated to facilitate wildlife movement – e.g., oversized drainage culverts with a terrestrial 'bench' to allow wildlife passage, or dedicated wildlife tunnels separate from the drainage culverts, with the associated exclusion fencing placed along habitat boundaries to direct wildlife to the crossing locations. Existing aquatic culverts may be retrofit or replaced during redevelopment to provide similar wildlife crossing considerations as well as to remove barriers to fish passage and improve aquatic habitat. In all cases, the culvert design process should ensure appropriate sizing and siting to allow for water flow, fish passage, and terrestrial wildlife movement.

Further discussion related to natural heritage and related requirements is provided in **Section 7.2** and **Section 8.4.3**.

5 Alternative Stormwater Strategies

Four potential stormwater management control approaches were considered as part of the process, and are described in the subsequent sections below:

1. Do Nothing
2. Traditional (Conventional) Stormwater Management
3. Low Impact Development (LID)
4. Traditional Stormwater Management and LID

5.1 Do Nothing Approach

This scenario illustrates the impacts if no stormwater management is applied. For this study, the "Do Nothing" approach refers to not providing any form of water quantity control for new development within the Robinson Creek and Tooley Creek watersheds. Development using this approach would cause significant environmental and ecological degradation, contravene municipal, provincial and federal policy, as well as fail to meet the study purpose.

5.2 Traditional (Conventional) Stormwater Management

The traditional stormwater management approach involves establishing an end-of-pipe stormwater management facility (i.e. a wet pond or hybrid wetland-wet pond) within each new development area. For new development areas, siting and preliminary design of the stormwater management facility would be undertaken as part of the Secondary Plan process for Southeast Courtice and Southwest Courtice, while general locations were provided for the Courtice Employment Lands. It is most technically and economically feasible to site stormwater management facilities at site locations that are conducive to gravity drainage without excessive land grading. Stormwater management facilities typically discharge to natural drainage features (creeks, rivers, wetlands and lakes) or engineered conveyance structures such as ditches, swales, channels or pipes.

Wet ponds or hybrid wetland-wet ponds use active storage detention and elongated flow paths through the facility to settle suspended sediments and associated pollutants. Both facility types require a forebay for pre-treatment and easier maintenance. While both facilities can be designed to meet MECP's enhanced level of water quality treatment corresponding to a long-term sediment removal efficiency of 80%, the wetland component of a hybrid design provides enhanced biological removal during the summer months.

Figure 5.1: A wet pond SWM facility provides water quality treatment via the settlement of suspended pollutants and flood control via the temporary detention and peak flow reduction

5.3 Low Impact Development (LID) Approach

Low Impact Development (LID) is a stormwater management strategy that seeks to mitigate the impacts of increased runoff volume 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 predevelopment 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. The key principles for Low Impact Development Design are to “soak it up or slow it down”:

1. **Use existing natural systems as the integrating framework for planning;**
   - Consider regional and watershed scale contexts, objectives and targets;
   - Look for stormwater management opportunities and constraints at watershed/subwatershed and neighbourhood scales;
   - Identify and protect environmentally sensitive resources; and,
   - Restore, enhance, and expand natural areas.
2. **Focus on runoff prevention**
   - Minimize impervious cover through innovative site design strategies and application of permeable surfaces;
   - Incorporate green roofs and rainwater harvesting systems in building designs;
   - Drain roofs to pervious areas with amended topsoil or stormwater infiltration practices; and,
   - Preserve existing trees and design landscaping to create urban tree canopies.

3. **Treat stormwater as close to the source area as possible**
   - Utilize decentralized source and conveyance stormwater management practices as part of the treatment train approach;
   - Flatten slopes, lengthen overland flow paths, and maximize sheet flow; and,
   - Maintain natural flow paths by utilizing open drainage (e.g., swales).
4. **Create multifunctional landscapes**
   - Integrate stormwater management facilities into other elements of the development to conserve developable land;
   - Utilize facilities that provide filtration, peak flow attenuation, infiltration and water conservation benefits;
   - Design landscaping to absorb runoff, decrease need for irrigation, urban heat island effect and enhance site aesthetics.

In March 2020, a meeting was held with the Municipality to discuss the use of LIDs. Both the Municipality of Clarington and CLOCA accept the use of LIDs for stormwater management. LID measures will be accepted to meet design criteria associated with water quality, erosion control, or water balance, but not for quantity control. However, LIDs on residential lots are not accepted for meeting water quality, erosion control, or water balance criteria because homeowners frequently modify their properties and there is no guarantee of the facility's longevity. Slides from this presentation are included as **Appendix A.**

To provide water quality, water balance, and erosion targets, an aggressive LID approach would be required. This approach would see LID practices integrated on municipal property (road ROWs, parks, municipal buildings, etc.) and on private property (commercial, institutional and industrial (ICI) properties). This approach requires performance verification and a maintenance framework to be approved by CLOCA.

Low Impact Development stormwater management practices that are accepted to meet design criteria associated with water quality, erosion control or water balance are listed in **Table 5.1,** including their general classification.

Table 5.1: LID Stormwater Management Practices

LID BMP	Notes
Soakaways, Infiltration Trenches and Perforated Pipe Systems (including pervious catch basins)	Suitable for use within the road right-of-way or on public and private (ICI) sites to control runoff at the source
Bioretention/ Bioswales (a.k.a rain gardens)	
Rain water harvesting	Suitable for use on public and private (ICI) sites to control runoff at the source
Permeable Pavements	

In addition to the LID BMPs listed in **Table 5.1**, the use of scarified subsoil, amended topsoil, and extra topsoil depth on yards is recommended on all sites to reduce post-development runoff volume, but these amendments will not be accepted to meet water quality, erosion control or water balance criteria.

Specific types of LID practices that are generally appropriate for different land uses are listed in **Table 5.2**.

Table 5.2: Municipal LID Applicability by Land Use

Land Use		**Single Family Residential**	**Multi-Family (Medium Density)**	**Multi-Family (High Density)**	**Industrial, Commercial & Institutional**
Soil Amendments		☑	☑	☑	☑
Perforated Pipe (PP)	PP as Storm Sewer	☑	☑	☑	☑
	Parallel PP ("3rd Pipe")	☑	☑	☑	☑
	Grassed Swale PP System	☑	☑	☑	☑
Permeable Pavements			☑	☑	☑
Bioretention, Bioswales and Enhanced Swales			☑	☑	☑
Rainwater Harvesting				☑	☑

5.3.1 LID Approach for Municipal ROW

LID SWM practices that would be incorporated into an overall municipal stormwater management approach include:

Soil Amendments - Compost amendments are tilled or mixed into existing soils thereby enhancing or restoring soil properties by reversing the loss of organic matter and compaction (**Figure 5.2)**. They also are used to make Hydrologic Group C and D soils suitable for on-site stormwater BMPs such as downspout disconnection, filter strips, and grass channels etc. Soil amendments benefits include increased infiltration, stormwater storage in the soil matrix, survival rate of new plantings, root growth and stabilization against erosion, improved overall plant/tree health and decreased need for irrigation and fertilization of landscaping. Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process. While soil amendments will never be used solely to meet stormwater management objectives, they are effective in reducing the overall runoff volume, will contribute to a lower peak discharge, and can help improve water quality by reducing contaminate loads. Soil amendments can be applied on private property and do not require ongoing maintenance activities.

Perforated Pipe Systems - Perforated pipe systems, also called exfiltration systems, can be thought of as long infiltration trenches that can be designed for both conveyance and infiltration of stormwater runoff (**Figure 5.2)**. They are underground stormwater systems composed of perforated pipes installed in gently sloping granular stone beds lined with geotextile fabric that allows infiltration of runoff into the granular bed and underlying native soil. Perforated pipe systems can be used in place of almost any conventional storm sewer pipes where topography, water table depth, and runoff quality conditions are suitable. They are capable of handling runoff from roofs, walkways, parking lots, and roads. For road applications, these systems can be located within boulevard areas or beneath the roadway surface itself. There are three configurations of perforated pipe systems that are feasible within residential road rights-of-way. The first is a perforated pipe system that functions as the minor system conveyance. The second is a perforated pipe that runs parallel and discharges to the conventional storm sewer. Because the conventional storm sewer meets conveyance requirements, the parallel pipe (also known as a "3rd pipe system") can be sized to infiltrate smaller volumes. This configuration is shown in the associated figure and is consistent with the PCSWMM modeling approach used for this study. The third configuration is a catchbasin lead to either a perforated or solid pipe that conveys flows to an infiltration chamber within the municipal ROW. There are also perforated pipes available up to 1200mm in diameter that can be used instead of a solid walled storm sewer to promote infiltration.

Soakaway Pits, Infiltration Trenches and Chambers - Soakaways, infiltration trenches and chambers can be used to reduce runoff volume and maintain or enhance recharge (**Figure 5.2)**. Most surface areas can be directed to infiltration practices without pre-treatment. Roads and parking lots should be provided with pre-treatment devices to prevent clogging and extend their lifecycle.

These practices are also known as infiltration galleries, trench drains and / or dry wells, and are excavations in the native soil that are lined with geotextile fabric and filled with clean granular stone. They are typically designed to accept runoff from a relatively clean water source such as a roof or pedestrian area. Where possible, they should be installed where native soils allow for infiltration; however, like other infiltration techniques, underdrains can be installed where poorly drained soils are present. These practices can be designed in a broad range of shapes and sizes.

Infiltration chambers are a variant that use prefabricated modular plastic or concrete structures (as opposed to only aggerates) installed over a granular base to provide maximum void space (up to 90%) and provide structural support. These systems provide more storage capacity than equivalently sized soakaways and have minimal footprints. Infiltration chambers are ideal for heavily urbanized sites because they can be installed below parking lots or other impervious surfaces. Infiltration chambers have also been successfully installed below recreational fields and public urban courtyards. They can be designed in many configurations to suit site constraints.

Figure 5.2: Example LID Practices from Top Left to Right: Soil Amendment (Mississauga, ON), Exfiltration System (Etobicoke ON); Exfiltration System (Guelph, ON); Perforated Pipe (Toronto, ON)

Bioretention, Bioswales and Enhanced Grass Swales - As a stormwater filtration and infiltration practice, bioretention temporarily stores, treats and infiltrates runoff. The primary component of the practice is the bioretention soil media (**Figure 5.3**). This component is comprised of specific ratio of sand, fines and organic material. Another important element of bioretention practices is vegetation, which can be either grass or a more elaborate planting arrangement such as an ornamental garden.

Bioretention can be integrated into a diverse range of landscapes including as roadside practices, open space, and as part of parking lots and landscaped areas a perimeter control. Perimeter controls are placed adjacent to the impermeable surface (i.e. parking lot) typically at the low point where it can efficiently collect runoff. Bioretention practices are commonly referred to as “rain gardens”. Depending on the native soil infiltration rate and site constraints, bioretention practices may be designed without an underdrain for full infiltration, with an underdrain for partial infiltration, or with an impermeable liner and underdrain for filtration only (commonly called a biofilter) where infiltration is not desired or where contaminated soils are encountered.

Bioswales are similar to bioretention cells. They include a filter media bed, gravel storage layer and optional underdrain components. The main difference is that bioswales are also designed to provide linear conveyance via their swale-like surface geometry and slope. Pre-treatment and rock check dams are often included in the design. In general, bioswales are open channels designed to convey, treat and attenuate stormwater runoff. Vegetation or aggregate material on the surface of the swale slows the runoff water to allow sedimentation, filtration through the root zone and engineered soil bed, evapotranspiration, and infiltration into the underlying native soil. Bioswales may be planted with grasses or have more elaborate landscaping. They are implemented to provide water quality treatment and water balance benefits beyond those of a conventional ditch. Bioswales are sloped to provide conveyance, but due to their permeable soil media and gravel, surface flows are only expected during intense rainfall events. Bioswales are the most commonly applied LID as part of complete streets and parking lots.

Enhanced grass swales are vegetated open channels designed to convey, treat and attenuate stormwater runoff (also referred to as enhanced vegetated swales). Check dams and vegetation in the swale slows the water to allow sedimentation, filtration through the root zone and soil matrix, evapotranspiration, and infiltration into the underlying native soil. Simple grass channels or ditches have long been used for stormwater conveyance, particularly for roadway drainage. Enhanced grass swales incorporate design features such as modified geometry and check dams that improve the contaminant removal and runoff reduction functions of simple grass channel and roadside ditch designs. Enhanced grass swales are not capable of providing the same water balance and water quality benefits as dry swales, as they lack the engineered soil media and storage capacity of that best management practice (**Figure 5.3**).

Figure 5.3: Example LID Practices from Top Left to Right: Bioretention (Toronto, ON); Bioretention (Bostwick Community Centre, London, ON); Grass Swale (Mississauga, ON)

5.3.2 LID Approach for Private Property

The BMPs already described above (Soil Amendments, Perforated Pipe, Permeable Pavements, Bioretention & Bioswales, Enhanced Swales, and Soakaway Pits, and Infiltration Trenches and Chambers) are suitable for municipal ROW and on private property. The following BMPs are also suitable for private property.

Rainwater Harvesting - Rainwater harvesting is the process of intercepting, conveying and storing rainwater for future use. Harvesting rainwater for domestic purposes has been practiced in rural Ontario for well over a century. Roof runoff is the ideal source for this practice due to the large surface area and minimal exposure to contaminants. Rainwater harvesting not only reduces the volume of runoff that is conveyed offsite, but also reduces the onsite usage of potable water for irrigation and associated costs (**Figure 5.4**).

Rainwater harvesting systems convey runoff to a storage tank or cistern. Prefabricated storage units can range in size from a simple rain barrels that tie into downspouts to precast concrete tanks capable of storing tens of thousands of litres or more from much larger catchment areas. Cisterns can be located inside a building or outside.

Rainwater that is collected in a cistern can be used for non-potable indoor or outdoor uses. Sufficient pre-treatment options include gravity filtration or first flush diversion. The irrigation of landscaped areas and washing of site features and vehicles are common uses of harvested rainwater. The 2017 Ontario Building Code explicitly allows the use of harvested rainwater for toilet and urinal flushing (See Section 7.1.5.3 of the Code).

Permeable Pavements - Permeable pavement is a collective term that describes LID BMPs that can be used in place of conventional asphalt or concrete pavement (**Figure 5.4**). These alternatives contain pore spaces or joints that allow stormwater to pass through to a stone base for infiltration into underlying native soil or temporarily detained for flood control purposes. Typical types of permeable pavement include:

- pervious concrete;
- porous asphalt;
- permeable interlocking concrete pavers (PICP) (i.e., block pavers);
- plastic or concrete grid systems (i.e., grid pavers or grass pavers); and
- rubberized granular surfaces, bricks and pads.

Permeable Pavements can be implemented as sidewalks, driveways, multi-use pathways, on-street (lay-by) parking, alleyways, road shoulders and even minor or local roadways themselves but are most commonly applied in parking lots. When implemented as within a parking lot, permeable pavement can be implemented as:

- Full permeable pavement parking surface (drive lanes and parking stalls); and
- Partial permeable pavement parking surface where permeable pavement is strategically constructed within the parking stall areas only and the central drive-lanes remain as conventional asphalt. In this manner, the permeable pavement systems can accept runoff from impervious areas (i.e. drive lanes).

An ongoing maintenance plan is required for permeable pavements, to ensure clogging of void space does not occur.

Figure 5.4: Example LID Practices from Left to Right: Green Roof (Portland, OR); Rainwater Harvesting (Portland OR); Permeable Pavements (London, ON)

5.4 Traditional (Conventional) Stormwater Management and LID Approach

LID stormwater management practices used together with conventional stormwater management as part of an overall holistic treatment train approach have been shown to better meet stormwater management targets and objectives, provide better performance, are more cost effective, have lower maintenance burdens, and are more protective during extreme storms than conventional stormwater practices alone. The underlying concept is that each LID stormwater management and traditional practice within the treatment train provides successive storage, attenuation and water quality benefits.

Figure 5.5 illustrates the generalized impact of a holistic approach to stormwater management on the four (4) primary and most common stormwater management objectives when LID and conventional stormwater management solutions are used.

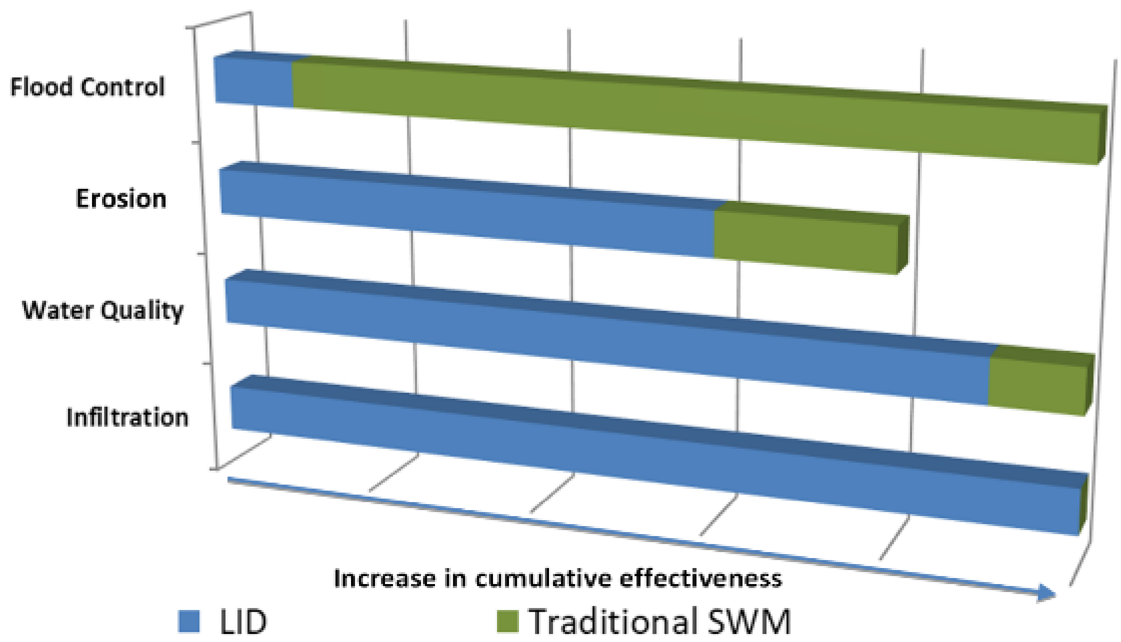


Figure 5.5: The Rationale for the Traditional Stormwater Management and LID Approach

Quantity control volume reductions for LID measures will not be accepted, per CLOCA's requirements, so all conventional SWM ponds must be sized for the full quantity control volume. However, the permanent pool and extended detention volumes may be reduced based on the implementation of LIDs throughout the catchment.

As discussed previously, LID is a green infrastructure approach to stormwater management that uses simple, distributed and cost-effective engineered landscaped features and other techniques to infiltrate, store, filter, evaporate and detain rainfall where it falls. The principles of LID are part of the evolution of stormwater management whereby rainwater is managed as a resource. The conventional stormwater management and LID approach uses both end-of-pipe facilities and LID stormwater management practices in the form of source and conveyance controls, including:

- Bioretention;
- Bioswales;
- Perforated pipe / Exfiltration trenches;
- Soakaway Pits;
- Rain water harvesting; and
- Permeable pavements.

The LIDs are incorporated into new development areas to provide water quality control via runoff volume reductions and filtration. Where these LIDs can treat the runoff generated from the 90th percentile event, the end of pipe facilities can be designed to provide water quantity control only. For these catchment scenarios, a dry stormwater management pond and/or multi-use flood storage facility may be feasible. In new development areas where LIDs can treat only a portion of the runoff, the end-of-pipe facilities will need to provide a volume of water quality storage. In this situation, the water quality volume can be reduced by reducing the calculated imperviousness of the catchment based on the impervious area fully controlled by LIDs. For example, if LIDs control 3.6 ha out of 10 ha of impervious area in an 18 ha catchment, the percent imperviousness for sizing the wet pond can be reduced from 55% to 35%.

The traditional (conventional) stormwater management and LID approach can be developed in a way that fosters complete corridors wherever possible throughout the study subwatersheds, whereby stormwater management features are integrated with natural heritage, open space and recreational opportunities. This involves properly integrating green infrastructure with consideration for passive, ecologically supportive land uses adjacent to creek and tributary corridors. The complete corridor approach is a proactive way to protect, maintain, rehabilitate and/or restore critical ecological function. Properly implemented, a complete corridor provides continuous natural area and enhanced ecological connectivity for the movement of water, wildlife and people.

6 Modeling of the Stormwater Strategy

Four alternative stormwater strategies were identified in **Section 5** to address the potential impacts associated with future development (**Section 4.2**). **Section 6** will describe the criteria used to evaluate these strategies, followed by the evaluation and selection of the preferred alternative. An assessment of the effects of climate change is also provided.

6.1 Criteria Description

Five criteria have been identified that must be met through the preferred stormwater strategy. These criteria include:

- **Flood control:** Potential to reduce the impact of new development on peak flows associated with both urban and riverine flooding, such that the 2-year through 100-year post-development flows are less than or equal to the predevelopment flows, and that the post-development uncontrolled flows are less than the existing regulatory floodlines.
- **Water quality:** Potential to improve water quality based on existing water quality conditions and ability to provide Enhanced water quality as per the MECP requirements.
- **Water balance:** Potential to meet a water balance within the subwatershed area that is consistent with a natural catchment area lacking anthropogenic impervious surfaces (i.e., meet pre-development water balance).) High Volume Recharge Areas (HVRAs) and Ecologically Significant Groundwater Recharge Areas (ESGRAs) will require a site-specific water balance to be completed as a component of the stormwater management submission.
- **Erosion control:** Potential to maintain existing fluvial geomorphic regime or improve erosion conditions within Robinson Creek and Tooley Creek and associated tributaries. The reestablishment of a natural erosion and sediment deposition regime is closely tied to matching the runoff responses associated with pre-development conditions.
- **Thermal impacts:** Potential to maintain cooler water temperatures discharged into streams to sustain coolwater habitat. Impervious surfaces, such as roads and rooftops, can reach very high temperatures, especially during the summer months, and this heat is transferred to stormwater running over it.

6.2 Flood Control

Since LID measures will not be accepted for flood control purposes, only traditional stormwater management was considered in addition to the do nothing approach.

A Visual Otthymo 6.1 model provided by CLOCA was updated to account for any changes within each subwatershed. Land use was updated based on 2018 existing conditions and the future land use described in the Secondary Plans (**Section 4.1.2**), and some of the drainage in the headwater area of Robinson has been diverted to Black Creek. This diversion was included in both the Existing Conditions and Future Conditions model, as it is assumed to have occurred before 2018. **Appendix B** describes the model updates.

Flows at key locations (**Figure 6.1**) are presented in **Table 6.1** and **Table 6.2** to show existing conditions, future uncontrolled conditions, and future conditions with stormwater ponds. Dry end-of-pipe SWM facilities were modelled wherever development is proposed. Pond locations proposed by the Secondary Plan land use for Southeast Courtice and Southwest Courtice were accepted and used by this study, and placed near the outlets of subcatchments for the CEL (**Figure 6.2**). The drainage area for each facility was defined based on the Secondary Plans provided by the Municipality, while pond sizing was obtained by varying the storage volumes per hectare until both of the following conditions were met:

1. Post-development flows at key nodes throughout the watershed from the 2-year through 100-year events were less than or equal to the 2-100 year existing flows; and
2. Uncontrolled flows were less than the existing regulatory flows, where the regulatory flow is defined as the larger of the 100-year or Regional flow.

The objective of the assessment for the first condition is to define storage volumes for proposed development such that peak flows within Tooley Creek or Robinson Creek do not increase as a result of development. The assessment was carried out using land use information which was available at the time of undertaking the study. The storage volumes will need to be updated once further work is completed, which will modify parameters such as percent impervious, drainage area and patterns, location of Stormwater Facilities are updated at the Draft or Site Plan phases. The first condition was met in both subwatersheds when ponds were designed with a storage volume of 450 m^3/ha. Storage volumes will also be required to maintain pre-development stream flows where diversions are approved by CLOCA.

For condition 2, uncontrolled flows during the regulatory event were greater than CLOCA's existing regulatory flows, requiring additional considerations (see **Section 6.2.1**). Key results from the model are described below:

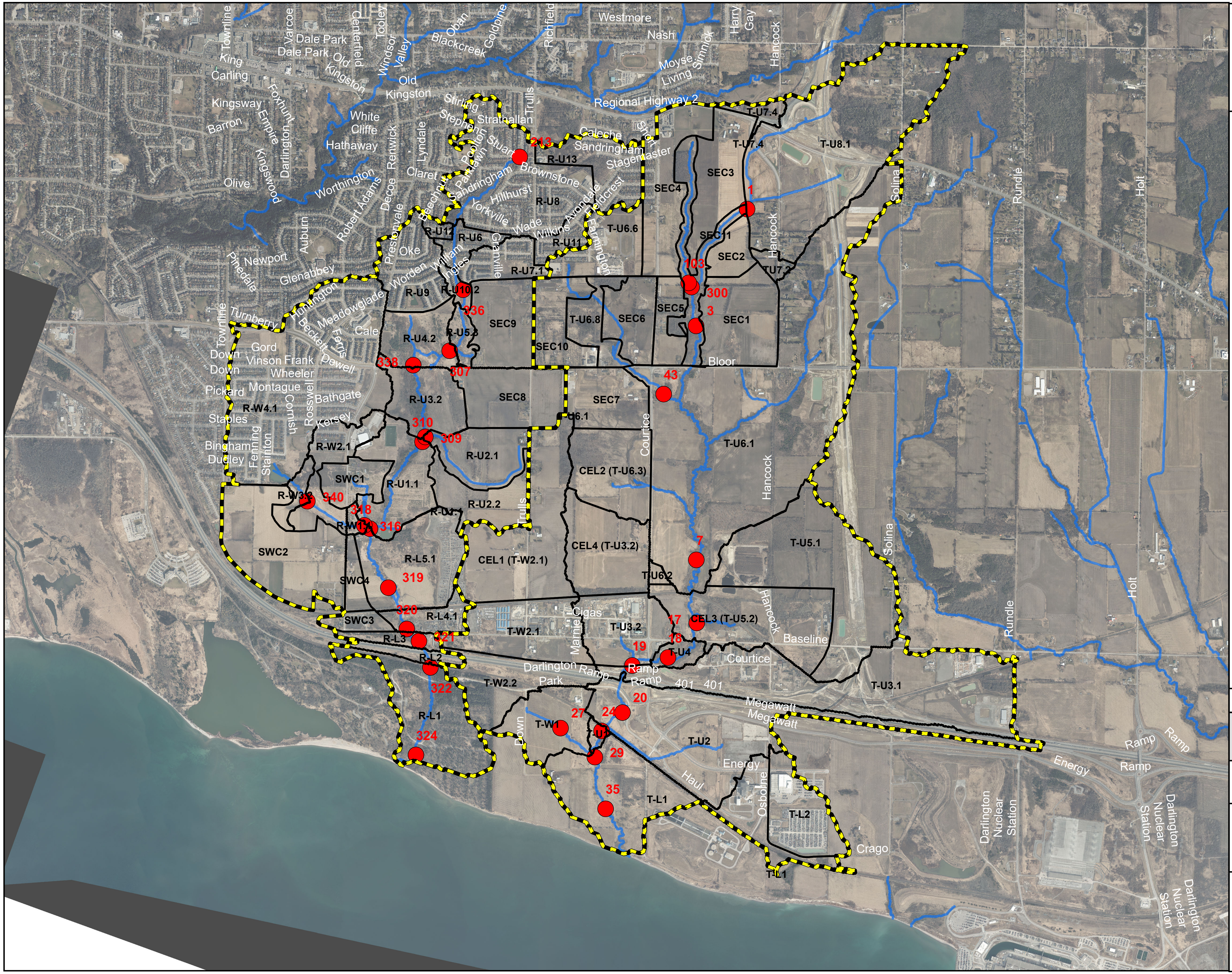
Robinson Creek:

- Flows during the 100-year event exceed the Regional event in Robinson Creek during the Existing Conditions, so the 100-year event will continue as the Regulatory event; and
- Uncontrolled future flows for the 100-year and Regional events exceed existing flows.

Tooley Creek:

- The Regional event exceeds the 100-year event, so the Regulatory event will continue to be the Regional storm;
    - The exception is that the 100-year peak flow exceeds the Regional peak flow for Tooley West reach West (South of the 401), so the Regulatory flood hazard is regulated by the 100-year flood line limits for this reach (**Appendix C**); and
- Uncontrolled future flows for the 100-year and Regional events exceed existing flows.

Clarington



Legend

- Flow Nodes
- Robinson and Tooley
- Streams
- Robinson and Tooley Boundaries

Subwatershed boundary delineation and diversions to be confirmed during MESP/MDP or Functional Servicing Report and must be approved by CLOCA.

Figure 6.1

Robinson & Tooley Subdivided Subcatchments

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.3 0.6 1.2
Kilometers

N

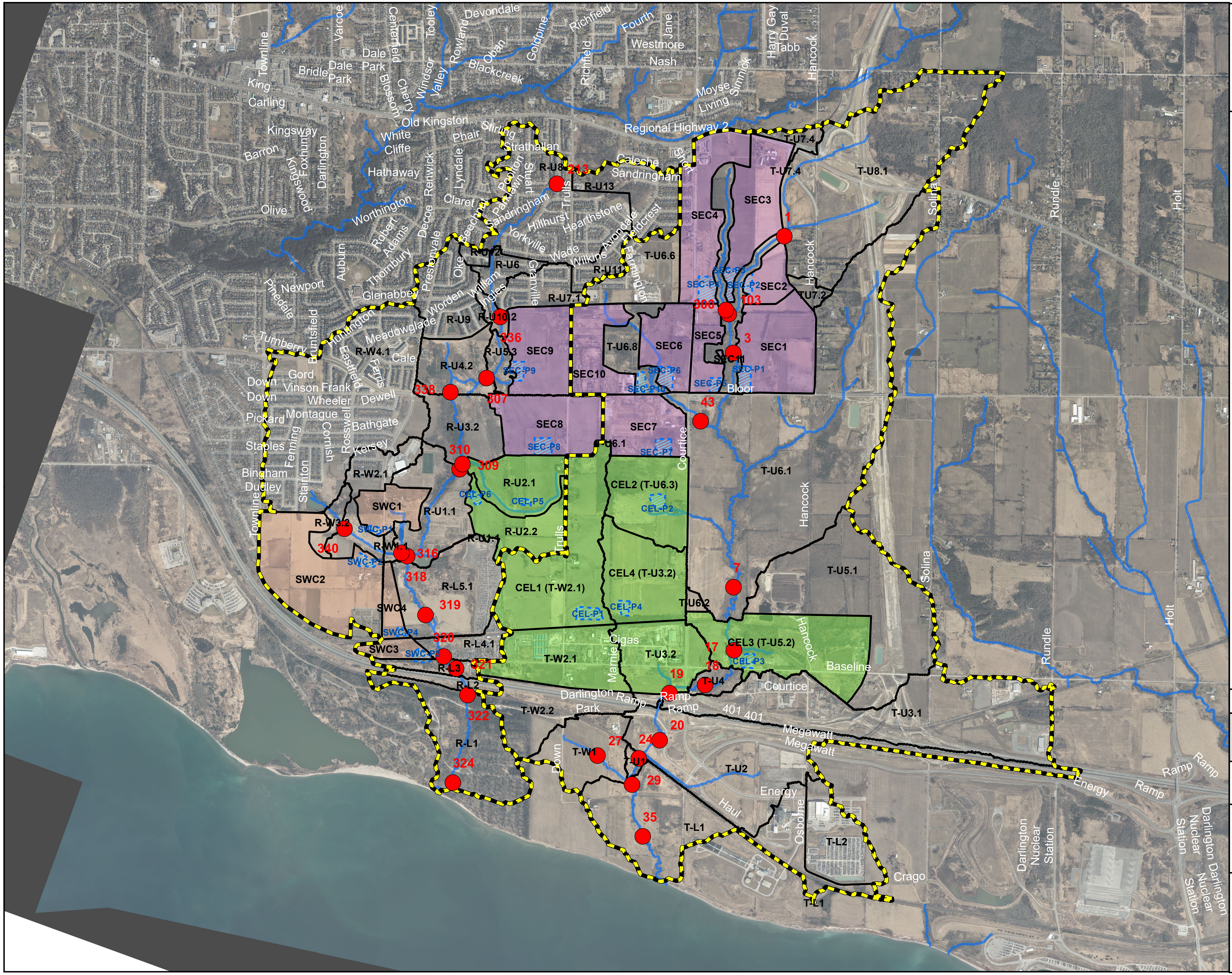
Aquafor Beech Limited

Table 6.1: Summary of Estimated Flood Flows – 100-Year Event (m^3/s)

	NHYD	Existing- 2018	Future (Uncontrolled)	Future (Traditional) - 450 m^3/ha
Robinson	336	12.91	18.63	14.41
	310	33.64	45.41	32.282
	319	65.76	90.19	65.325
	324	68.23	91.11	67.543
Tooley	3	22.33	26.075	11.135
	7	39.53	50.69	27.196
	17	46.59	66.93	32.479
	18	46.95	76.191	32.973
	19	62.19	96.783	52.042
	20	69.30	109.624	67.583
	29	95.85	132.779	85.819
	35	92.30	122.242	81.977

Table 6.2: Summary of Estimated Flood Flows – Regional Event (m^3/s)

	NHYD	Existing- 2018	Future (Uncontrolled)	Future (Traditional) - 450 m^3/ha
Robinson	336	2.40	1.487	1.487
	310	25.50	25.595	23.144
	319	56.50	59.809	55.246
	324	63.90	66.892	62.195
Tooley	3	25.846	27.181	20.838
	7	62.365	65.717	53.926
	17	76.723	82.003	65.776
	18	77.354	83.18	66.366
	19	94.013	102.691	81.509
	20	102.074	112.406	89.691
	29	119.598	130.287	103.176
	35	128.682	139.608	113.272



Clarington

Legend

- Robinson and Tooley
- SWM
- Flow Nodes
- SWC Catchments with SWMF
- CEL Catchments with SWMF
- SEC Catchments with SWMF
- Streams
- Robinson and Tooley Boundaries

Figure 6.2

Robinson & Tooley
Proposed Stormwater Facilities

Date: August 2022
Projection: NAD83_UTM_Zone_17N
Data Source: Municipality of Clarington, CLOCA

0 0.3 0.6 1.2
Kilometers

N

Aquafor Beech Limited

6.2.1 Flood Control Considerations

Since the Uncontrolled Future flows exceeded Existing regulatory flows during the Regional Regulatory event in Tooley Creek, additional flood control measures need to be considered. Through discussions with CLOCA and the Municipality, several measures were identified which may be implemented to address this, including floodproofing, construction of berms, increasing existing watercourse crossing hydraulic capacity, and the use of stormwater management facilities that meet the criteria as outlined in CLOCA's Technical Guidelines for Stormwater Management Submissions (CLOCA, 2020). A preliminary assessment of these measures was conducted, as described in **Sections 6.2.1.1** to **6.2.1.4**. However, an additional Flood Control Study will be required for Tooley Creek Subwatershed to determine the preferred approach for flood control (see **Section 8.4.1**).

The Existing and Future Uncontrolled floodlines in comparison with the existing CLOCA regulatory floodline can be seen in **Figure 6.3**. The most significant difference can be observed between the CNR and the CPR for both subwatersheds, where the Future Uncontrolled floodlines are more extensive than the Existing CLOCA floodplain. For Robinson Creek the Future Uncontrolled Regulatory floodline is still larger than the existing floodplain upstream the CPR as well.

6.2.1.1 Floodproofing

Floodproofing is discussed in Appendix 6 of the MNRF Technical Guide – River and Stream Systems: Flooding Hazard Limit (2002), where it is defined as "a combination of structural changes and/or adjustments incorporated into the basic design and/or construction or alteration of individual buildings, structures or properties subject to flooding so as to reduce or eliminate flood damages."

A number of properties are potentially impacted by flooding during the Regulatory event, as described in **Table 6.3** and illustrated in **Figure 6.4**.

Table 6.3: Properties Impacted by Flooding Under Future Uncontrolled Conditions

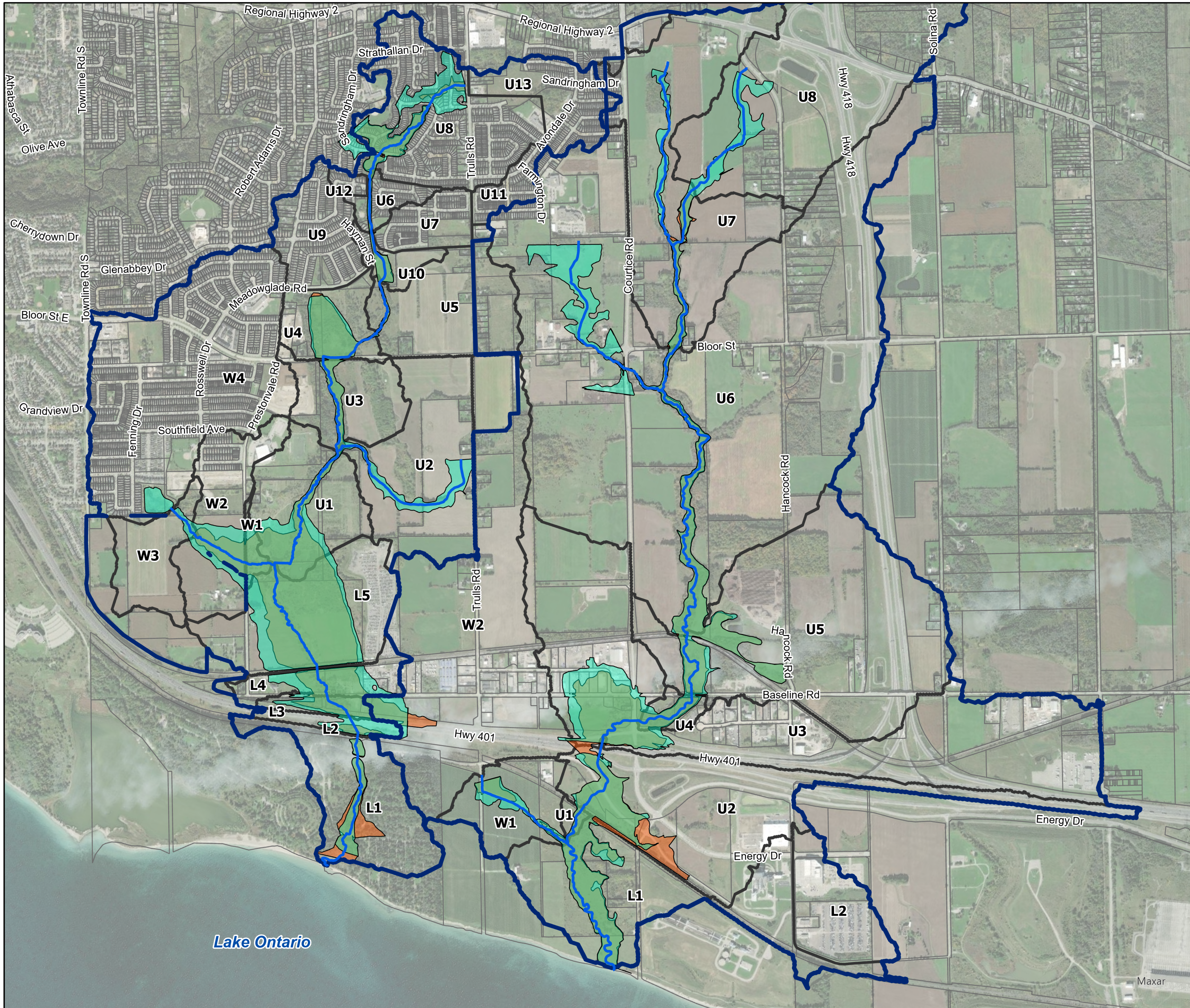
		Robinson Creek	Tooley Creek	Outside of the watersheds
Number of Properties Impacted	Existing CLOCA	132	34	0
	Future Uncontrolled	281	48	18
Area Impacted (ha)	Existing CLOCA	350.87	369.05	0
	Future Uncontrolled	386.65	427.01	0.82

6.2.1.2 Construction of Berms

Berms may be constructed to restrict flood flows from spreading to an undesirable location, such as a residence or other structure. Property design is more complex since material and construction practices must be closely monitored, the berms must be regularly maintained, and they may require adequate pumping facilities to handle interior drainage and seepage.

Berms must be designed by a qualified professional engineer (i.e. acceptable soils with low permeability to be used, inspection by a geo-technical engineer and compaction requirements).

The cost of installing berms may be significant, depending on the area to be enclosed. Berms would also have to be designed to meet MNRF standards including specified side slopes and design considerations. As defined by MNRF the berms are typically referred to as Flood Protection Structures.



Clarington

Legend

- River Reaches
- Robinson 100-yr Future Uncontrolled Floodline*
- Tooley Regulatory Future Uncontrolled Floodline*
- CLOCA Existing Regulatory Floodline
- Property Parcel
- Subcatchments
- Subwatershed

*Future floodlines are subject to future study

Figure 6.3

Existing CLOCA Floodplain and Future Uncontrolled Regulatory Floodlines in Robinson and Tooley Creeks

0 0.5 1
Kilometers

N

Projection: UTM_Zone_17N
Datum: NAD_83 / CGVD28
Date: March 2023
Source: Municipality of Clarington

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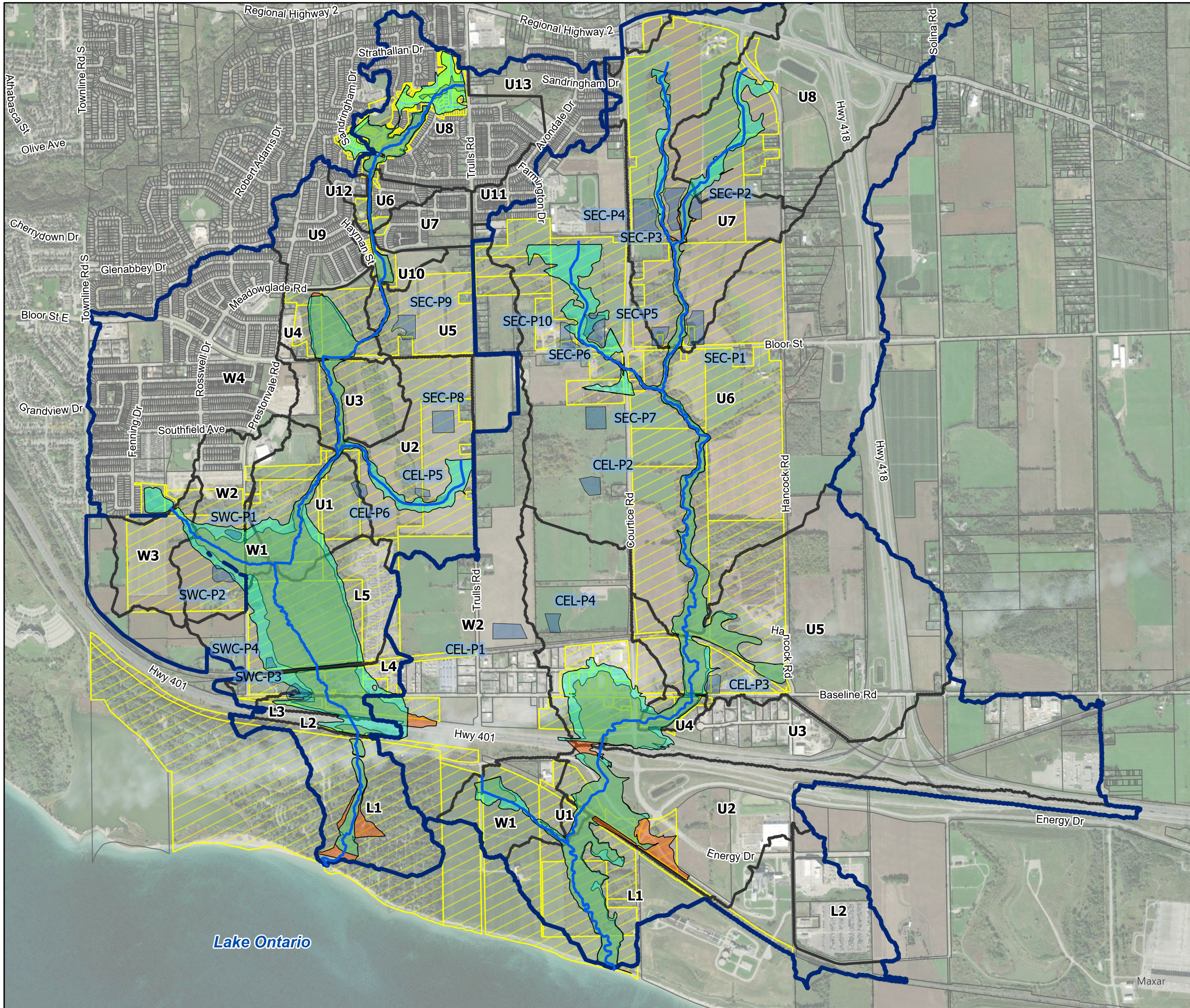

Clarington

Legend

- River Reaches
- Robinson 100-yr Future Uncontrolled Floodline*
- Tooley Regulatory Future Uncontrolled Floodline*
- CLOCA Existing Regulatory Floodline
- Property Parcel
- Subcatchments
- Subwatershed
- SWMF
- Parcel Intersecting Floodlines

*Future floodlines are subject to future study

Figure 6.4

Properties Intersecting Future Floodplain

0 0.5 1
Kilometers

N

Projection: UTM_Zone_17N
Datum: NAD_83 / CGVD28
Date: March 2023
Source: Municipality of Clarington

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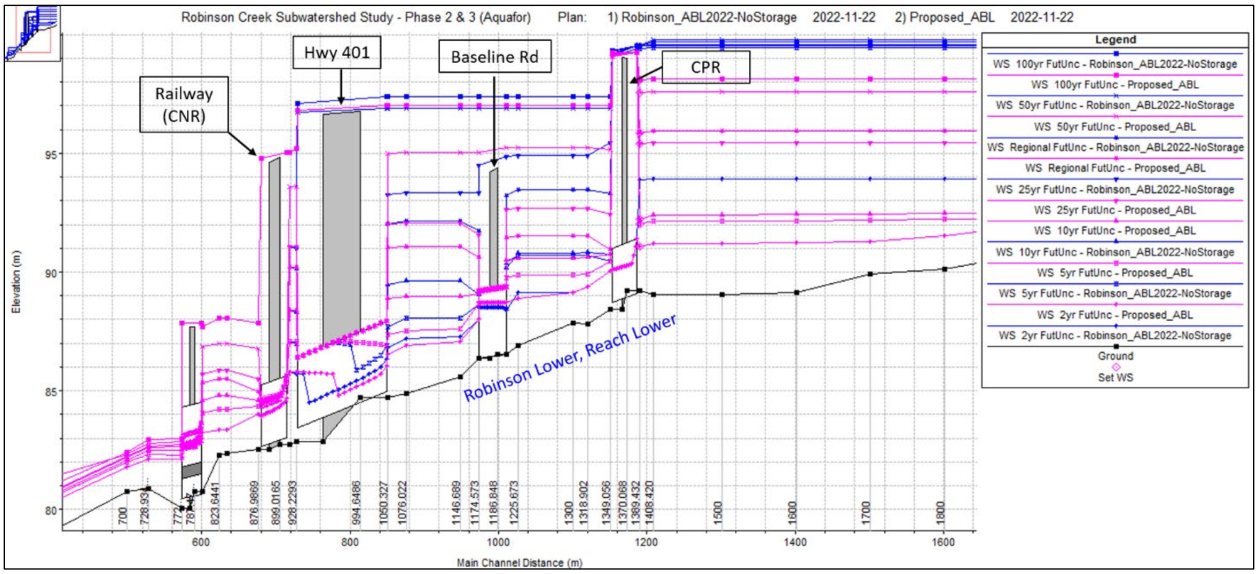
6.2.1.3 Upgrading existing watercourse crossing capacity

Analyzing the water surface elevation profile of creeks, it was determined that culverts in the southern reaches of both creeks may be creating a backwater effect (**Figure 6.5** and **Figure 6.6**). The structures in the area between the CPR and the CNR were therefore reviewed to identify the possibility of upgrading the culvert structures. Proposed scenarios were created in the hydraulic model to see if increasing the capacity of the identified undersized culverts would reduce the upstream floodplain extent. Regulatory floodlines under proposed scenario were compared with the Future Uncontrolled floodlines and CLOCA Existing Floodplain as provided in **Figure 6.7**.



* The profile for the existing conditions is the scenario without the storage upstream the CPR

Figure 6.5. Water Surface Elevation Profile for Robinson Lower reach Lower under Future Uncontrolled Conditions

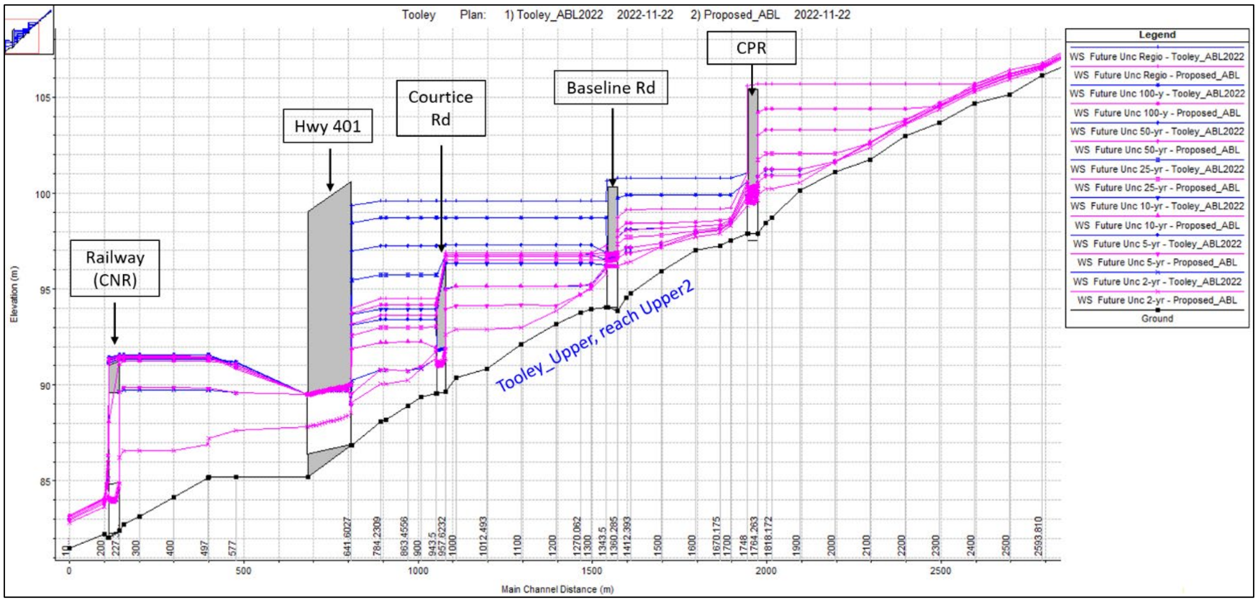


Figure 6.6. Water Surface Elevation Profile for Tooley_Upper reach Upper2 under Future Uncontrolled Conditions

CNR and Highway 401 are two crossings creating a backwater effect due to the undersized hydraulic structures for both watersheds. For Robinson Creek, Baseline Road crossing is one crossing that can plan to be upgraded, after the upgrade of the highway 401 culvert, if the objective is to reduce upstream flood impact for smaller storms than the 25-year storm return period. For Tooley Creek, Courtice Road crossing is one culvert crossing that can plan to be upgraded, after the upgrade of the highway 401 culvert, as well if the objective is to reduce upstream flood impact for the smaller storms than the 50-year storm return period.

Therefore, as the area located between the CNR and Highway 401 for Robinson Creek watershed does not have a specific interest for future development, a preliminary scenario of increasing by 50% the span of the culverts opening for the Highway 401 and Baseline Road was modeled for Robinson Creek. For Tooley Creek, a scenario of increasing by 50% the span of the culverts located beneath the CNR and the Highway 401 was simulated. Increasing the opening of the CPR for Robinson Creek was not analyzed because the estimated water surface elevation upstream CPR was manually set for each storm event in the Future Uncontrolled scenario (baseline scenario for comparison). Regarding Tooley Creek subwatershed, the backwatering from the CPR crossing does not impact a large area which furthermore is not an area of specific interest for future development. Thus, increasing its opening was not analyzed in this study.

Results suggest the proposed scenarios would slightly reduce the future uncontrolled water level from the Highway 401 to the CPR for Robinson Creek while would reduce considerably the future uncontrolled floodlines for Tooley Creek. Indeed, between Highway 401 and Courtice Road the proposed floodline extent would be much smaller than the existing CLOCA floodlines, and improvement on the flood line extent would be observed from the CNR to the CPR.

In conclusion, the proposed estimated floodlines show a smaller extent compared to the future uncontrolled scenario modeled between the 401 and the CPR, but would be still stayed larger than the existing CLOCA floodline for Robinson Creek subwatershed. For Tooley Creek subwatershed, the proposed floodlines extent would be smaller than the existing CLOCA floodplain, especially between the CNR to the CPR.

Additionally, road overtopping analysis under future uncontrolled conditions has been performed and results are presented in **Table 6.4** for Robinson Creek subwatershed and **Table 6.5** for Tooley Creek subwatershed.

Table 6.4: Road and Railway Flooding Status in Robinson Creek Subwatershed

River	Reach	Roadway Crossing	Structure Type	Road Elev. (m)	Difference between WES and Road Elevation (m)													
					2-year		5-year		10-year		25-year		50-year		100-year		Regional	
					Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.
Robinson Upper	Upper2	Bloor Street	Circular Culvert	111.64	0	0	0	0	0.08	0.08	0.15	0.15	0.16	0.16	0.25	0.25	0	0
RobinsonLower	Lower	CPR	Arch Culvert	99.00	-7.91		-6.97		-6.78		-3.61		-1.46		-0.92		-3.12	
RobinsonLower	Lower	Baseline Road West	Box Culvert	93.87	-5.47	-5.15	-3.47	-4.1	-3.69	-3.38	0.99	-1.23	3.01	1.39	3.51	3.15	-0.65	-2.42
RobinsonLower	Lower	Hwy 401	Box Culvert	95.03	-8.2	-8.51	-7.33	-7.69	-5.56	-6.14	-1.76	-2.99	1.85	-0.02	2.35	1.98	-2.63	-4.01
RobinsonLower	Lower	Railway (CNR)	Box Culvert	168.42	-82.64	-82.64	-81.37	-81.37	-80.02	-80.02	-77.36	-77.36	-74.85	-74.85	-73.39	-73.39	-78.23	-78.23

Green Not overtopped
Orange Less than 0.3m water depth
Red Greater than 0.3 m water depth

Note: CPR crossing capacity was not increased because it's under a storage effect and estimated the WSE is entered in HECRAS

Table 6.5: Road and Railway Flooding Status in Tooley Creek Subwatershed

River	Reach	Roadway Crossing	Structure Type	Road Elev. (m)	Difference between WES and Road Elevation (m)													
					2-year		5-year		10-year		25-year		50-year		100-year		Regional	
					Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.	Fut. Unc.	Prop.
Upper2-West	Upper3	Bloor Street	Box Culvert	120.19	-1.78	-1.78	-1.27	-1.27	-0.87	-0.87	-0.18	-0.18	0.15	0.15	0.25	0.25	0.31	0.31
Upper-West	West	Bloor Street	Circular Culvert	127.48	0.13	0.13	0.13	0.13	0.12	0.12	0.11	0.11	0.1	0.1	0.08	0.08	0.13	0.13
Upper-West	West	Courtice Road	Circular Culvert	123.8	0.35	0.35	0.43	0.43	0.42	0.42	0.42	0.42	0.42	0.42	0.41	0.41	0.42	0.42
Tooley_Upper	Upper2	CPR	Con/Span Culvert	105.45	-5.52	-5.52	-4.91	-4.91	-4.57	-4.57	-3.73	-3.73	-2.41	-2.41	-1.26	-1.26	0.2	0.2
Tooley_Upper	Upper2	Baseline Road West	Box Culvert	100.33	-4.12	-4.12	-3.71	-3.71	-3.49	-3.49	-3.01	-3.01	-2.61	-2.63	-0.62	-2.32	0.42	-1.63
Tooley_Upper	Upper2	Courtice Road	Box Culvert	96.69	-4.05	-4.05	-1.69	-2.74	-0.35	-1.73	0.09	-0.2	0.59	0.01	2.03	0.11	2.91	0.18
Tooley_Upper	Upper2	Hwy 401	Box Culvert	101.14	-10.88	-12.06	-8	-11.59	-7.46	-9.26	-5.69	-8.57	-4.15	-7.99	-2.69	-7.43	-1.8	-7.13
Tooley_Upper	Upper2	Railway (CNR)	Con/Span Culvert	91.3	-1.66	-5.1	0.05	-1.65	0.08	-0.25	0.15	0.07	0.2	0.14	0.25	0.2	0.26	0.21

Green Not overtopped
Orange Less than 0.3m water depth
Red Greater than 0.3 m water depth

Clarington

Legend

- River Reaches
- Robinson 100-yr Future Uncontrolled Floodline
- Tooley Regulatory Future Uncontrolled Floodline
- CLOCA Existing Regulatory Floodline
- Robinson Proposed 100-yr Future Uncontrolled Floodline
- Tooley Proposed Regulatory Future Uncontrolled Floodline
- Subcatchments
- Subwatershed
- 50% Upsized Culvert

Figure 6.7

Robinson & Tooley
Watercourse Crossing Capacity

0 0.5
Kilometers

Projection: UTM_Zone_17N
Datum: NAD_83 / CGVD28
Date: November 2022
Source: Municipality of Clarington

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6.2.1.4 Stormwater Management

During the Regulatory event, all SWM facilities must be assumed to be non-operational unless they are designed in accordance with the Lakes and Rivers Improvement Act (LRIA) standards for small dams, per CLOCA's Technical Guidance document (CLOCA, 2020). If the proposed stormwater management facilities identified in **Figure 6.2,** which provide 450 m^3/ha of storage, are constructed to these standards, then they could be assumed to be functional during the Regulatory event and would reduce future flood flows below existing conditions. This would bring the post-development flows below pre-development flows. **Table 6.1** and **Table 6.2** summarize the findings. Requirements for these facilities are presented in **Section 7.1.1.**

6.2.2 Additional Floodplain Mapping

The hydrologic and hydraulic modeling used to develop **Figure 6.3** was completed for the purposes of comparing existing CLOCA and future uncontrolled conditions, and not to update or replace CLOCA Regulatory floodlines. An additional scope was added to extend the floodlines, where they presently do not exist, through areas within the Secondary Plan that are currently not floodplain mapped.

A separate task was completed, which involved the extension of the riverine Regulatory floodlines for four tributaries located in the headwaters of Robinson and Tooley Creeks. These tributaries were identified by CLOCA, and included one tributary in Robinson Creek subwatershed and three tributaries in Tooley Creek subwatershed. The methodology and resulting floodplain mapping is presented in **Appendix C.**

6.3 Water Quality

An Enhanced level of protection is required for both Robinson Creek and Tooley Creek Subwatersheds. To achieve this level of control, LID measures are prioritized for achieving the water quality criteria, followed by stormwater management facilities and then manufactured treatment devices (CLOCA, 2020). The MECP's Consolidated Linear Infrastructure Environmental Compliance Approval (CLI ECA) accepts control of the 90^{th} percentile storm event (27 mm) to achieve Enhanced water quality treatment, as presented in **Figure 6.8**, where the Runoff Volume Control Target (RVC_T) corresponds to the runoff generated from the regionally specific 90^{th} percentile rainfall event.

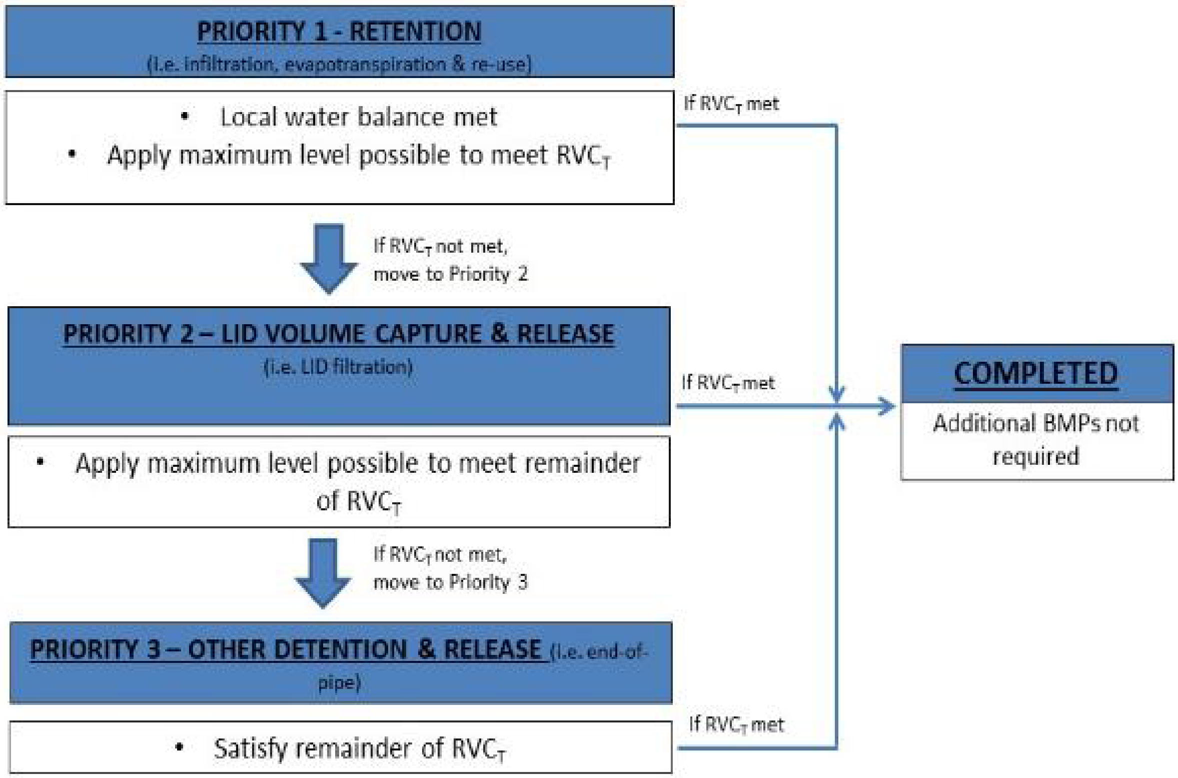


Figure 6.8: The runoff control hierarchy from the MECP's LID Stormwater Management Guidance Manual

LID measures were therefore modeled throughout the new developments in the Secondary Plan areas. The VO6.1 model assumed a bioretention system is implemented for all proposed land uses. Treatment of the 27 mm event throughout both subwatersheds was feasible using LIDs, so the use of stormwater management facilities or manufactured treatment devices was not necessary to achieve an Enhanced level of treatment. The runoff volumes for each subcatchment associated with the 27 mm event are presented in **Table 6.6.**

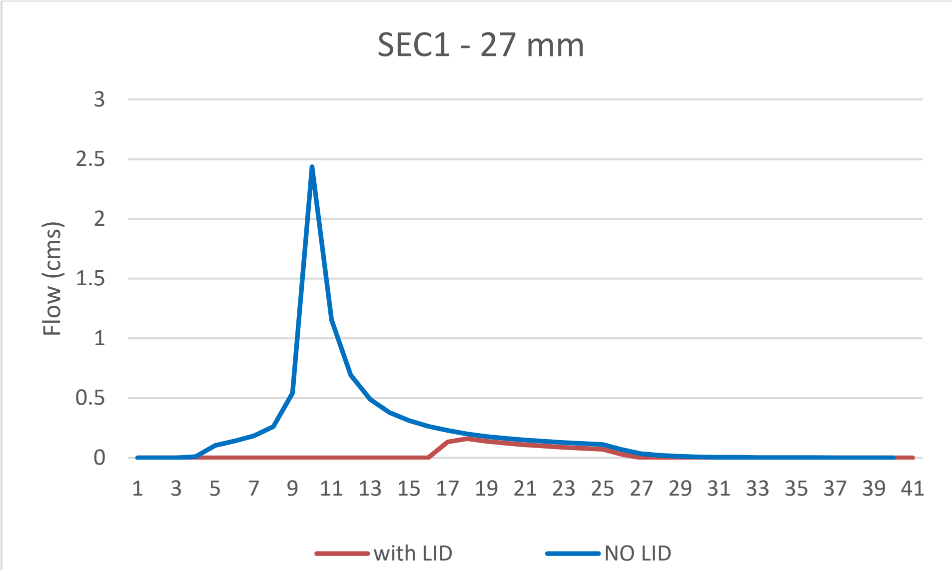
Table 6.6: Required 27 mm Runoff Volumes

		Subcatchment	27 mm (4 Hour Chicago) Runoff Equivalent Depth (mm)	27 mm (4 Hour Chicago) Runoff Volume (m^3)
Robinson		CEL5	11.90	2578.73
		SEC8	18.65	5290.27
		CEL6	24.02	4606.27
		SEC9	16.79	4215.22
		SWC1	17.68	2120.07
		SWC4	19.09	1122.26
		SWC3	19.29	1053.18
		SWC2	17.47	7831.85
Tooley		SEC3	16.02	4258.38
		SEC6	19.48	3441.76
		SEC7	19.43	4226.24
		CEL3	19.06	9145.93
		CEL4	23.94	7707.71
		SEC10	18.46	3555.20
		CEL2	17.59	5325.52
		SEC1	16.04	5127.67
		CEL1	23.97	13161.18
		SEC2	15.77	1452.69
		SEC4	20.39	6456.88
		SEC5	17.27	1906.94

Flows at two catchments, SEC1 and CEL3, are presented in **Table 6.7**, **Figure 6.9** and **Figure 6.10** to illustrate the performance of LID measures during the 27 mm and 2 year events. The locations for SEC1 and CEL3 can be found in **Figure 6.2**. With the implementation of LIDs controlling the 27 mm event, peak flows during the 27 mm event drop significantly. During the 2-year event, flows at both locations drop to about 50% of the flows if no LIDs were implemented. LID implementation also delays the peak flow, which is typically more in line with what is observed in a less developed watershed.

Table 6.7: Flows at SEC1 and CEL3 with LID Measures During 27 mm Event

		Flow (m^3/s)	Runoff (mm)
SEC 1	**Uncontrolled**	2.437	16.09
	LID Only	0.160	1.924
CEL3	**Uncontrolled**	4.551	19.06
	LID Only	0.759	5.685



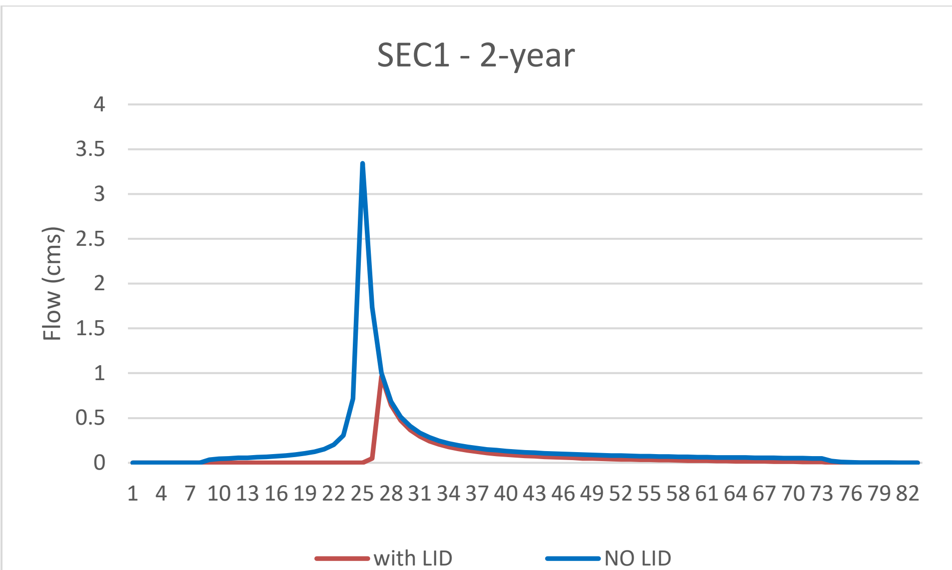
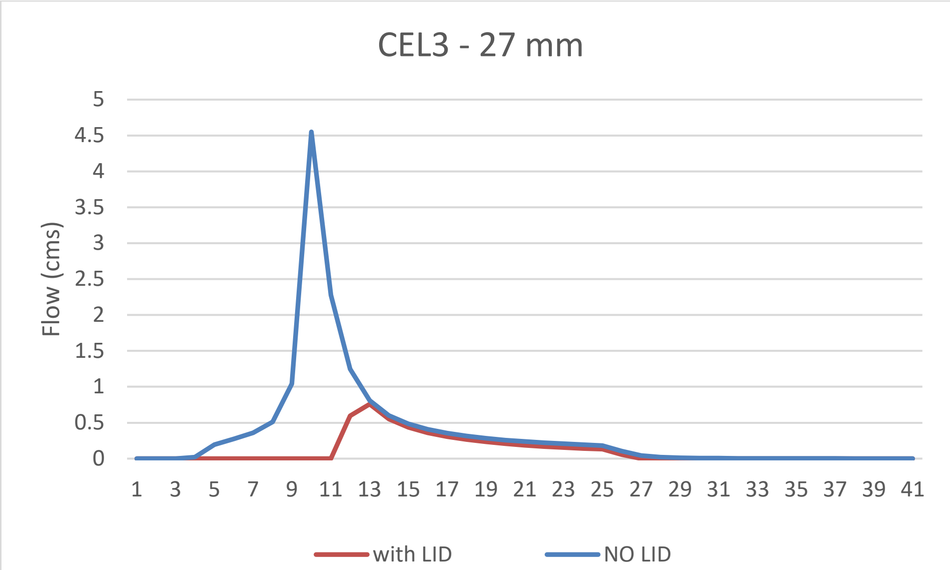


Figure 6.9: Flows at SEC1 with LID Measures Implemented



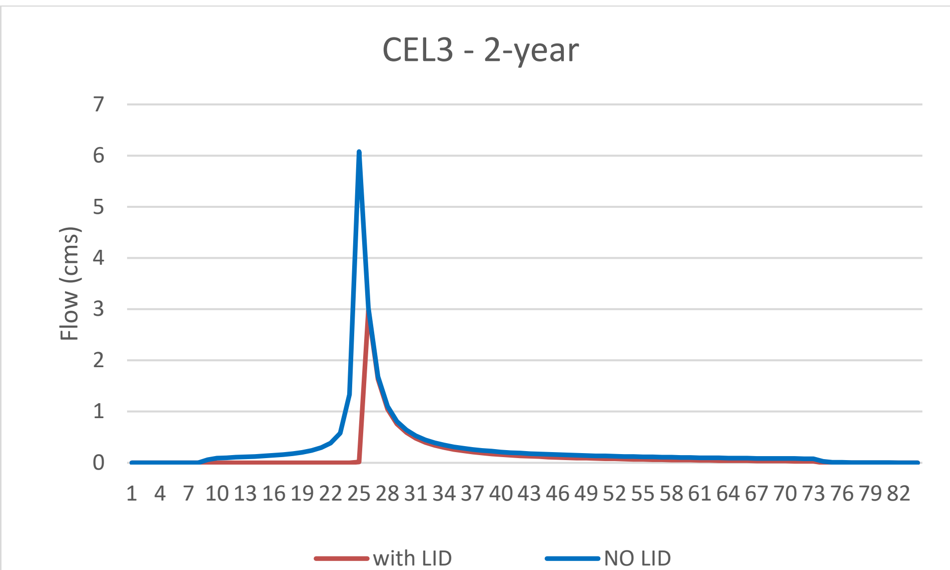


Figure 6.10: Flows at CEL3 with LID Measures Implemented

6.4 Erosion Control

Erosion potential within both Robinson Creek and Tooley Creek was determined to be as high as 15 m/100 years as part of the geomorphic assessments completed as part of the **Robinson Creek and Tooley Creek Subwatershed Study: Phase 1 Report**. A number of assessed reaches throughout Robinson Creek and Tooley Creek were determined to be in a state of geomorphic adjustment, or transitioning to said state. In order to protect against increased rates of erosion, and thus unstable channel adjustments, stormwater management facilities, including LIDs, will be a necessary part of future development to prevent increased peak flow rates and increased durations of critical discharge exceedance.

A minimum of a 27 mm rainfall event is required to be captured, retained, or detained from all new and/or fully reconstructed impervious surfaces. The first priority is retention of the full volume from the 27 mm event through infiltration, evapotranspiration, reuse, bioretention, etc. If this is not feasible, then volume reduction to the maximum extent practical, as demonstrated through supporting documentation, is required with a minimum of 5 mm. The remaining runoff volume must then be detained on site and released over 24 to 48 hours. This requirement from CLOCA has been adopted as part of this Subwatershed Study.

As presented in **Section 6.3,** control of the runoff from the 27 mm event is possible using LID measures. The LID measures were able to reduce the Future Uncontrolled peak flow during the 27 mm event to be equivalent or below the Existing peak flow at most node locations (**Table 6.8**). Runoff volumes are presented in **Table 6.6**.

Table 6.8: Peak Flow (m^3/s) during the 27 mm 4-hour Chicago Storm

	NHYD	Existing - 2018	Future (Uncontrolled)	LID Only (1min)
Robinson	336	0.40	0.47	0.467
	310	3.08	9.36	4.856
	319	6.35	12.33	7.129
	324	6.85	13.08	7.671
Tooley	3	3.15	7.07	
	7	4.53	12.50	1.338
	17	6.27	15.87	2.943
	18	6.29	18.51	4.877
	19	8.74	24.80	5.186
	20	12.50	27.96	10.210
	29	17.07	34.07	14.167
	35	17.10	34.05	17.900

6.5 Water Balance

The impervious surfaces associated with future urban development will reduce the capacity of the site to infiltrate rainfall events into the groundwater system, creating an increase in the volume of surface runoff instead. For the Robinson Creek and Tooley Creek Subwatersheds, two methods were used to estimate existing infiltration values on a yearly basis, namely:

1. Thornthwaite and Mather model; and
2. PRMS model as estimated in the Phase 1 report.

6.5.1 Water Balance Method 1: Thornthwaite and Mather Model

The hydrologic cycle is a complex process and its natural components are dependent on many factors (e.g. soils, topography, vegetation, geology, climate). Any change to these natural factors will result in a change to the hydrologic cycle. The water budget analysis is a comprehensive examination of the hydrological cycle based on the following expression:

Precipitation (P) = Evapotranspiration (ET) + Runoff (R) + Infiltration (I)

Evapotranspiration (ET) was calculated according to the Thornthwaite and Mather model (Thornthwaite and Mather, 1957) which uses an accounting procedure to analyze the allocation of water among various components of hydrologic system. This was completed by AECOM (2010) based on weather data from 1971 to 2000 at the Bowmanville Mostert Meteorological Station and assuming a water retention value of 150 mm. As presented in Table 6.9, AECOM (2010) found that the annual actual evapotranspiration was 493.7 mm out of a total annual precipitation of 857.8 mm.

Table 6.9: Thornthwaite Evapotranspiration Components (AECOM, 2010)

Month	Mean Monthly Precipitation (mm)	Mean Monthly Temperature (°C)	Actual ET (mm)	Water Balance – Surplus (mm)
January	63.1	-6.3	0	63.1
February	47.2	-5.3	0	47.2
March	60.7	-0.5	0	60.7
April	72.9	6	28.3	44.3
May	73.7	12.2	59.6	14.1
June	81.5	17.1	85.1	-3.6
July	63.7	19.8	99.2	-35.5
August	81.0	18.9	94.5	-13.5
September	90.5	14.7	72.6	17.9
October	67.9	8.4	40.3	27.6
November	84.0	3.1	14.1	69.9
December	71.6	-2.7	0	71.6
Average/Total	**857.8**	**7.12**	**493.7**	**364.1**

Note: when mean monthly temperatures fall below 0°C, the Thornthwaite and Mather method assumes evapotranspiration does not occur.

The computed evapotranspiration values were then used to estimate annual and monthly water surplus. The results of the water budget analysis highlight the importance of infiltration and evapotranspiration in the natural hydrological cycle (i.e. predevelopment) of the study area (**Table 6.10**).

Table 6.10: Water Budget

Water Budget Component	Source of Information	Value (mm/year)			
		Newmarket Till	Glaciolacustrine Silt and Clay	Glaciolacustrine Fine Sand	Total
Annual Precipitation (P)	Environment Canada	857.8			
Actual ET (ET)	Thornthwaite & Mather	493.7			
Water Surplus	P – ET	364.1			
Runoff	-	218.5	236.7	163.8	220.2
Infiltration	-	145.6	127.4	200.3	143.9

6.5.2 Water Balance Method 2: PRMS Model

As part of the **Robinson Creek & Tooley Creek Subwatershed Study: Phase 1 Report**, a fully distributed hydrologic model was developed for the study area (EarthFX, 2008 and EarthFX, 2011). This model provided estimates of the components of the water budget under existing conditions. A summary of these water budget elements for each subwatershed is shown in **Table 6.11**.

Table 6.11: PRMS Water Budget Summary

Water Budget Element PRMS Recharge Model Results:	Robinson	Tooley
Average Observed Precipitation (mm/yr)	868.0	872.3
Average Net Precipitation (mm/yr)	732.7	711.5
Avg. Net Precip. After EV(DP) Losses (mm/yr)	695.4	683.5
Average Potential ET (mm/yr)	762.6	761.4
Average Actual ET (mm/yr)	424.1	401.2
Average Interception Losses (mm/yr)	133.9	159.2
Average Depression Storage Losses (mm/yr)	37.3	28.0
Average Total ET (AET+INT) (mm/yr)	557.9	560.4
Average Runoff (mm/yr)	203.4	184.4
Average GW Recharge (mm/yr)	106.7	127.0

Note:
ET = Evapotranspiration
Observed Precipitation = Total measured precipitation from climate stations
Net Precipitation = Precip. that reaches the ground surface (after interception losses to plant canopy)
Interception Losses = Water captured by the plant canopy and lost to evaporation
Depression Storage Losses (DP) = Evaporation lost from small closed depressions on the ground surface
Net Precip. after EV and DP = Net precip. that reaches the ground surface (after interception and depression storage losses)
Potential ET = The amount of water that could evaporate if the soil was always saturated
Actual ET = The amount of water that actually evaporates based on actual available soil moisture.
Runoff = Water that flows along the ground surface downslope
GW Recharge = Water that passes through the unsaturated zone to reach the groundwater table
GW Discharge = Groundwater that discharges to streams and wetlands (baseflow)
The model results indicate an annual average groundwater recharge of 106.7 mm in Robinson Creek Subwatershed and 127.0 mm in Tooley Creek Subwatershed. The actual values on a site by site basis will vary depending on soil type, slopes, vegetation cover and depth to water table.

6.5.3 Comparison of Two Methods

The two methods provide an annual infiltration rate of between 106 and 144 mm/year on a subwatershed basis. Given that there are approximately 40 rainfall events per year the average infiltration rate per event is relatively modest (2.5 – 3.5 mm per event). The actual values on a site by site basis will vary depending on soil type, slopes, vegetation cover and depth to water table.

The above recharge targets can be achieved by incorporating appropriate LID source and conveyance control measures as outlined in **Section 5** together with the requirements to meet the Water Quality targets as noted in **Section 6.2.1.4**. Collectively the LID measures should ensure that post-development infiltration rates equal or exceed pre-development levels. Monitoring has shown that, for soils of a similar nature, infiltration of up to 10 mm per event is possible.

High Volume Recharge Areas (HVRAs) and Ecologically Significant Groundwater Recharge Areas (ESGRAs) will require additional attention to ensure pre-development recharge rates are maintained (**Section 7.4**).

6.6 Thermal Mitigation

Both Robinson Creek and Tooley Creek were characterized as coolwater streams by AECOM (2010). Aquatic investigations by Aquafor Beech as part of the **Robinson Creek and Tooley Creek Subwatershed Study: Phase 1 Report** confirmed the presence of coolwater species. The use of LID measures reduces stormwater temperature, it is expected that the implementation of the proposed stormwater strategy is expected to adequately cool stormwater temperatures when combined with best management practices for the SWM facilities. Since the preferred alternative is for dry facilities will be implemented, there is less of an opportunity for standing water to increase in temperature as exists with wet facilities.

6.7 Preferred Alternative

Based on the above evaluation, the Preferred Alternative is **Traditional Stormwater Management with LIDs**. This approach meets the required flood control criteria using dry stormwater facilities, and uses LID measures to achieve the water quality, erosion control, water balance, and thermal mitigation criteria.

6.7.1 Costs of Preferred Alternative

Unit cost estimates for the preferred alternative were estimated based on implementation of similar projects within the Greater Toronto and Hamilton Area:

- LID: $400 per linear metre
- Dry Ponds: $175 per cubic metre of pond volume

Costing of the culverts was not completed, as it has been agreed that a future flood control study would be completed to address culvert sizing and other flood control alternatives.

6.8 Potential Impacts Associated with Climate Change

Climate change has the potential to alter rainfall patterns in Ontario as more moisture in a warmer atmosphere is expected to cause an increase in extreme weather events and result in less climate predictability from year-to-year. A change in the intensity and/or frequency of rainfall events can have both acute and long-term effects on stream flow and municipal stormwater management. Rainfall events that produce a larger volume of water than the design flow can result in many complications. If a sufficient outlet or emergency overflow is not provided, large volumes of water can cause surcharging of the storm sewer systems, resulting in flooding in upstream urban areas.

The Municipality of Clarington has completed the first two stages of a five-stage corporate Climate Action Plan. The Stage 3 Plan is currently in progress and consists of “a series of work sessions to set goals and identify options, actions and constraints to respond to climate change. The Working Group will evaluate potential actions, and financing and implementation alternatives to create the Climate Change Action Plan. At the end of this phase, staff will present a Draft Climate Action Plan to Council for approval” (Clarington, 2020).

The following section quantifies potential changes to extreme rainfall events. These changes are included as a scenario in the model (**Section 6.2.1.4**) thereby contributing to the Action Plan by identifying actions for responding to climate change.

6.8.1 Future IDF Projections

Several tools have been developed by climate scientists and statisticians to project future intensity-duration-frequency (IDF) relationships for rainfall events in Ontario. Three (3) of these tools are discussed below:

1) The **Ontario Climate Change Data Portal (Ontario CCDP)** was developed through the University of Regina with funding from the Ontario Ministry of the Environment and Climate Change (now Ministry of Environment, Conservation and Parks - MECP). This tool was launched to ensure technical or non-technical end-users (e.g. municipalities, private sector) have easy and intuitive access to the latest climate data over the Province of Ontario. Climate projections for several parameters are made on a 25 km grid resolution based on regional climate modelling using PRECIS model and the RegCM model under three (3) emissions scenarios.
2) The **IDF_CC Tool 4.0** was developed through the University of Western Ontario and the Institute for Catastrophic Loss Reduction. This tool was designed as a simple and generic decision support system to generate local IDF curve information that accounts for the possible impacts of climate change. It applies a user-friendly GIS interface and provides precipitation accumulation depths for a variety of return periods (1:2, 1:5, 1:10, 1:25, 1:50 and 1:100 years) and durations (5, 10, 15 and 30 minutes and 1, 2, 6, 12 and 24 hours), and allows users to generate IDF curve information based on historical data, as well as future climate conditions that can inform infrastructure decisions. The IDF_CC tool stores data associated with 700 Environment and Climate Change Canada operated rain stations from across Canada. The IDF_CC tool allows users to select multiple future greenhouse gas concentration scenarios and apply results from a selection 24 Global Circulation Models (GCMs) and 9 downscaled GCMs that simulate various climate conditions to local rainfall data.
3) The **MTO IDF Curves Finder** was developed by the Ontario Ministry of Transportation (MTO) to provide a convenient method to interpolate IDF curve parameters between Meteorological Services Canada stations for MTO projects. As part of the tool, a time-trend analysis was conducted on data between 1960 and 2010 to establish trends in IDF parameters. The tool projects data forward to 2060 using a linear trend line. It should be noted that this methodology is not based in climate projections but rather historical observations and as such results vary considerably from the two models introduced above which rely on downscaled global climate models.

All three models were considered in order to create IDF projections to 2050 for the Robinson Creek and Tooley Creek Subwatersheds.

- The Ontario CCDP website has been experiencing a technical issue with their servers since early September 2020, and was thus unavailable for analysis.
- The IDF_CC Tool 4.0 was used to generate IDF curves for the Oshawa WPCP station under three climate change scenarios from 2035-2065 using the “all models ensemble” raw GCMs model selection default. The projections included RCP 2.6, RCP 4.5, and RCP 8.5 which correspond to low, moderate, and severe climate change severity.

- MTO IDF Curve Finder used data from the Oshawa WPCP station to project rainfall intensities in 2050.

6.8.1.1 Existing IDF Curve

The 100-year storm was estimated for all three projections and compared with the existing 100-year storm. The Municipality of Clarington provides an IDF curve using the Yarnell formula is provided for the 2-year through to 100-year storm, but notes that for the 100-year storm, the Chicago formula should be used for the 100-year storm as it is more conservative.

Yarnell (mm/hr): $I = \frac{5588}{T_c+28}$

Chicago (mm/hr): $I = \frac{1770}{(T_c+4)^{0.82}}$

6.8.1.2 Projection Results

The rainfall intensity results from the two models are presented for the 100-year storm in **Table 6.12**.

Table 6.12: Rainfall Intensity Projections for 100-Year Storm to 2050

	IDF_CC			MTO
	RCP 2.6	RCP 4.5	RCP 8.5	
5 min	196.21	201.66	200.14	271.30
10 min	144.13	147.76	146.44	167.50
15 min	111.27	114.99	113.56	126.30
30 min	67.49	70.77	69.15	78.00
1 h	48.81	50.47	50.05	48.20
2 h	32.61	33.78	33.39	29.80
6 h	14.48	14.71	14.8	13.90
12 h	10.83	11.21	11.26	8.60
24 h	5.62	5.82	5.91	5.30

For short duration events (5-minute to 30-minute) the linear interpolation by the MTO is more conservative, whereas the IDF_CC predictions for longer duration events (1-hour and longer) were more conservative.

These results are compared with the existing Yarnell and Chicago rainfall intensities generated from the equations above provided by CLOCA (2010). The percent increase from existing design rainfall intensities to the projected climate change rainfall intensity in 2035-2065 is presented for both the Yarnell and Chicago formulas in **Table 6.13**.

Table 6.13: Percent Increase from Existing 100-Year Rainfall Intensity to Projected Climate Change Intensity in 2035-3065

	Yarnell				Chicago			
	IDF_CC			MTO	IDF_CC			MTO
	RCP 2.6	RCP 4.5	RCP 8.5		RCP 2.6	RCP 4.5	RCP 8.5	
5 min	**15.9**	**19.1**	**18.2**	**60.2**	-32.8	-31.0	-31.5	-7.1
10 min	-2.0	**0.5**	-0.4	**13.9**	-29.1	-27.3	-28.0	-17.6
15 min	-14.4	-11.5	-12.6	-2.8	-29.7	-27.3	-28.2	-20.2
30 min	-29.9	-26.5	-28.2	-19.0	-31.3	-27.9	-29.6	-20.6
1 h	-23.1	-20.5	-21.2	-24.1	-16.5	-13.7	-14.4	-17.6
2 h	-13.6	-10.5	-11.6	-21.1	-4.1	-0.6	-1.8	-12.3
6 h	**0.5**	**2.1**	**2.8**	-3.5	**3.0**	**4.7**	**5.3**	-1.1
12 h	**45.0**	**50.1**	**50.7**	**15.1**	**35.4**	**40.2**	**40.8**	**7.5**
24 h	**47.6**	**52.9**	**55.3**	**39.2**	**23.8**	**28.2**	**30.2**	**16.7**

Under most scenarios, the existing IDF curve is more conservative than the climate change predictions, especially when considering the recommended Chicago formula. The exception is with the 12-hour and 24-hour storm events, which are predicted to have substantially higher rainfall intensities under each climate change scenario. There was a slight increase in predicted rainfall intensity for the 6-hour event using the IDF_CC model results, but not the MTO.

Since the 12-hour and 24-hour climate projects are substantially greater than the existing IDF curves, it is recommended that the effects of climate change be taken into account by using the IDF projection results to 2050 as a sensitivity analysis during the design of stormwater infrastructure.

As illustrated in **Table 6.13**, the existing Chicago IDF curve is more conservative than the climate change predictions, with the notable exception of the 12-hour and 24-hour storm events. These two events are consistently predicted to have substantially higher rainfall intensities than under existing conditions. It is therefore recommended that the effects of climate change be taken into account by using the IDF projection results to 2050 as a sensitivity analysis during the design of stormwater infrastructure. This sensitivity analysis is recommended, but not required, by the Subwatershed Study. This recommendation may be implemented at the Municipality’s discretion.

7 Description of the Recommended Plan

This chapter will summarize the overall Management Strategy for the Secondary Plan lands in consideration of the preceding sections. **Section 4** outlined the proposed land uses, while **Sections 5** and **6** identified alternative stormwater strategies and selected a preferred approach. The discussion in this section will focus on targets and appropriate measures related to stormwater management (surface water), erosion, natural heritage plans and groundwater. While the work reported in this section was conducted prior to the release of CLOCA's October 2020 update to their Technical Guidelines for Stormwater Management Submissions, it has since been updated to align with these guidelines.

7.1 Stormwater Management (Surface Water)

Changes in land use, including the conversion of rural lands to urban development alters the water balance as pervious surfaces are converted to impervious surfaces, infiltration characteristics of the soils are altered and vegetation is removed. When rural lands are urbanized, porous soils are replaced with impervious materials such as concrete and asphalt which yield high runoff during precipitation events. Consequently, land use change can lead to a significant and sometimes radical alteration in the watershed hydrology and water quality.

In order to mitigate the impact of urbanization of the Robinson Creek and Tooley Creek Subwatersheds, stormwater management in the form of source, conveyance and end-of-pipe facilities will need to provide:

- water quality treatment consistent with MECP "enhanced" level quality control;
- infiltration opportunities to maintain pre-development water balance characteristics and support Ecologically Significant Groundwater Recharge Areas (ESGRAs) and High Volume Recharge Areas (HVRAs);
- detention of peak flows to mitigate flooding in tributaries and critical reaches of Robinson Creek and Tooley Creek; and
- erosion controls to ensure critical erosion thresholds are not exceeded.

The Runoff Volume Control Target (RVC_T) corresponds to the runoff generated from the regionally specific 90th percentile rainfall event, which is approximately a 27 mm event in Robinson Creek and Tooley Creek Subwatersheds, which is more stringent than CLOCA's volume control criteria to capture, retain or detain runoff from a 25 mm rain event. To meet the more conservative criteria, new projects in the Robinson Creek and Tooley Creek Subwatersheds will therefore have a RVC_T corresponding to the 27 mm event. The runoff generated from a 27 mm rainfall event should be controlled using a control hierarchy whereby retention via LID retention technologies which utilize the mechanisms of infiltration, evapotranspiration and or re-use are preferred. The control hierarchy is shown below in **Figure 7.1**.

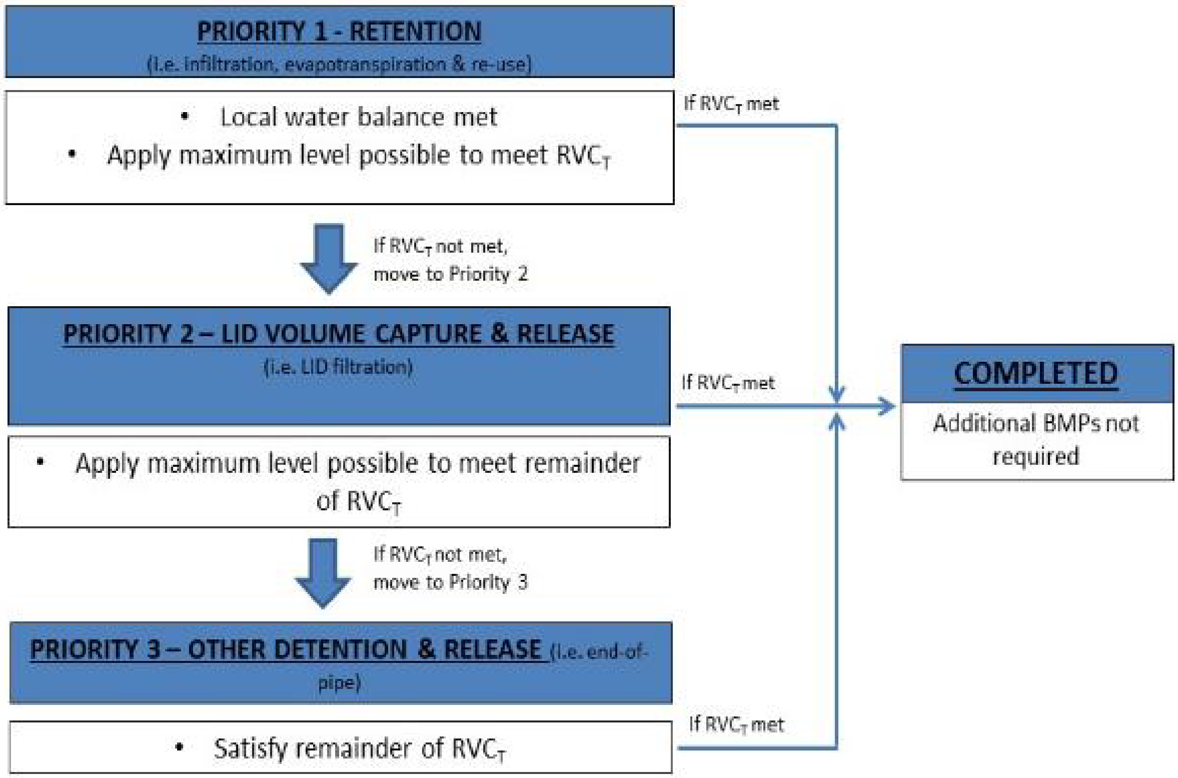


Figure 7.1: The runoff control hierarchy from the MECP's LID Stormwater Management Guidance Manual

7.1.1 Flood Control

This section will address the flood control strategy for up to the 100-year and Regional storms to ensure that proposed development does not increase flows within the creeks or their tributaries. CLOCA requires the following criteria, also adopted by this study:

1. Post-development flows from the 2-year through 100-year events were less than or equal to the 2-100 year existing flows; and
2. Uncontrolled flows were less than the existing regulatory flows, where the regulatory flow is defined as the larger of the 100-year or Regional flow.

Since post-development flows exceeded existing flows in both Robinson Creek and Tooley Creek, stormwater detention ponds are necessary. The required detention can be provided within the end-of-pipe stormwater ponds as recommended as part of the preferred stormwater strategy. This consists of 20 (twenty) municipal dry ponds which were located in accordance with the Secondary Plan land use for Southeast Courtice and Southwest Courtice, but placed near the outlets of subcatchments for the CEL.

The list of the proposed ponds and stormwater control facilities and their storage volumes are presented in **Table 7.1** based on the locations identified in **Figure 6.2**. The assumed footprint of each facility is also provided, using an average facility depth of 2m. The proposed storage volumes and footprints are preliminary and need to be confirmed through the design process. In addition, these ponds must be designed to ensure that the post-development flow rates at key flow nodes (**Figure 6.1**) are controlled to the pre-development flow rates.

If the Flood Control Study (see **Section 8.4.1**) indicates that the stormwater ponds will be required to act as flood control facilities during the Regulatory event in Tooley Creek Subwatershed (generally the Regional storm; see **Appendix C**), they must be designed in accordance with the Lakes and Rivers Improvement Act (LRIA) standards for small dams. For Tooley Creek Subwatershed, all conventional SWM facilities were assumed to be constructed to these standards within this Subwatershed and were therefore included in the model.

CLOCA outlines the requirements for designing SWM facilities to meet the LRIA standards in Section 5.2 of their Technical Guidelines (CLOCA, 2020), which are also reproduced below:

- The design must consider the Probable Maximum Flood (PMF) as the inflow design flood unless an assessment of the losses in the event of a dam failure show that a lower IDF is appropriate. This assessment must be in accordance with the 2011 MNRF Technical Bulletin for Classification and Inflow Design Flood Criteria.
- A geotechnical analysis confirms all existing and proposed slopes are stable when saturated. This must consider the inflow design flood, as described above.
- Outlet pipes must be fitted with anti-seepage collars.
- The emergency spillway must safely convey the inflow design flood away from the facility.
- A minimum freeboard of 0.3 m is required above the maximum spillway flow depth based on the inflow design flood.
- A long-term operations and maintenance program is required to ensure the facility is maintained properly.

Table 7.1: Summary of Conceptual Municipal Stormwater Management Ponds

Secondary Plan	Pond Name	Subwatershed	Drainage Area (ha)	Storage Volume (m^3)	Assumed Footprint (ha)
Courtice Employment Lands	CEL-P1	Tooley	54.9	24706	1.24
	CEL-P2	Tooley	30.3	13626	0.68
	CEL-P3	Tooley	48.0	21587	1.08
	CEL-P4	Tooley	32.2	14491	0.72
	CEL-P5	Robinson	21.7	9752	0.49
	CEL-P6	Robinson	19.2	8631	0.43
	SWC-P1	Robinson	12.0	5396	0.27

Secondary Plan	Pond Name	Subwatershed	Drainage Area (ha)	Storage Volume (m^3)	Assumed Footprint (ha)
Southwest Courtice	SWC-P2	Robinson	45.0	20250	1.01
	SWC-P3	Robinson	5.5	2453	0.12
	SWC-P4	Robinson	5.9	2646	0.13
Southeast Courtice	SEC-P1	Tooley	31.9	14355	0.88
	SEC-P2	Tooley	9.2	4144	0.21
	SEC-P3	Tooley	26.6	11951	0.60
	SEC-P4	Tooley	31.7	14250	0.71
	SEC-P5	Tooley	10.9	4927	0.25
	SEC-P6	Tooley	10.9	7931	0.40
	SEC-P7	Tooley	21.7	9770	0.49
	SEC-P8	Robinson	28.4	12762	0.64
	SEC-P9	Robinson	25.1	11300	0.57
	SEC-P10	Tooley	19.3	8668	0.43

7.1.2 Water Quality

Following the approach outlined in **Figure 7.1**, it is recommended that new development areas within the Robinson Creek and Tooley Creek Subwatersheds maintain a water quality target that will not vary and will remain as control of the runoff generated from a 27 mm event using infiltration LID measures as a first priority, followed by filtration measures if full infiltration is not feasible. This approach is aligned with the requirements of CLOCA and the MECP CLI ECA, which prioritizes LID measures to achieve an Enhanced level of treatment within Robinson Creek and Tooley Creek Subwatersheds. An Enhanced level of treatment corresponds to a long-term load reduction of total suspended solids of 80%.

Achieving control of the 27 mm event is possible through infiltration, with **Table 7.2** presenting the equivalent runoff volume within each subcatchment. However, local conditions may indicate that infiltration of the full 27 mm is not feasible (**Section 7.1.2.1** for discussion of site-specific factors). If any of these factors apply to a specific site, then LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes should be considered. If using these techniques to treat the full 27 mm is still not feasible, then the use of stormwater management facilities (eg. Wet ponds, wetlands, or hybrid ponds) or manufactured treatment devices (eg. Oil and grit separators) are permitted. Regardless of the method used to achieve the water quality criteria, SWM quantity controls to control peak flows will still be required at the end-of-pipe.

Table 7.2: Runoff Volumes

	NHYD	Subcatchment	27 mm (4 Hr Chic) Runoff Equivalent Depth (mm)	27 mm (4 Hr Chic) Runoff Volume (m^3)
Robinson	502	CEL5	11.90	2578.73
	547	SEC8	18.65	5290.27
	548	CEL6	24.02	4606.27
	549	SEC9	16.79	4215.22
	550	SWC1	17.68	2120.07
	551	SWC4	19.09	1122.26
	552	SWC3	19.29	1053.18
	553	SWC2	17.47	7831.85
Tooley	520	SEC3	16.02	4258.38
	521	SEC6	19.48	3441.76
	522	SEC7	19.43	4226.24
	524	CEL3	19.06	9145.93
	525	CEL4	23.94	7707.71
	527	SEC10	18.46	3555.20
	528	CEL2	17.59	5325.52
	529	SEC1	16.04	5127.67
	530	CEL1	23.97	13161.18
	550	SEC2	15.77	1452.69
	553	SEC4	20.39	6456.88
	554	SEC5	17.27	1906.94

7.1.2.1 Site-Specific Factors Limiting Use of LIDs

The use of infiltration LID measures may be limited by site-specific factors. These factors, as listed by CLOCA (2020), include:

- Shallow bedrock;
- High groundwater;
- Zoning, setbacks or other land-use requirements;
- Property or infrastructure restrictions;
- Poor soils (low infiltration rates, highly compacted, contaminated); or
- Highly vulnerable aquifer.

In addition to these factors, the presence of high-risk site activities within the catchment area may also restrict the use of LIDs. For all sites, infiltration practices should not accept runoff from drainage areas within the site which are associated with higher risks such as fueling stations, waste disposal areas, vehicle washing stations, salt storage areas, stockpiling areas and shipping and receiving areas. A complete list of high-risk site activities based on O.Reg. 153/04(Records of Site Condition) and O.Reg. 287/07 (Clean Water Act) is provided in **Table 7.3**. These regulations provide guidance for protecting soil and water from contamination. This prohibition includes the use of flexible liners and or gated/ closeable inlets to prevent infiltration of runoff due to the potential for punctures and or winter by-pass, respectively. Should ‘permanent’ and or ‘hardened’ impermeable closed bottom structure be used (i.e. plastic or concrete tanks, vaults, or chambers) be proposed, explicit approval from the Municipality of Clarington shall be obtained.

Instead of infiltration-based stormwater practices, pollution prevention practices in the form of administrative and engineering controls should be applied in these areas, followed by treatment using conventional stormwater management controls such as ponds, wetlands and hybrid facilities as well as hydrodynamic separators (OGS units) and/or membrane or media filtration units (e.g. Jellyfish filters, StormFilters, etc.).

Table 7.3 identifies individual high-risk site activities based on O.Reg. 153/04 and O.Reg. 287/07. High-risk site activities are defined as those with the potential for high levels of contamination such as hydrocarbons, metals, organic and inorganic compounds, sediments and chlorides. At this scale of study, it is impossible to predict the long-term site-specific activities of individual sites; however, **Table 7.3** can be used a screening framework for identifying portions of each site where additional focus and review is needed to where LIDs should be discouraged, due to risk associated with the specific uses.

Drainage areas containing a site with high-risk activities (**Table 7.3**) will generally be discouraged from incorporating LID techniques that utilize infiltration as its primary function within the identified catchment because of the associated risk to groundwater contamination. However, high-risk site activities do not preclude the use of those LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes. Additionally, the infiltration of rainwater from catchments that are isolated from the respective high-risk site activities such as rainwater emanating from rooftops, employee parking facilities or directly falling on permeable surfaces is generally considered relatively ‘clean’ and should not be excluded from infiltration.

While the application of road salt is identified in **Table 7.3** due to its inclusion in O.Reg. 287/07 as a Prescribed Drinking Water Threat, the need for winter maintenance of roads and parking surfaces, including the application of de-icers, is recognized due to safety and liability concerns. However, there is also the need to target impervious surfaces with infiltration-based LIDs in order to meet infiltration targets and sustain critical surface water – groundwater connections. To balance these needs, it is recommended that:

1) Infiltration practices are recommended for Local Roads only. Local roads typically have less intensive winter deicer application as a result of lower usage and posted speed limits; and
2) A Salt Management Plan must be completed for the subject property for paved surfaces between 200 to 2000 m^2. Infiltration practices are discouraged for runoff originating from paved surfaces in excess of 2000 m^2 the facility is not used during winter months or an appropriate engineering solution is implemented to the satisfaction of Municipality staff.

7.1.2.2 Additional Water Quality Best Practices

In addition to providing water quality treatment, the reduction of pollutant loading through the implementation of best management practices is recommended. Recommendations include:

- Residents:
    - Reducing the use of fertilizer and pesticides on lawns and gardens;
    - Pick up and dispose of litter and pet waste in a timely manner;
    - Manage yard waste so that grass clippings and leaves stay out of the street;
    - If residents wash their car at home, make sure they do so on the grass instead of in the driveway, and use phosphorus-free detergents;
    - Promote native landscaping to reduce turfgrass. If planting grass, keep a thick cover at least 8 cm tall to reduce soil erosion; and
    - Don’t leave uncovered soil exposed to the elements – stabilize it using grass or native vegetation.
- Municipalities:
    - Practice good sanitary sewer maintenance to ensure the system doesn’t leak;
    - Reduce the use of fertilizer and pesticides, and ensure vegetative debris doesn’t enter storm sewer systems;
    - Implement broader Municipality-wide initiatives to prevent pesticide use by residents;
    - Reduce turfgrass cover and use native vegetation where feasible;
    - Control waste-generating wildlife such as geese;
    - Remove debris from storm sewer system, especially inlets and catch basins;
    - Manage exposed soil to prevent wind or water erosion; and
    - Maintain vehicles to prevent pollutant releases.

Table 7.3: High-Risk Site Activities Which Preclude the Use of Infiltration-Based LID BMPs Within the Contributing Catchment Area

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		

7.1.3 Erosion Control

Erosion potential within both Robinson Creek and Tooley Creek was determined to be as high as 15 m/100 years. In order to protect against increased rates of erosion, and thus unstable channel adjustments, stormwater management facilities, including LIDs, will be a necessary part of future development to prevent increased peak flow rates and increased durations of critical discharge exceedance. The 27 mm event will be used as an erosion control target.

As discussed in **Section 7.1.2.1**, there may be technical constraints preventing infiltration and filtration practices from controlling the runoff generated from the 27 mm event. In this scenario, a minimum volume retention of 5 mm is still required. Given the ability to achieve the required storage volumes as presented in **Table 7.2** through the implementation of LID measures, the recommended stormwater strategy is expected to meet the erosion control requirements. However, if retention of the full 27 mm runoff is not feasible, the remaining runoff volume that is not retained should be detained on site and slowly released over 24 to 48 hours.

7.1.4 Water Balance

The impervious surfaces associated with future urban development will reduce the capacity of the site to infiltrate rainfall events into the groundwater system, creating an increase in the volume of surface runoff instead.

The two methods of estimating pre-development groundwater recharge (see **Section 6.4**) provide an annual infiltration rate of between 106 and 144 mm/year on a watershed basis. Given that there are approximately 40 rainfall events per year the average infiltration rate per event is relatively modest (2.5 – 3.5 mm per event). The actual values on a site by site basis will vary depending on soil type, slopes, vegetation cover and depth to water table.

The above recharge targets can be achieved by incorporating appropriate LID source and conveyance control measures as outlined in **Section 5** together with the requirements to meet the Water Quality targets as noted in **Section 7.1.2** above. Collectively the LID measures should ensure that post-development infiltration rates equal or exceed pre-development levels. The impervious surfaces associated with future urban development will reduce the capacity of the site to infiltrate rainfall events into the groundwater system, creating an increase in the volume of surface runoff instead.

High Volume Recharge Areas (HVRAs) and Ecologically Significant Groundwater Recharge Areas (ESGRAs) will require additional attention to ensure pre-development recharge rates are maintained (see **Section 7.4**, **Figure 7.8**, and **Figure 7.9**).

7.1.5 Thermal Mitigation

Both Robinson Creek and Tooley Creek were characterized as coolwater streams by AECOM (2010). Aquatic investigations by Aquafor Beech as part of the **Robinson Creek and Tooley Creek Subwatershed Study: Phase 1 Report** confirmed a cool-warmwater thermal regime (with coolwater occurring in upstream reaches with groundwater input). A map of the geomorphic creek reaches is shown in **Figure 7.2** below.

Since the use of LID measures reduces stormwater temperature, it is expected that the implementation of the recommended stormwater strategy is expected to adequately cool stormwater temperatures when combined with best management practices for the SWM facilities. The latest thermal mitigation technologies should be considered in addition to more common practices which include, but are not limited to (STEP, no date):

- Bottom draw outlets;
- Cooling trenches;
- Subsurface trench outlets;
- Shading of permanent pool, outfall channel, and paved surfaces throughout the catchment;
- Improved pond design (eg. Location, orientation, length-to-width ratio, planted berms); and
- Use of facilities without a permanent pool.

Since all proposed facilities are dry ponds without a permanent pool, there will be less opportunity for standing water to heat up.

Clarington

- Geomorphic Stream Reaches
- Urban Boundary
- Subwatershed Boundary
- Secondary Plan

Figure: 7.2

Geomorphic Stream Reaches

0 0.25 0.5 1
Kilometers

Date: July 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

Aquafor Beech Limited

7.2 Natural Heritage

This section generally provides an overview and summary of natural heritage considerations and policy requirements that were discussed previously in the Phase 1 SWS report, with additional discussion provided as appropriate related to the proposed land use plan. The following subsections discuss: the natural heritage features in the study area and their associated Vegetation Protection Zones; the identification of Headwater Drainage Features and how those features were proposed to be managed; existing and potential linkages between natural heritage features; the identification of constraints to development in the study area; and the potential for restoration or naturalization to improve the existing Natural Heritage System.

7.2.1 Application of NHS Criteria

The Municipality of Clarington's Official Plan defines the Natural Heritage System (NHS) as:

> A system made up of natural heritage features and areas, hydrologically sensitive features and linkages intended to provide connectivity (at the regional or site level) and support natural processes which are necessary to maintain biological and geological diversity, natural functions, viable populations of indigenous species, and ecosystems. These systems can include natural heritage features and areas, hydrologically sensitive features, federal and provincial parks and conservation reserves, other natural heritage features, lands that have been restored or have the potential to be restored to a natural state, areas that support hydrologic functions, and working landscapes that enable ecological functions to continue.

The OP further lays out criteria to be used in identifying natural heritage features and hydrologically sensitive features which should be included in the municipal NHS. These criteria were used in Phase 1 of the Robinson-Tooley SWS as part of the identification of eligible natural heritage features and subsequent discussion of developmental constraints. Natural heritage features which are identified by the Municipality's OP (section 3.4.2) as being eligible for inclusion in the NHS are:

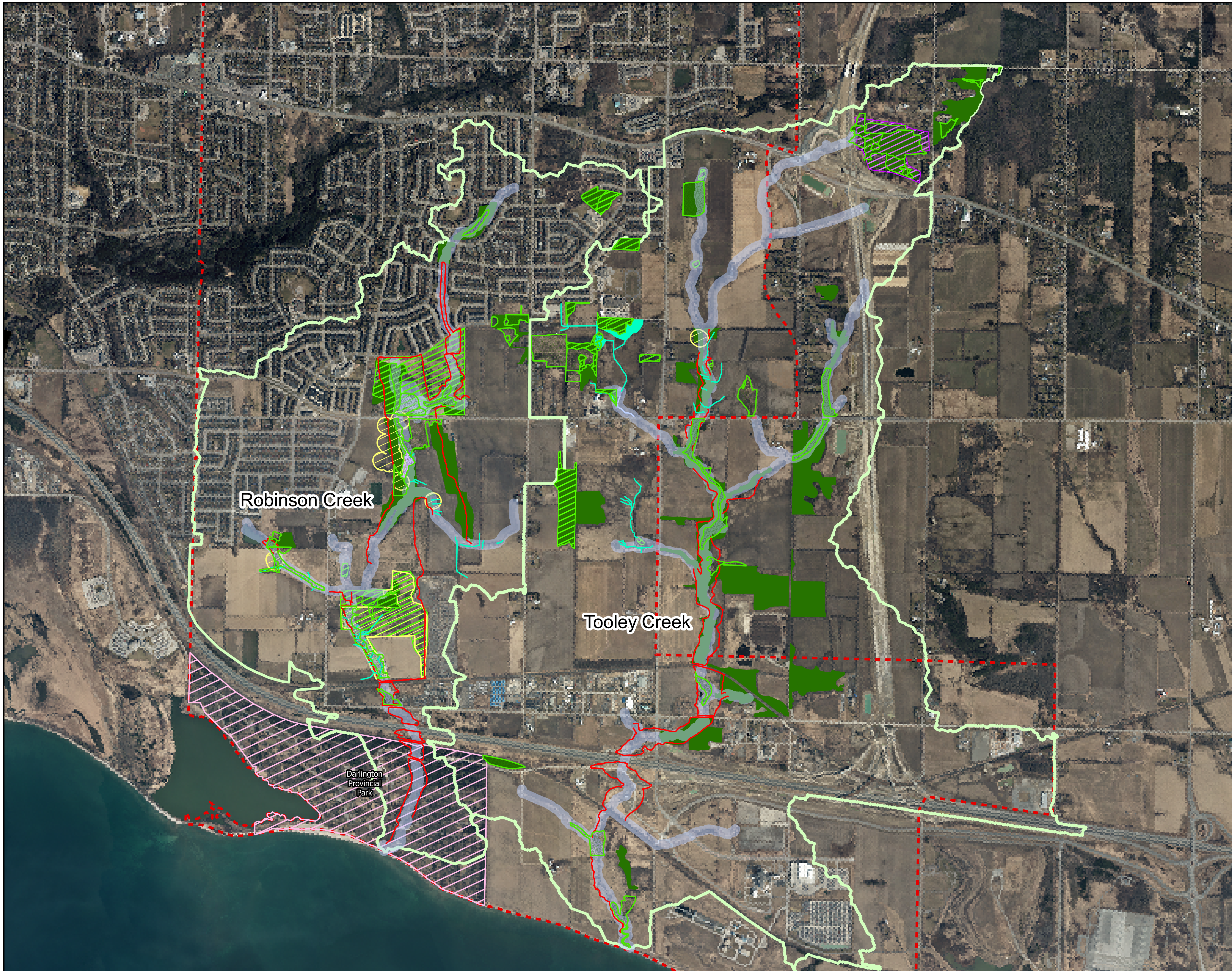
- Wetlands;
- Areas of Natural and Scientific Interest;
- Significant Woodlands;
- All significant Valleylands;
- Fish Habitat and Riparian Corridors;
- Habitat of endangered species and threatened species;
- Rare vegetation communities, including sand barrens, savannahs and tallgrass prairie; and
- Wildlife habitat.

The following Hydrologically Sensitive Features are also identified by the OP (section 3.4.2) as being eligible for inclusion in the NHS:

- Wetlands;
- Watercourses;
- Seepage areas and springs;
- Groundwater features; and
- Lake Ontario and its littoral zones.

The OP (section 3.4.3) further states that other environmentally sensitive features and areas, natural heritage features, and hydrologically sensitive features which are important to the integrity of the NHS may be identified on a site-by-site basis for protection.

Figure 7.3 illustrates the features within the study area that were determined to be eligible for inclusion in the NHS, or which required additional study in order to confirm their eligibility, per the investigations and analysis detailed in the Phase 1 SWS report. The information contained in **Figure 7.3** and the supporting technical discussion were key deliverables of Phase 1, are intended to inform the Secondary Plans and other subsequent studies, and were used during Phase 1 to identify constraints to development (see **Section 7.3**).



Clarington

- Watercourse
- Significant Valleylands
- Fish Habitat
- Fish Habitat (Further Study Req.)
- Fish Habitat And Riparian Corridors
- Fish Habitat (Further Study Req.)
- Habitat of Endangered & Threatened SAR
- Wetlands
- Significant Woodlands
- Darlington Provincial Park
- Subwatershed Boundary
- Urban Boundary

Significant Wildlife Habitat Types

- Confirmed
- Candidate
- Seepage Area And Spring

Figure: 7.3

Features Meeting Criteria For The Natural Heritage System

0 0.25 0.5 1
Kilometers

Date: July 2019
Datum: NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

Aquafor Beech Limited

7.2.2 Vegetation Protection Zones

Vegetation protection zones (VPZs), as defined in the Municipality of Clarington's OP, are vegetated buffer areas surrounding Natural Heritage Features or Hydrologically Sensitive Features, within which development and site alteration is generally prohibited save for:

- Forest, fish and wildlife management;
- Conservation and flood or erosion control projects, but only if they have been demonstrated to be necessary in the public interest after all alternatives have been considered;
- Transportation, infrastructure and utilities, but only if the need for the project has been demonstrated by an Environmental Assessment, there is no reasonable alternative, and it is supported by a project specific Environmental Impact Study;
- Low intensity recreation; and
- Low-impact development stormwater systems such as bioswales, infiltration trenches and vegetated filter strips, provided that the intent of the VPZ is maintained and it is supported by an Environmental Impact Study.

A VPZ "is intended to be restored with native, self-sustaining vegetation and be of sufficient width to protect the feature and its functions from effects of the proposed change and associated activities before, during, and after, construction, and where possible, restore and enhance the feature and/or its function from effects of the proposed change and associated activities before, during, and after construction, and where possible, restore and enhance the feature and/or its function". The OP further indicates that "approval of any development application shall ensure that a self-sustaining vegetation protection zone be planted, maintained or restored in order to protect any on-site or adjacent natural heritage feature and/or hydrologically sensitive feature" (Municipality of Clarington 2018). Direction from CLOCA has also indicated their requirement for active restoration of VPZs with native, self-sustaining vegetation (as opposed to passive regeneration). VPZs are to be imposed where new development and/or site alteration is to occur (i.e., they do not retroactively affect pre-existing development or current land uses/practices such as agriculture).

Minimum VPZs that are to be applied to components of the NHS within the urban boundary, in keeping with the requirements of the Municipality of Clarington's OP, are as follows:

- 30 m from the outermost extent of wetlands;
- 15 m from the outermost extent of Watercourses/Fish Habitat and Riparian Corridors (note that the Municipality of Clarington defines the Fish Habitat and Riparian Corridor feature to include the drainage channel plus 30 m on either side of the channel for a total 60 m riparian corridor);
- 15 m from the stable top of bank associated with Valleylands;
- 15 m from the dripline of the outermost tree associated with Significant Woodlands;
- 15 m from the outermost extent of Seeps and Springs; and

- An appropriate width to preserve the functionality of Habitat of Endangered and Threatened Species and Significant Wildlife Habitat, as determined through site-specific study.

In application, the Municipality allows only the outer 5m of the VPZ to contain uses such as trails and infiltration trenches, provided these uses are supported by the EIS. The above values denote the minimum VPZ width that is acceptable under policy around the various features. The presence of sensitive features or functions may warrant an increase to the minimum recommended VPZ; site-level studies such as an Environmental Impact Study (EIS) shall investigate whether the minimum VPZ is appropriate for all features in its study area or whether greater than the minimum value is required to ensure ecological features and/or functions are preserved.

One such sensitive feature was identified in the Phase 1 SWS: the woodlot located south of Bloor Street between Trulls Road and Courtice Road, identified as vegetation community polygon D5 in the Phase 1 SWS report (**Figure 7.4**). This area was identified as a Significant Woodland using the NHS criteria but was also documented as containing vernal pools providing amphibian breeding habitat. It was therefore concluded that the minimum VPZ that should be applied to this feature is 30 m based on the minimum VPZ applied to wetlands under municipal policy, to reduce potential impacts to water quality in vernal pools and associated habitat function.

Figure 7.4: Vegetation Community Polygon D5

7.2.3 Headwater Drainage Features

Headwater Drainage Features (HDFs) are typically shallow, seasonal/ephemeral drainage features that are important in maintaining primary and secondary inputs to surface water, groundwater, and/or fish habitat as applicable. HDFs within the study area were previously defined in Phase 1 of the Robinson-Tooley SWS using the Evaluation, Classification, and Management of Headwater Drainage Features Guidelines (CVC & TRCA, 2014), which is the accepted protocol for the identification and classification of HDFs in Ontario. All HDFs on properties for which the study team was given permission to enter were fully evaluated using the noted guidelines and one of four Management Recommendations was applied. Briefly, the four Management Recommendations are as follows:

- **Protection**: feature and its riparian zone, groundwater discharge and hydroperiod to be protected, maintained or enhanced in-situ. Realignment generally not permitted.
- **Conservation**: feature and its riparian zone to be maintained, relocated, or enhanced such that valued functions and downstream connections are maintained.
- **Mitigation**: functions associated with the HDF may be replicated through enhanced lot level conveyance measures.
- **No Management Required**: features and/or functions are not present which require management or preservation moving forward.

The *2019 Growth Plan for the Greater Golden Horseshoe*, prepared under the *Places to Grow Act* (2005), considers HDFs to be a component of “significant surface water contribution areas” and recommends their protection as Key Hydrologic Features. The Municipality of Clarington’s OP does not specifically identify HDFs as a component of the NHS; however, those features contributing to fish habitat would appropriately be considered under the “Fish Habitat and Riparian Corridor” designation which is a protected component of the NHS. That said, it is recognized that the HDF guidelines and the Management Recommendations therein provide direction specifically related to HDF management and should therefore be taken into account when determining how these features are to be treated.

During Phase 1 of the SWS, it was investigated and discussed with the Municipality of Clarington how to bring the HDF Management Recommendations and the OP NHS policies into agreement, and the following practice was eventually decided to be carried forward:

- HDFs with a “Protection” Management Recommendation are to be treated as Fish Habitat and Riparian Corridor and part of the NHS with all applicable protections under the OP. The Fish Habitat and Riparian Corridor feature includes the drainage channel plus 30 m on either side of the channel for a total 60 m riparian corridor. An additional 15 m VPZ is to be applied to the feature as discussed in **Section 7.2.2**. Additional studies in the form of an EIS may be required to determine the extent and verify the functions of the protected feature and guide the VPZ delineation prior to alteration. In no circumstances is the VPZ to be less than the minimum outlined in the OP.

- HDFs with a “Conservation” Management Recommendation may be relocated or realigned in keeping with the HDF guidelines. Once in its final configuration, however, the realigned channel then is to be designated Fish Habitat and Riparian Corridor with all applicable protections as described above. In keeping with the above, site specific studies verifying the extent and function of the feature may be required prior to alteration in order to guide VPZ delineation.

- HDFs with a “Mitigation” Management Recommendation will not be included in the NHS, but functions contributing to fish habitat and other valued components of downstream systems must be replicated. The completion of an EIS or other appropriate study will be required to demonstrate no net loss of function to downstream systems.

- There are no requirements associated with HDFs with a "No Management Required" status.

7.2.4 Linkages

Sections 3.5.8, 3.5.9, and 3.5.10 of the Municipality of Clarington's OP state:

> Connections or linkages between natural heritage features and hydrologically sensitive features provide opportunities for wildlife movement, hydrological and nutrient cycling, and maintain ecological health and integrity of the overall Natural Heritage System. The Municipality recognizes the importance of sustaining linkages.
>
> The Municipality shall support the protection of connections between natural heritage features and hydrologically sensitive features and across the Natural Heritage System through the identification of linkages in subwatershed plans, subwatershed plans, Environmental Impact Studies and other studies where appropriate.
>
> Linkages shall be evaluated, identified and protected through the preparation of Secondary Plans.

The Phase 1 SWS report identified existing linkages within the study area (e.g., hedgerows) and included these features as "Moderate" level constraints.

The Phase 1 SWS report also identified potential locations where linkages do not currently exist but could be established to provide some benefit to the existing system (e.g., to provide connection between the Robinson Creek and Tooley Creek systems, since currently there is very little connectivity between the two), as illustrated on **Figure 7.6**. The identified opportunities do not represent binding constraints nor are they intended to be taken as the only locations where enhancement of linkage function is possible in the study area. They were, however, identified as a starting point for discussions that are intended to be continued in site-level studies. Secondary Plans, site-level EISes, and/or other applicable studies must review and evaluate existing and potential linkages, identify appropriate locations for enhancement, and ensure that linkage function is maintained or enhanced both within the subwatershed and with the surrounding landscape.As was touched on in **Section 4.2.2**, new development and, particularly, new roads can create barriers to wildlife movement on the landscape. In order to minimize the fragmentation and isolation of habitats, as well as road mortality of wildlife, new roads should first and preferentially be sited such that they do not pass through natural heritage features. Where fragmentation of habitat is determined through the completion of an appropriate study to be unavoidable, the road design should include provision for wildlife movement via the adaptation of aquatic culverts or the installation of wildlife-specific terrestrial culverts that allow animals to move beneath the road surface. Culvert design will need to incorporate all current best knowledge of wildlife movement principles, such as sizing (e.g., shorter culverts with larger openings are typically better), light penetration (e.g., via surface grates), and materials (e.g., concrete versus steel; natural substrate placed within the culvert), and will need to be tailored both to the site conditions and to the target species that are to be addressed. Fish passage must also be considered where new aquatic crossings are constructed or where existing crossings are retrofitted. Exclusion fencing must be installed in association with crossing culverts such that animals are directed to the crossing locations and restricted from entering the road corridor.

7.3 Identification of Constraints to Development

The natural heritage features and hydrologically sensitive features discussed in the preceding subsections were considered in concert with natural hazards in order to identify constraints to future development. Constraints were classified as High, Moderate, or Low, where:

- **High** was applied to areas where development intrusion is generally not allowed (although specific exceptions may be applicable to flood hazard constraints) - these areas have been or will be carried forward as 'Environmental Protection Area' or similar designation on the proposed land use plans;
- **Moderate** was applied to areas requiring further study to fully define natural heritage features or determine the appropriate level of protection, or where some development intrusion or modification of features may be allowed if supported by a scoped Environmental Impact Study, Geotechnical Slope Stability Study, or other appropriate study; and
- **Low** was applied to features or areas for which municipal policy does not preclude development intrusion, but which represent natural cover on the landscape and therefore may be associated with ecological offsetting requirements (as previously touched on in **Section 4.2.2**) or to which other requirements may apply. Such features are generally recommended for incorporation into site-level plans where possible (e.g., parks or SWM blocks, preservation of individual specimen trees, alignment with rear lot lines or trail routes, etc.).

Features which were included in the above-listed categories are illustrated on **Figure 7.7** and include:

High

- Natural Heritage System features (discussed in **Section 7.2.1**).
- Natural hazards – meander belt, regulatory flood line, slope hazard, and long-term stable slope setback.
- HDFs with a 'Protection' management recommendation.

Moderate

- Vegetation Protection Zones – some development or site alteration may be permitted as discussed in **Section 7.2.2**.
- Existing linkages - since it is typically the linkage *function* that is valued, some modification or relocation of the feature itself may be considered so long as the function is maintained.
- HDFs with a 'Conservation' or 'Mitigation' management recommendation.
- Agricultural/pasture lands evidencing hydrologic function (e.g., ponding, saturated soils, wetland plants).
- Natural heritage features not previously identified as High constraint, for which additional study is required to confirm sensitivity or presence/absence, such as candidate Significant Wildlife Habitat, complex vegetation communities containing both high/medium- and low-constraint areas, Species at Risk habitat/setbacks.
- Additional areas or features specifically identified in the Phase 1 SWS report, where those areas may meet NHS criteria but are isolated or of lower quality/function and therefore could be reviewed related to proposed development if supported by an EIS and if suitable compensation/offsetting is also proposed.

Low

- Natural heritage features not meeting the criteria for inclusion in the municipal NHS and not identified by this SWS as significant.
- HDFs with a 'No Management Required' management recommendation.

The above information and the mapping shown in **Figure 7.7** were key deliverables of Phase 1 of this SWS, and provided a basis for the land uses developed in the Secondary Plans. As the SWS is a landscape-scale study, natural heritage features were not field-delineated and surveyed. It is the intention that site-level studies such as an EIS (see **Section 8.4.3**) may confirm and/or refine the boundaries of features at a later date (e.g., by staking and surveying the dripline of a woodland or a wetland boundary).

7.3.1 Compensation, Restoration, and Enhancement Opportunities

The policies of the Municipality of Clarington's OP support sustainable development and enhancement of the natural heritage system. The Phase 1 SWS report identified potential locations where ecological restoration or enhancement could be carried out to improve upon the existing NHS (see **Figure 7.6**). Similar to the new linkage opportunities mentioned in **Section 7.2.4**, the identified restoration/enhancement areas do not represent binding constraints nor are they intended to be interpreted as the only locations where restoration could be undertaken in the study area. The SWS, by necessity, looked at the subwatershed as a whole and identified large-scale opportunities based on the natural heritage features and functions that were identified. Site-level studies may refine the shown locations and/or identify more localized opportunities in keeping with the following general principles:

- **Size**: Larger patches of habitat are generally more valuable than smaller. Opportunities to increase the size of existing patches of natural cover (e.g., by designating open space or establishing parks adjacent to existing natural areas) should therefore be considered.

- **Shape**: Habitat patches which are compact (i.e., those which have less 'edge' per area) are generally more valuable than those which are linear or elongated. Opportunities to fill in gaps and reduce the edge to interior ratio of natural heritage patches should therefore be considered.

- **Complexity**: Natural areas with a high diversity of vegetation communities, microhabitats, and topographical features often support a wider variety of species (and a greater proportion of rare species) than those which are more uniform. Opportunities to increase the diversity of habitat across the landscape (e.g., by planting restoration areas with a variety of native species, by creating sloughs or pit/mound topography in restoration areas, or by conserving successional meadows and thickets in addition to forests) should therefore be considered.

- **Connectivity**: Fragmentation of natural areas by development can lead to the isolation of habitat patches and the wildlife they support, limiting dispersal of individuals and reducing genetic variability within the population. Opportunities to improve existing connections between natural areas and to create new connections where they are currently lacking should therefore be considered.

Proposed restoration/enhancement in keeping with the above must be considered wherever ecological offsetting or compensation is required related to anticipated impacts of development. The minimum goal for offsetting/compensation should be no net loss of natural cover or ecological function within the subwatershed.

Aquatic corridors often provide a valuable opportunity for restoration and enhancement. Not only do these features provide both aquatic and riparian habitat in themselves, they also often provide corridors across the landscape which allow for wildlife movement. Many HDFs occur on cropped agricultural properties with little to no natural vegetation currently present. These HDFs may be enhanced through riparian plantings, as may watercourses within the study area that currently do not have consistent riparian vegetation.

It was noted in **Section 7.2.2** that certain land uses and activities could be permitted within a VPZ subject to the completion of an EIS which supports the action and/or, specifically such as in the case of transportation infrastructure, where there is demonstrable need and no viable alternative. In such cases, the supporting studies (e.g., EIS, transportation EA) will be expected to not only demonstrate that alternatives were considered (and provide the reasons for why those alternatives were not viable) but also to provide compensation/mitigation measures to offset any loss of the required VPZ and its function. Compensation/mitigation should preferentially be applied to the affected feature and not 'offsite' (e.g., additional planting area connected to a woodland with reduced VPZ, as opposed to planting in an isolated park some distance away). Further, planting of vegetation within the minimum VPZ is not eligible to propose as compensation since, as stated above, the VPZ is already intended to actively "be restored with native, self-sustaining vegetation". Restoration of the VPZ is therefore considered the baseline requirement, to which additional compensation measures must be added where required.

A key example of this is related to the same vegetation community referenced in **Section 7.2.2**, D5. In this case, not only the VPZ has been affected by proposed development but a component of the NHS itself. The two narrow projections of woodlot at the north end of the feature (shown shaded in the land use plan excerpt in **Figure 7.5**) have been proposed for removal to allow the creation of a new road in the proposed Southeast Courtice Secondary Plan. The supporting transportation study will be expected to investigate alternatives which would preserve the NHS in its current state, since avoidance is always the preferred option when it comes to natural heritage impacts. If the study concludes that avoidance is not possible then the supporting study would need to provide evidence that the two woodlot projections do not in themselves contain natural heritage features or functions that cannot be compensated for, and propose compensation measures to ensure no net loss of natural area or ecological function associated with that specific woodlot.

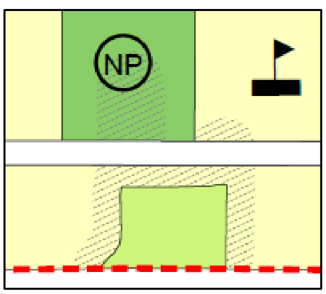


Figure 7.5: Land Use Plan at Vegetation Community D5

Management of restored areas over the short term is expected to be required in order to ensure establishment of the intended species and habitat, and discourage the establishment of non-native and/or invasive species. Where invasive species are identified on a property or there is a risk of spread from an adjacent property, a management plan for these problem species should be developed as part of the EIS.

7.3.2 Erosion Hazards for Development Constraints

Interim erosion hazard limits have been evaluated in Section 3.2.2 of the Phase 1 report based on meander belt delineation approaches (TRCA, 2004 subwatershed study procedures) and identification of potential slope hazard areas requiring additional geotechnical investigations. Recommended meander belt widths are provided for reaches within the development lands, ranging between 26 - 66 m in width, to be centered around the belt axis. These meander belt widths may be refined based on further detailed studies.

In addition to meander belt delineations intended for unconfined fluvial systems (MNR, 2002), erosion hazards for confined and partially confined reaches require that long-term stable slope (LTSS) setbacks be defined to determine development setbacks and constraints. Conservative estimates of the LTSS have been delineated as part of this Subwatershed Study using generic provincial guidelines (MNR, 2002) and CLOCA's GIS-based procedure for hazard mapping. Referred to as "priority LTSS areas", these are generally locations where the watercourse is within 15 m of the toe of slope for embankments with slopes steeper than 15% and heights greater than 3 metres. The priority LTSS areas are to represent preliminary mapping of the stable slope component for delineation of the erosion hazard limit and development constraints. It must be emphasized here that these mapped areas from this sub-watershed study do not provide conclusive LTSS setbacks consistent with the provincial MNR (2002) guidelines, and may not provide a conservative enough estimate for the LTSS setback in all cases. Ultimately, the LTSS will need to be confirmed and/or refined with detailed geotechnical analysis as part of Functional Service Reports, and is to include a stable slope allowance that accounts for future channel erosion, long-term stable slope formation, and an erosion access allowance of 6 m. It is recommended that the Slope Inspection Record (Table 4.1) and Slope Stability Rating Chart (Table 4.2) of the MNR (2002) Technical Guide – River and Stream Systems be completed for all priority LTSS areas to determine detailed geotechnical stable slope investigation requirements and document existing slope conditions.

For the Subwatershed Study constraint mapping, the erosion hazard limit is the greater of the meander belt and the priority LTSS hazard lines. The final erosion hazard limits for the corridors including both meander belts for unconfined reaches and stable slope setbacks in identified confined reaches—are to be integrated with other development constraints to delineate final development limits (e.g., Regulatory floodplains and NHS protected areas).

Clarington

- Watercourse
- Potential Natural Heritage Constraint (Pending Further Study)
- Enhancement/Restoration and Linkage Improvement Opportunities
- Natural Heritage System
- Linkages: Category 1 And 2 Hedgerows
- Vegetation Protection Zone
- Darlington Provincial Park
- Subwatershed Boundary
- Urban Boundary

Headwater Drainage Features

- Protection
- Conservation
- Mitigation
- No Management Required
- Tile

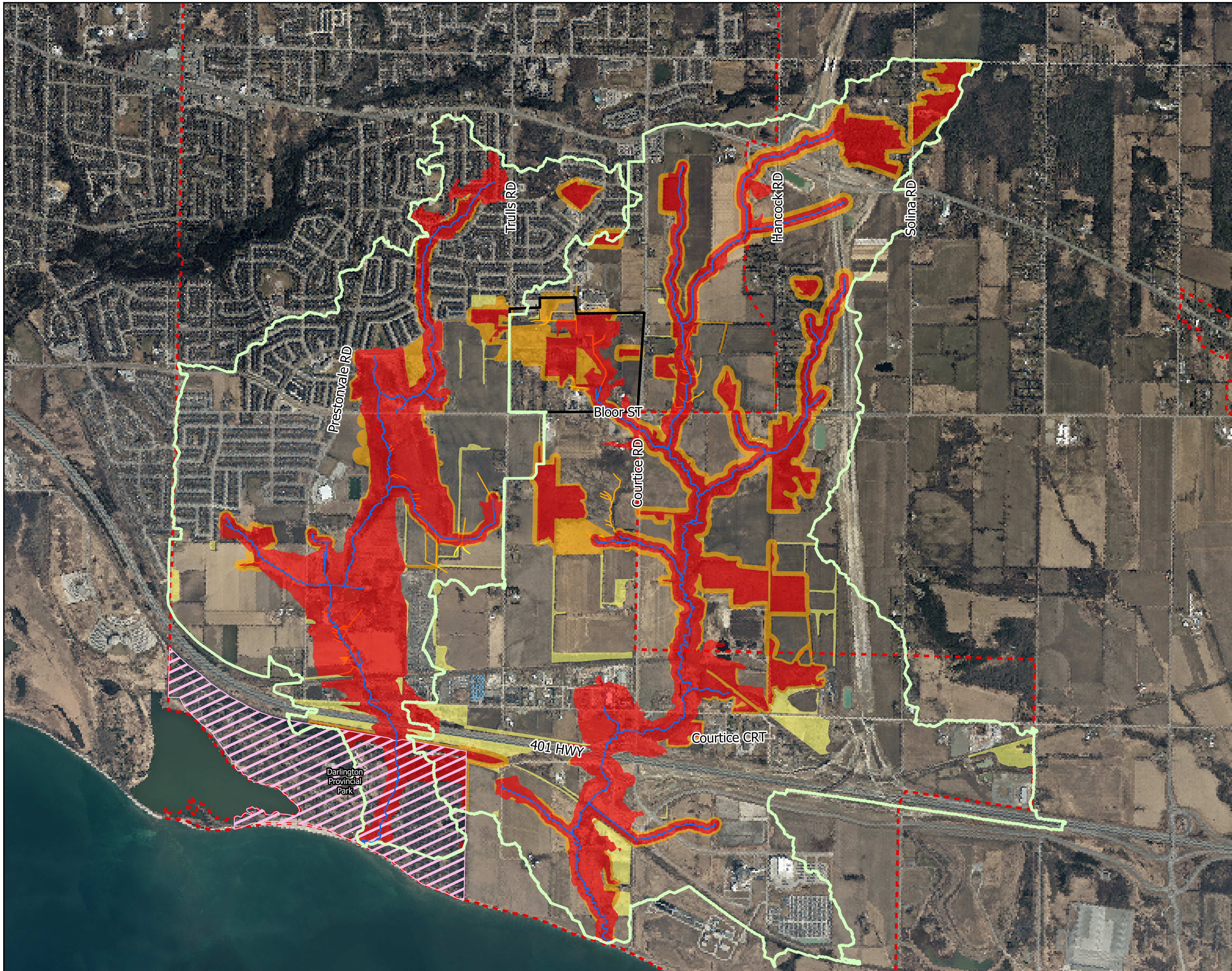
Figure: 7.6

Vegetation Protection Zones, Linkages, and Restoration/Enhancement Opportunities

0 0.25 0.5 1
Kilometers

Date: July 2018
Datum: NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

Aquafor Beech Limited



Clarington

Watercourse
Darlington Provincial Park
Special Study Area
Subwatershed Boundary

Tier Constraints to Development

High
Moderate
Low
High Constraint HDF
Moderate Constraint HDF
Low Constraint HDF

Figure: 7.7

Constraints To Development

0 0.25 0.5 1
Kilometers

Date: November 2022
Datum:NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington

Aquafor Beech Limited

7.4 Groundwater Strategy

7.4.1 High Volume Recharge Area

High Volume Recharge Areas (HVRA) were identified during the modelling completed as part of the **Robinson Creek and Tooley Creek Subwatershed Study: Phase 1 Report** and are presented in **Figure 7.8**. The Ministry of Environment (2007, Page 142) defines five methods to delineate high volume recharge areas. Methods 1 through 4 are simpler methods whereas Methods 5 is described as follows: "Recharge rates are developed from a calibrated complex model and are therefore likely to be more accurate". The combination of PRMS and MODFLOW models used by Earthfx in this study conform to the Methods 5 approach and level of accuracy (see Earthfx, 2008b for additional model development details).

The HVRA areas generally correspond to the location of surficial sand and gravel deposits, however as these are based on the average recharge in the local subwatershed, some silt deposits in Robinson Creek are also considered locally important.

7.4.2 Ecologically Significant Groundwater Recharge Area

Two small Ecologically Significant Groundwater Recharge Areas (ESGRAs) are present in Robinson Creek Subwatershed, but many exist in Tooley Creek Subwatershed, especially in the northern reaches (**Figure 7.9**). Maintaining infiltration in ESGRAs will ensure baseflow contributions to the annual flow regime are maintained which is essential for the ecological health of the stream systems, wetlands and lowland habitat. Water quality degradation is possible if proactive measures are not taken during development. The main groundwater quality concern will be chloride loading to the groundwater as a result of salt application for winter maintenance. Salt management planning and contractor certification for development areas in and draining to the ESGRAs will be essential to maintain water quality.

7.4.3 High Aquifer Vulnerability Area

The Regional Municipality of Durham has identified High Aquifer Vulnerability Areas (HAVA) throughout the Robinson Creek and Tooley Creek subwatersheds (**Figure 7.10**). HAVAs are lands whose uppermost aquifer is most vulnerable to contamination as a result of surface activities or sources. These areas are to be protected per the Region's guidelines, as outlined in the Official Plan, as amended from time to time. Per the 2020 Consolidation of the Region's Official Plan, the following requirements are applicable:

> 2.3.30 Areas of high aquifer vulnerability are shown on Schedule 'B' – Map 'B2', High Aquifer Vulnerability and Wellhead Protection Areas. Additional areas may be identified through future studies such as source water protection plans or watershed studies. The Region and area municipalities shall protect areas of high aquifer vulnerability, when considering new development or site alteration. Outside of designated Urban Areas, uses considered to be a high risk to groundwater, as identified in Schedule 'E' – Table 'E5', shall be prohibited. The Region may also require a hydrogeological investigation to assess whether other uses not included in

Table 'E5' will be a potential risk to groundwater within the areas of high aquifer vulnerability thereby requiring potential prohibitions, restrictions and/or mitigation.

2.3.31 Within Urban Areas, an application to permit any of these high risk land uses within a high aquifer vulnerable area shall be accompanied by a contamination management plan that defines the approach to protect water resources.

2.3.32 Existing land uses considered to be a high risk to groundwater that are located within high aquifer vulnerability areas, are encouraged to implement best management practices.

When completing a Contamination Management Plan for high-risk land uses within an HAVA, proponents are directed to **Table 7.3**, which outline high-risk site activities which preclude the use of infiltration LID BMPs within the contributing catchment area. The infiltration of rainwater from catchments that are isolated from the respective high-risk site activities such as rainwater emanating from rooftops, employee parking facilities or directly falling on permeable surfaces is generally considered relatively 'clean' and may therefore be considered for infiltration.

7.4.4 Submission Requirements

A water budget is to be submitted to CLOCA as part of the stormwater management submission when a proposed development contains an HVRA or ESGRA. Infiltration rates should be measured in situ using test pits and/or boreholes, and post-development infiltration rates should match pre-development rates on an annual basis.

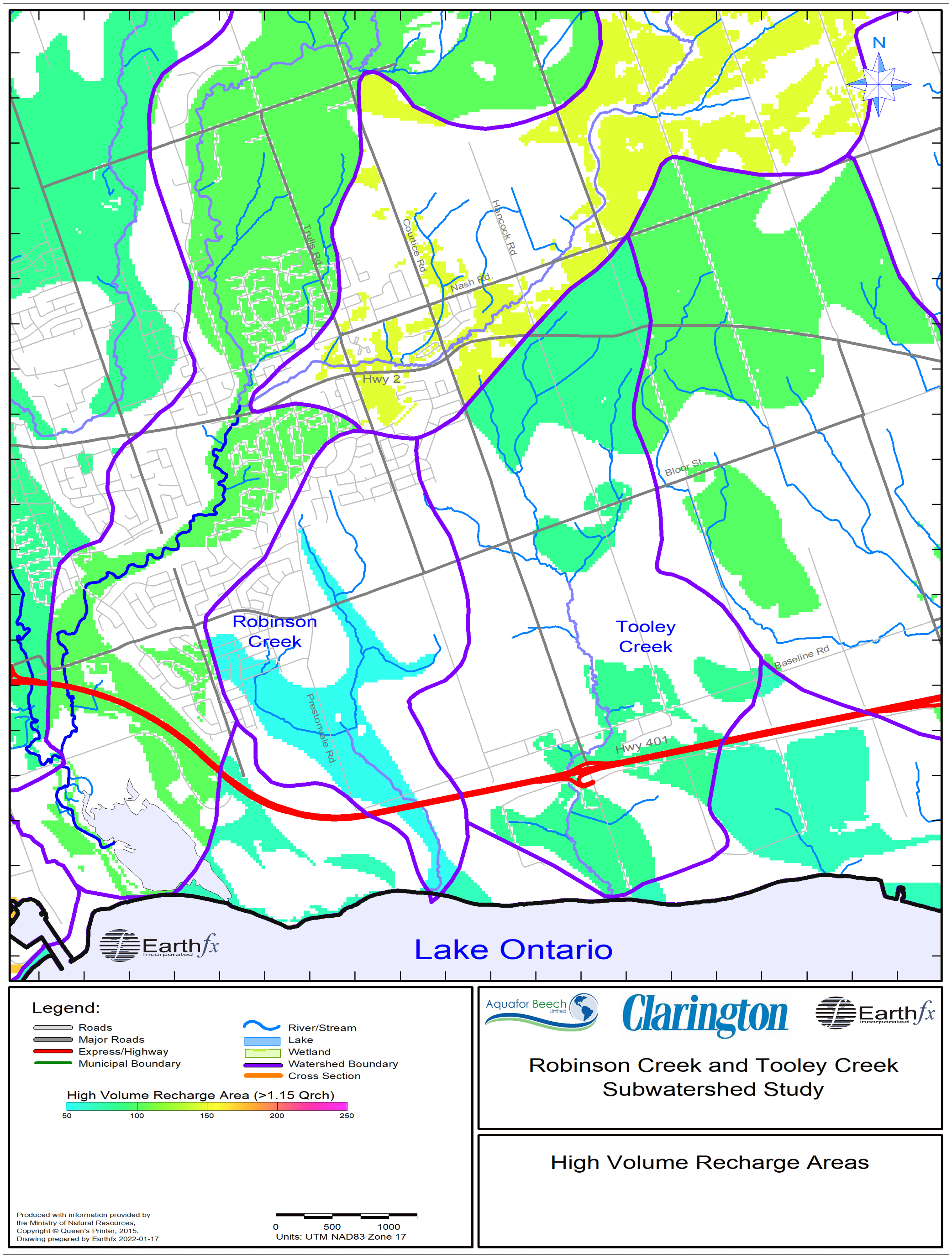


Figure 7.8: High Volume Recharge Areas

Clarington

- Watercourse
- Urban Boundary
- Ecologically Significant Groundwater Recharge Areas (CLOCA)
- Subwatershed Boundary

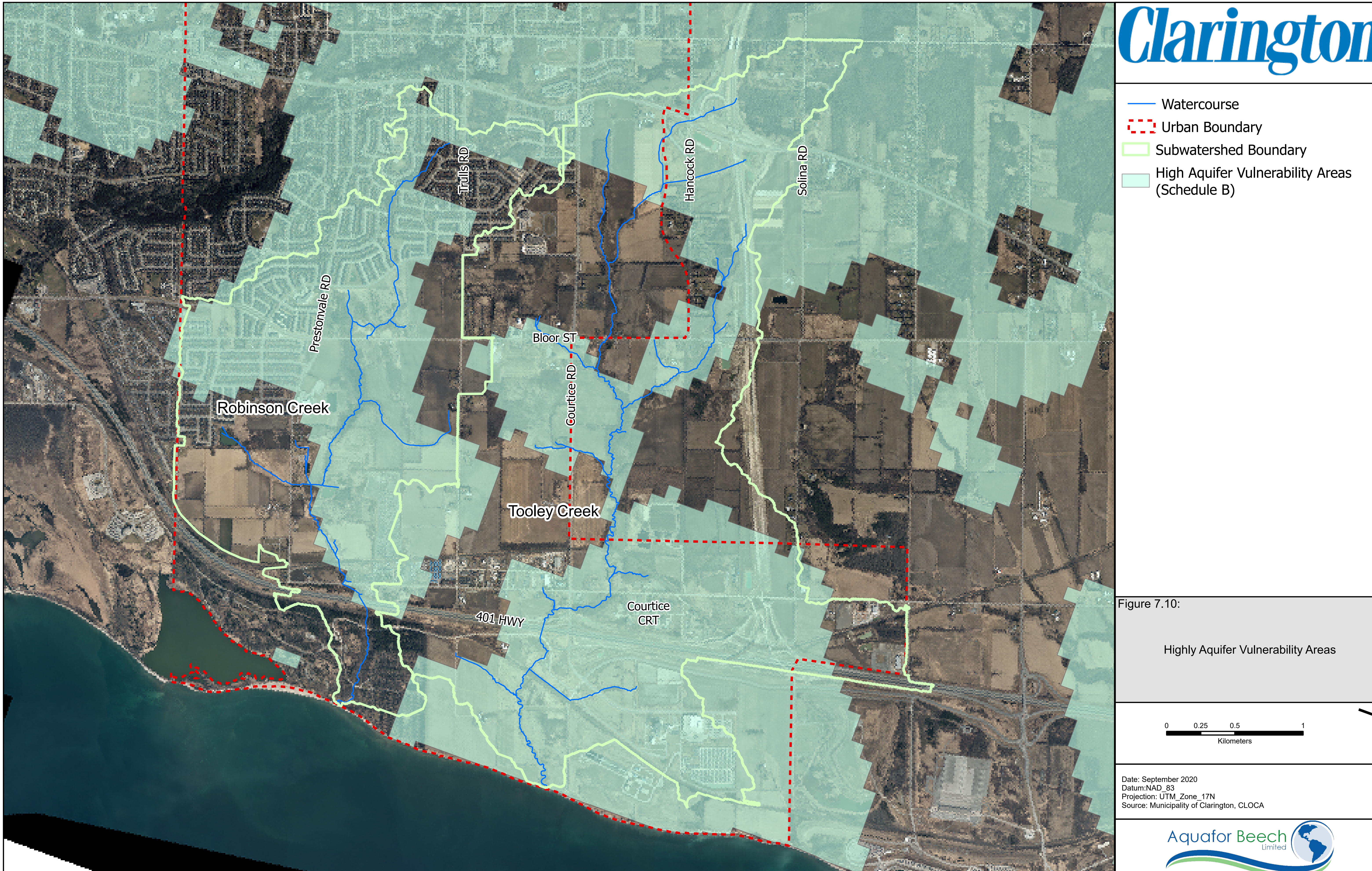
Figure: 7.9

Ecologically Significant Groundwater Recharge Areas (CLOCA)

0 0.25 0.5 1
Kilometers

Date: September 2020
Datum:NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington, CLOCA

Aquafor Beech Limited



Clarington

Figure 7.10:

Highly Aquifer Vulnerability Areas

Date: September 2020
Datum:NAD_83
Projection: UTM_Zone_17N
Source: Municipality of Clarington, CLOCA

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8 Implementation

8.1 Introduction to Implementation Strategy

The preceding chapters have summarized the investigations, inventories and analyses used to define existing environmental conditions, future impacts, and recommended management measures for the Southeast Courtice, Southwest Courtice, and Courtice Employment Lands Secondary Plans. The recommended measures include actions to address stormwater management requirements, protection of the natural heritage system and associated ecological features together with groundwater resources.

In terms of the land development and environmental planning process, the role of the Robinson Creek and Tooley Creek Subwatershed Study is to provide a framework and broad-scale guidance to the next level of planning and design study as urban development proceeds. As such, the focus of this chapter is to provide guidance for the future work required to implement the recommendations. This includes direction with respect to future studies, timing/phasing of the works, policy/design guidance, and approvals.

8.2 Stormwater Management Controls

Stormwater management controls consist of the recommended works required to mitigate the impacts from proposed future development. This includes:

- End-of-pipe stormwater ponds for flood control; and
- Low Impact Development (LID) source control techniques to meet water quality, water balance and erosion requirements.

The Visual Otthymo 6.1 model was used to define flows for existing and proposed development conditions. **Table 7.1** of this document summarizes the names, type, drainage area and flood storage requirements for each of the proposed facilities. The location of the proposed facilities is shown in **Figure 6.2**.

Sections 7.1.1 through **7.1.5** of the report outline the requirements for water quality, water balance, erosion control and thermal mitigation. As noted, the primary driver is to control the runoff generated from a 27 mm rainfall event, using a control hierarchy whereby retention via LID retention technologies which utilize the mechanisms of infiltration, evapotranspiration and or re-use are to be implemented. Where the LID approach is utilized and the runoff volume from the full 27 mm event is controlled, end-of-pipe SWM facilities may be designed without the water quality component. The approach to meeting stormwater management targets is outlined in **Table 8.1**.

Table 8.1: Approach to Meeting SWM Targets

Target Category	Target	Approach	Notes
Flood Control	Peak flow rates from the 1:2-year to 1:100-year events must be controlled to pre-development levels. Post-development peak flow rates from the Regulatory storm must be below Existing Regulatory peak flow rates or implement alternative flood mitigation measures, to be established through the future Flood Impact Study and approved by the Municipality and CLOCA	End-of-Pipe SWM facilities in the form of Dry detention ponds.	The Regulatory storm is the 100-year event in Robinson Creek Subwatershed, and the Regional storm in Tooley Creek Subwatershed. On Tooley West reach West (South of the 401), the 100-year peak flow exceeds the Regional peak flow, so the Regulatory flood hazard is regulated by the 100-year flood line limits for this reach (**Appendix C**).
Water Quality	Preferred Target: Capture and retain runoff resulting from the 27 mm rainfall event using infiltration-based LIDs.	Infiltration-based Low Impact Development Practices located on private property and municipal property, following the runoff control hierarchy (**Figure 7.1)**.	
Stream Erosion Control	Runoff from a 27 mm rainfall event must be retained on site through infiltration, evapotranspiration, reuse, bio-retention, etc. to the maximum extent practical with a minimum of 5 mm	Site-level Low Impact Development practices (See **Section 5.3**)	Where site-level LIDs cannot meet the 27 mm retention target, any remaining runoff volume from the 27 mm event must be detained on site for 24 to 48 hours.

Target Category	Target	Approach	Notes
Water Balance	Match pre-development annual infiltration volume in all stormwater catchments.	Infiltration-based Low Impact Development Practices located on private property and municipal property. A site-specific water budget will need to be completed as part of the stormwater management submission for sites within an HVRA or ESGRA.	This target is to be refined via in-situ infiltration testing (see **Section 8.4.1**). It was calculated in **Section 7.1.4** that an average infiltration target across the study area of 2.5 to 3.5 mm per rainfall event would be sufficient to maintain pre-development water balance. Within HVRAs or ESGRAs the target will be higher.
Thermal Mitigation	Cool runoff as appropriate for a coolwater receiver.	Use of Low Impact Development and dry stormwater ponds.	

Land use mapping completed as part of the Southeast Courtice and Southwest Courtice Secondary Plans indicated the location of the stormwater management facilities. This level of detail was not available for the Courtice Employment Lands Secondary Plan, so stormwater management facilities were modeled at the outlet of each subcatchment. Further direction regarding stormwater management facilities is provided below in **Section 8.4**.

All stormwater management facilities must be designed to meet the design requirements set out in the Technical Guidelines developed by CLOCA (2020) in addition to the MECP Stormwater Management Planning and Design Manual (SWMPDM) which provides technical and procedural guidance for the planning, design, and review of stormwater management practices. Facilities within Tooley Creek Subwatershed that may be required to act as flood control facilities during the Regional Regulatory event, as indicated by the forthcoming Flood Control Study, must be designed in accordance with the Lakes and Rivers Improvement Act (LRIA) standards for small dams.

8.2.1 Low Impact Development

The starting point for this Subwatershed Study was to complete the study using an environment-first approach. A meeting was therefore held with the Municipality of Clarington to discuss the type of LID measures that are suitable for different land uses. These also align with the LID measures accepted by CLOCA for meeting water quality, erosion control, and water balance criteria. These acceptable LID measures are described in **Section 5.3** for different land uses, with a summary table provided in **Table 8.2**.

LID design requirements are provided in Table 5-1 of CLOCA's 2020 Technical Guidelines which provides direction with respect to the requirements that must be considered for approval. These requirements, together with other technical manuals, should be used as a basis for conceptual and design drawing submissions.

In Ontario, the Toronto Region Conservation Authority (TRCA), Credit Valley Conservation (CVC) and Lake Simcoe Conservation Authority (LSRCA) are supporting a Wiki-based "living design manual" on the Sustainable Technologies website. This is a key resource for consultants as well as the public with respect to general information and design considerations surrounding LID systems.

Since the publication of the 2003 SWMPDM, advancements have been made in the approaches used to manage stormwater and the technologies available to the stormwater practitioner. To encourage stormwater solutions that treat stormwater as a resource and provide a high level of stormwater quality control, the MECP is in the process of finalizing a LID Stormwater Management Guidance Manual. The draft manual outlines a Runoff Volume Control Target (RVC_T) to be used for new development, and should be referred to for additional design guidance.

The use of LIDs may be constrained by site-specific conditions, as outlined in **Section 7.1.2.1**. If any of these factors apply to a specific site, then LID techniques that utilize filtration, evapotranspiration (ET) or re-use as the primary processes should be considered. If control of the full 27 mm is still not feasible through the use of LID measures, then the use of stormwater management facilities (eg. wet ponds, wetlands, or hybrid ponds) or manufactured treatment devices (eg. oil and grit separators) are permitted. Regardless of the method used to achieve the water quality criteria, SWM quantity controls to control peak flows will still be required at the end-of-pipe. It is recommended that in-situ infiltration testing be completed early in the development process to ensure ideal locations for LIDs are considered during the formation of draft plans.

Additionally, the use of scarified subsoil, amended topsoil, and extra topsoil depth on yards is recommended on all sites to reduce post-development runoff volume, but these amendments will not be accepted to meet the above stormwater targets.

Recommended types of LID practices that are generally appropriate for different land uses are listed in **Table 8.2**.

Table 8.2: Municipal LID Applicability by Land Use

Land Use		Single Family Residential	Multi-Family (Medium Density)	Multi-Family (High Density)	Industrial, Commercial & Institutional
Soil Amendments		✓	✓	✓	✓
Perforated Pipe (PP)	PP as Storm Sewer	✓	✓	✓	✓
Perforated Pipe (PP)	Parallel PP ("3rd Pipe")	✓	✓	✓	✓
Perforated Pipe (PP)	Grassed Swale PP System	✓	✓	✓	✓
Permeable Pavements			✓	✓	✓
Bioretention, Bioswales and Enhanced Swales			✓	✓	✓
Rainwater Harvesting				✓	✓

8.2.2 SWM Facility Maintenance

Regardless of the type of stormwater management infrastructure that is in place, maintenance, rehabilitation, and replacement is necessary to maintain the intended level of service to the public. SWM ponds may require sediment dredging and disposal at a recurring interval dependent on loading rate and facility design. LID operation and maintenance varies with practice. For perforated pipes, very little maintenance is required. For bioswales and bioretention facilities, the O&M is similar to that of municipal gardens which require weeding and mulching occasionally (or mowing if the low maintenance turf option is preferred).

8.2.3 Ecologically Significant Groundwater Recharge Areas and High Volume Recharge Areas

A site-specific water budget is required to be submitted as part of the stormwater management submission when a proposed development contains an HVRA or ESGRA (see **Figure 7.8** and **Figure 7.9** for locations). The site-specific water budget should be completed per the 2003 SWMPDM requirements and the 2013 Conservation Authority Guidelines for Hydrogeological Assessment Submissions (Cuddy et al., 2013).

8.3 Monitoring Program

It is recommended that a water quality monitoring program be developed, taking an Adaptive Management Approach (AMA) and span pre-construction, construction and post-construction phases. This approach will allow for adjustments to monitoring sites, parameters and protocols to be made over time, as gaps are identified in order to optimize the program. The monitoring program will likely require extensive coordination and collaboration through annual monitoring meetings among representatives of CLOCA, the Municipality, the development community and their consulting teams. Specific monitoring details would be defined in an EIS or similar study.

8.4 Future Studies

This Subwatershed Study also lays the groundwork for future studies. Additional studies will be required as follows:

8.4.1 Flood Control Study

Since the Uncontrolled Future flows exceeded Existing regulatory flows during the Regional Regulatory event in Tooley Creek, additional flood control measures need to be considered. While this Subwatershed Study identified measures which may be implemented to provide these flood control measures, a full assessment of these measures was beyond the scope of the Subwatershed Study. Therefore, an additional Flood Control Study is recommended to further define and evaluate different alternatives in order to identify the preferred approach to provide Regional flood protection along Tooley Creek. It is recommended that, at a minimum, the following alternatives be investigated: floodproofing, construction of berms, increasing existing watercourse crossing capacity, compensating affected landowners, and the use of stormwater management facilities as flood control facilities. As the diversions between Robinson Creek and Tooley Creek subwatersheds in catchments SEC8, SEC10, and SWC2 are subject to CLOCA's approval during future submissions, the Flood Control Study should use the existing drainage boundaries. Municipal infrastructure improvements should be prioritized as part of the overall report recommendations.

8.4.2 Stormwater and Groundwater

While the Robinson Creek and Tooley Creek Subwatershed Study has provided significant information on the proposed development lands, additional studies will be required. CLOCA outlines all study requirements as part of the Technical Guidelines for Stormwater Management Submissions (2020) in Table 6-1. Some of these requirements have been met through the completion of the Robinson Creek and Tooley Creek Subwatershed Study, but the list below outlines the study contents which must still be completed.

Notes and assumptions to be carried forward through all future studies:

- Note: Some modifications were made to the Secondary Plan land uses and boundaries after the Visual OTTHYMO model was developed. The model should therefore be updated to account for these changes.
- Note: SWMF locations have already been identified as part of the Southeast Courtice and Southwest Courtice Secondary Plans.
- Note: Approximate sizing of all stormwater ponds has also been completed, using 450 m^3/ha to meet pre-development peak flows.

- Note: The LID strategy was outlined in **Section 7.1.2** to **7.1.5**, and includes control of the runoff from the 27 mm storm using infiltration practices preferentially, followed by filtration measures and/or reuse. A minimum of the runoff volume of 5 mm shall be retained on site if it is not possible achieve the full volume due to the factors outlined in **Section 7.1.2.1.**
- Note: A Conceptual Grading and Servicing Study is still required to identify required services or improvements to municipal infrastructure required to support development.

Additional study requirements include:

- New road crossing evaluations/checklists (hydraulics, fish passage, wildlife passage, etc.). As the developments proceed, proposed watercourse crossings will need to be sized based on the Regulatory floodlines and the standards provided by CLOCA (2020). The impact of the proposed watercourse crossings will also have to be incorporated into the Hec Ras model to define the impact on adjacent upstream lands. In some cases, it may be necessary to oversize structures in order to preserve lands that are proposed for development and to protect existing lands. In addition, these crossings must ensure that at any time of year, the free movement of water and the passage of fish may not be blocked or otherwise impeded up and down stream of the crossing, with the exception of a temporary blockage due to water crossing construction/removal activities. In most cases, clear-span bridges or open bottom culverts are preferred with appropriate span to accommodate natural channel migration. All in-water construction and removal activities must abide by the appropriate fisheries in-water timing windows documented in approved FMPs and/or forest management guides in order to avoid disrupting sensitive fish life stages. In cases where the fishery community inventories at the location of the proposed project are not well documented, the most restrictive in-water timing window must be used. All in-water construction and removal activities must be undertaken in an uninterrupted fashion and be completed in an appropriate timeframe to minimize the potential for site disturbance. The construction and removal activities must not employ the use of any explosives.

- Master Environmental Servicing Plan / Master Drainage Plan
  - Requirements for an MESP/MDP the CEL Secondary Plan have not been completed for the CEL Secondary Plan and will be required as the secondary plan moves forward.
    - Note: While SWMF locations within the Courtice Employment Lands were assumed to be at the subcatchment outlet for this Subwatershed Study, they will have to be finalized as part of the MESP/MDP.
    - Note: Location planning and design of future stormwater management ponds should take into account adjacent developments within a catchment, rather than on a site-by-site basis, in order to identify opportunities to minimize the overall number of facilities by providing larger, more efficient centralized ponds. The centralized ponds would

provide benefits to both the development proponent and the City through savings in land and lower future maintenance requirements. From a land use perspective, ponds are 'green infrastructure' that contribute to the urban fabric and can contribute as a connective element in the overall pathways system.

- The MESP/MDP must follow all requirements outlined by CLOCA and the Municipality. Additional requirements may be subsequently identified by the Municipality.

- Functional Servicing Report
    - This report will require the following:
        - Top of bank staking/slope stability analysis
        - Minor and major flow routes identified, and capacities verified
        - Preliminary sizing for SWM Facility
        - SWM outfall locations (may require site walk with approval agencies)
        - LID siting, footprints, soils and infiltration values, and preliminary sizing. Define the types of LID techniques that are to be incorporated into the future urban landscape to meet the targets identified in **Table 8.1** over the respective study areas. Infiltration rates should be measured in situ using test pits and/or boreholes, and post-development infiltration rates should match pre-development rates on an annual basis. In–situ infiltration testing characterizes the field saturated hydraulic properties of the existing native material on-site. On-site infiltration testing using industry standard methodologies (e.g. Guelph Permeameter, Double ring infiltrometer, etc.) to determine the in-situ field saturated hydraulic conductivity infiltration rates and the design infiltration rate per the LID Stormwater Planning and Design Guide is recommended (https://wiki.sustainabletechnologies.ca/wiki). Field testing should be performed within the approximate location and invert of proposed LID practices.
        - Other requirements as may be outlined by the Municipality

- Stormwater Management Report
    - None of the requirements for a Stormwater Management Report have been completed yet. This stage of planning builds upon the preliminary work at the functional design level in order to finalize the drainage and stormwater pond designs. This report will require:
        - Detailed SWMF design
        - Detailed LID design
        - Other requirements as may be outlined by the Municipality

- Stormwater Management Brief
    - None of the requirements for a Stormwater Management Brief have been completed yet. This report will require:

        - Detailed BMP design (SWMFs, LIDs, OGS, etc.)

- Other
    - Hydrogeologic Assessment - It is recommended that field testing, through the installation of boreholes and monitoring wells, be used to verify soil and groundwater conditions including any constraints associated with high or perched groundwater. As part of a complete field program soil samples should be collected as part of geotechnical and/or hydrogeological investigations in order to characterize the soil properties.
    - Erosion and Sediment Control Plan

8.4.3 Environmental Impact Studies

Phase 1 of this SWS characterized natural heritage features and hydrologically sensitive features within the study area, and identified constraints to development which were to be carried forward by the Secondary Plans (see **Section 7.2** for an overview of these tasks). As this SWS is a landscape-level study, it is appropriate to complete site-level studies moving forward to: refine or expand upon the current findings (e.g., by field-staking and surveying feature boundaries); address features which require additional assessment (such as those included in the Moderate constraint category, discussed in **Section 7.3**, or those present on properties for which site access permission was not granted for this SWS); and ensure that up-to-date information is available to assist approving agencies in their decision-making. Environmental Impact Studies (EIS) are the primary tool identified by the Municipality of Clarington's OP (2018 consolidation) for this purpose.

The OP indicates that the purpose of an EIS is "to determine the potential for development to adversely impact environmentally significant and sensitive areas, and natural heritage features". The OP further states that an EIS shall be undertaken for all development proposals within 120 metres of a natural heritage feature and shall:

a) Examine the functions of the natural heritage features;
b) Identify the location and extent of natural heritage features;
c) Identify the potential impacts of the proposed development on the natural heritage features and their ecological functions;
d) Identify any lands to be preserved in their natural state;
e) Identify mitigating measures to address the adverse effects of development on the natural heritage features and their ecological functions, including setbacks for development;
f) Identify the potential for restoration and/or creation of wildlife habitat; and
g) Examine the cumulative impact of the existing, proposed and potential development, including the impact on groundwater function and quality.

Any proposed development within 120 m of identified components of the NHS (see **Section 7.2.1**) must therefore complete an EIS in keeping with the above requirements.

The scope of an EIS is to be determined at the onset of a project through pre-consultation with the Municipality and any applicable stakeholders, typically through the preparation and submission of a study Terms of Reference. The necessary scope of each EIS will vary depending on: the nature and proximity of natural heritage features; the amount of existing data available for the study area; and how recently the existing information was obtained. Ecological conditions change over time, and therefore past ecological survey data may be considered to 'expire' and need updating as part of a current EIS scope.

Tasks which may be included in the scope of an EIS include (but are not necessarily limited to) the list provided below. Pre-consultation and study scoping, as described above, will confirm which of the tasks listed below will be required for the subject property addressed by the EIS, and also whether additional work may be appropriate based on updated conditions. The presence of habitat as well as the potential impact to that habitat should be used to determine the need for related surveys.

- Confirmation/refinement of natural heritage feature boundaries assessed and identified as part of this SWS (e.g., staking and surveying the dripline of a woodlot, or wetland delineation per the provincial Ontario Wetland Evaluation System protocol) and confirmation on the presence/absence of 'other' features as identified in Section 3.4.3 of the Municipality's OP which may warrant protection despite not meeting the OP criteria for inclusion in the NHS;

- Targeted aquatic surveys (e.g., Ontario Stream Assessment Protocol, fish community assessment) to confirm the presence/absence of fish, direct construction timing considerations, update existing records, and/or fill in data gaps;

- Targeted wildlife surveys (e.g., breeding bird survey, amphibian calling survey) to confirm the presence/absence of Significant Wildlife Habitat, update existing records, and/or fill in data gaps;

- Targeted botanical inventories to confirm vegetation community assessment and address data gaps (e.g., additional seasonal surveys to target spring ephemerals – most botanical surveys for this SWS occurred in the summer and fall);

- Species at Risk assessment and associated consultation with the Ministry of the Environment, Conservation, and Parks (see also **Section 8.6.1**);

- Review of areas identified by this SWS as Low Constraint to confirm the presence/ absence of features such as heritage trees/wildlife trees, regionally rare or uncommon plants, and similar features which may be appropriate to preserve or may be subject to offsetting or mitigation requirements;

- Assess linkages on the site level and discuss how the proposed development will maintain or enhance landscape connectivity, including discussion of applicable wildlife road crossing design principles if appropriate;

- Identification of appropriate VPZ widths to provide adequate protection for natural heritage features on the site (minimum VPZ as per the municipal OP must be observed, but the EIS should assess if this minimum is sufficient for the protection of identified features and functions or whether additional area is required, e.g. adjacent to sensitive features or areas, or where high-impact adjacent land uses are proposed);
- Identification of site-specific restoration and enhancement opportunities, including species suggestions for planting plans as appropriate (e.g., for VPZ naturalization). Other restoration and enhancement opportunities could include the daylighting of tiled agricultural fields and/or buried watercourses which should be evaluated as a part of an EIS to determine the form and function of the feature(s); and
- Evaluation on the need for a feature-based water balance, and completion of this water balance if required.

8.4.4 Headwater Drainage Feature Assessment

HDF assessments were completed as part of this SWS for all properties for which staff were granted permission to enter. In some areas a lack of land access restricted surveys from occurring as part of this subwatershed study, however. As such, HDF assessments have yet to be completed in areas where valuable features may be found and must be completed as part of site-specific environmental assessments prior to any approval of a proposed development plan.

Furthermore, the HDF assessment protocol is limited to field observations and is inherently biased, limiting the scope of observations to a number of external factors such as weather, timing, resources and land access among other factors. Many HDFs may have been overlooked during this exercise and should be considered in future site-specific exercises.

It should also be noted that the Guidelines and Classification process recommends that features defined by, "…evidence of cultivation, furrowing, presence of a seasonal crop, lack of vegetation, and fine textured soils," should be considered to provide Limited or Recharge Hydrologic Functions. These defining characteristics are typical of agricultural fields, of which contain some of the larger and potentially hydrologically significant drainage features. This is the case for features given the lowest management recommendations within the two subwatersheds, that are not ponds. Furthermore, these assessments do not account for agricultural features that are tiled. In these cases, management recommendations would be up-ranked if the agricultural fields would be left to re-naturalize making these areas suitable for restoration works. It is the opinion of Aquafor Beech Limited, in support of the Municipality, that additional HDF Assessments be undertaken on features identified on agricultural properties prior to any development approval in order to accurately assess hydrologic functions of these features. This is especially the case if cultivated lands are allowed to go fallow in the intervening time. If, based on detailed assessments and review, it is determined that the feature provides form and function that would increase the management characterization, it is recommended that the more conservative management approach be adopted. Alternatively, if the feature represents that with the same or less function, management in the form of mitigation through appropriate lot conveyance may be appropriate.

8.5 Secondary Plan Policy

As stated in **Section 3** of this report, the Robinson Creek and Tooley Creek Subwatershed Study was undertaken through an integrated approach with the Southeast Courtice Secondary Plan and the Southwest Courtice Secondary Plan. The Phase 1 subwatershed characterization report provided a detailed summary of existing conditions associated with subwatershed health and defined constraints to development associated with natural heritage features and natural hazards. The subwatershed characterization report also provided direction for policy development related to natural heritage features, natural hazards, headwater drainage features, and provided recommendations for a volume-based stormwater approach where runoff is treated as a resource and pre-development water balance rates are maintained to the greatest extent possible.

Using the subwatershed characterization report as a foundation for development constraints for Secondary Plan development, the separate Secondary Plan teams responsible for the Southeast Courtice Secondary Plan and the Southwest Courtice Secondary Plan developed preliminary land use plans and associated Secondary Plan policies which were reviewed by the Robinson Creek and Tooley Creek Subwatershed Team as well as SGL Planning and Design Inc. on behalf on the Municipality of Clarington.

The policy recommendations are provided in **Appendix D** and focus on sustainability, linkages, LIDs, headwater drainage and stormwater management. These recommendations were made before the Secondary Plans were adopted and prior to the completion of Phase 2 and 3 of the Subwatershed Study. As such, an encompassing policy has been included in the Secondary Plans that directs the reader to the Subwatershed Study when they are preparing studies. This states that "Detailed studies prepared in support of a development application may refine on site by site basis the recommendations of the Robinson Creek and Tooley Creek Subwatershed Study however the study must address the issues raised by the Subwatershed Study."

8.5.1 Southwest Courtice and Southeast Courtice

Recommendations for the Southwest Courtice and Southeast Courtice Secondary Plans included increased consistency between the policies. General recommendations included:

- Clarification on approach for addressing constraint areas;
- Addressing headwater drainage features requirements;
- Expanding low impact development sections; and
- Demonstrating how the stormwater management plans meet the water balance target in this Subwatershed Study.

These recommendations were developed before the completion of Phase 2 and 3 of the Subwatershed Study, and did not therefore include any recommendations from it.

8.5.2 Courtice Employment Lands

Policies that consider and respect the approach to natural heritage features, natural hazards, headwater drainage features and a volume-based approach to stormwater management as discussed in the Robinson Creek and Tooley Creek Subwatershed Study will be developed for the Courtice Employment Lands. Due to the timing of the updated Courtice Employment Lands Secondary Plan, these policies will be developed after the completion of the Robinson Creek and Tooley Creek Subwatershed Study. The policies developed for Southwest Courtice and Southeast Courtice may be used for reference as these are being developed; however, it is noted that the land use intensities associated with the Courtice Employment Lands will require unique policies provisions with respect to both stormwater management (e.g. additional lot-level infiltration practices within parking areas) and the maintenance of natural heritage form and function (e.g. linkages to stream corridors).

8.6 Permits and Approvals

8.6.1 Ontario Endangered Species Act

The Ontario Ministry of the Environment, Conservation, and Parks (MECP) is responsible for the administration of the Endangered Species Act (ESA), under which Species at Risk (SAR) and their habitat receive protection in Ontario. As the list and rankings of SAR in the province is always being updated with new information, future studies (e.g., EIS) will be required to include an updated screening and assessment for SAR and SAR habitat within their study area. This process is expected to include consultation with the MECP to confirm the list of species potentially occurring in the study area and to identify any targeted surveys that will be necessary for the project.

Projects which will potentially impact Endangered or Threatened species are required to submit an Information Gathering Form (IGF) to the MECP so that they may review the project and determine the requisite actions under the ESA (i.e., whether a permit will be required for the proposed action or whether it may be covered under a regulatory exemption or letter of advice).

Eight Endangered or Threatened species were identified as occurring or potentially occurring in the subwatershed, and are expected to require additional work or consultation to determine their requirements under the ESA, either because they are commonly found in anthropogenic habitats (e.g., buildings, agricultural fields) and therefore their habitat is not protected in the NHS, or because their general habitat extends out of the NHS into adjacent lands (e.g., habitat radius around a tree trunk). These species are as follows:

- **Butternut (*Juglans cinerea*)** – An Endangered tree species confirmed to occur at multiple locations within the SWS study area, often along woodland edges. Additional locations not specifically identified in the SWS are possible, and site-specific surveys should be completed to identify all Butternuts present in areas associated with proposed future development, including hedgerows and other treed areas not identified as part of the NHS. General habitat for Butternut includes the area up to 25-50 m from the stem. Where development is proposed that would impact a Butternut or its habitat, a Butternut Health Assessment must be completed according to the provincial protocol.

This Assessment will result in the ranking of trees as Category 1, 2, or 3 which have different requirements under the ESA. DNA testing may be carried out if hybridity is suspected; only pure Butternut trees are protected under the ESA.

- **Bobolink (*Dolichonyx oryzivorus*) and Eastern Meadowlark (*Sturnella magna*)** – These two Threatened bird species utilize meadows, pastures, old fields, and similar open habitats. One patch of habitat for these species was identified in the Robinson Creek valley (see **Figure 7.3**) but other suitable habitat patches in the study area could also be used by birds in the future and the presence/absence of these species should be confirmed prior to land development or site alternation which would destroy potential habitat. At the time of this document's publication, there is a regulatory exemption available for land development in Bobolink and Eastern Meadowlark habitat within certain defined parameters; outside of those parameters, a permit under the ESA may still be required.
- **Barn Swallow (*Hirundo rustica*)** – A Threatened bird species that constructs nests on human-made structures (e.g., buildings such as barns, culverts, bridges). Any proposed development or site alteration that requires demolition or alteration of such structures should be preceded by a nest search to determine if the site is used for Barn Swallow nesting. At the time of this document's publication, there is a regulatory exemption available for the alteration of a structure that provides habitat for Barn Swallow, which avoids the need for a permit under the ESA provided that defined mitigation/ compensation measures are followed.
- **Myotis spp. and Tricolored Bat (*Perimyotis subflavus*)** – The four Endangered bat species of Ontario are typically associated with wooded habitats containing cavity trees or other features suitable for maternity roosting. Proposed tree removals adjacent or near to woodlands, or the removal of small woodlands or hedgerows that are not part of the NHS, may required additional work to identify the potential to support bats. Requirements under the ESA for these species would be determined on a case-by-case basis in consultation with the MECP.

8.6.2 Fisheries Act: Department of Fisheries and Oceans Canada Regulatory Review

The federal *Fisheries Act* requires that projects avoid causing the death of fish and the harmful alteration, disruption or destruction of fish habitat unless authorized by the Minister of Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near waterbodies that support fish at any time during any given year or are connected to waterbodies that support fish at any time during any given year. Many watercourses and aquatic features within the study area fit this definition and therefore, the *Fisheries Act* applies to works conducted in or near water in many cases. However, review of the *Fisheries Act* and the site-specific aquatic resources should be reviewed on a site by site basis to determine if the Act applies to the aquatic resource.

Upon completion of the detailed design for the channel works at the study site, the works should be cross-referenced with the DFO "Projects Near Water" online service to determine if a request for regulatory review under the federal Fisheries Act is required (Fisheries and Oceans

Canada, 2020). Using field investigations, background information and correspondence with regulatory bodies, the site-specific study area shall be examined to determine if the potential to contain fish at any time during any given year, or that a certain connection to waterbodies that do support fish at any time during any given year, is demonstrated. Following the guidance of the DFO, the need for a request for regulatory review by Fisheries and Oceans Canada will be determined. It is recommended that a proponent exercise the measures listed by Fisheries and Oceans Canada to avoid contravention with the Federal *Fisheries Act* and exercise due diligence by further mitigating accidental death of fish and the harmful alteration, disruption or destruction of fish habitat.

9 References

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