Clair-Maltby Secondary Plan and Master Environmental Servicing Plan (CMSP / MESP)

Comprehensive Environmental Impact Study (CEIS)
Phase 1 and 2: Characterization Report
Project # TPB168050; City of Guelph

Prepared for:

City of Guelph
1 Carden Street, Guelph, Ontario N1H 3A1

September 5, 2018

wood.

Clair-Maltby Secondary Plan and Master Environmental Servicing Plan (CMSP / MESP)
Comprehensive Environmental Impact Study (CEIS)
Phase 1 and Phase 2: Characterization Report

Submitted to:

City of Guelph, Ontario

Submitted by:

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1.0 Introduction

1.1 Planning Process for Clair-Maltby Secondary Plan Area

The City of Guelph is preparing the Clair-Maltby Secondary Plan which is supported by Master Environmental Servicing Plan (MESP) and Comprehensive Environmental Impact Study (CEIS) to comprehensively plan the last unplanned greenfield area in the City (ref. Figure 1-1). The MESP is intended to satisfy and fulfill the requirements of the Environmental Assessment Act and the Planning Act. A key component of the Clair-Maltby MESP and Secondary Plan process is the Comprehensive Environmental Impact Study (CEIS) and MESP technical studies being conducted by Wood (formerly Amec Foster Wheeler) with support from Matrix and Beacon (ref. Figure 1-1).

Three scales of study area (ref. Figure 1-2) have been identified for the CEIS, as per the following:

i. The Secondary Plan Area (SPA): The SPA is the area within which land use change will occur in accordance with an approved Secondary Plan. The SPA includes the lands south of Clair Road East, north of Maltby Road East, west of Victoria Road South, and approximately 1 km east of the Hanlon Expressway in the City of Guelph.
ii. The Primary Study Area (PSA): The PSA includes the SPA plus a 500 m (+/-) zone beyond this boundary to allow for consideration of natural heritage functions and connectivity in the landscape.
iii. The Secondary Study Area (SSA): The SSA includes the PSA plus the surface water / groundwater receiving systems beyond the Clair-Maltby SPA. This area has been defined based on the area's hydrology and hydrogeology to ensure that landscape scale connectivity is considered from a groundwater and surface water perspective. The SSA is based on appropriate groundwater and surface water model boundaries, which inherently consider subwatershed boundaries (Mill Creek, Hanlon Creek, Torrance Creek, Irish Creek and Lower Speed River), as well as groundwater flow divides.

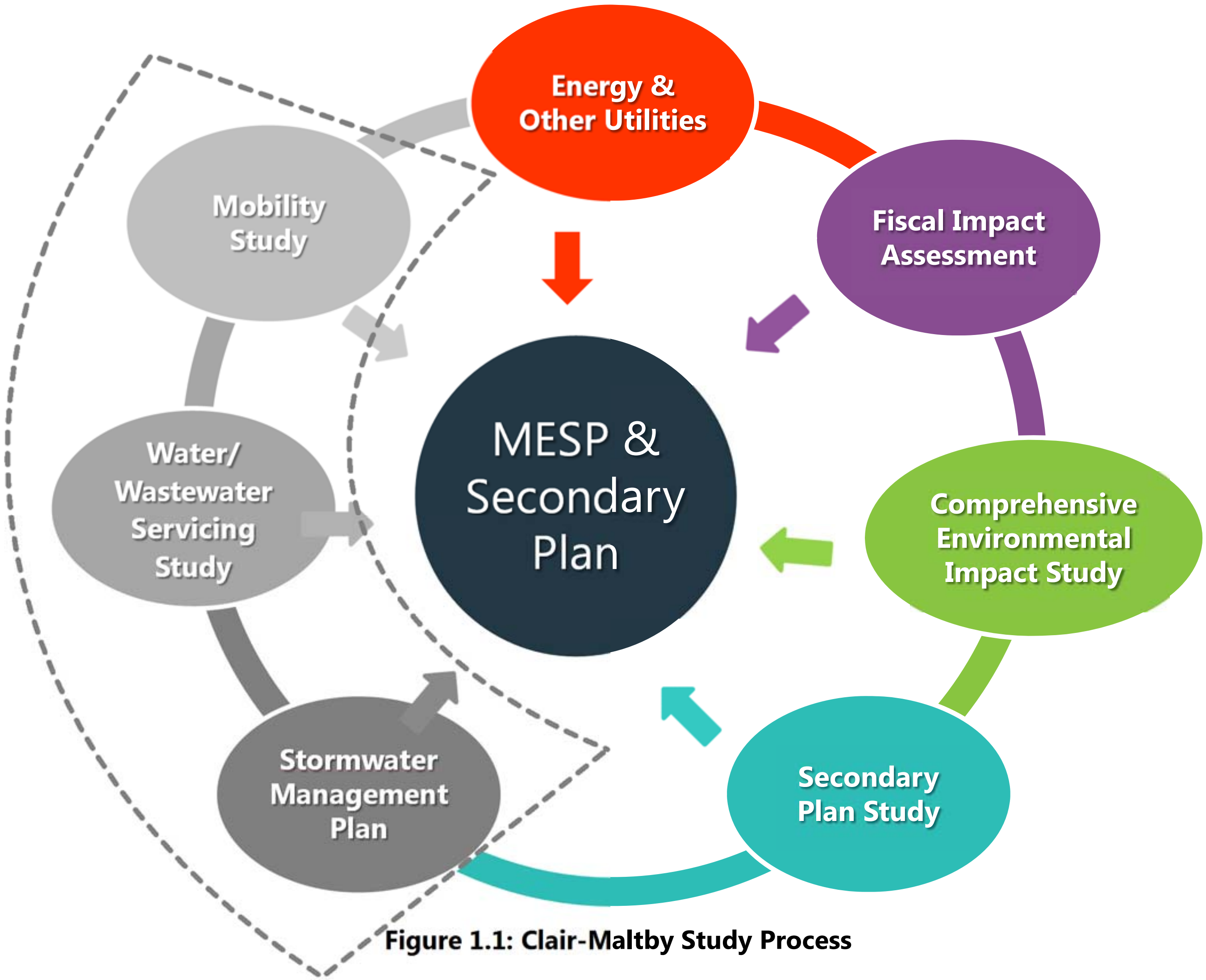


Figure 1.1: Clair-Maltby Study Process

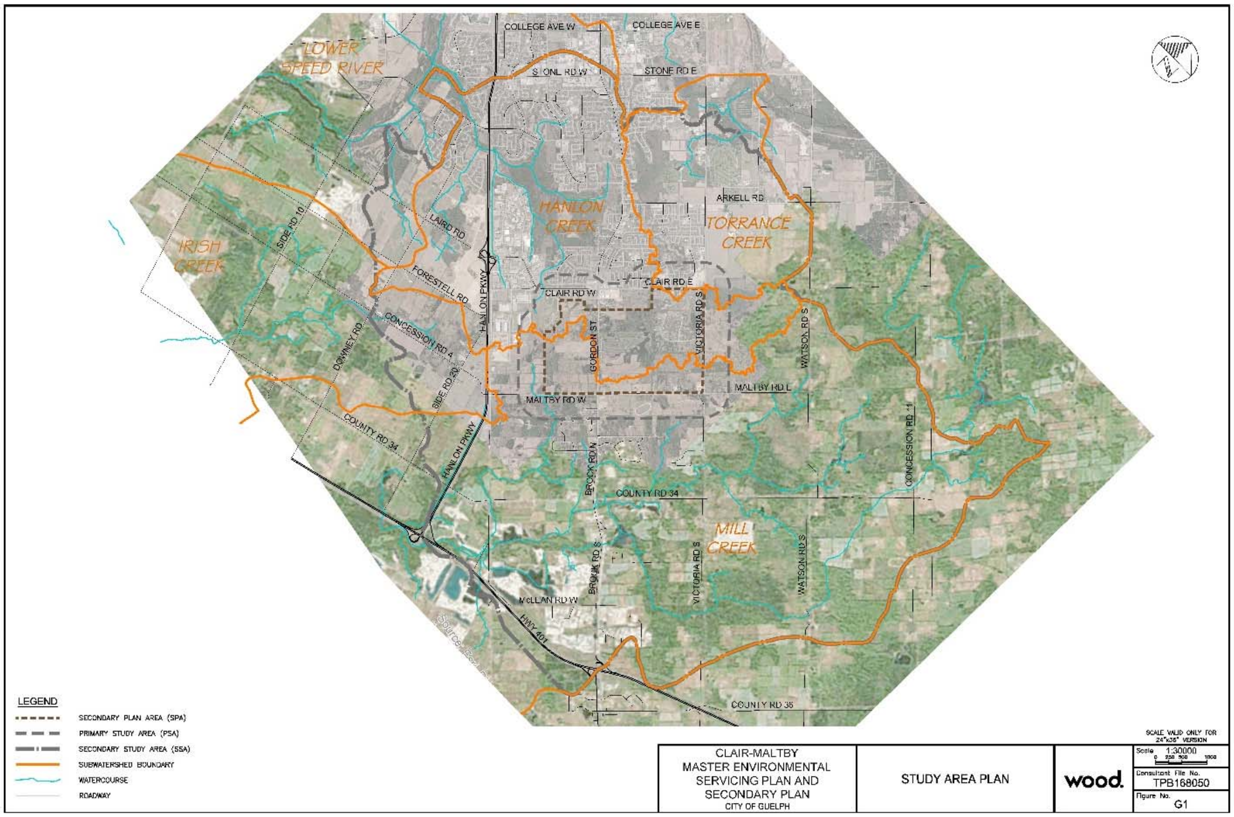


Figure 1.2: Study Area Scales

The SPA (and the City as a whole) has an identified Natural Heritage System (NHS) which was incorporated into the City's Official Plan in 2010 through Official Plan Amendment (OPA) 42, refined through the Ontario Municipal Board (OMB) settlement process, and finalized through approval of OPA 42 in June 2014 by the OMB.

The purpose of the CEIS is to serve as a comprehensive and strategic document to address natural heritage and water resource protection incorporating subwatershed scale assessments to inform environmental, land use and infrastructure planning and associated decision-making, as part of a broader integrated development framework for informing the Secondary Plan and its policies.

The Phase 1 and Phase 2 Integrated Technical Reports provide the basis for the CEIS and are being developed in order to aligns with the broader project process as follows.

The Phase 1 and Phase 2 Characterization Report (this report) focusses on the characterization of the SPA and specifically includes:

a) Characterization of all aspects of the SPA, with consideration for the PSA and SSA as appropriate, with respect to surface water, ground water and natural heritage features and associated functions in the context of the applicable environmental legislation, policies and guidelines;
b) Updates and refinements to the NHS based on new information gathered through the CMSP process (as detailed in the 2016 and 2017 Monitoring Reports for this project) and based on the direction set out in the approved OPA 42; and
c) Preliminary targets and objectives for protecting, maintaining and enhancing the local water and natural heritage assets through the development process.

The Conceptual Community Structure incorporating input from the Community Charrette (April 2018) was presented to and approved by Council in June 2018. The next phase of the CEIS will include an Impact Assessment which will involve:

a) Incorporating refinements to the NHS based on feedback and additional information received over the summer and fall of 2018, and considering related refinements to the Conceptual Community Structure where needed and appropriate;
b) An evaluation of the impacts to existing surface water, ground water and natural heritage features and functions based on the approved and, if needed, refined Conceptual Community Structure and associated MESP servicing alternatives;
c) Refining targets and objectives for protecting, maintaining and enhancing the local water and natural heritage assets through the development process; and
d) Developing recommendations and approaches to protect, maintain and, where possible, enhance the NHS and associated water resources in the SPA through implementation of the Secondary Plan.

2.0 Study Process

The CEIS forms one of the primary foundational studies to support the Secondary Plan (ref. Figure 1-1). Environmental features and the management of surface water and groundwater informs all aspects of land use change, including community and built form, transportation and servicing. As such, it is paramount for these studies to accurately define the key features within the study area (ref. Phase 1) and establish their relationship to surrounding lands in terms of landscape scale functionality.

Based upon this understanding (i.e. characterization), the potential for impacts due to proposed land use change can be assessed. Premised on the anticipated scope and nature of impact, appropriate management strategies, including mitigation (i.e. avoidance, minimization and compensation, including restoration), will need to be considered as part of a comprehensive evaluation. Given the unique characteristics of the study area, which serves as a headwater for the Mill, Hanlon and Torrance systems, along with the unique Paris Moraine topography, establishing a strong understanding of surface water / groundwater interactions and their influence on local features, which will support the Natural Heritage System (NHS), will constitute a core undertaking of the CEIS. The study phases include the following:

Phase 1: Background

Phase 1 provides the characterization of the natural heritage, surface and groundwater features, functions and form in the PSA and the SSA, with more focus and detail available for the PSA. This information subsequently supports a preliminary constraints and opportunities analysis for both the PSA and SSA. Due to the nature of this study, having a three (3) year monitoring period (i.e. 2016, 2017 and 2018), the initial constraints and opportunities have been established following year 1 and 2 subsequently year 3, 2018, is proposed to be used to test and verify the assumptions established under years 1 and 2. Some of the key constraints and opportunities have included the following:

•	•
• **Topography**	• Deficient conveyance infrastructure
• **Natural Heritage System feature and area boundaries, including Linkages**	• Natural hazards, including steep slopes
• **Discharge locations (including seeps and springs)**	• Confirmed habitat for provincially Endangered and Threatened species

This preliminary information has, as part of the Conceptual Community Structure Analysis, been fed into the overall study process including the Planning Charrette, in order to synthesize the understanding of the existing environment and how it informs future land use planning.

Based upon the input from Phase 1 Year 1 and 2, an Existing Conditions report (this report) has been prepared which focuses on the NHS (including Significant Landform), surface water / groundwater interaction, and other key elements including the existing conditions water budget for both the PSA and SSA. Water budgets have been established for representative natural heritage features within the PSA. Preliminary stormwater management targets for the PSA, based upon the existing land use conditions, have been determined through numerical modelling.

Phase 2: Conceptual Community Structure Analysis

Following the Characterization of the PSA and SSA after year 1 and 2, and the Conceptual Community Structure analysis premised on constraints and opportunities, a series of Community Structure Alternatives for the CMSP area have been made available to the Wood Team and subsequently used to conduct a high-level preliminary impact assessment to establish the scale and extent of potential impacts along with a preliminary management hierarchy. Three (3) Community Structure Alternatives have been evaluated concurrently at a high-level related to preliminary data / information. The preliminary information from the respective evaluations have been used as input to ultimately establish a preferred Community Structure Alternative for detailed analysis pending Council support.

Phase 3: MESP and Secondary Plan Input

The CEIS, as noted earlier is a fundamental undertaking to establish the Secondary Plan and associated MESP for the Secondary Plan Area. Following the preliminary Impact Assessment of the three (3) Community Structure Alternatives, ultimately leading to a preferred plan and the detailed technical assessment of the preferred plan, the third phase of the study will establish a formal Management Plan specific to the respective water-based and natural systems in the CMSP. While the focus of this study complement will be within the PSA, consideration will be made for the SSA as well, particularly as it relates to NHS / surface water / groundwater connections. The scope includes: developing the Management Plan, as well as the implementation / Monitoring Plan which will ultimately provide direction on how the City and its study partners as to how best to implement the recommendations and ultimately monitor the effectiveness of the management strategy.

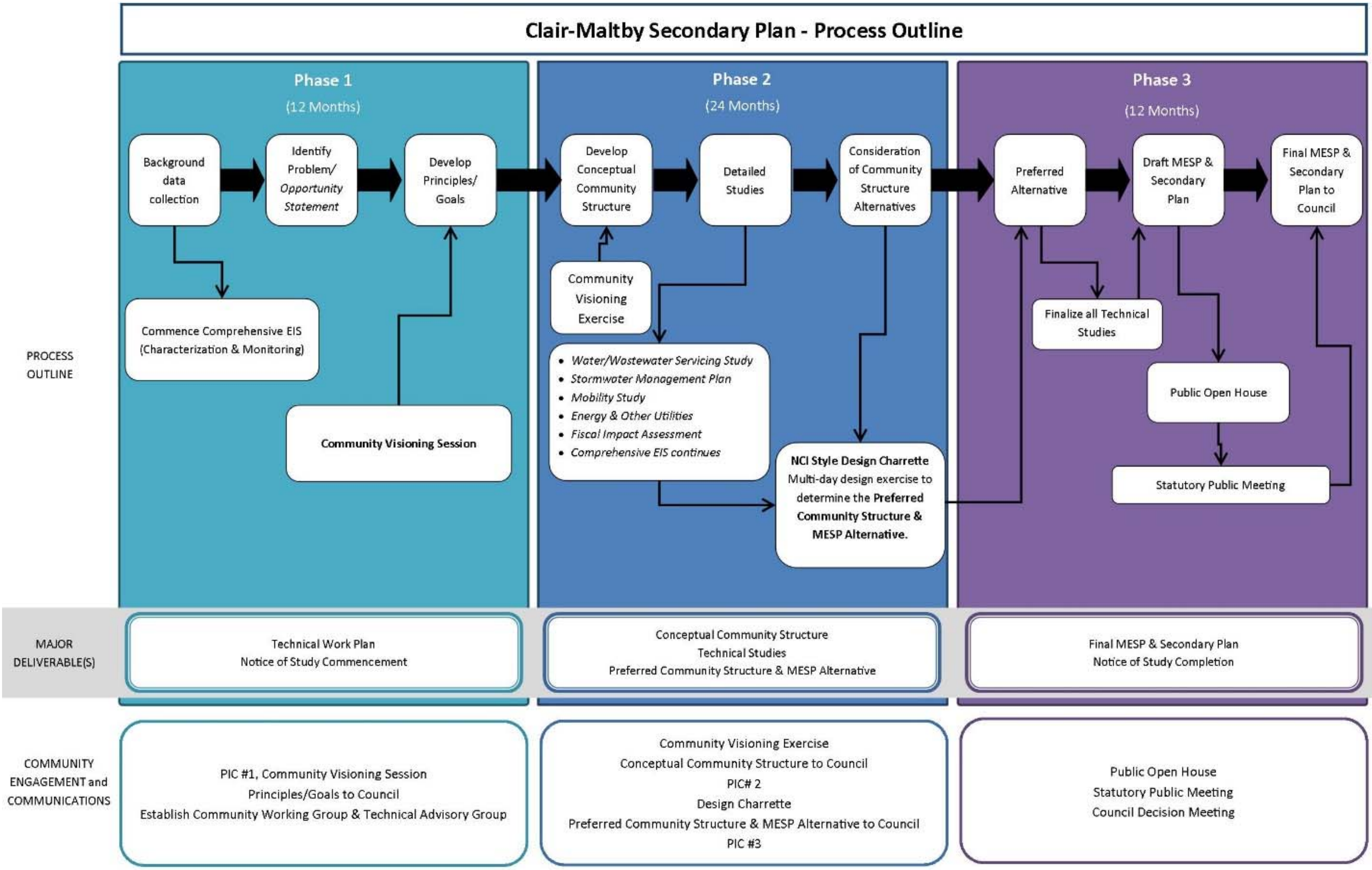


Figure 2.1: Clair-Maltby Secondary Plan Process

3.0 Study Framework

The City's objective for this community requires a collaborative, design-driven process that is based on a strong technical understanding of the opportunities and constraints unique to this study area. This process integrates with the requirements of the Planning Act and Environmental Assessment Act, and also includes a comprehensive and inclusive consultation process.

- Task A – Comprehensive Environmental Impact Study (CEIS)
  - Natural Heritage, Geology/Hydrogeology/Hydrology/ Water Quality
    - Existing Conditions Analysis (this report)
    - Development Impact Assessment
    - Implementation and Monitoring Plans
- Task B – Water/Wastewater Plan
- Task C – Stormwater Management Plan
- Task D – Mobility Study
- Task E – Energy & Other Utilities
- Task F – Secondary Plan
- Task G – Community Engagement & Communications

3.1 Planning Objectives and Framework

The Clair-Maltby Secondary Plan will have regard for the vision, principles, goals and objectives set out in the Official Plan for the entire City. The Secondary Plan will be guided by the growth management objectives of the Official Plan, outlined in Section 2.4.2. Guiding principles developed by the City include:

- Virbrant and Urban
- Green and Resilient
- Healthy and Sustainable
- Interconnected Interwoven
- Balanced and Liveable

The vision for Clair-Maltby includes:

- Clair-Maltby will be a vibrant, urban community that is integrated with Guelph's southern neighbourhoods, as well as having strong connections to Downtown, employment areas and the rest of the City.
- The Natural Heritage System and the Paris Moraine provide the framework for the balanced development of interconnected and sustainable neighbourhoods.

- This area will be primarily residential in character with a full range of mix of housing types and a variety of other uses that meet the needs of all residents
- A system of parks, open spaces and trails will be interwoven throughout to provide opportunities for active and passive recreation

The objectives providing direction for elements to be studied include:

- Building a compact, vibrant and complete community for current and future generations
- Planning the greenfield area to provide for a diverse mix of land uses at transit supportive densities
- Maintaining a healthy mix of residential and employment uses at approximately 57 jobs per 100 residents
- Maintaining a strong and competitive economy
- Supporting a multi-modal transportation network and efficient public transit system
- Planning for community infrastructure to support growth in a compact and efficient form
- Ensuring sustainable energy, water and wastewater services are available to support existing development and future growth
- Promoting protection and enhancement of the natural heritage system
- Supporting and protecting water, energy, air quality and cultural heritage resources, as well as innovative approaches to waste management
- Supporting transit, walking and cycling for everyday activities

3.2 Study Goals and Objectives

The purpose of the Clair-Maltby Secondary Plan is to develop a land use plan for the study area which provides more detailed planning objectives and a policy framework to direct future growth in this area.

The Clair-Maltby Secondary Plan should generally address, but is not limited to:

i. patterns of land use, land use designations and density, and associated population and employment densities
ii. connectivity and integration in the secondary plan area and with existing developed or planned development areas of the City
iii. urban design
iv. natural heritage features and systems

Previous Studies

Goals and objectives have also been established by previous studies. The following are considered of relevance to the Clair-Maltby SPA:

i. ***Hanlon Creek Watershed Plan Goals:***

- To minimize the threat to life and the destruction of property and natural resources from flooding and preserve or re-establish natural flood plain hydrologic functions
- To restore, protect and enhance water quality and associated aquatic resources and water supplies
- To restore, protect, develop, and enhance the historic, cultural, recreational, and visual amenities of rural and urban stream corridors

ii. ***Hanlon Creek Watershed Plan Objectives:***

- To ensure that runoff from developing and urbanizing areas is controlled such that it does not unnecessarily increase the frequency and intensity of flooding at the risk of threatening life and property
- To adopt appropriate land use controls and performance standards for controlling development of flood plains
- To minimize erosion and prevent sedimentation of waterways
- To prevent the accelerated enrichment of streams and contamination of waterways from runoff containing nutrients, pathogenic organisms, organic substances, and heavy metals and toxic substances
- To maintain or restore a natural vegetative canopy along streams where required to ensure that mid-summer stream temperatures do not exceed tolerance limits of desirable aquatic organisms
- To maintain the stream or waterway free from litter, trash, and other debris
- To minimize the disturbance of streambed and prevent streambank erosion and, where practical, to restore eroding streambanks to a natural or stable condition
- To restore, rehabilitate, or enhance water quality and associated resources through the implementation of an appropriate Bes Management Practices on the land
- To take full advantage of stream baseflow enhancement opportunities
- To enhance the fishery habitat, specifically to increase the quantity and quality of Brook Trout in the headwaters area and to extend their range downstream of the Hanlon Parkway to the Speed River
- To maintain or enhance the buffer provided by wetlands
- To minimize disturbance of wetlands, persevering or enhancing the habitat they provide
- To provide buffers to wetlands to maintain or enhance their biological health
- To ensure that environmental resource constraints are fully considered in establishing land use patterns in the watershed

- To retain and preserve open space and visual amenities in urban and rural areas by establishing and maintaining greenbelts along stream corridors and adjacent natural areas
- To ensure that the recreational and fisheries potential of a stream corridor are developed to the fullest extent practicable
- To maximize the use of creative and imaginative resources to rehabilitate and transform urban stream corridors, which through neglect may represent a source of urban decay and blight, into attractive community assets consistent with historical or other cultural amenities.

iii. Mill Creek Subwatershed Plan Goals:

- To restore, protect, and enhance water quality and associated aquatic resources and water supplies
- To conserve, protect and restore natural land, water, forest and wildlife resources
- To protect restore and enhance groundwater quantity and quality
- To minimize the threat to life and the destruction of property and natural resources from flooding and preserve or re-establish natural flood plain hydrologic functions
- To restore, protect, develop, and enhance the ecological, historical, cultural, recreational and visual amenities of rural and urban areas
- To recognize and encourage meaningful and timely public participation in the development, finalization and implementation of the subwatershed plan.

iv. Mill Creek Subwatershed Plan Objectives:

- Maintain existing recharge and discharge characteristics
- Control sediment discharges and provide erosion control during development
- Ensure appropriate water quality control measures are in place following development
- Maintain/reduce existing erosion rates following development
- Maintain/enhance cold-water fisheries' potential as subwatershed creeks
- Protect natural area functions/features from development
- Enhance natural area features and functions in long term
- Maintain infiltration, baseflow and discharge to natural features
- Ensure continued aggregate extraction does not impair existing groundwater quantity or quality
- Minimize risk to life and property with future development
- Control development in the floodplain
- Protect natural area functions/features from development
- Enhance natural area features and functions in long term
- Recognize that the public retains important subwatershed information
- Involve and incorporate public views in all aspects of the subwatershed planning process

The CEIS takes an integrated approach that considers all three defined study areas (CSPA, PSA, SSA) to, ultimately, recommend strategies intended to sustain and, where possible, enhance the diversity and connectivity of natural heritage features and areas, surface water features and groundwater features and their functions for the long-term.

As stated in the Terms of Reference for the CMSP, the specific objectives for the CEIS include:

- The protection of natural systems at a landscape level and the protection of ecological corridors between subwatersheds
- The protection of natural heritage features and areas, recognizing the important ecosystem services that benefit current and future generations
- The protection and enhancement of the City's tree canopy cover and urban forest while also providing for a range of habitat types to support local biodiversity
- The protection of significant portions of the Paris Galt Moraine and associated functions as characterized by areas identified as Significant Landform
- To recognise and address potential negative impacts that can result from urban development and identify opportunities to mitigate these impacts through community design, stewardship, monitoring and management strategies, and
- To ensure opportunities for the protection of trees within the urban forest are considered and incorporated.

This Phase 1 and Phase 2: Characterization Report is to be followed by the Phase 1 and Phase 2: Impact Assessment Report and, ultimately, the CEIS will identify targets intended to meet the objectives cited in the foregoing, along with recommended implementation strategies and a monitoring plan (i.e. Phase 3).

3.2.1 Governing Acts, Policies and Guidelines

As a complement to the overall process of establishing Secondary Plan Area scale goals, objectives, and targets, there also needs to be a recognition/understanding of the context of the governing legislation with respect to resource management. Various acts, guidelines, and policies exist at a federal, provincial and municipal (upper and lower tier) level to provide a framework for managing the impacts associated with land use change.

The following table provides a summary of the key legislative and policy documents that provide direction on environmental matters applicable to subwatershed and secondary planning studies in the City of Guelph. In addition, there are supporting guidelines and decision-making systems to help implement a number of these Acts and policies, which are also included in the table.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Federal	Federal Fisheries Act (I)	Act	Purpose is to manage threats to the sustainability and ongoing productivity of Canada's commercial, recreational and Aboriginal fisheries.
	Migratory Birds Convention Act (1994)(I)	Act	Protection of migratory songbirds and their nests from disturbance or destruction
	Species at Risk Act (2003)	Act	Protection of Wildlife species at risk; recovery plans
	Canadian Environmental Protection Act (CEPA)(1999)	Act	The goal of the Canadian Environmental Protection Act (CEPA) is to contribute to sustainable development through pollution prevention and to protect the environment, human life and health from the risks associated with toxic substances.
	Canadian Environmental Assessment Act	Act	The Act requires federal departments, including Environment Canada, agencies, and crown corporations to conduct environmental assessments for proposed projects where the federal government is the proponent
	Department of the Environment Act	Act	Establishes the department of the Environment and sets forth the various powers and responsibilities of the minister.
	Canadian Water Quality Guidelines for the Protection of Aquatic Life	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended "safe limits" for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and groundwater's and not to estuarine and marine waters.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Federal	Canadian Water Quality Guidelines for the Protection of Agricultural Water Uses	Guideline	The Canadian Water Quality Guidelines consist of a set of recommended "safe limits" for various polluting substances in raw (untreated) drinking water, recreational water, water used for agricultural and industrial purposes, and water supporting aquatic life. They are designed to protect and enhance the quality of water in Canada. The guidelines apply only to inland surface waters and groundwater's and not to estuarine and marine waters.
	Guidelines for Canadian Drinking Water Quality	Guideline	To provide a national guideline for the protection of drinking water.
	Guidelines for Canadian Recreational Water	Guideline	To provide a national guideline for the protection of recreational waters used for primary contact recreation such as swimming, windsurfing and water skiing and for secondary contact recreation activities including boating and fishing.
	How Much Habitat is Enough? A Framework for Guiding Habitat Rehabilitation in Great Lakes Areas of Concern (2013, EC/CWS, OMNR, OME) (D)	Guideline	Initiated in 1990 as part of the federal Great Lakes Action Plan, the Cleanup Fund represents a significant part of Canada's commitment to restore the Great Lakes Basin Ecosystem as outlined in the 1987 Protocol to the Great Lakes Water Quality Agreement between Canada and the United States (GLWQA).
Provincial	Nutrient Management Act (OMAF) (2002)	Act	As part of the Ontario government's Clean Water Strategy, the *Nutrient Management Act* provides for province-wide standards to address the effects of agricultural practices on the environment, especially as they relate to land-applied materials containing nutrients.
	Lakes and Rivers Improvement Act (1990)	Act	The Lakes and Rivers Improvement Act gives the Ministry of Natural Resources the mandate to manage water-related activities, particularly in the areas outside the jurisdiction of Conservation Authorities.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Provincial	Provincial Planning Act (1990)	Act	The purpose of this Act is to promote sustainable economic development in a healthy natural environment, as well as to provide a land use planning system led by Provincial Policy. The Act is intended to be interpreted according to the Provincial Policy Statement, which was last updated in 2014.
	Ontario Water Resources Act	Act	The Ontario Water Resource Act deals with the powers and obligations of the Ontario Clean Water Agency, as well as an assigned provincial officer, who monitors and investigates any potential problems with regards to water quality or supply. There are also extensive sections on Wells, Water Works, and Sewage works involving their operation, creation and other aspects.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Provincial	Clean Water Act, 2006		The provincial Clean Water Act, 2006, established the need to protect Ontario's existing and future drinking water sources as part of an overall commitment to safeguard human health and the environment. A key focus of the legislation is the preparation of locally-developed Source Protection Plans (SPP). The goal of each SPP is to eliminate and/or manage existing significant threats and to ensure no future drinking water threats become significant. According to the Act, Source Protection Plans must include: ・ Policies and programs to eliminate and/or manage existing significant threats ・ Policies and programs to ensure no future activities become significant drinking water threats These policies might include: ・ Rules for activities in wellhead protection areas and intake protection zones, e.g., activities that will be allowed, with conditions (e.g., risk management plans) ・ Public education programs ・ Programs to promote best management practices for voluntary action
	Environmental Protection Act	Act	The purpose of this Act is to provide for the protection and conservation of the natural environment. R.S.O.1990, c.E.19, s.3.
	Endangered Species Act (ESA) (2007)	Act	Enacts the protection of Endangered, Threatened and Special Concern species (provincial) and their habitats; regulates activities which may affect these species, and provides for development of Recovery Strategies.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Provincial	Fish and Wildlife Conservation Act (1997)	Act	*Fish and Wildlife Conservation Act* enables the Ministry of Natural Resources (MNR) to provide sound management of the province's fish and wildlife.
	Safe Drinking Water Act (MOE) (2002)	Act	Its purpose is the protection of human health through the control and regulation of drinking-water systems and drinking-water testing.
	Threats Assessment	Regulation	(Section 1.1 of Ontario Regulation 287/07 Province identified 21 activities that are prescribed as drinking water threat activities. For water quantity vulnerable areas with a significant risk level, all existing and new water takings (prescribed drinking water threat #19) located within the areas that draw water from the municipal aquifers or Eramosa River or activities that reduce groundwater recharge (prescribed drinking water threat #20) are classified as Significant Drinking Water Quantity Threats (significant threats) Recharge reduction is or would be a significant drinking water threat in WHPA-Qs and IPZ-Qs that are assigned a significant risk level.
	Municipal Act	Act	The Municipal Act sets forth regulations in regard to the structuring of municipalities in Ontario.
	Ontario's New Drinking Water Protection Regulation for Smaller Waterworks Serving Designated Facilities O. Reg. 505/01	Regulation	The Regulation is Part of the New Drinking Water Regulations administered through the Ministry of the Environment.

Table 3.2.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/ Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Ontario Drinking Water Protection Regulation	Regulation	In August 2000, the Government of Ontario announced a new *Drinking Water Protection Regulation* (Ontario Regulation 459/00) to ensure the safety of Ontario's drinking water. The regulation issued under the *Ontario Water Resources Act* was a part of the comprehensive Operation Clean Water action plan. This regulation put the Ontario Drinking Water Standards into law, updating and strengthening the Ontario Drinking Water Objectives.
	Bill 127, Ontario Water Resources Amendment Act (Water Source Protection), 2002	Act	The Bill amends the *Ontario Water Resources Act* in regard to the availability and conservation of Ontario water resources. Specifically, the Bill requires the Director to consider the Ministry of Environment's statement of environmental values when making any decision under the Act. The Bill also requires that municipalities and conservation authorities are notified of applications to take water that, if granted, may affect their water sources or supplies.
	Provincial Water Quality Objectives (MOE) (1994)	Guideline	To provide objectives for the protection of aquatic life.
	Natural Heritage Reference Manual for the Natural Heritage Policies of the Provincial Policy Statement (2010)	Guideline	Provides guidelines for the implementation of the natural heritage components of the PPS by planning authorities.
	Significant Wildlife Habitat Technical Guide (OMNR 2000)	Guideline	Significant Wildlife Habitat (SWH) is one of the natural heritage feature areas under the Provincial Policy Statement. This guide provides technical support for its identification and protection Province-wide with additional technical guidance provided in Ecoregional criteria schedules (MNRF 2015) and the SWH Mitigation Support Tool (MNRF 2014b).

Table 3.2.1: Summary of Acts, Guidelines, Policy			
Level of Government	**Name of Management Tool: Act/Regulation/Policy/ Guideline/Program**	**Type of Tool**	**Purpose**
Provincial	Protection and Management of Aquatic Sediment Quality in Ontario (MOE 1993)	Guideline	The purpose of the sediment quality guideline is to protect the aquatic environment by setting safe levels for metals, nutrients and organic compounds.
	Guidelines for Evaluating Construction Activities Impacting on Water Resources (MOE 1995)	Guideline	These guidelines were developed to protect the receiving environment according to the physical, the chemical and the biological quality of the material being dredged.
	Incorporation of the Reasonable Use concept into MOE Groundwater Management Activities (1994)	Guideline	This guideline establishes the basis for the reasonable use of groundwater on property adjacent to sources of contaminants and for determining the levels of contaminants acceptable to the ministry.
	Ontario Drinking Water Standards (MOE 2001)	Guideline	The purpose of the standards is to protect public health through the provision of safe drinking water.
	Technical Guideline for Private Wells: Water Supply Assessment (MOE 1996)	Guideline	Guidance manual for the development of private wells.
	Technical Guideline for On-site Sewage Systems (MOE)	Guideline	Guidance manual for assessing the proposed impacts on on-site sewage systems on groundwater.
	Subwatershed Planning (MOE 1993)	Guideline	Technical manual on conducting subwatershed planning in Ontario.
	Integrating Water Management Objectives into Municipal Planning Documents (MOE 1993)	Policy	Policy manual on the integration of watershed management practices into municipal planning documents.
	Watershed Management on a Watershed Basis (MOE 1993)	Guideline	Guideline manual on watershed management practices.
	Provincial Policy Statement (2014)	Policy	Provincial Policy Statement was issued under Section 3 of the Planning Act, came into effect on May 22, 1996 and was last updated in April 2014.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Provincial	Drainage Act	Act	Provides for the regulation of drainage practices in Ontario.
	Public Lands Act	Act	
	Environmental Bill of Rights (EBR)	Bill of Rights	On February 15, 1994, the Environmental Bill of Rights (EBR) took effect and the people of Ontario received an important new tool to help them protect and restore the natural environment. While the Government of Ontario retains the primary responsibility for environmental protection, the EBR provides every resident with formal rights to play a more effective role.
	Conservation Authorities Act (1990)	Act	Originally developed in 1946 in response to Hurricane Hazel flooding, the purpose of this Act is "to provide for the organization and delivery of programs and services that further the conservation, restoration, development and management of natural resources in watersheds in Ontario". As stated in the legislation, "the objects of an authority are to provide, in the area over which it has jurisdiction, programs and services designed to further the conservation, restoration, development and management of natural resources other than gas, oil, coal and minerals".
Municipal	City of Guelph Official Plan (1994, updated through OPA 39, 42 and 48)	Policy	The Official Plan is a statutory document under the Ontario Planning Act that sets out land use policy to guide future development and to manage growth. It provides a policy framework for Council decisions regarding the use of land, the provision of municipal services required to support growth, and the phasing of development.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Water Quantity Policy Development Study (In Progress)	Grand River Conservation Authority, City of Guelph, Guelph/Eramosa Township, Wellington Source Water Protection, Wellington County, Ministry of the Environment and Climate Change,	Policies	For areas in WHPA-Q or IPZ-Q recharge reduction; lay out policy tools; Clean water policy tools include: education and outreach and incentive programs, to land use planning, prescribed instruments, and Part IV approaches, such as risk management plans, and prohibition
Stormwater Management Master Plan 2008 / Stormwater Management policy	City of Guelph	Policies	The SWM Master Plan explores, evaluates and identifies innovative approaches to manage stormwater runoff using low impact development and water sensitive urban design for both new construction and existing developed areas.
	City of Guelph Private Tree Protection By-law (2010-19058)	Regulation	Regulates the damage or destruction of any tree measuring at least 10 centimetres in diameter at 1.4 metres above the ground on lots larger than 0.2 hectares (0.5 acres). Some trees are exempt from the bylaw and can be removed without a permit including dead or dying trees, trees posing danger to life or property, or trees impacted by unforeseen causes or natural events. Please refer to the full list of exemptions in the by-law.
Conservation Authority	Ontario Regulation 150/06: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (last amended Feb. 8, 2013)	Regulation	Under the Conservation Authorities Act, Ontario Regulation 150/06 allows Conservation Authorities including the GRCA to prevent the loss of life, minimize property damage, prohibit or regulate development in or adjacent to shorelines, wetlands, floodplains, watercourses, valleys, dynamic beaches and hazard lands.

Table 3.2.1: Summary of Acts, Guidelines, Policy

Level of Government	Name of Management Tool: Act/Regulation/Policy/ Guideline/Program	Type of Tool	Purpose
Conservation Authority	GRCA's Policies for the Administration of the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (approved and effective Oct. 23, 2015)	Policy	In valleys and/or valley systems and stream corridors, to further its objectives relating to flooding and erosion, and the maintenance of natural environmental integrity, including the conservation of land. These are the policies, procedures and guidelines the GRCA uses for permit applications under Ontario Regulation 150/06. This document outlines the policies to be followed by the GRCA in making decisions regarding the outcome of all applications made under O. Reg. 150/06.
	GRCA's Wetland Policy, 2003		The policy provides a comprehensive planning process to allow for appropriate studies to identify natural heritage form and functions and determine methods to minimize negative environmental impacts.

Relationship Between the OPA 42 NHS and the CMSP

The City of Guelph Official Plan established, through mapping and policies, a Natural Heritage System (NHS) within the City including the SPA (see City of Guelph Official Plan, 2014 Consolidation and Map NH-1). This NHS was based on the technical work and consultations undertaken as part of the City's Natural Heritage Strategy between 2004 and 2009 (Dougan & Associates 2009a, b) and approved by City Council in 2010 through Guelph Official Plan Amendment 42 ("OPA 42"). This NHS was then further refined and finalized through the final approval of OPA 42in 2014 by the Ontario Municipal Board.

The purpose of the natural heritage work undertaken through the CMSP process has been to update and refine the NHS based on (a) application of current environmental legislation, policies and guidelines applicable to the SPA, and (b) new information collected since the approval of OPA 42.

It should be noted that site-specific settlements were made and approved by the Ontario Municipal Board on a number of properties in the SPA as part of the OPA 42 hearing process (see Maps NH-1 and NH-2, Appendix F). As part of these settlements, specific agreements were made with respect to the mapping of significant woodlands and in some cases significant landform, ecological linkages and wetlands. The site-specific agreements made on each parcel through the OPA 42 hearing process with respect to these features have been respected and carried forward into the CMSP NHS. However, refinements to the NHS on these properties have been applied where new information has been brought forward as part of the CMSP based on field work undertaken for this project or background information provided to the City since June 2014. For example, based on new information, candidate and confirmed areas of significant wildlife habitat (SWH) have been identified. The new information is documented in the 2017 Monitoring Report for this project and the analysis of the results and proposed mapping refinements are provided in this Characterization Report.

In addition, there is one property (also identified on Maps NH-1 and NH-2) that is before the courts on matters related to natural heritage. On this property the NHS as approved by the OMB in June 2014 is to be retained.

4.0 BASELINE INVENTORY

4.1 Climate

4.1.1 Importance/Purpose

Climate data are critical to developing the hydrologic and hydrogeologic/groundwater system modelling for characterization of the surface and substrate water conditions, as well as the respective interactions for the Hanlon Creek, Mill Creek, Torrance Creek and Irish Creek Subwatersheds. Long-term and short-term meteorological data sets have been used and specifically collected as part of this study for use in multi-seasonal, multi-year assessments.

4.1.2 Background Information

A climate data set was developed to provide a long term, 1950-2017, set of observations for the site featuring hourly precipitation and daily temperature records. This data set was constructed using data in close proximity to the site wherever possible and hourly precipitation observations are used throughout the dataset. The assembled observed climatic conditions are representative of the temporal variability at hourly to multi-year scales during the period of observations and considered suitable for evaluating both short and long term hydrologic processes, such as infiltration or drought. . Rainfall observations collected as part of the field program were incorporated for the period of 2016-2017.

The climate stations used to develop a continuous set of climate observations for the study are summarized in Table 4.1.1.

Table 4.1.1 Climate Stations

Data Source	Station ID	Station Name	Latitude	Longitude	Elevation (m ASL)	Period of Record	Observed Data and Frequency
Environment Canada	6143090	Guelph Turfgrass CS	43.55	-80.22	325	1950-2005	Hourly Precipitation, Daily Temperature
Environment Canada	6142286	Elora RCS	43.65	-80.42	376	2003-2015	Hourly Precipitation, Daily Temperature
Environment Canada	6147188	Roseville	43.35	-80.47	328	1972-2017	Hourly Precipitation Daily Temperature

Table 4.1.1 Climate Stations							
Data Source	**Station ID**	**Station Name**	**Latitude**	**Longitude**	**Elevation (m ASL)**	**Period of Record**	**Observed Data and Frequency**
Environment Canada	6149388	Region of Waterloo Airport	43.46	-80.38	321	2002-2011	Daily Precipitation, Daily Temperature
Environment Canada	6144239	Kitchener/ Waterloo	43.46	-80.38	322	2010-2017	Daily Precipitation, Daily Temperature
GRCA	N/A	Guelph	43.60	-80.26	361	2004-2015	Hourly Rainfall
GRCA	N/A	Road 32	43.48	-80.28	297	2008-2015	Hourly Rainfall
GRCA	N/A	Cambridge	43.38	-80.29	290	2004-2015	Hourly Rainfall
Amec Foster Wheeler	N/A	500 Malbty Road	43.50	-80.16	342	2016-2017	15-Minute Rainfall
University of Waterloo	N/A	University of Waterloo Climate Station	43.47	80.56	334	1998-2017	15 Minute Precipitation

A quality control process was conducted to ensure that the climate data selected for numerical modelling, including the City's EMS rainfall gauge and the study's installed Gauge at 500 Maltby Road, was reasonable for the study. Climate data were screened for data gaps, outliers and compared to nearby high quality Environment Canada climate data. Further the selected climate data also were evaluated annually and seasonally to determine the similarity of observations at a given station to nearby climate stations.

Climate data more proximate to the study area were prioritized over observations further from the site. Where data climate data were identified to likely be erroneous due to significant disagreement with nearby climate stations, they were not used and data from the next closest station were used instead.

Through this process a continuous climate data set was compiled from the climate station observations for the period of 1950-2017 featuring hourly precipitation rates and daily temperature observations. The data used for the assembled climate dataset is summarised in Table 4.1.2.

Table 4.1.2 Climate Data Used		
Period	**Temperature Data Source**	**Precipitation Data Source**
1950-2005	Guelph Turfgrass - Environment Canada	Guelph Turfgrass - Environment Canada
2006	Guelph Turfgrass CS - Environment Canada	Guelph Lake - GRCA, Roseville, Elora RCS and Region of Waterloo Airport- Environment Canada
2007	Guelph Turfgrass CS - Environment Canada	Roseville, Elora RCS and Region of Waterloo Airport - Environment Canada
2008-2015	Guelph Turfgrass CS - Environment Canada	Road 32 Station, Guelph Lake, Cambridge - GRCA Roseville, Elora RCS, Region of Waterloo Airport, Kitchener/Waterloo - Environment Canada
2016-2017	Guelph Turfgrass CS - Environment Canada	500 Maltby Road Rain gauge - AFW, University of Waterloo Climate Station, Kitchener/Waterloo - Environment Canada

Reference evapotranspiration rates were computed on a daily basis for the study using daily temperature observations and the FAO 56 Penman-Monteith method (ref. Allen et al. 1998).

In addition to the foregoing, rainfall data from three local stations during the 2016 to 2017 monitoring period have been used, namely:

- From a rainfall gauge installed (July 14, 2016) on the roof of the Guelph Home Building Supply, located at 500 Maltby Road East (ref. Figure SW-1) intended to remain in place for the duration of the monitoring for this project (i.e. 2016-2018), with data downloaded on a monthly basis;
- From the City's rainfall gauge on the EMS Centre at 160 Clair Road West (ref. Figure SW-1); and
- From the University of Guelph's rainfall gauge at the Guelph Turfgrass Institute at 328 Victoria Road South (available on-line).

Monthly precipitation (rainfall) data from the Clair-Maltby gauge located at 500 Maltby Road for the months of April to December 2017 have been summarized in Table 4.1.3 (2016 values have also been provided for comparison) and compared to the monthly totals from Environment Canada's (EC) Elora gauge. The rainfall gauges are approximately 30 km apart which explains the difference in monthly rainfall amounts.

In addition to the monthly data presented in Table 4.1.3, daily rainfall totals for days with major storm events and high recorded water levels have been summarized in Table 4.1.4 for all data sources (ref. Figure SW-1, Appendix E) (EC Elora, Clair-Maltby and City of Guelph's Clair Road rainfall gauges). Where storm systems have lasted multiple days, values have been summed.

Table 4.1.3 Monthly Precipitation Totals for 2016 and 2017 and Climate Normals (mm)

Month	2016 & 2017 Total [2.]	1981-2010 Climate Normal [1]	Percent Difference [2]
2016			
April	57.8 (NA)	74.5	-22% (NA)
May	57.3 (NA)	82.3	-30% (NA)
June	53.0 (NA)	82.4	-36% (NA)
July	102.4 (NA)	98.6	+4% (NA)
August	152.6 (134.4)	83.9	+82% (+60%)
September	77.1 (58.2)	87.8	-12% (-34%)
October	85.8 (43.8)	67.4	+27% (-35%)
November	55.6 (40)	87.1	-36% (-54%)
December	90.1 (NA)	71.2	+27% (NA)
TOTAL	731.7 (NA)	735.2	-0.5% (NA)
2017			
April	92.0 (NA)	74.5	+23% (NA)
May	120.5 (107.2)	82.3	+46% (+30%)
June	117.8 (94.6)	82.4	+43% (+15%)
July	35.5 (37.4)	98.6	-64% (-62%)
August	68.1 (51.6)	83.9	-19% (-38%)
September	55.5 (23.8)	87.8	-37% (-73%)
October	85.8 (56.2)	67.4	+27% (-17%)
November	96.1 (69.8)	87.1	+10% (-20%)
December	55.6 (NA)	71.2	-22% (NA)
TOTAL	726.9 (NA)	735.2	-1% (NA)

Notes: [1] From Environment Canada Waterloo Wellington Airport
[2] First value is based on Environment Canada's Elora RCS gauge, value in brackets is based on Clair Maltby Project gauge

Table 4.1.4 Summary of Daily Rainfall Totals for Major Rainfall Events of 2016 and 2017 (mm)

Day (M/D/Y)	Environment Canada Elora RCS Gauge Total	Wood Clair Maltby Project Gauge Total	City of Guelph Clair Road Emergency Services Gauge Total
2016			
08/11/16 - 08/13/16	59.6	21.0	17.2
08/16/16	24.4	10.6	14.2
08/19/16 - 08/21/16	25.6	58.6	59.2
08/25/16 – 08/26/16	30.3	31.8	33.6
09/07/16 – 09/08/16	41.8	33.6	27.0
09/17/16 - 09/18/16	10.8	8.8	9.6
09/26/16	8.6	6.2	7.2
09/29/16 - 09/30/16	0	7.4	9.6
10/08/16	3.3	8.0	5.2
10/20/16 – 10/21/16	19.4	16.2	16.4
11/02/16 – 11/03/16	NA	8.6	NA
11/19/16	11.5	9.6	NA
11/24/16 – 11/26/16	10.0	10.4	NA
11/28/16 – 11/30/16	12.5	9.0	NA
2017			
04/06/17	22.3	28.2	30.2
04/20/17	NA	26.8	32.0
04/30/17	14.5	9.0	4.6
05/01/17	13.4	13.6	25.8
05/04/17	23.0	19.8	13.8
05/05/17	17.4	14.2	24.2
05/04/17 – 05/05/17	40.4	34.0	38.0
05/21/17	21.9	14.6	10.2
05/25/17	18.9	19.8	27.6
06/23/17	33.7	39.4	31.2
08/11/17	12.6	12.6	12.2
10/09/17	12.7	7.6	7.4
10/23/17	12.4	9.8	15.0
10/24/17	2.5	3.4	12.8
10/23/17- 10/24/17	14.9	13.2	27.8
11/02/17	23.4	12.0	12.2
11/18/17	22.5	16.4	22.2

4.1.3 Methods

For the 2016 to 2017 monitoring program, monthly rainfall totals for both the Clair-Maltby gauge and the Elora gauge for the months of August to November, 2016 (monitoring in 2016 commenced in mid-July and ended early December) were 276.4 mm and 371.1 mm, with the 1981-2010 climate normal for the same period being 326.2 mm. As such, the Clair-Maltby August to November rainfall total was approximately 15% below normal for this period. It is worth noting that the months of April to June, 2016 were also considered below normal based on the Elora gauge monthly amounts compared to the monthly climate normal.

Daily rainfall amounts between the three (3) gauges for most storm events, demonstrate fairly consistent rainfall recordings. The City and the Wood Team rainfall gauges recorded 2017 storm event totals that are considered reliable, as there is limited deviation in the rainfall amounts, apart for the May 1, May 4 and October 24, 2017 events.

For 2017, five (5) storm events were above 25 mm and are considered significant, with the largest event occurring on June 23rd, 2017 with a rainfall total of 39.4 mm over 9 hrs, which is comparable to 2 year storm event based on a 12 hour rainfall total of 39.9 mm at the Guelph Turfgrass Institute [Intensity Duration Frequency (IDF) relationship for 1954 to 2003]. Using the same IDF relationship, all other events for 2017 would be considered to be less than a 2 year storm.

4.1.4 Interpretation

Based on the annual precipitation rates from the assembled climate data for the previous 30 years, 1988-2017 (a subset of the 68 year data), are summarized in Figure 4.1.4. For this period the average precipitation rate is 820 mm/year. The wettest year observed occurred in 1992 with 1127 mm of precipitation and the driest year occurred in 2007 with 530 mm of precipitation.

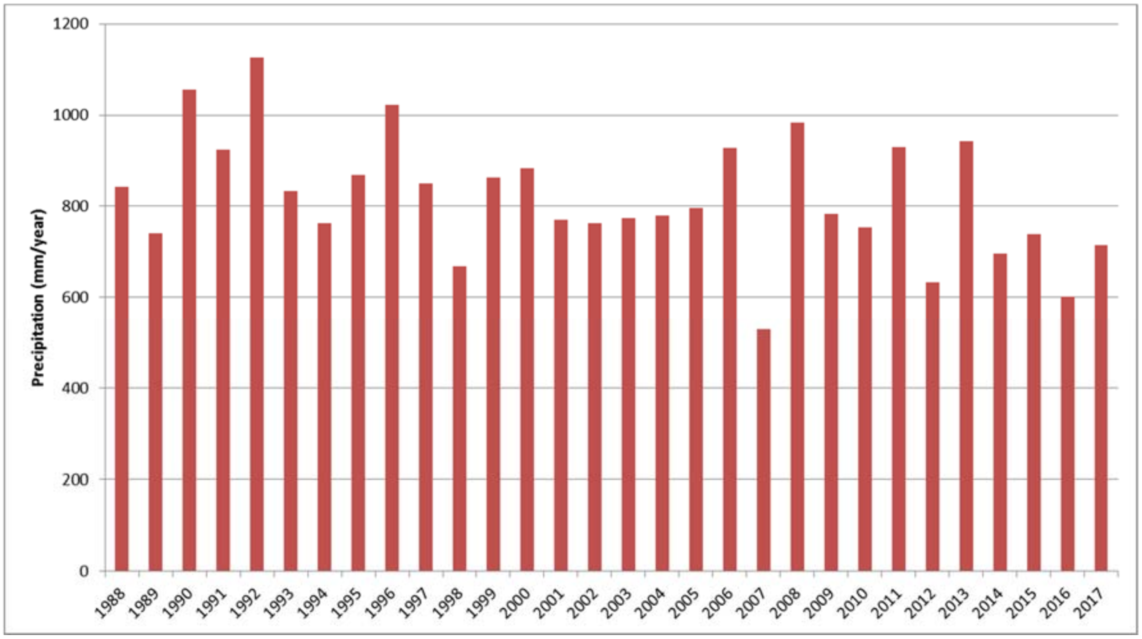


Figure 4.1.4 - Annual Precipitation - 1988-2017

The mean monthly, maximum monthly and minimum monthly temperature from the assembled climate data set are presented for the period of 1988-2017 in Figure 4.1.5.

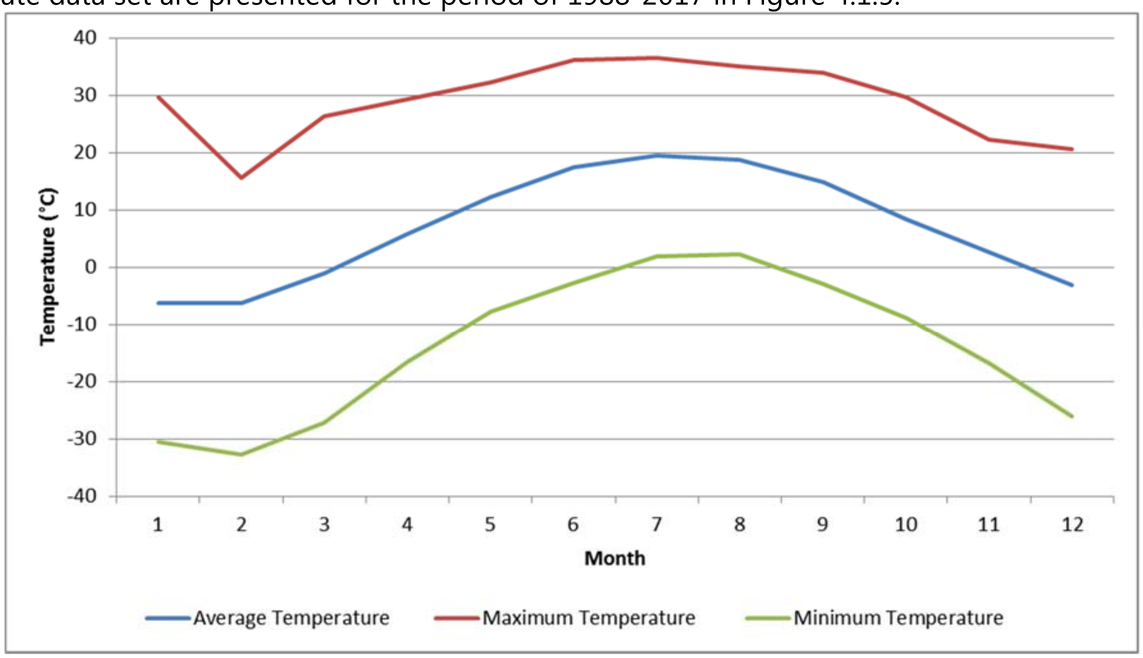


Figure 4.1.5 - Monthly Temperature Average and Range - 1988-2017

The annual reference evapotranspiration rates computed for the period of 1988-2017 are presented in Figure 4.1.6. An average annual reference evapotranspiration rate of 830 mm is estimated for this period.

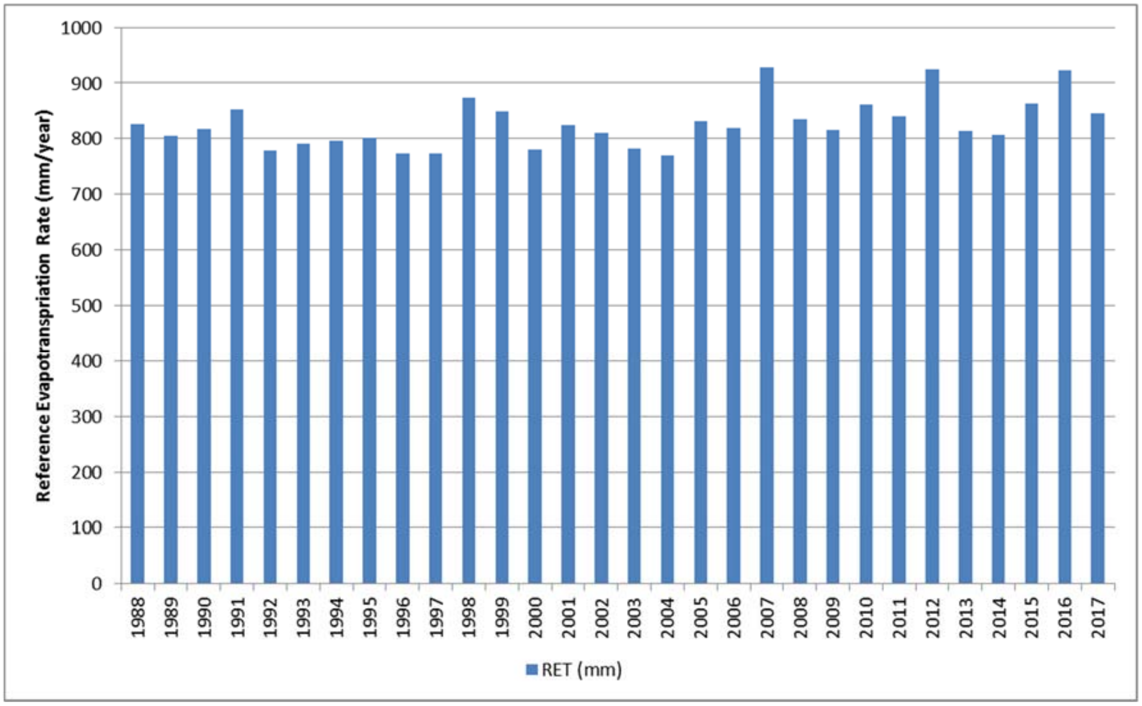


Figure 4.1.6 - Evapotranspiration Rates - 1988-2017

It is recognized that precipitation patterns are evolving due to the influence of the greenhouse gases and associated climatic changes. Southern Ontario has experienced a number of '100 year storm events' over the past several years. The frequency of larger storm events appears to be increasing and meteorological data collected prior to the year 2000 may no longer provide an accurate basis of the precipitation trends to come.

It is also recognized that precipitation may be impacted by changes in daily temperatures. Southern Ontario has been noted to be generally trending toward milder winters. The results of milder temperatures will be reduced snow pack depths, higher runoff events when precipitation occurs as rainfall during 'winter' and a reduced spring freshet.

Phase 3 Impact Assessment of this study will review/assess the influence of severe storms on the performance of the existing and proposed future drainage system serving the Clair-Maltby SPA, as part of a climate change stress test.

4.2 Hydrogeology

4.2.1 Importance/Purpose

It is important to understand the interrelationship between the hydrogeologic conditions, the ecosystem and the use of groundwater for anthropogenic needs, in order to assess and manage potential impacts from future land use changes on the groundwater flow system.

4.2.2 Background Information

A background review of existing data and documentation was completed to provide a preliminary understanding of the local and regional hydrogeological setting and to inform and complement the groundwater field program and modelling exercise. This review included sources on a regional and local scale.

City of Guelph and Township of Guelph Eramosa Tier Three Water Budget Assessment and Local Area Risk Assessment (Matrix Solutions Inc., March 2017).

The Tier 3 report provides the regional hydrogeologic setting including the physiography, surficial geology, bedrock geology, topography and stratigraphy, groundwater flow pathways, recharge and discharge. The Tier 3 groundwater model was utilized, in part, as the basis for the regional component for the MIKE-SHE model for this study. The well log database which provided borehole logs and groundwater levels used within the Tier 3 model was also used as starting point within the current study.

The following individual consulting groundwater, geotechnical and ecological studies carried out within and adjacent to SPA provided, in part, detailed borehole logs, historical groundwater level data including water levels from mini-piezometers associated with ponds and wetlands, water balance calculations and hydraulic conductivities. Interpretations relating to groundwater flow, groundwater discharge and groundwater function were also provided in some studies. The stratigraphic data from these studies is derived from cores or overburden samples and groundwater level data is derived from discrete monitoring wells. As such this data is considered high quality data and complements data obtained from the current field program.

City of Guelph-South Guelph Secondary Plan Area Scoped EIS Hydrogeological Assessment (Gartner Lee Limited, December 1997).

132 Clair Road West Guelph Ontario Draft Environmental Impact Study (Aquafor Beech, September 2012).

Hydrogeologic, Water & Sediment Depth Evaluation for Thomasfield Homes Lake (Ecologistics, 1988)

City of Guelph and Township of Eramosa Tier Three Water Budget and Local Area Risk Assessment (Matrix, 2017)

Guelph Waterworks Groundwater Monitoring System (Golder, 2009)

City of Guelph Southwest Quadrant Water Supply Class Environmental Assessment -Interim Draft Hydrogeological Report (Golder 2010)

Hydrogeological Investigation Environmental Impact Study, Proposed Development, 132 Clair Road West, City of Guelph (Banks Groundwater Engineering, 2015)

Groundwater Monitoring Program – Bird Landing Residential Development Site, 1897 Gordon Street, Guelph (Banks Groundwater Engineering, 2016)

Hydrogeological Assessment, 1888 Gordon Street, City of Guelph, Ontario (Stantec, 2017)

'Springfield Golf and Country Club 2009 to 2013 Groundwater Monitoring Report' (Stantec, November 2013)

A list of all the reports that were reviewed for groundwater content is provided in Appendix A

Figure GW-1 shows the location of high quality wells monitored as part of this study. Figure GW-2 shows the location of spot baseflow surface water monitoring completed as part of this study. Figure GW-3 shows all of the borehole/monitoring wells, mini-piezometers and domestic wells that were identified as part of the study through review of consulting reports and the MOECC Water Well Information System (WWIS) or installed as part of this study. All of these monitoring locations and types provide insight on the subsurface system and are key data for understanding groundwater flow and interaction with surface water and terrestrial features. However, study wells and consultant drilled wells typically provide more detailed and reliable information. The WWIS wells although typically less reliable provide additional information and spatial and temporal coverage (water levels), and when interpreted in the regional context with correlation to higher quality wells are a valuable data source. NOTE: All groundwater figures are presented in Appendix B.

4.2.3 Methods

The groundwater field program was designed to support refinements to the existing local hydrogeological characterization and establish baseline conditions within the SPA and PSA. An understanding of the three dimensional and time-varying (e.g., seasonal) characteristics of the surface water and groundwater flow systems will support the establishment of Community Structure plans for the SPA. In addition, the field program supports to a water balance evaluation of groundwater function, identification of constraints and opportunities, and provides monitoring locations that will form part of the long-term monitoring network.

The groundwater field work was coordinated with the work being completed by the other disciplines in recognition of the inter-relationship between the hydrogeological and hydrologic systems, other users of water for anthropogenic needs, and the local ecosystem.

Groundwater field work completed as part of the Study included:

- Borehole Drilling and Monitoring Well Installations
- Downhole Geophysical Logging
- Drive Point Mini Piezometer Installations
- Groundwater Level Monitoring
- Groundwater Quality Sampling
- Enriched Tritium Analysis
- Single Well Hydraulic Response Testing
- Guelph Permeameter Testing
- Surface Water Base Flow Measurements
- Pond Bathymetry Surveys
- Seeps and Springs Observations

Complete methodology details and preliminary results of the field work completed in 2016 and 2017 can be found in the Year 1 and Year 2 Monitoring Reports (Amec Foster Wheeler 2017, 2018). The following sections provide a brief summary of the groundwater field work and results completed to date.

4.2.3.1 Borehole Drilling and Monitoring Well Installation

A drilling and well installation program was completed between July 25 and August 24, 2016. The installation of monitoring wells was intended to further refine the understanding of the function of the overburden hydrostratigraphy, hydraulic conductivity, transient groundwater levels, vertical gradients, groundwater flow directions, and to collect water quality samples.

In total, 17 boreholes at 9 locations were advanced and all boreholes were completed as monitoring wells. The borehole locations were strategically positioned across the study area in a series of three transects trending northwest to southeast through the SPA with each transect crossing a topographic low through the centre of the transect. At each location, one shallow and one deep 152 mm borehole was drilled side by side and completed as an overburden monitoring well nest; except at MW07, where only one well was completed due to the availability of existing shallow monitoring wells in the area. The target depth for each deep borehole was just above the top of bedrock, which was guided by the hydrostratigraphic interpretations from the Tier Three Water Budget Study (Matrix Solutions Inc. 2017). Further details of the borehole drilling methods are described in the Year 1 Monitoring Report (AMEC FW 2017).

Matrix monitoring wells were installed in the following stratigraphic layers:

- MW01-S, MW02-S, MW02-D, MW03-S, MW03-D, MW05-S, MW05-D, MW06-S, MW06 D, MW07-D, MW08-S, MW08-D and MW09-S were completed in primarily sand/gravel to silty sand
- MW01-D, MW04-S, MW04-D, and MW09-D were completed in clayey to sandy silt

Borehole logs can be found in Appendix B and monitoring well completion details can be found in Table B1 (Appendix B).

4.2.3.2 Downhole Geophysical Logging

On September 3, 2016, downhole gamma logging was completed to help distinguish between clay-rich soils from clay-poor soils and to improve the local stratigraphic interpretation across the transitional ice margin deposits of the Paris Moraine within the study area. The logging was conducted in three monitoring wells to test its utility: MW01-D, MW02-D and MW03-D (Figure GW-1).

Due to the coarse-grained nature of the soils encountered and the relative lack of clay units to correlate between wells, the results did not support completing downhole surveys in the other six monitoring well locations.

4.2.3.3 Drive Point Mini Piezometer Installations

In August and September 2016, a total of 18 drive point mini piezometers were installed by Matrix personnel at 14 wetland locations identified as areas of potential groundwater – surface water interaction and where property access was granted (Figure GW-1). These locations were also coordinated with the wetland surface water quantity and quality stations, as well as flow stations where possible. At four of the locations, pairs of shallow and deep mini piezometers were installed to more closely examine vertical hydraulic gradients. Further details of the installation are described in the Year 1 Monitoring Report (AMEC FW 2017) well installation details can be found in Table B2 (Appendix B) of this report.

The nested mini piezometers MP13-D and MP13-S were destroyed during a highway traffic collision in August 2017. Data were recovered from MP13-D but had not been successfully recovered from MP13-S.

4.2.3.4 Groundwater Level Monitoring

Groundwater levels were monitored at all monitoring wells and mini piezometers from their installation in 2016 through 2017 (Figure GW-1) with the exception of the mini piezometers during the winter months and MP13-S and MP13-D following their destruction in August 2017. Three additional, pre-existing wells (MW1-11, MW2-11, and MW3-11) located at 132 Clair Road are also being monitored with the landowner's permission (Figure GW-1). All wells and piezometers are being monitored using manual measurements approximately every three months and, with the exception of MW1-11 and MW2-11, are all equipped with data loggers which provide a continuous record of water levels showing hourly changes in water levels.

Manual groundwater levels obtained from the monitoring wells and mini piezometers since their installation are presented in Tables B1 and B2 (Appendix B). Hydrographs can be found in Appendix B presenting groundwater fluctuations in each monitoring well outfitted with a pressure transducer. Wetland hydrographs are also included in Appendix B and include automatically recorded shallow groundwater elevations in the mini piezometers, surface water elevations and, where in close proximity to monitoring wells, deep overburden groundwater elevations are also included.

Monitoring Well Water Levels

The monitoring well hydrographs show that the overburden groundwater elevations have fluctuated seasonally and reached a peak during the early summer of 2017 with the lowest elevations occurring in January of 2016 and 2017. The majority of monitoring wells show water levels varying between 330 masl to 335 masl. Seasonal variations tend to indicate lows in early January and highs in early July. The vertical groundwater flow gradients can be determined for a given monitoring well nest by comparing the recorded groundwater elevations in each of the nested wells that make up a well pair. Where the shallow groundwater elevation exceeds the deeper groundwater elevations the flow gradient is downwards. Where the gradient is reversed, groundwater flows upwards through the saturated zone. All monitoring well hydrographs show a downward groundwater flow gradient, except at MW9-D and MW9-S where the hydraulic gradient is consistently upwards throughout all seasons.

The monitoring well hydrographs show a series of distinct groundwater drawdown events that occurred through August and September 2017 at the following monitoring wells listed from largest drawdown to smallest:

- MW4-D and MW4-S
- MW5-D and MW5-S
- MW6-D and MW6-S

Given that this these months received less rainfall, and with the distinct drawdown and recovery pattern of a groundwater pumping well, it is likely the drawdown at these wells was a result of nearby irrigation pumping at the Springfield Golf and Country Club as these trends are similar to seasonal pumping trends reported in *'Springfield Golf and Country Club 2009 to 2013 Groundwater Monitoring Report' (Stantec, November 2013)*.

The hydrographs for MW1-S/D, MW2-S/D, MW4-S/D, MW5-S/D, MW6-S/D, MW7-D and MW08-S demonstrate responses that are potentially related to the start of seasonal recharge in early January. MW8-S appears to show 2 distinct recharge events in the second half of January 2017.

Wetland (Mini-Piezometer) Water Levels

Hydrographs of mini-piezometer water levels, wetland water levels, and groundwater monitoring well water levels plotted for a location provide further information on shallow vertical groundwater flow conditions. Groundwater and surface water elevations indicate vertical flow directions with water always moving towards the lowest hydrostatic elevation. Hydrographs show that for most of the year, most wetlands (e.g. Neumann's Pond Station 1) have a surface water elevation that exceeds, or is equal to the shallow groundwater (mini piezometer) elevations. As such, it is interpreted that the wetland is losing water to or is in equilibrium with the shallow groundwater system as is shown in hydrographs for Stations 1, 2, 3, 5, 6, 7, 8, 9 and 13 (Appendix B).

However, some wetlands or areas of wetlands (e.g. Hall's Pond –Station 7) show the reverse gradient for all or part of the year where the shallow groundwater (mini piezometer) elevations exceed the surface water elevations as shown in hydrographs for Stations 4, 10, 11, and 12.

Some wetlands show a pattern of seasonal reversal where the nest mini piezometers show a reversal of shallow groundwater flow direction where the water elevation in the deep mini piezometer eventually exceeds that of the shallow mini piezometer and in some cases, it also exceeds the surface water elevation. This is shown in the hydrographs (Appendix B) for the following stations:

- Station 1 (Neumann's Pond 1) – gradient between the deep and shallow mini-piezometer becomes upwards for the second half of 2017 but returns to a downward gradient in the late fall of 2017. At all times the surface water level is greater than the mini-piezometer levels.
- Station 7 (Hall's Pond) – gradient in the shallow groundwater system becomes upwards in July 2017 with the deep mini piezometer water elevation exceeding the surface water elevation for the remainder of 2017.
- Station 14 (Mill Creek Headwater) – the shallow groundwater elevation in the mini piezometer exceeds that of the surface water for the first half of 2017.

Hydrographs from monitoring wells located in close proximity to a wetland monitoring location show that some wetlands are located where the deep overburden groundwater system (monitoring well water elevations) are near to or exceed the surface water and shallow groundwater elevations associated with the wetland indicating periods of groundwater discharge to wetland or flow into the shallow groundwater system. In other hydrographs, it is shown that the deep overburden groundwater system is much lower than the surface water and shallow groundwater elevations associated with the wetland. These conditions are shown in the hydrographs (Appendix B) for the following stations:

- Station 9 – (groundwater discharge to wetland area north Hall's Pond in ice-contact deposits) the peak groundwater elevations from the nearby monitoring wells exceed the shallow (mini-piezometer) groundwater and surface water elevations in spring 2017.
- Station 10 – The groundwater elevations from the nearby monitoring well (200 m northeast) are near equal to the shallow groundwater and surface water elevations (expression of water table at Tim Horton's Pond on northwestern boundary of SPA).
- Station 1 (Neumann's Pond 1) – The deep overburden groundwater elevations are significantly lower (approximately 10 m) than the wetland water elevations (leakage to groundwater system).
- Hall's Pond – A combined hydrograph (Appendix B) shows all shallow (mini-piezometer) and deep (monitoring well) overburden groundwater elevations associated with Hall's Pond along with the surface water elevation. The shallow groundwater elevations exceed the deep elevations, suggesting a downwards groundwater flow direction.

4.2.3.5 Groundwater Quality Sampling

Three separate groundwater quality sampling events were completed at the Matrix monitoring wells (Figure GW-1) on the following dates:

- October 19 to 21, 2016,
- April 19, 2017, and
- October 4, 5 and 10, 2017.

Field measured parameters, including pH, EC, temperature, dissolved oxygen and turbidity, were conducted on groundwater samples collected from the wells.

Samples collected in 2016 and 2017 were analyzed for the following parameters:

- general and inorganic parameters, including pH, EC, calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), dissolved iron (Fe), dissolved manganese (Mn), chloride (Cl), carbonate (as CaCO3), bicarbonate (as CaCO3), hydroxide (as CaCO3), sulphate (SO4), nitrite nitrogen (NO2 N), nitrate nitrogen (NO3 N), total Kjeldahl nitrogen (TKN), total dissolved solids (TDS), total hardness (as CaCO3) and total alkalinity (as CaCO¬3).
- dissolved metals including silver (Ag), aluminum (Al), arsenic (As), boron (B), barium (Ba), beryllium (Be), bismuth (Bi), cadmium (Cd), cesium (Cs), cobalt (Co), chromium (Cr), copper (Cu), lithium (Li), molybdenum (Mo), nickel (Ni), phosphorus (P), lead (Pb), rubidium (Rb), sulfur (S), antimony (Sb), selenium (Se), silicon (Si), tin (Sn), strontium (Sr), tellurium (Te), thorium (Th), titanium (Ti), thallium (Tl), uranium (U), vanadium (V), tungsten (W), zinc (Zn), and zirconium (Zr).

Laboratory results are presented in Appendix C in Table C1 (Field Parameters), Table C2 (Routine Parameters), and Table C3 (Dissolved Metals). Copies of the laboratory Certificates of Analysis are provided in the Year 1 and 2 Monitoring Reports (AMEC FW 2017, 2018).

Laboratory analytical results were compared against the Ontario Drinking Water Standards (MOE, 2006) to provide a relative characterization of the groundwater against the appropriate potable water standard in Ontario. All analytical results to date were reported below the Ontario Drinking Water Quality Standards with the exception of the following:

- Analytical results for dissolved iron exceeded the ODWS at MW02-S/D, MW05-S/D and MW06-S. The peak reported concentration to date is 2.91 mg/L (MW05-D, April 19, 2017) compared to the ODWS aesthetic objective of 0.3 mg/L.
- Analytical results for dissolved manganese exceeded the ODWS at MW02-S/D, MW04-S, MW05-S/D, MW06-S, MW07-D and MW09-D. The peak reported concentration to date is

0.482 mg/L (MW02-S, April 19, 2017) compared to the ODWS aesthetic objective of 0.05 mg/L.
- Analytical results for total dissolved solids (TDS) exceeded the ODWS at MW01-S and MW08-D. The peak reported concentration to date is 718 mg/L (MW08-D, April 19, 2017) compared to the ODWS aesthetic objective of 500 mg/L.
- Analytical results from all monitoring wells exceeded the ODWS for total hardness. Total hardness levels ranged between 131 mg/L (MW01-D) and 411 mg/L (MW06-S) compared to the ODWS operational guidelines of 80 to 100 mg/L.
- Analytical results from MW02-S exceeded the ODWS for arsenic on April 19, 2017 where the concentration was reported as 0.0315 mg/L compared to the ODWS interim maximum acceptable concentration of 0.025 mg/L.
- Analytical results from MW06-S exceeded the ODWS for aluminum on April 19, 2017 where the concentration was reported as 0.627 mg/L compared to the ODWS operational guideline of 0.1 mg/L.
- Analytical results from MW05-S exceeded the ODWS for uranium on October 19, 2016 where the concentration was reported as 0.024 mg/L compared to the ODWS maximum acceptable concentration of 0.02 mg/L.

The exceedances noted above are not considered significant and are commonly found in natural groundwater quality.

Piper plots were used to characterize the groundwater analytical results by plotting each sample of groundwater according to its relative proportion of each major groundwater constituent. The plots illustrate the predominant cations and anions constituting the water from each sample. Piper plots are provided in Appendix C. The 2016 and 2017 analytical results show a consistent calcium-magnesium carbonate groundwater characterization.

The piper plots also show that chloride concentrations and TDS at MW08-D and MW01-S are observed to be consistently elevated over the results from other locations. Although elevated, chloride concentrations at these locations have remained below the ODWS, whereas TDS exceeds the ODWS.

Matrix personnel collected samples for enriched tritium analysis on October 28, 2016 from four monitoring wells (MW05-S, MW05-D, MW03-S, and MW07). Tritium levels provide insights on the age of groundwater, which may help the understanding of the recharge function of the Paris Moraine and surrounding area. The results are provided in Table C4 Appendix C, where tritium is summarized to range from 6.4 TU to 13.1 TU. The potential ages for these values represent multiple regression peaks and the results can only be interpreted as water younger than post 1954. Additional discussion on groundwater chemistry is provided in Section 4.2.5.2.

4.2.3.6 Single Well Hydraulic Response Testing

Hydraulic response tests for all Matrix monitoring wells were completed on September 23, 28 and 30, 2016 in order to estimate the horizontal hydraulic conductivity of the hydrostratigraphic units being tested.

The hydraulic response test data were interpreted using AQTESOLV™ software (HydroSOLVE 2007). The Bouwer-Rice (1976), Hyder et al. (KGS; 1994) and Springer-Gelhar (1991) methods for partially penetrating wells were selected to estimate the hydraulic conductivity values. The individual well results are presented in Table B1 Appendix B and the analytical solution curves are provided in Year 1 Monitoring Report (AMEC FW 2017). Ranges of hydraulic conductivity within Matrix monitoring wells for this study are provided in Table 4.2.1.

Table 4.2.1 Hydraulic Conductivity

Hydraulic Conductivity Range (m/s)	Screened Lithology
2×10^{-4} to 2×10^{-3}	sand and gravel
2×10^{-6} to 8×10^{-6}	sandy silt and silty sand
8×10^{-8} to 6×10^{-7}	clayey/ silt

4.2.3.7 Guelph Permeameter Testing

In-situ soil hydraulic conductivity testing, using a Guelph Permeameter, was completed on November 1 and 2, 2016 at testing locations adjacent to the nine monitoring wells (Figure GW-1).

The field saturated hydraulic conductivity results are summarized in Table B3 (Appendix B), where values range from 4E-08 m/s to 1E-05 m/s.

4.2.3.8 Surface Water Spot Baseflow Measurements

Surface water spot base flow measurements have been collected to observe the seasonal and spatial variability of base flow along watercourses. Base flow conditions are present during periods when overland flow to a watercourse is absent and the watercourse has returned to its "dry" weather level. It is during these conditions that areas of potential groundwater discharge and recharge along the length of a watercourse can be evaluated. Dry weather conditions were considered to be following any period of three continuous days with less than 5 mm of cumulative rainfall. Base flow measurements were collected during spring (May 2017), summer (August 2016 and 2017) and fall (November 2016 and 2017) field events to capture seasonal variability.

Base flow locations were initially selected at watercourse crossings near the SPA and PSA and were also guided by flow system interpretation from the City's Tier Three Water Budget model. There are no potential baseflow locations within the SPA. Initial locations included measurements within the Hanlon Creek, Mill Creek and Lower Speed River subwatersheds (Figure GW-2). Since the initial base flow event, locations were refined with the addition of three locations in the Torrance Creek Subwatershed and an additional location in the Mill Creek Subwatershed for a total of 27 locations (Figure GW-2).

The surface water base flow measurement results collected to date are summarized in Table B4 (Appendix B).

Stream discharge ranged across the regional study area from 0 L/s in headwater areas to 676 L/s (May 11, 2017) at the most downstream station along Mill Creek during the spring 2017 monitoring event. The summer and fall base flow measurements are consistent between 2016 and 2017 in spite of receiving significantly more rainfall in 2017 than in 2016 at the Clair Maltby CEIS rainfall gauge.

4.2.3.9 Pond Bathymetry Surveys

On November 14, 2016, Groundwater Science Corp. completed bathymetry surveys (ie water depths) of Halligan's Pond, located in the southeast ROW at Victoria Road South and Maltby Road East; Neumann's Pond 1, located at 132 Clair Road; and, at an unnamed pond (informally referred to as Tim Horton's Pond) located in the east portion of 950 Southgate Drive (Figure GW-1). Further details of the surveys can be found in Appendix B. The data from these surveys was used to represent the base of the wetland/pond areas in the integrated groundwater / surface water model.

A bathymetric survey was conducted for Hall's Pond as part of a larger investigation (Ecologistics Ltd., June 1988) which presented water depths of up to 1 m and sediment depths of up to 2 m.

4.2.3.10 Seeps and Springs Observations

Spring locations have been documented for this study but flows could not be quantified. Matrix field staff observed and documented a series of springs on May 10, 2017 at 63 Brock Road in the Mill Creek Subwatershed, south of the SPA in the broader SSA, following an invitation by the property owner to visit the springs (Spring 1 on Figure GW-1). The property owner reported that their domestic water well is approximately 21 m deep and flowed artesian groundwater to surface when it was originally constructed. The predominantly cedar forested area of the property contains numerous springs and pools of water along an area of topographic relief. Wood PLC field staff observed an additional area of springs within the Mill Creek subwatershed on April 26, 2017 (Spring 2 on Map GW-1). More springs associated with this approximate ground surface elevation are anticipated in the Mill Creek, Hanlon Creek and Speed River subwatersheds.

During the background review, it was noted that two groundwater seeps were previously documented at 132 Clair Rd. (Aquafor Beech 2012), south of Neumann's Pond 1 (Seep 1 and

Seep 2 on Map GW-1). Beacon field staff also reported observing a seep at 2162 Gordon Street (Seep 3 on Map GW-1).

4.2.4 Geologic and Hydrogeologic Setting

The following characterization sections rely on mapping and interpretations from a geological/hydrogeological database created for this study. This database includes MOECC water well records, consultant and current study borehole logs (Figure GW-3) and water levels from studies described in Section 4.2.2

4.2.4.1 Physiography

The physiographic description of an area commonly includes summaries of topography, landform, drainage and the occurrence of surface soils types along with an overview of the depositional and erosional history that created the landform. Geologic descriptions commonly detail the overburden and bedrock composition and form below the surface as well as the relationship of the geology to the physiography of that area. Together, these two descriptions are used to characterize the physical setting of a study area and form the basis of any groundwater interpretation. Within the study area, the physiography and geology are very closely related that, for the purposes of this study, the physical setting overview is a synthesis of both.

The Secondary Plan Area is predominantly within the Horseshoe Moraine physiographic region and transitions into the Guelph Drumlin Field to the north in proximity to Clair Road (Chapman and Putnam 1984). The main features of the Horseshoe Moraine are the Paris and Galt Moraines occurring as a broad composite moraine through the SPA and are responsible for the rough, hummocky terrain and often steep, irregular slopes. The Guelph Drumlin Field is situated northwest of the Paris/Galt moraine and is mapped in the northern extent of the SPA. However, there are no drumlins mapped within the SPA and the predominant surficial feature of the Guelph Drumlin Field within the SPA is the coarse fluvial outwash deposits that occupy the intervening low ground of the drumlin field.

The variability of the bedrock surface, as well as the stratigraphy of the overburden, is a result of the repeated glacial advances and retreats, which have occurred in southern Ontario. The most recent glacial advance and retreat formed much of the land surface and geology present in the area today. This event is referred to as the Wisconsinan Glaciation, and was accompanied by various meltwater lakes and channels. The last glacial retreat ended between 10,000 and 20,000 years ago, blanketing the area in glacial sediments.

Streams and Creeks are absent in the SPA reflecting the high infiltration capacity of the area. The headwaters of Hanlon, Mill and Torrance Creek form on the north and south slopes of the moraine as described in Section 4.3. Spotflow measurements showing perennial flow, seep observations, and presence of riparian wetlands in these headwater areas indicate the groundwater discharge supports these creeks.

4.2.4.2 Bedrock Geology

The bedrock surface slopes north to south from approximately 320 to 300 masl. The Paleozoic bedrock stratigraphy beneath the SPA consists of sedimentary Silurian aged dolostones, shales, limestones, and associated interbedded sedimentary bedrock formations that dip regionally to the southwest as part of the Michigan Basin. The sub-cropping bedrock is predominantly of the Guelph Formation with limited exposures of the Eramosa Formation (Matrix 2017). None of the boreholes drilled as part of this study intersected the bedrock but may have contacted the top of bedrock at some locations based on drill cuttings and comments from the driller.

Table 4.2.2 is republished from the City of Guelph's Tier 3 Water Budget and Local Area Risk Assessment and lists the bedrock formations found in the Study Area from youngest (top) to oldest (bottom), as well as a brief description of the bedrock lithologies and the estimated thicknesses of the units beneath the more regional area. Table 4.2.2 also summarizes bedrock stratigraphy for the past (Golder 2006a) and revised (Brunton 2009) conceptualizations.

The City of Guelph bedrock groundwater supplies are derived primarily from the Guelph, Goat Island and Gasport Formations. The Carter and Burke wells to the northwest of the PSA and extract their supplies from the Goat Island/Gasport Formation. Domestic wells supplies are typically derived from the Guelph or Goat Island Formations in the PSA.

Table 4.2.2 Bedrock Geology underlying the Study Area

Previous Conceptualization [1]		Revised Conceptualization [2]		Lithology Description	Approximate Thickness (m)
Formation	**Member**	**Formation**	**Member**		
Guelph Fm.		Guelph	Hanlon	Cream-coloured, medium to thick bedded dolostone, fossiliferous grainstones, wackestones, and reefal complexes	Up to 62
			Wellington		
Amabel	Eramosa	Eramosa	Stone Road	Cream-coloured, coarsely crystalline dolostone	
			Reformatory Quarry	Light brown-cream, pseudo-nodular, thick bedded, coarsely crystalline dolostone	5 to 50
			Vinemount	Grey-black, thinly bedded, fine crystalline dolostone with shaley beds	2 to 10
	Wiarton / Colpoy /	Goat Island	Ancaster / Niagara Falls	Ancaster-Grey, cherty, fine crystalline dolostone; Niagara Falls-Fine crystalline,	5 to 40

Table 4.2.2 Bedrock Geology underlying the Study Area					
Previous Conceptualization [1]		Revised Conceptualization [2]		Lithology Description	Approximate Thickness (m)
Formation	Member	Formation	Member		
	Lions Head			cross-laminated crinoidal grainstone with small reef mounds	
		Gasport	Gothic Hill	Cross-bedded crinoidal grainstone-packstone with reef mounds and shell beds	25 to 70
		Rochester / Irondequoit / Rockway / Merritton Fm.		Rochester- Calcareous shale with carbonate interbeds; Irondequoit- Thick-medium bedded crinoidal limestone; Rockway- Fine crystalline argillaceous dolostone with shaley partings; Merritton- Fine crystalline dolostone with shaley partings	3 to 5
Cabot Head / Reynales Fm.		Cabot Head Fm.		Non-calcareous shale interbedded with sandstone and limestone	10 to 39

Notes: [1] Golder (2006a)
[2] After Brunton (2009)

4.2.4.3 Surficial Geology and Stratigraphy

The regional surficial geology mapping and data is provided by the Ontario Geological Survey (OMNDM 2010). Mapping and related investigation of the Quaternary deposits in the region surrounding the project area have determined the glacial materials present were deposited during the Late Wisconsinan (i.e., the period between 20,000 and 10,000 years B.P.). Three till sheets have been identified that represent major ice advances of a fluctuating ice mass (Karrow 1968, 1974). The oldest advance deposited the Catfish Creek Till which is found only in the subsurface in scattered locations in the Guelph area. Following a retreat of the ice, a glacial re-advance across the project area deposited the Port Stanley Till. This till is found at surface to the north and west of the project area and is likely to exist, to varying degrees, in the subsurface within the SPA.

The last advance of the glacier into the project area deposited the Wentworth Till which forms the surface material over a large region within and to the south and east of the project area (Karrow 1968, 1987). The till is described as a sandy to silty sand till, often bouldery or stony. The maximum extent of the ice depositing the Wentworth Till is marked by the position of the Paris

Moraine (Karrow 1974). As the moraine was being constructed large volumes of sediment-rich meltwater were discharged forming a broad outwash plain in front of the ice.

The Paris Moraine is a southwest trending feature extending from Caledon in the north to Lake Erie. The moraine formed during a halt in the retreat of the ice, contemporaneous with the deposition of the Wentworth Till in the project area. Although termed a "till moraine" by Chapman and Putnam (1984), due to till forming the surface material over much of its length, regional scale mapping in the Guelph area indicates that significant deposits of ice-contact and outwash deposits are also present at surface in the moraine (Karrow 1968, 1987).

The Paris Moraine occupies the entire project area and occurs as a belt of hummocky topography approximately 3 to 4 km in width. The regional surficial mapping indicates that, in general, till is the dominant material on the higher elevations of Paris. It is of note, however, that the within the moraine in the Guelph area the texture of the Wentworth Till becomes coarser and the distinction between poorly-sorted kame gravel and coarse till is often arbitrary (Karrow 1968, 1987) and will be discussed in more detail below. The moraine may overlie till deposited by a previous ice advances (Port Stanley Till) and there is the possibility that coarse-grained moraine material may bury drumlins (Chapman and Putnam 1984). The surficial geology is presented on Figure GW-1. The overburden within the SPA ranges in thickness from 15 m to 50 m.

As discussed in Section 4.2.3.1 the project drilling was conducted at nine locations within the SPA. The detailed logging of sediment recovered during the drilling of the monitoring wells, in combination with logs of water wells and previous studies in the area, allows for a better understanding of subsurface conditions and internal characteristics of the Paris Moraine in the SPA.

The picture that emerges from the drilling completed as part of this investigation and borehole logs from previous studies is that the Paris Moraine in the project area dominantly consists of glaciofluvial sand and gravels deposited in an ice-contact environment. Till was found at or near the bedrock contact in four of the nine boreholes (MW1, MW 4, MW 6 and MW 8) but with the exception of MW4, and to a lesser extent MW1, the thickness of the till was minimal. MW4 was unique not only for the thickness of the till but also for the fact that it occurred from the ground surface to bedrock with the only notable interruption being a 1.5 m thick sand lens. MW4 had no indication of clay within the entire log whereas MW1, MW6 and MW8 had varying clay content in the lower overburden. The only other borehole in which till occurred at a shallow depth was MW5 where 5.5 m of till occurred at a depth of 3 m. The regional surficial mapping (Karrow 1968, 1987) would suggest that till would be more common in the near surface. The regional nature of the mapping and the observation that the distinction between poorly-sorted gravel and coarse-grained till is arbitrary, account for the discrepancy between lithology in boreholes and surficial geology map. Slight variations in the texture of the till with depth and the presence of thin layers of silt, sand and gravel suggest that some, if not most, of the till was deposited by melting out of debris from the ice and subsequent slumping (i.e., generating flow tills or diamicts).

Coarse-grained glaciofluvial sediments (sand- and gravel-rich units) dominate all monitoring wells, except MW4, however, there is no commonality to the sediment stratigraphy between drill sites. Thick units of sand and gravel occur above sand-rich units or till in some boreholes (MW1, MW2 and MW5) while in other boreholes gravel-rich units are found in the middle or immediately above bedrock (MW2, MW 5, MW 7 and MW 9). Sandy units, often either gravelly or silty, account for the majority of the material in six of the monitoring wells (MW2, MW3, MW5, MW6, MW8, and MW9) and a significant percentage of another (MW7). The sandy-rich units ranged from well to poorly sorted with the later often containing fine gravel.

Relative thin silt-rich units (1.5 to 6 m) were intersected in four monitoring wells (MW1, MW 6, MW 7 and MW 9). The texture of these minor glaciolacustrine units ranged from clayey to sandy silt; material was well to poorly sorted. These silt-rich units are likely to have been deposited in restricted basins, either in a subglacial (MW6, MW7, MW9) or surface setting (MW1, MW7).

The monitoring wells and information from other studies demonstrate that the depositional environment of the Paris Moraine is complex. While the ice front was mainly stagnant during the formation of the moraine is it possible that minor ice-push events may have occurred and created linear hillocks or ridges (McGill, 2012). The hummocky nature of the moraine is attributed to two means of formation. The first occurred when sediment covered (buried) ice blocks melted and the overlying material sagged forming depressions or swales on the ground surface (i.e., relief inversion). The second cause of a rolling topography involved the melting of the ice on either side of a sediment filled channel or crevice; removal of the ice walls which provided support allowed a repositioning of the sediment.

The release of large amounts of sediment from the melting ice combined with significant amounts of meltwater resulting in several deposit types in the moraine. Till, mass flows, ice-contact deposits and localized glaciolacustrine deposits were emplaced in close proximity. The dynamic nature of the setting resulting from the constant introduction of material and high energy flowing water enabled the transport and reworking of material. The fact that deposition was occurring in an arctic like environment, with ongoing freeze-thaw cycles, allowed for multiple successions of debris reworking separated by periods of no or limited deposition.

The units comprising the Paris Moraine are horizontally and vertically variable in terms of texture and thickness due to their deposition in an unstable, rapidly changing setting. The combination of in situ wasting ice (possibly occasionally reactivated), abundant running water and mass movement (slumps) creating localized depositional setting along the length of the moraine in the Guelph area. This resulted in units that have highly variable thickness and lateral extent that may overlap and/or inter-finger.

Sediments within the wetlands and the bottom of ponds throughout the SPA can be made of up organic and peat like deposits as shown in various borehole logs adjacent to the ponds as well and pond sample (Ecologistics, 1988).

Cross sections presenting borehole logs, screened or open borehole intervals and associated available water levels are presented on Figures GW-4a through GW-4e. Borehole and cross-section locations can be found on Figure GW-3. The variable thickness and the lateral extent or discrete nature of the various stratigraphic units is demonstrated within these cross sections. Domestic well logs frequently present substantial thicknesses of material described as containing clay. Borehole logs from consulting wells and the geophysical survey carried out for this study do not support the frequent clay description presented in the domestic water well logs. It is interpreted that the clay content described in the water well logs reflects silt in most cases. It should be noted that water levels presented for the domestic water wells represent an average water level in the entire open portion of the well which is most frequently within the bedrock.

The permeable nature of the various stratigraphic units has been quantified through hydraulic conductivity testing on the monitoring wells for this study (Section 4.2.3.6) and testing carried out for other consulting studies. Well screens in consulting studies of this nature are typically screened in the more permeable units. Tests carried out in silty sand with some clay deposits at 132 Clair Road West had a range of 9.4 E-08 to 1.6 E-04 to m/s (Banks Groundwater Eng., July 2015). Tests reported from three of the City of Guelph monitoring wells within the SPA (Golder, June 2009) presented values of 1.0 E-07 to 2.0 E-06 m/s in the silty sand till and 2.0E-05 m/s in a medium sand. Tests at 132 Clair Road West (Aquafor Beech, September 2012) in the silt sand and gravel ranged from 1.2 E-07 to 3.2 E-06 m/s.

Guelph permeameter tests provide another measure of hydraulic conductivity (Section 4.2.3.7). The field saturated hydraulic conductivity results carried out at sites MW01 – MW09 are summarized in Table B3 (Appendix B), where values range from 4E-08 m/s to 1E-05 m/s. Permeameter tests carried out at 132 Clair Road ranged from 9.9 E-06 to 1.1 E-06 m/s (Banks Groundwater Eng., July 2015).

4.2.5 Conceptual Model (CM) of Groundwater Flow System

During precipitation or snowmelt events a portion of precipitation percolates or infiltrates into the ground based on the intensity of rainfall or snow melt and the infiltration capacity, slope of the surface, and existing soil moisture. The portion of precipitation that does not infiltrate runs off to downslope areas where it may infiltrate or flow into a surface water features (e.g. wetlands, creeks).

Water which reaches the water table may provide recharge to the overall groundwater flow system. Areas where water moves downward to the water table are known as recharge areas.

These areas are commonly in areas of topographically higher relief. Areas where groundwater moves upward to the water table are known as discharge areas and these generally occur in areas of topographically low relief, such as creek valleys. Groundwater that discharges to creeks or streams maintains the baseflow of the creek. Wetlands may also be fed by groundwater discharge.

There are different types and rates of recharge and discharge. Water percolating into the ground at a specific location may discharge to a small pond or wetland a short distance away. This is local recharge and local discharge. Some water may recharge in a certain area and discharge to a creek or stream basin more distant from the source of recharge; this is known as regional recharge and regional discharge, or regional groundwater flow system.

Permeable geologic materials that can transmit locally or regionally significant quantities of water are known as aquifers. Aquifers are "water bearing" formations meaning that water can be relatively easily extracted from these units. The less permeable units are known as aquitards, and although water can move through these units, it moves slowly and it is difficult to extract water from these units. How these aquifers are connected within a hydrogeologic setting is what controls much of the movement of groundwater.

A delineation of the flow system(s) in this way provides a framework to characterize where groundwater originates, where it discharges, and the most prominent paths it travels between these points (e.g., the aquifer pathways or more permeable hydrostratigraphic units). The framework enables an assessment of the relative sensitivity of the linkage of the groundwater system to the aquatic or terrestrial or water supply systems or the function of groundwater in supporting these systems. Knowing the level of sensitivity of the receptor, the impacts of particular types and scales of land uses or land use changes on the groundwater flow system and other linked ecosystem components can be estimated. Best management practices can then be developed to minimize unacceptable impacts associated with future development.

4.2.5.1 Regional Groundwater Flow System

The regional groundwater flow system is presented in the Tier 3 Water Budget Assessment (Matrix Solutions Inc. 2017). Groundwater levels presented in the report indicate a lateral component of groundwater flow into the SPA through the deep overburden and bedrock. The overburden tends to flow from the east/northeast into the SPA. Larger scale components show westward flow towards the Eramosa River, south towards Mill Creek within the study area and east of the study area, and west through the study area towards the Speed River. Flow within the upper bedrock (Guelph and Eramosa Formations) tends to follow the same pattern. The direction of flow in the Gasport Formation (municipal aquifer) below the Vinemount Member aquitard is similar as well. The Tier 3 potentiometric surfaces show downward hydraulic gradients between the upper bedrock and the lower Gasport Formation (across the Vinemount Member). This regional flow particularly within the lower overburden and upper bedrock Guelph Formation is expected to influence water levels in the deeper overburden within the study area as well as provide for groundwater discharge to Hanlon and Mill Creek.

The capture zone of the Burke well within municipal aquifer below the Vinemount aquitard extends to eastern boundary of the SPA.

4.2.5.2 SPA Scale Groundwater Flow System

Characterization of groundwater flow within the SPA is dynamically linked to the regional flow system in the PSA and beyond as described in the previous section. The SPA groundwater flow system characterization uses the regional context to evaluate local groundwater contributions to the regional flow system, such as municipal aquifers and discharge to Mill Creek; as well as the potential smaller scale flow systems (Section 4.2.5.3) related to wetlands, ponds, seeps and springs within the study area.

The results of the drilling program for this study along with detailed stratigraphic information from other consulting drilling programs allow for the recognition of several factors that have been interpreted to influence the hydrogeological setting of the Paris Moraine and the overburden in general within the SPA:

- Layers of till within the Paris Moraine are likely to have restricted areal dimensions and may occur as lens encased by permeable glaciofluvial deposits and bedrock. Due to the mode of deposition the till may contain thin layers of coarse-grained sediment and/or grade laterally into stratified ice-contact material thus affecting its ability to act as an aquitard.
- The coarse-grained glaciofluvial units which form the bulk of the moraine in the SPA can be considered as an interconnected, highly permeability assemblage. Units logged as sandy silt, sand and sand and gravel can be treated as a single hydrostratigraphic unit.
- The fine-grained silt-rich units are likely of limited areal extent and do not serve as aquitards.
- The lowermost till unit is generally thin and discontinuous and as a result is does not act as a regional aquitard. On the scale of the SPA a direct connection exists between the overburden and upper bedrock aquifers (above the Vinemount Member), and surface recharge can migrate to bedrock.

A water table map (Figure GW-5) has been prepared utilizing observation water level data from monitoring wells established for this study, historical consultant monitoring wells and shallow domestic water wells. The observed water table shows horizontal flow components radiating out from the centre of the SPA west towards Hanlon Creek and south towards Mill Creek as well as a shallower gradient to the north. It is important to note that the relative values of the horizontal gradient compared to the vertical gradient more fully inform the three-dimensional nature of the groundwater flow system. The horizontal components vary from 0.015 to 0.003 and the vertical downward component varies from 0.015 to 0.222. In general, given the ratio of vertical to horizontal gradient the downward gradients are a greater controlling factor in groundwater flow except for an area in the vicinity of MW-09 (Figure GW-1) where an upward gradient is observed. Groundwater levels are consistently below ground level or in some cases at ground level in the vicinity of some ponds and wetlands which is discussed in more detail in Section 4.2.5.3.

A conceptual SPA hydrogeologic flow system is presented in cross-section in Figure GW-6 and the cross-section location is presented on Figure GW-3. The depth to the water table varies from 0 m at Halls Pond to 20 m in the vicinity of Gordon Street. Conceptual groundwater flow lines generally reflect the relative vertical and horizontal groundwater gradients. The groundwater levels and gradients reflected in Figures GW-5 and GW-6 do not indicate any large scale connections of the groundwater flow system to the SPA wetlands or ponds although potential smaller scale groundwater flow adjacent to the ponds or wetlands may contribute limited discharge (Figure GW-6). This is discussed in more detail in Section 4.2.5.3. Groundwater recharge within the SPA contributes to components of groundwater flow in the lower overburden and shallow bedrock of the Guelph Formation (Figure GW-6), adding to the more regional groundwater flow entering the SPA and subsequently contribute to groundwater discharge to Hanlon Creek, Mill Creek and potentially a minor contribution to Torrance Creek. Potential hydraulic connections between the bedrock and overburden appear to be demonstrated on hydrographs for MW-4, MW-5 and MW-6 (Appendix B). Distinct drawdown of water levels during the summer months appears to potentially correlate with pumping of the deeper bedrock well irrigation wells for the Springfield Golf Course.

Groundwater quality analysis (Section 4.2.3.5) presented in the piper plots indicate the overburden water consistently represents a calcium-magnesium carbonate system. There doesn't appear to be a significant difference in the majority of basic anions and cations between the shallow and deeper groundwater in the overburden monitoring wells. In addition, the basic anions and cations within the two PGMN bedrock wells (W0046, W0024) appears to be similar to the overburden monitoring wells.

Elevated chloride in MW01-S and MW02-S likely reflects winter de-icing. Elevated chloride and nitrate in both MW08-S/D appears to indicate an more isolated source possibly from agricultural applications. The enriched tritium results indicate that the overburden water can range from 2 to 63 years with no unique solution given the multiple regression peaks. The water recharging the SPA appears to recharge to the deeper overburden without any indications of significant mixing with the more regional lateral flow entering the SPA.

4.2.5.3 Groundwater Flow Related to Surface Water Features

Hydrologic inputs to surface water features, including ponds, wetlands, seeps and springs, and stream reaches can be influenced by a variety of factors. The local topography can act as a hydraulic controlling force for both groundwater gradients and overland flow. The permeability of the pond or wetland sediments can also determine the flux of water movement, both recharge or discharge through the bottom of the feature can occur. Wetlands can exhibit recharge conditions or discharge conditions both spatially and on a seasonal or event basis.

Surface water features which exhibit perennially unsaturated conditions at some depth beneath them are considered “perched” groundwater systems. Surface water features can also be hydraulically connected to the water table through an underlying saturated zone directly below the feature which may exhibit groundwater discharge if the surrounding water table is higher than the surface water in the feature or may be a recharge feature where now adjacent groundwater levels are higher that the surface water level.

Seasonal and year to year precipitation trends combined with evapotranspiration (ET) trends and spring snow melt and runoff act as significant controlling factors which adjust the local water table. Increased ET can drive upward gradients/flow to the water table.

Local fine grained and coarse-grained soils/surficial geology units can control the amount of water recharging or moving overland. Local small-scale permeability contrasts within local stratigraphy can control movement of infiltrating water and cause groundwater to discharge locally as seeps and contact springs through interflow in the unsaturated zone above the water table during spring melt and extended precipitation events. Ponds or wetlands may be in contact with an underlying saturated zone on a perennial basis (i.e. Hall’s Pond) or on a seasonal basis but do not continually present groundwater levels above surface water levels in the adjacent lands to promote ongoing groundwater discharge. It may be the case that spring melt or extended precipitation events provide for saturated conditions in close proximity to these features to allow for episodic groundwater discharge.

Neumann’s Pond 1 has been assessed through a number of studies carried out for the property referred to as 132 Clair Road. (Banks Groundwater Eng., May 2016, Aquafor Beech, September 2012). Typical water levels in the pond range around 342-342.5 masl with pond depths up to 2.75 m. Adjacent monitoring wells (MW1-11, MW2-11 Figure GW-1) indicate that a deeper water table exists close to 330 masl which would indicate that this pond exhibits a perched condition with an unsaturated zone below. Hydrographs for the mini piezometers MP01 s/d established for this study indicate seasonal upward gradients from the deep to the shallow but no upward gradient into the pond (Appendix B). It was previously concluded (Aquafor Beech, September 2012) that the pond is maintained by direct precipitation and runoff alone. There is a possibility that during spring melt and long-term precipitation events very local groundwater discharge may occur in the form of interflow as described above. This is supported by the previous interpretation that the mechanism providing water to ephemeral Seep 1 and Seep 2 just south of Neumann’s Pond 1 (Figure GW-1) is “temporary mounding of infiltrating precipitation in adjacent hillocks and subsequent lateral discharge down-gradient on steep slopes” (Aquafor Beech, September 2012). It is noteworthy that the borehole log for MW3-11, in the vicinity of Seep 2, indicates a shallow silt/clay layer which could act to intercept infiltrating water and direct it laterally. MP02 at Neumann's Pond 2 shows a downward gradient year-round in the hydrograph (Appendix B) and water levels at approximately 346 masl. Given a lower water table level of 333 masl it is interpreted that these associated wetland features are in perched groundwater condition.

Groundwater level monitoring (Banks Groundwater Eng., May 2016) immediately adjacent to Neumann's Pond 1 at 1897 Gordon Street (Bird Landing) showed wetland water levels from 339 to 342 masl with fluctuations interpreted to be in response to spring thaw and event precipitation. The water table within the sand and gravel deposits beneath the site is measured to vary between 330 and 332 masl indicating a substantial unsaturated zone and perched conditions.

A hydrogeological assessment (Stantec, January 2017) across from Bird Landing at 1888 Gordon Street assessed water levels within a local wetland. Shallow mini-piezometers screened 0.6 - 2.16 metres below ground surface (mbgs) within the feature indicated minor upward gradients in the spring and became dry leading into summer. During this same time period multi-level monitoring wells screened from 3.93 – 8.28 mbgs showed declining water levels from 1.57 – 8.12 mbgs. It is observed that shallow water levels in these monitoring wells in the spring are above the ground surface of the wetland but downward gradients occur at all times and a thick unsaturated zone develops below the wetland. This seasonal trend indicates there may be local groundwater discharge associated with spring melt adjacent to the wetland.

MP04 north of Hall's Pond tends to reflect a neutral gradient. The interpreted lower water table is approximately 6 m below and indicates a perched condition.

As presented in Section 4.2.3.4 Hall's Pond water level hydrographs from mini-piezometer MP07-D (Appendix B) show a downward gradient December through July and a gradient reversal to upward from July 2017 through November 2017. The water level in MP07-D is above the surface water level but the water level in MP07-S is still below the surface water level. This site does not indicate significant groundwater discharge to the pond but may indicate a low permeable layer between the shallow and deep mini-piezometers. Monitoring well hydrographs for MW05-D and MW05-S show downward gradients through the entire monitoring period. The water level in MW5-S was always lower than the surface water level and close to or above the bottom of the pond. This suggests that the pond has a potentially continuous saturated condition between the wetland and the deeper groundwater system and the pond exhibits a recharge condition within the larger groundwater system. Shallow test holes dug for a previous study adjacent to Hall's Pond exhibited layers of permeable sand and less permeable silt sand and clay (Ecologistics Ltd., June 1988) within the upper 4 m. Water levels were noted to be slightly higher than the pond level 25 m from the pond and at pond level 90 m from the pond possibly indicated the potential for local groundwater discharge described above.

The limited mini-piezometer data (Appendix B) at Halligan's Pond shows sporadic upward gradients during a limited spring period. The lower water table is interpreted to be 2-3 m below the bottom of the pond and as such may still have a potential saturated condition below the pond.

The Tim Horton's Pond (Figure GW-1) mini-piezometer MP10 hydrograph (Appendix B) indicates slight upward gradients in the spring and neutral or downward gradients the remainder of the year. Local monitoring well MW07 indicates a water table within 1 m of the pond water level and close to pond level during the spring.

A number of wetlands and ponds not described above appear to be at the level of the seasonal water table or slightly above it but in contact with the water table through a saturated zone, similar to Hall's Pond and Tim Horton's Pond. Features adjacent to the western boundary of the SPA south of the Tim Hortons Pond and north of Malty Road are interpreted to demonstrate this connection to the water table which was presented in the 'South Guelph Secondary Plan Area Scope EIS Hydrogeological Assessment' (Gartner Lee Ltd., December 1997). The wetland feature at Hawkins's Drive and Clair Road demonstrates the same water table relationship. The water table is also interpreted to be in contact at MP09 with potential upward gradients in the late spring given the water levels associated with MW02-s/d. MP11 south of Maltby Road (Figure GW-1) shows upward gradients from the late spring through early fall of 2017 (Appendix B) which may reflect interflow from the local topographic highs. MP12 to the west on Maltby Road shows neutral to downward gradients. Both MP11 and MP12 are within 2 m of the interpreted water table and may also exhibit underlying saturated conditions.

As described in Section 4.3.2.10 a series of springs were observed on May 10, 2017 at 63 Brock Road in the Mill Creek Subwatershed, south of the SPA (Spring 1 on Figure GW-1). In addition there is a flowing well on the property. The property also contains numerous springs and pools of water along an area of topographic relief. Wood PLC field staff observed an additional area of springs within the Mill Creek subwatershed on April 26, 2017 (Spring 2 on Figure GW-1). The groundwater discharge in this area south of the SPA is likely receiving water that has recharged within the SPA and flowed south along with regional water as discussed in Section 4.2.5.1. The perennial nature and consistency of spot baseflow values south of the SPA appears to reflect a consistent larger scale combined source of recharge water.

The potential connection of recharge to discharge and groundwater/surface water interactions are refined in more detail through the MIKE SHE modelling and presentation of the simulation results in Section 4.2.7.

4.2.6 Integrated Surface and Groundwater Model

The conceptualization of the groundwater flow system (characterization) (CM) provides the framework for developing a numerical model to represent and refine characterization of the system by calibration to historical water levels, stream flow, groundwater discharge and ponded water. The calibrated model provides an ability to further evaluate:

- groundwater recharge and discharge areas and features
- groundwater flow linkages between recharge and discharge areas (groundwater functions)
- spatial and temporal variations in these groundwater functions
- water budget for overall study area and key stream wetland and woodlot features
- PSA role in supporting municipal bedrock aquifers
- constraints and opportunities for future development to maintain groundwater function and support other objectives for stormwater management

In future phases of this study the numerical model can then be modified to simulate potential future conditions land use conditions. The future conditions models can be used to evaluate potential impacts to groundwater function and assess the potential effectiveness of mitigation strategies (e.g. LIDs) for maintaining groundwater function and provide input to the overall Storm Water Management planning.

MIKE SHE was selected as the numerical modelling software to represent the SSA. MIKE SHE is a three-dimensional integrated surface water and groundwater model. MIKE SHE provides a fully dynamic and physically based representation of all the major hydrologic and hydrogeological processes and their interactions. The major processes represented include but are not limited to: precipitation, evapotranspiration, surface runoff, channel flow, unsaturated flow, groundwater recharge, groundwater discharge and groundwater flow.

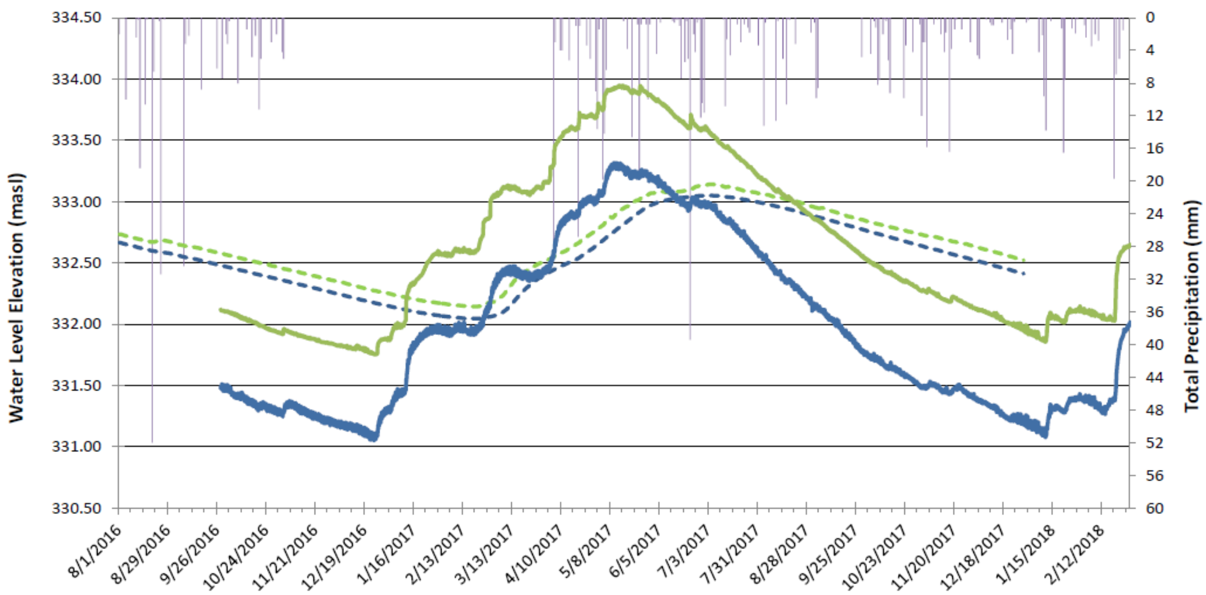
The MIKE SHE model was constructed to represent the three-dimensional characteristics of the study area as described in Conceptual Groundwater Flow discussion (Section 4.2.5). A Technical Modelling Memorandum is presented in Appendix B providing the detailed modelling set up, parameters and calibration. Initially a coarser MIKE SHE model with a larger domain (50 x 50 m grid cells) was developed that extended to include north and south branches of Mill Creek and headwaters of Hanlon and Torrance Creek. This model was used to check the consistency of model representation with the flow conditions at the Mill Creek Water Survey Canada gauge and spot flows in the Hanlon Creek. This coarser model was also used to identify a smaller model domain to complete the more detailed analysis in the SSA. The SSA model domain extends beyond the boundary of the SPA and the PSA and has dimensions of approximately 7 km east-west and north-south (GW-7). Model processes were simulated with 25 x 25 m grid cells size enabling representation of spatial variability features such as geology, vegetation and land use at this scale. Domain boundaries are presented the

Hourly precipitation and daily temperature rates sourced from local climate stations (1950-2017) were used to characterize local climatic conditions in the model (See Section 4.1). The model employed an adaptive time stepping process which uses fine time discretization during precipitation events and coarser time stepping during dry periods. Overland flow processes are represented using a 2D diffusive wave representation and consider the effects of topography on overland flow at refined 12.5 x 12.5 m cell scale. Channel flow representation is simulated using a kinematic routing representation. Unsaturated flow processes are represented by a gravity flow representation which is appropriate for determining time varying recharge to the subsurface and computed at a fine level of vertical discretization, 0.2-0.4 m thick cells, in the unsaturated zone. Saturated flow is simulated using a 3D finite difference implementation of Darcy's equation.

The model was calibrated to observed water levels, transient water levels, mapped perennial ponded areas and observed discharge rates for the period of 2003-2017. This 15 year period was selected as it provides representative range of wet and dry years and an average precipitation rate comparable to a 30 year climate normal period of 1988-2017 average precipitation (lower by 6%). Furthermore this period of evaluation is consistent with the land use data applied in the model which is based on 2009-2011 data.

Model input parameters for are informed by field observations of where data was collected (e.g. hydraulic conductivity) and previous studies. Ranges for field hydraulic conductivity in the various overburden hydrostratigraphic units was presented Sections 4.2.3.6 and 4.2.4.3. A full summary of model parameter values is provided in the Technical Modelling Memorandum (Appendix B).

The numerical model domain and observational datasets are presented in Figure GW-7. This figure illustrates the various sources of surface water and groundwater observation data which were considered in calibrating the model. The datasets considered in the numerical model and presented in Figure GW-7 include surface water flows, spot flows, static groundwater levels and transient groundwater levels. The model was evaluated against the most recently available groundwater observations collected at the wells commissioned for this study, consultant wells, WWIS wells and wells considered in the Tier Three numerical model. Groundwater levels were calibrated to a mean error of 1.8 m and an NRMS of 9.4% for this period. Considering only the high quality wells commissioned for this study water levels are well represented with a mean error of 0.7 m and RMS of 1.6 m. Simulated transient water levels for 2017 reproduce a seasonal head change of approximately 1 m as illustrated by the MW2 hydrographs presented in Figure 4.2.1. A full summary of model calibration and transient water levels simulated at study wells please refer to the Technical Modelling Memorandum (Appendix B).



Well ID	Ground Surface Elevation (masl)	Top of Casing Elevation (masl)	Elevation of Top of Screen (masl)	Elevation of Bottom of Screen (masl)
MW02-S	335.40	336.36	328.69	327.17
MW02-D	335.29	336.11	316.09	314.56

Precipitation - AFW: Data set from rain gauge installed by AMEC Foster-Wheeler at 500 Maltby Rd. E.

Figure 4.2.1 Simulated and Observed Transient Water Levels at MW2-S and MW2-D

Spotflow measurements were made at locations in Mill Creek and Hanlon Creek as part of this study (Map GW-2). The consistency of with Mill Creek and Hanlon Creek simulated baseflow in the initially larger model was checked against observed spotflows. Spotflows for Hanlon Creek are not within boundaries of the SSA model domain. A summary of spotflow conditions evaluated outside of the SSA is provided in the Technical Modelling Memorandum (Appendix B).

Simulated discharge conditions for Hanlon and Mill Creek tributaries within the SSA model domain were compared against available observed water levels and mapped ponded water/wetlands see Table 4.2.3.

<table>
<tr><th colspan="8">Table 4.2.3 SSA Model - Observed Vs Simulated Baseflow Conditions</th></tr>
<tr><th rowspan="2">Drainage Area</th><th rowspan="2">Location</th><th colspan="3">Observed Flows (L/s)</th><th colspan="3">Simulated Flows (L/s) or Mapped Discharge Conditions</th></tr>
<tr><th>Min</th><th>Max</th><th>Average</th><th>Min</th><th>Max</th><th>Average</th></tr>
<tr><td>Mill Creek</td><td>MC-M3</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Mill Creek</td><td>MC-GN1</td><td>1</td><td>5</td><td>3</td><td colspan="3" rowspan="2">Consistent Discharge Conditions Identified at Location in Discharge Mapping</td></tr>
<tr><td>Mill Creek</td><td>MC-GN2</td><td>2</td><td>5</td><td>3</td></tr>
</table>

This comparison indicates consistent representation of field observations. Combined with the evaluation of spot flows in the larger initial model these simulated values represent the seasonal trends, locations and magnitude of conditions observed in the field and provides confidence the model can be used to represent discharge to Mill Creek.

Field data are still being collected and therefore the baseline characterization may be further refined in light of additional observational data, as the Wood proceeds to impact analysis.

4.2.7 Integrated Surface and Groundwater Model Results

The following section presents existing conditions simulated in the study area using the calibrated MIKE SHE model, for the period of 2003-2017. The results include maps of groundwater recharge, groundwater discharge, depth to water table, flux to the municipal bedrock aquifer and water budgets of representative NHS features. These results characterize existing conditions of the SSA and provide insight on the spatial and temporal trends in groundwater flow and function including:

- Recharge of overburden and bedrock aquifers including municipal bedrock aquifers
- Groundwater discharge to support creeks and wetlands
- Overall water budget

The characterization results provide context for identifying constraints and management opportunities for future development based on the current functions of groundwater. These functions, constraints and opportunities are generally discussed in Section 5.2.1.

4.2.7.1 Depth to Groundwater

A map depicting the spatial distribution of average depth to the groundwater table simulated for the period of 2003-2017 is presented in Figure GW-8. This figure represents the average depth from the ground surface to the water table as simulated by the model.

The simulated average depth to the water table is at or near ground surface within the headwaters of Mill Creek in the south east of the model domain and Hanlon Creek to the north west of the domain. These areas are largely mapped as wetland features, so a water table in close proximity to the ground surface is expected in these regions. The increased depth to groundwater through the middle of the domain corresponds to the area beneath the Paris Moraine which is higher in average elevation and has thicker overburden deposits. The correspondingly large increase in depth to water with minimal reduction in hydraulic conductivity in this area is consistent with moderate permeability of sandy silt till comprising most of the moraine and the observational groundwater level data. Within the residential developments of Clairfields and Westminster Woods the Greenways are areas which run in between the backyards of the developments and represent local low points in the topography that are designed to function as part of local stormwater management features. Depth to water in Greenways is typically less than 1 m or equal to ground surface in wetter periods. These conditions are reflected in the simulated depth to the water table.

Depth to groundwater below Neumann's pond is simulated to approximately 7 m below ground surface on average. This is consistent with previous observations and the conceptual interpretation provided in the CM that a significant unsaturated zone exists below Neumann's pond.

Depth to groundwater below Hall's pond is simulated to be approximately 0 m below ground surface on average. This is consistent with the CM interpretation which indicates that Hall's pond is perennially in contact with the water table although the area of ponded water will vary seasonally and from year to year based on climatic conditions.

The observed depth to water table below Halligan's pond is interpreted to be approximately 2-3 m on average. However, the potential for sustained saturated conditions below the pond is also possible based on the CM interpretation. The simulated depth to groundwater at Halligan's pond is on average approximately 0 m which is consistent with the latter interpretation.

4.2.7.2 Groundwater Levels and Flow

A map depicting the spatial distribution of simulated groundwater levels for the period of 2003-2017 is presented in figure GW-9. This figure represents the average groundwater water levels simulated within the upper overburden deposits of the model domain. Additionally this figure includes the groundwater residuals, the average error when compared to observed water levels, at the Matrix Wells and historic wells found within the Greenways of Clairfields and Westminster Woods.

In general the average simulated water levels are consistent with the observed water levels and are consistent with the SPA scale groundwater flow directions interpreted from the observed water levels which interprets radial flow emanating from the SPA. A westward flow from the SPA to Hanlon Creek, a flow to the south east towards the Mill Creek headwaters and a shallower gradient flow to the north are all present.

The simulated groundwater levels at Matrix wells have an average error of 0.7 m when compared against observed values. Given that a seasonal variation of 2 m in head has been observed in these wells the average error achieved by the model indicates the model is achieving a good representation of average water levels. These wells represent the highest quality groundwater observation data considered in this study and this result provides confidence that the conditions simulated within the PSA and the NHS features of interest are representative of observed conditions.

The simulated groundwater level found in the Greenways of the Clairfields and Westminster Woods developments are simulated to have an average error of 0.4 m when compared to observed values. This result indicates conditions within the Greenways are well represented on average. This result provides confidence that the effects development scenarios within the PSA will be reflected reasonably by the model.

4.2.7.3 Ponded Water Locations

A map depicting the spatial distribution of ponded water areas is presented in Figure GW-10. This map represents areas which feature ponded water exceeding 1 cm in depth for at least 10% of the simulation period (2003-2017).

The ponded water areas predicted by the model are very consistent with observed ponded water areas (Figure GW-1), as defined by the GRCA pond and lake mapping, and field observations throughout the model domain. Mapped ponded water areas in the SPA are consistently simulated as ponded for all most all ponded water features. Outside the SPA the ponded water is consistent with mapped ponded water locations as well the wetlands at the headwaters of Hanlon Creek and Mill Creek.

4.2.7.4 Groundwater Recharge

Water which passes through the unsaturated zone and reaches the water table is known as groundwater recharge. It's the portion of infiltration that is in surplus after meeting evapotranspiration and soil moisture needs above the water table. Evapotranspiration can also occur from below the water table. A map depicting the spatial distribution of average annual groundwater recharge for the period of 2003-2017 is presented in Figure GW-11. Groundwater recharge is influenced by the hydraulic conductivity of surficial materials, vegetation (evapotranspiration) and soil moisture conditions in an area. Additional factors which influence groundwater recharge include topography (slope), imperviousness, groundwater vertical hydraulic gradients and precipitation trends.

In the MIKE SHE model domain the surficial materials are predominately Wentworth Till and outwash sands and gravels. These materials comprise approximately 95% of the surficial material in the domain. An average annual recharge rate of 300 mm/year and 350 mm/year is predicted for the Wentworth Till and outwash sand and gravel respectively. These numbers are sensitive to the model input parameter assumptions for parameters such as hydraulic conductivity or rooting depth. However, the current conditions estimate is best fit to the available observations data. The effect of uncertainty in input parameters should be considered further at impact assessment phase.

The influence of topography may be illustrated through the increased recharge observed in the closed depression features found throughout the hummocky terrain on the Paris Moraine. Recharge rates, are 50-100 mm/year greater in depressions than in areas of similar vegetation and surficial geology in areas outside of the depressions. The higher recharge within the area of the Springfield golf course reflects the surficial permeability, the ET and the terrain. The influence of imperviousness can be seen in the developed residential areas of the model where the streets feature substantially reduced recharge rates relative to adjacent areas. Note that the model cells are 25 x 25 m dimensions and as such model cells comprise the road and also represent adjacent pervious areas with a single averaged impervious value.

In areas that are on average discharging, wetland areas associated with the headwaters of Hanlon Creek and Mill Creek in the north west and south east portions of the domain, recharge is reduced or zero. The shallow depth to water table and upward gradients in these areas result runoff rather than recharge during precipitation events. The shallow depth to water in the Greenways in Clairfields and Westminster Woods limits the capacity for infiltration in these areas, but seasonal trends indicate these do function to infiltrate groundwater over time.

4.2.7.5 Groundwater Discharge

Groundwater discharge occurs where the water table intersects ground surface typically in areas of topographic lows, locally or regionally. A map which depicts the areas groundwater discharge for the period of 2003-2017 is presented in figure GW-12.

Groundwater discharge is simulated in areas consistent with observed groundwater discharge, namely the wetlands associated with the headwaters of Hanlon Creek and Mill Creek. At many of the ponded areas within the PSA discharge ponds are observed with drive point monitors or seep observations. The model simulates groundwater discharge, primarily in the spring to Neuman's pond and Hall's Pond. However, the water budget analyses (Section 4.2.7.6) and observational data (Section 4.2.5.3) suggest groundwater discharge to pond and wetland features within the PSA is minor component of the overall water budget for these features.

4.2.7.6 Water Budget

The average annual water budget for the period of 2003-2017 simulated by the MIKE SHE model is presented for model domain and the areas of Mill Creek, Hanlon Creek and Torrance Creek within the model domain in Table 4.2.4. The average annual groundwater recharge rates for 2003-2017 are summarised in Table 4.2.5. The proportion of the primary outflows, as percentage of the total inflow of the model is presented in Table 4.2.6. Primary outflows include evapotranspiration, overland flow out (groundwater discharge), lateral flow through the overburden, lateral flow through the bedrock and vertical flow to the underlying municipal aquifer. Primary inflows include precipitation, overland flow in, later groundwater flow through the overburden and bedrock and vertical flow through the underlying municipal aquifer. The proportion of the primary outflows of the model as a percentage of total inflows less evaporative losses gives an approximation of the proportion of outflows as percentage of groundwater recharge and is presented in Table 4.2.7.

Table 4.2.4 Average Annual Water Budget (2003-2017, mm-year)

Area/Catchment	Precipitation	Evapotranspiration	Overland Flow In	Overland Flow Out	Lateral Groundwater Flow				Vertical Groundwater Flow		Pumping	Change in Storage
					Overburden		Bedrock Above Vinemount		Regional Bedrock Aquifer			
					Inflow	Outflow	Inflow	Outflow	Inflow	Outflow		
SSA Model Domain	-801	480	0	108	-35	126	-17	44	0	99	2	-7
Mill Creek	-801	498	-1	188	-41	36	-140	194	-1	66	7	-6
Hanlon Creek	-801	472	0	86	-19	60	-42	186	0	64	0	-7
Torrance Creek	-801	450	0	60	-48	95	-233	421	0	58	0	-4

Table 4.2.5 Average Annual Groundwater Recharge (2003-2017)

Area/Catchment	Groundwater Recharge (mm/year)
SSA Model Domain	325
Mill Creek	338
Hanlon Creek	326
Torrance Creek	302

Table 4.2.6 Water Budget Outflows as a Percentage of Total Inflow

Area/Catchment	Evapotranspiration	Overland Flow Out (Groundwater Discharge)	Overburden Lateral Flow out	Bedrock Lateral Flow Out	Bedrock Vertical Flow Out (Regional Aquifer)
SSA	-60%	-13%	-11%	-3%	-12%
Mill Creek	-62%	-23%	1%	-7%	-8%
Hanlon Creek	-58%	-11%	-5%	-18%	-8%
Torrance Creek	-56%	-7%	-6%	-23%	-7%

Table 4.2.7 Water Budget Outflows as Percentage of Groundwater Recharge

Area/Catchment	Overland Flow Out (Groundwater Discharge)	Overburden Lateral Flow out	Bedrock Lateral Flow Out	Bedrock Vertical Flow Out (Regional Aquifer)
SSA-Model Domain	33%	28%	8%	30%
Mill Creek	62%	-2%	18%	22%
Hanlon Creek	26%	12%	43%	19%
Torrance Creek	17%	13%	53%	16%

The water budget analysis indicates that:

- Conditions are relatively stable during the period of analysis as the change in storage is relatively small.
- Evapotranspiration losses account for approximately 60% of water flowing out of the SSA Model domain. Losses in the subcatchments are similar in magnitude.
- Outflows of the model, on average, as a percentage of groundwater recharge are apportioned in the following components:
  - Discharge to ground surface which may take the form of discharge to wetlands, ponds or streams accounts for approximately 33% of recharge on average in the SSA Model Domain. Discharge to wetlands specific to Hall's Pond, Halligan's Pond and Neumann's pond are discussed in the following section.
  - Flow through overburden units to the lateral boundaries of the SSA model accounts for approximately 28% of recharge on average
  - Flow though the bedrock units to the lateral boundaries of the SSA model accounts for approximately 8% of recharge on average.
  - Flow through the Vinemount vertically to the regional aquifer accounts for approximately 30% of recharge on average.

In general groundwater recharge is similar in all watersheds within the SSA.

Particle tracking provides a tool that links recharge and discharge areas and provides a means for further understanding the connection between recharge zones and potential receptors. Hypothetical particles were released within the first three layers of the MIKE SHE model and move through the simulated groundwater flow field to their discharge location or where they leave the model domain. The flow conditions observed for the period of 2007-2016 were used as representative conditions and repeated for a 200 year simulation to determine the ultimate fate of particles released in the overburden materials within the study area.

Particle tracking is consistent with the interpreted groundwater flow as described in the CM (ref. Section 4.2.5) and is consistent with water budget analysis. Particle tracking is presented in Figure GW-18 and further details on particle tracking can be found in the Technical Modelling Memorandum (Appendix B).

Surface Water- Groundwater Water Balanace for NHS Features

The local conditions observed and simulated at the NHS features of Hall's Pond, Neumann's Pond, Halligan's Pond and the 1992 Gordon St. Woodlot are presented in the figures GW7-GW10. These figures depict the interpreted water table contours from the observed groundwater levels and the average simulated groundwater level contours for the period of 2003-2017. The subcatchments depicted on the figures represent the area within which overland runoff contributes to a feature (e.g pond).

Figures GW-13 through GW-16 also illustrate the simulated average annual water budgets of the catchment and ponds or woodlots for the period of 2003-2017. Process diagrams on the individual figures illustrate the hydrologic processes that each item in the water budget corresponds to. The components of the water budget are influenced by the characteristics of the subcatchment and pond including but not limited to surface topography, vegetation, hydraulic conductivity of subsurface deposits, and groundwater hydraulic gradients. Water budget analysis presented in tables on GW-13 through GW-16 indicate that the ponds are primarily supported by direct precipitation with limited contributions from overland runoff and shallow groundwater. These results are consistent with the interpretation of conditions at the NHS features provided by the monitoring data and conceptual model of groundwater flow (CM) presented earlier.

Hall's Pond

The surface water and groundwater conditions for Hall's pond and the supporting subcatchment are presented in figure GW-13. The simulated pond water budget indicates that that the primary inflows to the pond are precipitation with overland runoff and shallow groundwater contributing a relatively small proportion of the flows to the pond. The primary outflows from the pond are evapotranspiration and groundwater recharge. These simulated conditions of the pond, primarily providing groundwater recharge or leakage to the subsurface and supported by minor discharge contributions are consistent with the CM interpretation of conditions at Hall's Pond. Groundwater heads observed at the nearby monitoring well pairs of MW5-S and MW5-D and MW6-S MW6-D report water levels in the overburden deposits which underlie the ponds. The average simulated water level, 334 m, in these wells are similar the observed value of 335 m. This representation of average groundwater heads near the pond may be considered reasonable as up to 2 m of seasonal head change has been observed in the transient water levels observed in the monitoring wells for the 2016-2017 monitoring period. This result provides confidence that conditions in Halls pond are being reasonable represented.

Neumann's Pond

The surface water and groundwater conditions for Neumann's pond are presented in figure GW-14. The simulated water budget indicates that the primary inflows to the pond are precipitation with overland runoff providing a moderate contribution and local shallow groundwater flow providing a minor contribution. The moderate overland runoff contributions are considered to be a result of the steep local topography within the catchment and small travel distance between the edges of the catchment and the pond itself leaving limited opportunity for losses to evapotranspiration or infiltration. The primary outflows from the pond are evapotranspiration groundwater recharge. The simulated conditions of the pond indicate that after losses to evapotranspiration balance of the pond water supports groundwater recharge.

Groundwater heads observed at the nearby historic monitoring wells of MW2-11 and MW2 report water levels in the overburden deposits underlying the pond. The average simulated water level, 333 m, in these wells is similar to the observed value of 331 m. This result is considered reasonable given 2 m of seasonal head change observed in monitoring wells and provides confidence that conditions at Neumann's pond are reasonably represented by the model.

Halligan's Pond

The surface water and groundwater conditions for Halligan's pond are presented in Figure GW-15. The simulated water budget indicates that the primary inflow to the pond is precipitation. The primary outflows of the pond are evapotranspiration and groundwater recharge with overland flow losses contributing a moderate component. Analysis of overland flow from the pond indicates these losses are to the adjacent pond just south east of Halligan's pond and occur intermittently during high water level periods after large precipitation events. Water budget analysis of Halligan's pond and the simulated groundwater recharge distribution indicate that Halligan's acts to recharge the groundwater flow system. Groundwater heads observed near the pond are interpreted to be approximately 330 m on average and average simulated groundwater levels are 332 m in the vicinity of the pond. Similar to Hall's and Neumann's pond conditions at Halligans are on average within 2 m of observed conditions on average. Given the seasonal head changes observed in the region this result provides confidence that conditions at the pond are being reasonably represented.

1992 Gordon Street Woodlot

The surface water and groundwater conditions for the 1992 Gordon St. Woodlot are presented in Figure GW-16. The simulated water budget indicates that the principal inflow to this area is precipitation. Shallow groundwater flow and overland flow provide negligible contributions to the area water budget when inflows and outflows are summed. Similar to all the features the primary outflow of the area is evapotranspiration with losses to groundwater recharge comprising the majority of the remaining outflows. Groundwater heads observed adjacent to the Woodlot at monitoring wells MW4-S and MW4-D, which monitor head in the overburden deposits the Woodlot is situated on, report an average head value of 335.5 m, while simulated heads are 334.3 m. Given the observed seasonal head change of 2 m these results are considered reasonable and build confidence that conditions in the woodlot are reasonably represented.

It is noted that for all catchments and ponds the water budget analysis indicates that conditions within these areas appear relatively stable; the long term change in storage over the period of analysis, 2003-2017 is small. Years of drought conditions, which result in losses to water storage in the catchments and ponds, are balanced by years of high precipitation, which result in increases in water storage in the ponds and catchments.

4.2.7.7 Recharge to Municipal Bedrock Aquifer

The spatial distribution of groundwater flux to the regional aquifer is presented in figure GW-17. This figure represents the average vertical flow in in mm/year for the period of 2003-2017 that is expected to occur between the between the regional groundwater system and the groundwater flow system represented in the model. Water budget analysis provides a quantitative assessment of local contribution within the SAA to the underlying municipal aquifer (Section 4.2.6.7).

In general we observe a predominantly downward flux throughout most of the model domain except for a limited upward flux noted to the wetland areas associated with the headwaters of Hanlon Creek and Mill Creek. These results are consistent with previous numerical modelling conducted in the Guelph Tier Three which indicate a predominantly downward flow potential in this region.

4.3 Hydrology

4.3.1 Importance/Purpose

The purpose of developing hydrologic and hydraulic models for urbanizing subwatersheds is to provide a better understanding of the operative factors which influence the amount and movement of water in the system, both under existing land use and proposed future land use conditions. By developing representative models, which reasonably predict seasonal and storm-based runoff response, the impacts of proposed future urbanization can be better quantified and thereby appropriate management strategies can be established in the future, as part of integrated management plans.

4.3.2 Background Information

Background information related to the watershed and subwatershed scale hydrology and hydraulics has been provided by the City of Guelph, GRCA, and the area landowners for this study. A complete list of background sources reviewed for this study is outlined in Appendix A. The following summarizes the specific background information used to support the baseline characterization of the surface water hydrology and hydraulics for the Clair-Maltby Study Area.

4.3.2.1 Reports

Several reports have been provided for reference in developing the baseline characterization for the surface water hydrology. The reports provided have ranged from detailed design reports for stormwater management facilities and systems within the urban areas north of the Clair-Maltby SPA, to watershed scale assessments such as the Hanlon, Torrance and Mill Creek Subwatershed studies. Those considered of specific relevance to the hydrology include:

- 132 Clair Road West, Guelph Scoped Environmental Impact Study, North-South Environmental Inc., August 28, 2105

- 2013 / 2014 Monitoring Report Bird Landing Subdivision, City of Guelph, GM Blue Plan Engineering, November, 2014
- 23T-03507 Former Pergola Lands Subdivision Phase 2: Environmental Implementation Report, Stantec, February 5, 2014
- 161, 205 and 253 Clair Road East, Guelph Environmental Implementation Report, North-South Environmental Inc., February 2014
- Environmental Implementation Report (EIR) February 13, 2013, City of Guelph, April 5, 2013
- Hanlon Creek Business Park 2009 -2011 Consolidated Monitoring Reports, City of Guelph, 2012-2013
- Stormwater Management Final Design Report, Bird Landing Subdivision 1897 Gordon Street, Draft Plan of Subdivision 23T-08505, City of Guelph, Gamsby & Mannerow, Revised December 17, 2013
- Springfield Golf and Country Club 2009 to 2013 Groundwater Monitoring Report, Stantec November 2013
- Environmental Implementation Report Addendum # 1, Bird Landing Subdivision, Draft Plan of Subdivision 23T-08505 (1897 Gordon Street), City of Guelph, October 23, 2013
- Environmental Implementation Report Bird Landing Subdivision, Draft Plan of Subdivision 23T-08505 (1897 Gordon Street), City of Guelph, February 13, 2013
- Geotechnical Investigation Gosling Gardens Extension 1897 Gordon Street, Guelph, Ontario, V.A. Wood (Guelph) Inc., January 2013
- Stormwater Management Final Design Report, Bird Landing Subdivision 1897 Gordon Street, Draft Plan of Subdivision 23T-08505, City of Guelph, Gamsby & Mannerow, Revised December 17, 2013
- 1897 Gordon Street (Bird Property) Environmental Impact Study and Tree Conservation Plan, 2nd Submission, City of Guelph, Aboud & Associates Inc., September 3, 2010
- Site Servicing and Stormwater Management Report, 1897 Gordon Street, City of Guelph, Gamsby & Mannerow, July 2010
- Preliminary Servicing Strategy for the Lands South of Clair Road with Appendix (separate file), City of Guelph, Gamsby & Mannerow Limited, April 2010
- Additional Geotechnical Investigation Proposed Residential Development, 1897 Gordon Street, City of Guelph, Ontario, V.A. Wood (Guelph Incorporated, December 2010
- City of Guelph Urban Design Action Plan, Urban Strategies Inc, May 2009
- Preliminary Geotechnical Investigation, Proposed Residential Development, Bird Property, City of Guelph, Ontario, V/.A. Wood (Guelph) Incorporated, December, 2004
- Hanlon Creek State-of-the-Watershed, Planning & Engineering Initiatives Ltd., September 2004
- Hanlon Creek Watershed Plan, Marshall Macklin Monaghan Limited et al., October 1993
- City of Guelph South Gordon Community Plan, Adopted by Guelph City Council on March 15, 1999, Administrative Update February 14, 2002
- Torrance Creek Subwatershed Study, Totten Sims Hubicki Associates et al., November 1998
- Mill Creek Subwatershed Plan, CH2M Gore & Storrie Limited, June 1996

4.3.2.2 Mapping and Drawings

The following mapping data have been provided and used for the baseline characterization and assessment of the surface water hydrology and hydraulics in the Clair-Maltby are:

- 2012 Contours and DEM of the Clair-Maltby SPA (City of Guelph)
- Existing building, property, streets, and infrastructure (storm, watermain, wastewater) (City of Guelph)
- 2006, 2009 and 2012 Aerial imagery (City of Guelph)
- 2018 Official Plan Land use (City of Guelph)
- Existing roads, property and buildings (Puslinch Township)
- 2018 Official Plan Land use (Puslinch Township)
- GRCA approved mapping for the open watercourse systems
- Subwatershed boundaries (GRCA)
- Contour mapping (GRCA)
- Surficial soils and surficial geology mapping (Province)
- Various As-built linear plans and profiles
- Southgate Business Park Third Submission Plan, 2011 IBI Group

4.3.3 Methods

4.3.3.1 Baseline Characterization

A baseline characterization of the existing hydrologic conditions within the Clair-Maltby SPA has been developed based upon a desktop review of the background information, mapping provided for this study and the two (2) year 2016-2017 monitoring conducted to-date. This review has characterized the existing drainage systems, soils, slopes, and land use conditions within the Clair-Maltby SPA, as well as lands contributing drainage to monitoring locations.

Drainage Systems

The Clair-Maltby SPA is located within the headwaters of the Torrance Creek Subwatershed, the Hanlon Creek Subwatershed and the Mill Creek Subwatershed, within the mid portion of the Grand River Watershed. The approximate contributing drainage areas within each Subwatershed within the Clair-Maltby SPA are summarized in Table 4.3.1.

Table 4.3.1: Summary of Contributing Drainage Areas within the Clair-Maltby SPA by Subwatershed

Subwatershed	Approximate Total Drainage Area (ha)	Percentage of the Clair Maltby SPA (%)
Torrance	5.24	1.0
Hanlon	320.90	60.0
Mill	209.17	39.0
Total Area	535.31	100

The lands within the Torrance Creek Subwatershed represent the headwaters of that subwatershed and discharge towards the Eramosa River located north of Stone Road East and east of Victoria Road South. The Torrance Creek does not become a defined riverine system until north of Arkell Road; within the Clair-Maltby SPA, the Torrance Creek drainage area consists of a network of storm sewers and overland drainage routes, primarily via existing roadways. The Torrance Creek subwatershed is also characterized by a significant number of depressional features, that capture overland drainage and infiltrate the drainage through sandy soils.

The lands within the Hanlon Creek Subwatershed generally drain overland to the northwest corner of the Clair-Maltby SPA. As per the Torrance Creek Subwatershed, the lands within the Hanlon Creek Subwatershed represent the headwaters of that subwatershed. Within the Hanlon Creek Subwatershed, the area within the Clair-Maltby SPA is also characterized by depressional features that result in little to no overland runoff to the defined watercourse system located north of the Clair-Maltby SPA, instead drainage is largely conveyed from the Clair Maltby SPA to the open watercourse via groundwater contributions.

The lands within the Mill Creek Subwatershed represent the headwaters of that Subwatershed and discharge toward the open watercourse system located south of Maltby Road South. The Mill Creek Subwatershed has a significant number of depressional features that contribute to the local ground water system.

Soils

Soils data within the Clair-Maltby SPA and the surrounding areas have been determined using the Provincial surficial geology mapping in the form of a GIS database (.dbf) and graphical (.shp) files. The surficial geology mapping within the limits of the north Clair-Maltby has been reviewed by the Wood Team based upon information provided within the background information and from Clair-Maltby landowner consultants where available. The resulting surficial geology mapping is presented in Figure HYD-4, Appendix D.

The information on Figure HYD-4 indicates that the surficial geology within the Clair-Maltby SPA consists primarily of loams, sand and some silty clay deposits. The soils within the Clair-Maltby area are known to be highly infiltrative, based on the numerous background reports provided by the City. Additional data on the surficial geology are documented in Section 4.2.

Slopes

The ground slopes at surface within the Clair-Maltby SPA have been characterized based upon the detailed 2012 DEM provided for this study by the City. The information in the DEM indicates that the surficial slopes within the area are relatively high, and are generally greater than 2 % with some areas approaching slopes as high as 8 % within the significant depressional features (ref. Figure HYD-6, Appendix D).

Land Use

Land use information provided by the City of Guelph and Puslinch Township has been used to characterize the existing land use conditions within the Clair-Maltby SPA and surrounding area within the respective subwatersheds (i.e. PSA and SSA). The existing land use mapping is presented on Figure HYD-3, Appendix D.

The existing land use conditions within the Clair-Maltby SPA are primarily open space, golf, agricultural, wooded areas, wetland and estate residential, which are consistent with the City's Official Plan. With some forests along and adjacent to the open watercourses within the Mill, Hanlon and Torrence Creek Subwatersheds.

The lands toward the north of the Clair-Maltby SPA are primarily residential, with some institutional, commercial and recreational land uses. The existing developments also include stormwater management facilities (i.e. greenways) to provide stormwater quality and quantity control.

The lands toward the west, which lie external to the Clair-Maltby SPA, are primarily industrial along the Hanlon Expressway corridor. South of Maltby Road East the lands are primarily agricultural and open space.

4.3.3.2 Field Monitoring

To understand and assess the Clair Maltby study area's unique surface water / ground water system and associated natural heritage character, a three (3) year monitoring program (2016-2018) has been conducted as part of the Comprehensive Environmental Impact Study (CEIS). The monitoring program is being conducted to supplement the available data from existing studies and reports and instrumentation. For the purpose of validating the hydrologic model, rainfall and flow monitoring (Stations 9A, 9B, 14 and 15) has taken place in addition to spot flow measurements.

Rainfall

For this CEIS, rainfall data from three local stations are being used:

- From a rainfall gauge installed (July 14, 2016) on the roof of the Guelph Home Building Supply, located at 500 Maltby Road East (ref. Map SW-1, Appendix E) intended to remain in place for the duration of the monitoring for this project, with data downloaded on a monthly basis;
- From the City's rainfall gauge on the EMS Centre at 160 Clair Road West (ref. Figure SW-1); and
- From the University of Guelph's rainfall gauge at the Guelph Turfgrass Institute at 328 Victoria Road South (available on-line).

As noted earlier, monthly precipitation (rainfall) data from the Clair-Maltby gauge for the months of April to December 2017 have been summarized in Table 4.1.4 (2016 values have also been provided for comparison) and compared to the monthly totals from Environment Canada's (EC) Elora gauge. The rainfall gauges are approximately 30 km apart which explains the difference in monthly rainfall amounts.

In addition to the monthly data presented in Table 4.1.4, daily rainfall totals for days with major storm events and high recorded water levels have been summarized in Table 4.1.4 for all data sources (ref. Map SW-1, Appendix E) (EC Elora, Clair-Maltby and City of Guelph's Clair Road rainfall gauges). Where storm systems have lasted multiple days, values have been summed. Daily rainfall amounts between the three (3) gauges for most storm events, demonstrated fairly consistent rainfall recordings. The City and the Wood rainfall gauges recorded 2017 storm event totals that are considered reliable, as there is limited deviation in the rainfall amounts, apart for the May 1, May 35 and October 24, 2017 events.

For 2017, five (5) storm events were above 25 mm and are considered significant, with the largest event occurring on June 23rd with a rainfall total of 39.4 mm over 9 hrs, which is comparable to 2 year storm event based on a 12 hour rainfall total of 39.9 mm at the Guelph Turfgrass Institute [Intensity Duration Frequency (IDF) relationship for 1954 to 2003]. Using the same IDF relationship all other events for 2017 would be considered to be less than a 2 year storm.

Flow Levels

One (1) gauge to monitor flow quantity in the Mill Creek Subwatershed was established near the south-east limit of the PSA (Station 14).

To monitor flow quantity in the Hanlon Creek Subwatershed, two (2) gauge locations (Stations 9A – Kilkenny Place and 9B – Serena Lane) had been tested over the summer of 2016 to monitor the discharge from the Hanlon Creek Subwatershed, draining to the north. Some minor flow responses were observed at the Serena Lane monitoring location for storms on August 20, August 25, and September 7, 2016 (ref. plots in Map SW-1 in Appendix E). However, the responses were minimal, and not considered to be significant enough to continue the monitoring at this location in 2017. A new location outside the PSA in the Hanlon Creek Subwatershed was identified in consultation with the City and GRCA for surface water monitoring (Station 15) and established in April 2017.

In the absence of a station with flow in the Hanlon Creek Subwatershed in 2016, one surface water level logger and water quality station were established in the southern extent of the large pond within Hall's Pond Provincially Significant Wetland (Station 7) in July 2016, with surface water level and quality data collected over the summer and fall of 2016. Although data from this station were used to inform the general surface water monitoring results in 2016, starting in 2017 data collected from this station were assessed in conjunction with data from the 11 other wetland monitoring stations (see Map SW-1, Appendix E).

Summary plots showing the observed water levels at Halls Pond for 2016 have been included in Appendix D.

Continuous water level monitoring was conducted for an open watercourse south of the study limits, within the municipality of Puslinch. The site is located on a private property at the end of Hammersely Road (Station 14). The site had continuously observed flow at all times during the monitoring period, suggesting a potential groundwater flow contribution. Velocity metering was conducted at this site over the course of 2016, which has been used to develop a preliminary rating curve for the site. The rating curve fit has been completed using a simplified HEC-RAS hydraulic model, based on topographic survey data.

The resulting recorded flow series at the Hammersley Road Station 14 site and the Hanlon Channel Station 15 site, have been included in Appendix D. Minimum and maximum water levels for both stations are provided in Table 4.3.2, with the Hammersley minimum and maximum water levels observed on November 29, 2017 and June 4, 2017 respectively. Minimum and maximum observed water levels for Station 14 occurred on April 30, 2017 and June 23, 2017.

Table 4.3.2 Observed 2017 Water Levels (m)

Minimum/ Maximum	Puslinch Channel (Station 14)	Hanlon Channel (Station 15)
Minimum Water Level	0.068	0.137
Maximum Water Level	0.248	0.327

Water levels and flows within the Hanlon Channel Station 15 site did not vary considerably during the monitoring period, with depths ranging from 0.14 m to 0.33 m and peak flows ranging from

0.02 m^3/s to 0.08 m^3/s respectively. Peak flows for the major recorded storm events of 2016 and 2017 are presented in Table 4.3.3.

Table 4.3.3: Estimated Peak Flows at Monitoring Station 14 (Hammersley Road) and Station 15 (Hanlon) for Major Storm Events Based on 2016 and 2017 Rating Curves

Date (M/D/Y)	Observed Rainfall (mm)	Observed Peak Flow (m^3/s)
Station 14		
2016		
7/25/2016	19.2	0.02
8/20/2016	52.0	0.10
8/25/2016	24.0	0.06
9/7/2016	33.6	0.02
11/2/2016	4.2	0.02
2017		
04/06/2017	27.8	0.05
04/20/2017	26.8	0.05
05/05/2017	14.2	0.04
05/25/2017	18.6	0.03
06/23/2017	39.4	0.04
07/01/2017	11.4	0.02
08/11/2017	12.6	0.01
11/05/2017	15.2	0.02
11/18/2017	15.4	0.02
Station 15 (Hanlon)		
04/06/2017	27.8	0.04
04/20/2017	26.8	0.04
05/05/2017	14.2	0.04
05/25/2017	18.6	0.06
06/23/2017	39.4	0.08
08/11/2017	12.6	0.05
11/18/2017	15.4	0.04

The streamflow data have been reviewed in order to determine whether the resulting peak flows and hydrogrpahs are representative of the anticipated hydrologic conditions, based upon the land use and soils within the contributing drainage areas. Based on the significant number of depressional features, most storm events do not result in a surface water response at the flow monitoring locations. The runoff response at the monitoring locations is considered largely a result of the local catchments immediately upstream of monitoring locations. In addition, both flow monitoring locations, Hanlon Creek (Station 15) and Hammersly (Station 14) are located downstream of groundwater discharge locations, which after certain storm events exhibit groundwater discharge conditions above the normal baseflow, therefore adding to the surface water response. Further discussion within the validation section has been provided on the storm events selected for hydrologic model validation.

4.3.4 Hydrologic Model

4.3.4.1 Hydrologic Model Development

Premised on the approved Work Plan, hydrologic analyses for the Clair-Maltby SPA have been completed using the PCSWMM modelling platform. The PCSWMM hydrologic model uses the EPA SWMM methodology as the central analytical platform for the hydrologic analyses, and includes a GIS-based pre-processor and post-processor to facilitate hydrologic model development and analysis of results. The EPA SWMM analytical methodology is fully supported and maintained by the US EPA.

Subcatchment Discretization

The PCSWMM modelling completed for the Clair-Maltby SPA has been developed using the 2012 DEM for the Clair Maltby SPA and Primary Study Area (PSA), while beyond the PSA, the GRCA contour mapping has been used. The subcatchment boundary plan for the overall PCSWMM hydrologic model is presented in Drawings HYD1 and HYD2 for the SPA and full model extent respectively.

Subcatchments have been developed to represent the drainage areas within each subwatershed, Hanlon Creek, Mill Creek and Torrance Creek to specific monitoring locations, which are located outside of the SPA. To develop subcatchment boundaries, the significant number of natural depressional features located within and adjacent to the Clair-Maltby SPA have been assessed to establish their cumulative storage volume for the contributing area, resulting in a depth (mm) of storage for each depressional feature (ref. Appendix D). Depressional features have been categorized into features with less (minor) or more (significant) than 300 mm of storage volume. The 300 mm storage volume threshold value was selected based on the Regional Storm Hurricane Hazel depth of approximately 285 mm, therefore each minor depressional feature with 300 mm storage or less may result in an overflow during a low probability (i.e. extreme) precipitation event. Drainage areas to minor depressional features were added to areas contributing directly to a significant depressional feature. The initial subcatchment plan Figure HYD-5 with areas defined for all depressional features is provided in Appendix D. The area-weighted depressional storage has been determined for areas contributing to minor depressional features, with a storage element representing the significant depressional features. Off-site greenway stormwater management facilities have also been represented using the foregoing approach. A total of 92 subcatchments with 49 storage elements has been developed using the foregoing approach; notably not every subcatchment has a significant depressional feature.

Each storage element has an outlet, modelled as either a weir, or in the case of some of the greenways, a culvert with a roadway weir based on the DEM. All of the greenways have been included in the model, with the combined storage volumes determined on per catchment basis. The DEM has been used to develop routing elements in the limited locations where overland flow drains from subcatchment to subcatchment.

Initial Parameterization

Soils

The PCSWMM model has used the Green-Ampt methodology to represent soil infiltration conditions. The Green-Ampt methodology is considered the most appropriate infiltration approach, as its parameters are based on well-defined physical values, and is the most appropriate for multiple-peaked or longer lasting storm events, and longer simulations. The soil parameters used in the PCSWMM modelling for the corresponding soils are presented in Table 4.3.4, with the soil types and parameterization indicated in italics being used for the local soils.

Table 4.3.4 Soil Parameterization for PCSWMM Hydrologic Model

Soil Type	Conductivity (mm/hr)	Suction Head (mm)	Initial Moisture Deficit (fraction)
Sand	235.6	49.5	0.346
Loamy Sand	59.8	61.3	0.312
Sandy Loam	*21.8*	*110.1*	*0.246*
Loam	*13.2*	*88.9*	*0.193*
Silt Loam	6.8	166.8	0.171
Sandy Clay Loam	3	218.5	0.143
Clay Loam	2	208.8	0.146
Silty Clay Loam	2	273	0.105
Sandy Clay	1.2	239	0.091
Silty Clay	*1*	*292.2*	*0.092*
Clay	0.6	316.3	0.079

The soil parameters for each subcatchment within the PCSWMM hydrologic model have been established based upon the surficial geology mapping (ref. Drawing HYD4) and applying the LOOKUP function within PCSWMM to determine the areally-weighted soil parameters for the subcatchment layer

Imperviousness

The impervious coverage for the subcatchments within the PCSWMM hydrologic model has been determined using the City of Guelph Official Plan land use with verification using aerial mapping. Imperviousness values for the different land uses have been applied based on standard values adopted in previous watershed-scale studies, [ref. Credit River Flow Management Study (Philips Engineering Ltd., 2007) and the Sixteen Mile Creek Subwatershed Update Study (AMEC, 2015)]. More recently directly connected impervious values had been developed for the Town of Oakville Stormwater Master Plan, which have been used for this study. The directly connected imperviousness values, by land use, are presented in Table 4.3.5.

Table 4.3.5 Directly Connected Imperviousness for Various Land Use Types

Land Use Designation	Impervious Coverage (%)
Community Mixed Use Centre	88
Corporate Business Park	88
General Residential	60
High Density Residential	80
Industrial	78
Institutional / Research Park	84
Low Density Greenfield Residential	40
Low Density Residential	35
Major Institutional	88
Medium Density Residential	70
Mixed Business	88
Mixed Office Commercial	85
Mixed Use Corridor	88
Neighbourhood Commercial Centre	85
Neighbourhood Commercial Centre	86
NHS	5
Open Space and Park	10
Other	5
Road	65
Road	75
Service Commercial	85

The impervious coverage for each subcatchment within the PCSWMM hydrologic model has been established based upon the 2018 City of Guelph's and Puslinch Township's Official Plans land use mapping and applying the LOOKUP function within PCSWMM to determine the areally-weighted directly connected imperviousness for the subcatchment layer. Verification of land use has been conducted using aerial mapping.

Subcatchment Slope

Subcatchment slope in the PCSWMM model represents the slope of the overland flow path. Previous sensitivity analyses conducted by Wood for other PCSWMM modelling exercises have shown that this is a relatively insensitive parameter, and has a nominal influence on the modelling results. Given this, and the variability in overland flow slope for the study area subcatchments, the overall subcatchment slope has been considered to be representative of the overland flow slope. This parameter has been calculated using a average catchment slope based on the DEM.

Overland Roughness

Overland flow roughness parameters of 0.01 and 0.10 have been applied for the impervious and pervious land segments respectively. The roughness coefficient for the pervious land segments is an order of magnitude higher in order to account for the slow travel time (sheet flow) across this land segment. The selected values are consistent with literature values (ref. Table 26.6 of the User's guide to SWMM5, 12th edition, 2008).

Overland Flow Length

PCSWMM (and EPA SWMM) does not apply a unit hydrograph approach for the transformation of excess rainfall depth to runoff flow. Rather, it applies a conceptual rectangular channel element where the channel width is determined by the overland flow length (Width = Area / Length). Manning's equation is then applied to determine the relationship between flow and depth. The conceptual channel element is meant to represent overland (sheet) flow, which has a significantly slower travel time than channel flow. The overland flow length therefore is an indirect substitute for time of concentration, in that the length affects the hydrograph form and duration. Longer overland flow lengths naturally result in longer times of concentration.

For urban land uses, the overland flow length is typically defined as the distance from the back of a representative lot to the street. For rural land uses, it can be measured as the average of the maximum overland flow path lengths (i.e. from the edge of the sub-catchment to the nearest identified channel section). Based on a review of available literature (EPA SWMM Applications Manual, 2009), a maximum overland flow path length of 500 feet, or approximately 150 m should be applied.

Based on input from agencies on previous PCSWMM subwatershed assessments, the appropriateness of applying the 150 m maximum limit to the surface length for rural subcatchments had been further assessed. The results of the assessment resulted in a preferred approach to establishing overland flow length [ref. Guo and Urbonas (August 2009)], which measures the physical length of the overland channel within the rural catchment, and applied a scaling factor of 1-7 which provides the best agreement between the simulated peak flow generated by the single catchment model and the more refined catchment model. This method has been applied within Clair-Maltby.

4.3.4.2 Model Validation

Model validation represents the process of modifying the model parameters, in order to reproduce observed runoff responses at streamflow gauges using observed rainfall data collected within or near the study area for the coinciding storm event (Note: With limited period data, 3 years or less, models are typically validated rather than calibrated; calibration typically requires at least 5 years of data 0.6*). Whenever possible, the validation process strives to limit the parameter adjustment to comply within an acceptable range of values consistent with scientific research and/or the methodology and documentation specific to the model software applied, with the range corresponding to the level of uncertainty associated with the model parameter and the source of information used to establish the initial values. Preference is placed upon first adjusting those parameters which are deemed most sensitive (i.e. which result in the greatest difference to simulated peak flow and/or runoff volume), since, in principle, model validation using only these values would require minor deviations and/or differences compared to the initial values established for the model. Once the most sensitive parameters have been adjusted to provide an optimal correlation between the observed and simulated responses, less sensitive parameters can be adjusted, if necessary, to further improve upon the condition.

Watershed scale model validation may be completed by applying a global parameterization approach or a local parameterization approach. A global parameterization approach seeks to establish a set of parameters for each soil type and land use condition within the watershed which, when applied uniformly throughout the watershed, yield an overall "best fit" of the simulated response to the observed response. Depending upon the quantity and quality of the data applied for model validation, this validation approach may yield a simulated response which, overall, is statistically similar to the observed response, but which generates local responses in smaller watercourses or catchment areas which can differ significantly from the observed response (i.e. simulated local responses are either significantly higher or lower than the observed responses, with little to no simulated local responses which are close to the observed responses).

A local parameterization approach seeks to establish model parameters for the contributing area to each flow gauge which yield the "best fit" of the simulated response to the observed response at each individual streamflow gauge. The local parameterization approach typically results in different sets of values for each contributing drainage area to the streamflow gauges used for validation. While the local parameterization approach would be anticipated to yield a better statistical fit locally and overall, compared to a global parameterization approach, the different values generated through this approach may in some circumstances be inconsistent with fundamental principles of hydrology (e.g. significantly different infiltration rates may be used for the same soil types in different parts of the watershed).

Recognizing the inherent assumptions and limitations associated with each approach, as well as the scale of the analyses completed for this study, the validation of the PCSWMM model for the

Clair-Maltby SPA has applied a global parameterization approach, whereby the parameters for a given soil type have been assumed to be uniform throughout the Watershed.

The validation of the PCSWMM hydrologic model has proceeded based on parameterization using the flow data collected for the Hanlon Creek monitoring site (Station 15) and the Mill Creek (Hammersly) (Station 14) monitoring site for the 2016 to 2017 monitoring period.

Parameter Refinement and Subwatershed-Scale Validation

The PCSWMM hydrologic model has been executed for the 2016 to 2017 monitoring period. The observed and simulated runoff hydrographs have been compared for both dry event and wet event periods using the rainfall hyetographs for the rainfall gauge installed on the roof of the Guelph Home Building Supply.

For both the Hanlon Creek and Mill Creek monitoring locations, and each of the 2016 and 2017 monitoring years (2017 only for Hanlon Creek), a baseflow contribution from groundwater discharge was noticed. The Hanlon Creek groundwater discharge occurs within the permanent pool of stormwater management facility located upstream of the monitoring station. The baseflow for the Mill Creek monitoring location is a result of groundwater seepage (groundwater spring) located upstream of the monitoring gauge. Based on the foregoing, a baseflow of 0.08 m^3/s and 0.03 m^3/s has been added for the subcatchments directly contributing to the Mill Creek and Hanlon Creek monitoring stations respectively.

The second adjustment to the PCSWMM hydrologic model has involved an increase to the percentage of impervious coverage which is routed across pervious surfaces. The PCSWMM hydrologic model default for the percentage of impervious coverage routing over pervious lands segments is zero (0). Typically a certain percentage of drainage from roof areas discharges to pervious land areas before being reaching roadways or parking surfaces. Based on previous PCSWMM hydrologic modelling assessments, the impervious coverage to be routed over pervious lands segments has been increased to 40%. A review of the simulated hydrographs at the Mill Creek Station resulted in the impervious coverage being routed increased to 50%. Increasing the impervious percentage routed over pervious land segments results in slightly reduced peak flows and runoff volumes.

A third adjustment to the PCSWMM modelling was required for the catchments representing the greenway stormwater management facilities within the Mill Creek and Torrance Creek subwatersheds. Runoff responses were occurring downstream of the greenways for relatively insignificant storm events. The greenways had been modelled based on the loam soils within the Clair-Maltby SPA. Based on the background information, the greenways have been designed to infiltrate storm events up to the 100 year storm event due to 0.30 m sand base with the greenways.

To model the infiltrative capabilities of the greenways, the soils within the storage elements representing the green ways has been revised to sand.

The PCSWMM hydrologic model has been executed in continuous mode for the 2016-2017 monitoring period, and the simulated peak flows and runoff volumes for the 2016-2017 storm events have been extracted from the model results and compared to the observed responses at all monitoring stations to assess model performance associated with the parameter changes. The soil parameters of hydraulic conductivity, suction head, and initial moisture deficit applied a global approach for parameter adjustment, whereby the relative adjustment for the given parameter (i.e. conductivity, suction head, and initial moisture deficit) was applied to the parameter for all soils.

Hydrographs for the 2016 and 2017 monitoring periods have been provide in Figures 4.3.1 to 4.3.3. The simulated hydrographs for each flow monitoring station provide a reasonable fit to the observed hydrographs. The peak flows observed at each location are less than 0.10 m^3/s which are considered low and make the validation process difficult, as there is a small flow range. The Hanlon Creek monitoring site has only one (1) year of data, as such the number of available events is currently only four (4). Both flow monitoring stations are downstream of groundwater discharge locations. The Hanlon Creek 2017 observed hydrograph exhibits a one (1) month long increase in flow in August and September 2017, when minimal rainfall occurs, which is a result of groundwater discharge (ref. Section 4.2). Groundwater discharge impacts the response to each precipitation event, resulting in runoff hydrographs and peak flows comparison not always having the anticipated correlation. Figures 4.3.4 to 4.3.7 provide a comparison of peak flows and runoff volumes for the selected validation storm events.

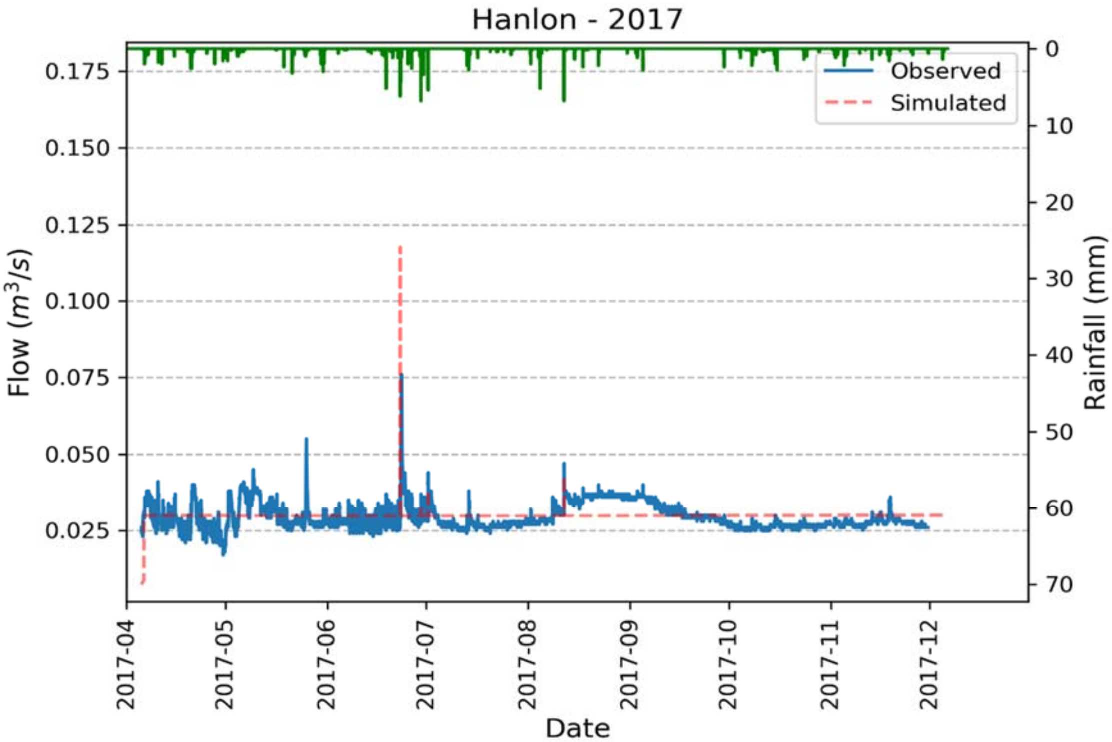


Figure 4.3.1: Hanlon Creek Monitoring Station 15 2017 Observed and Simulated Flow Hydrograph

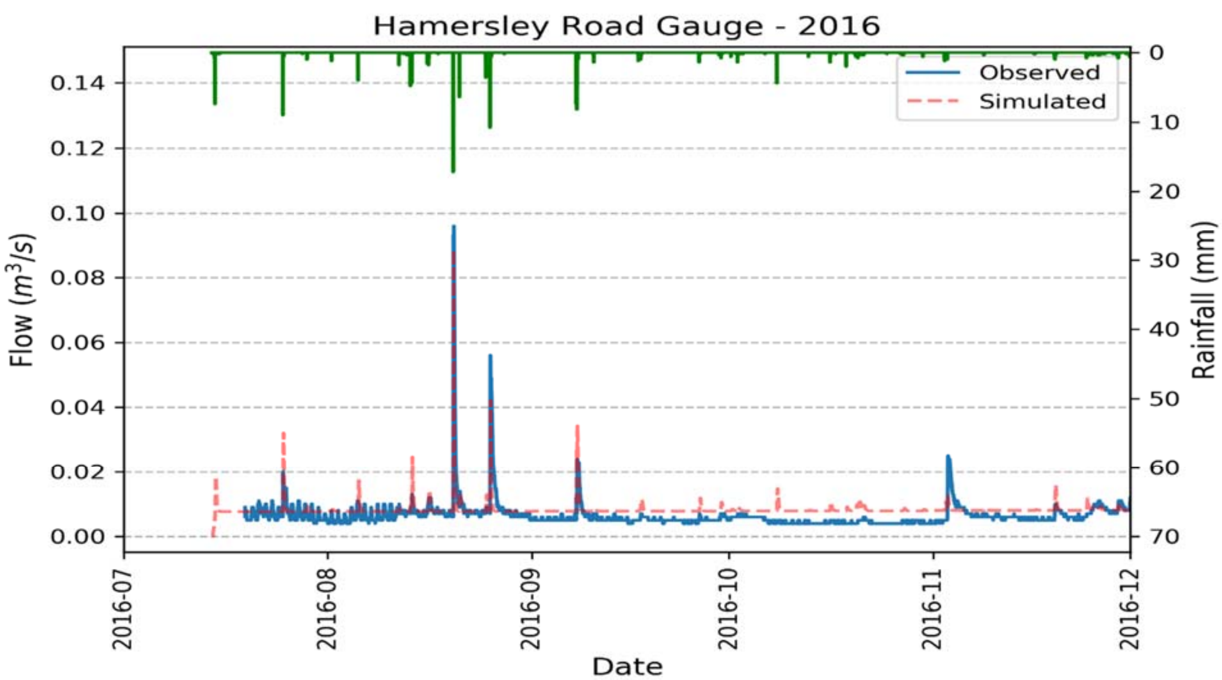


Figure 4.32: Mill Creek Monitoring Station 14 2016 Observed and Simulated Flow Hydrograph

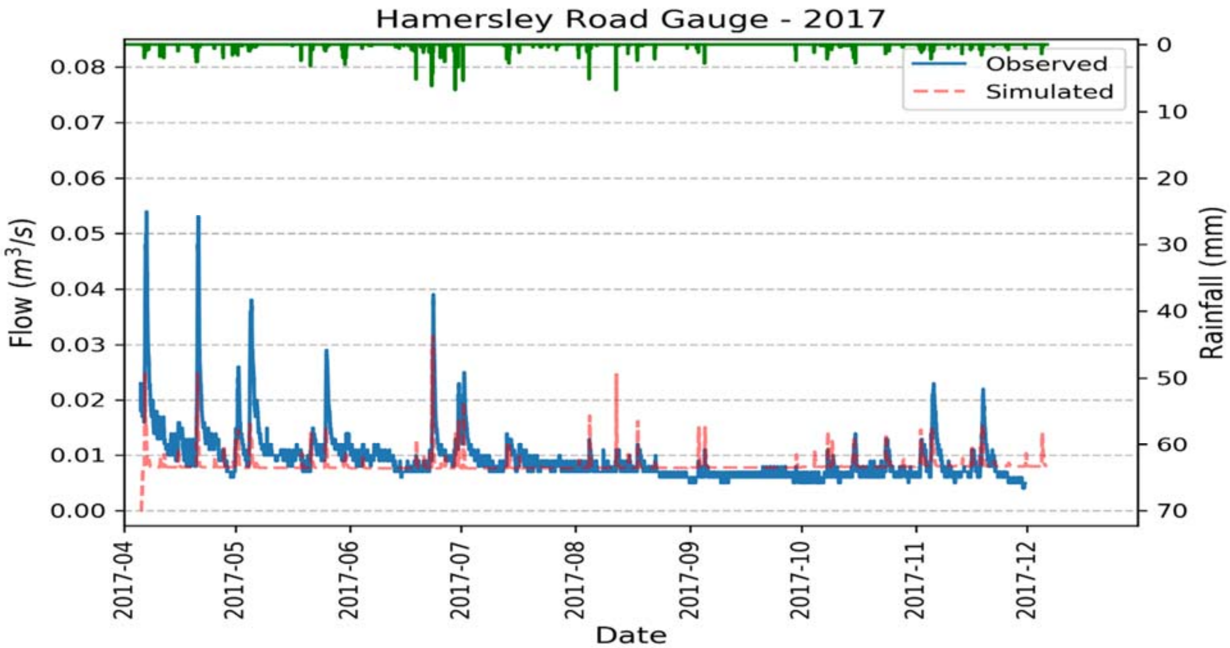


Figure 4.3.3: Mill Creek Monitoring Station 14 2017 Observed and Simulated Flow Hydrograph

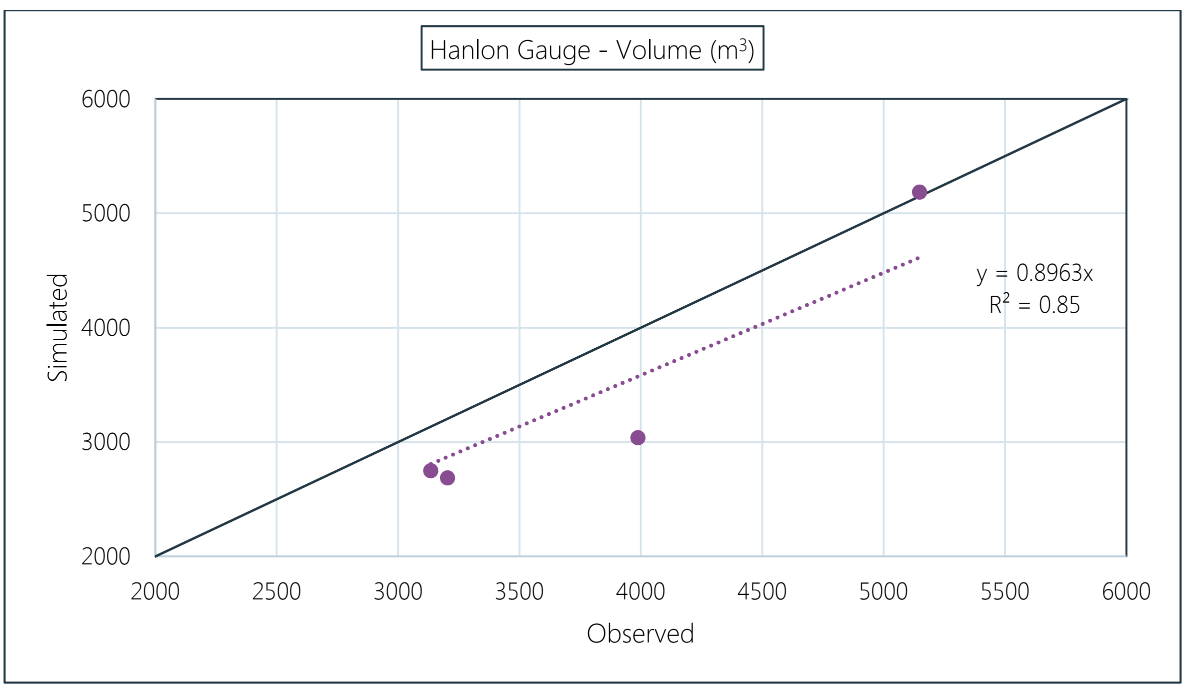


Figure 4.3.4: Comparison of Observed and Simulated Runoff Volumes for Hanlon Creek Monitoring Station 15

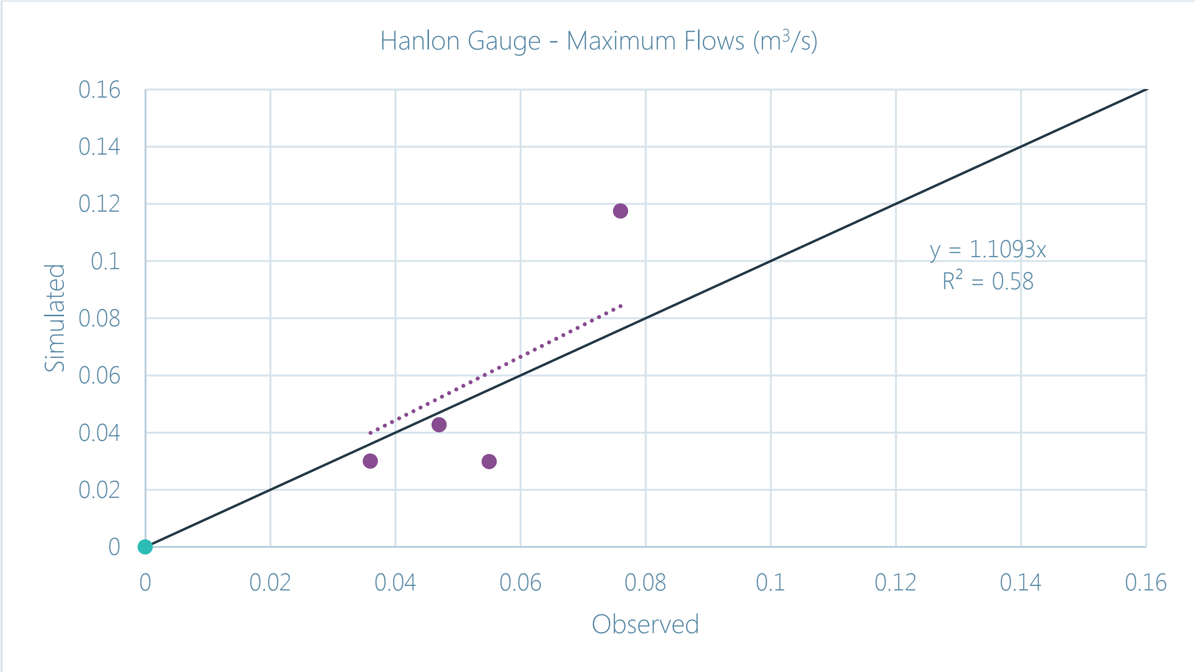


Figure 4.3.5: Comparison of Observed and Simulated Peak Flows for Hanlon Creek Monitoring Station 15

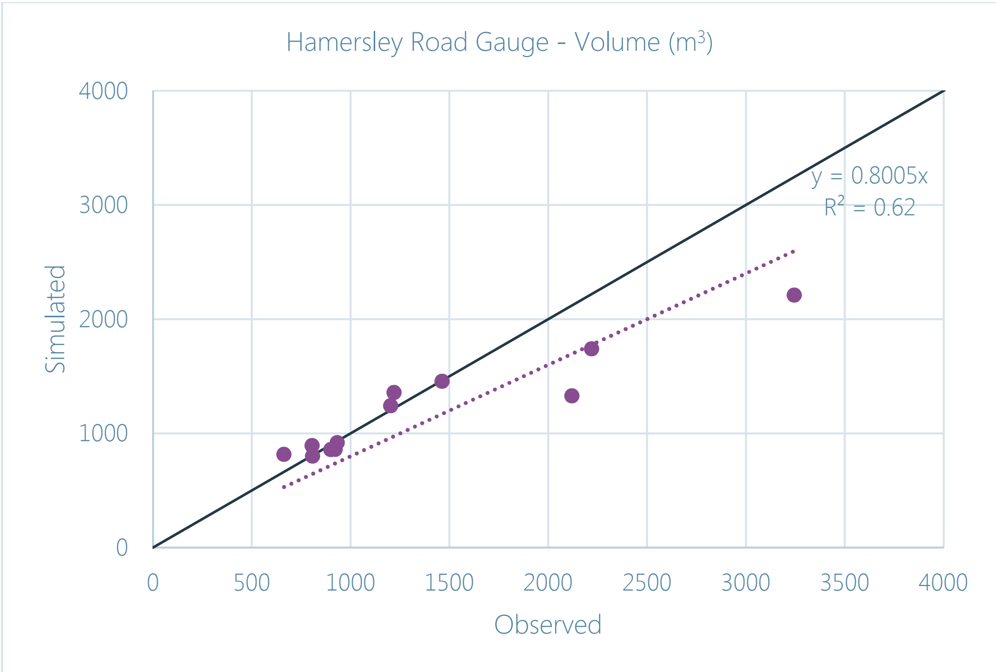


Figure 4.3.6: Comparison of Observed and Simulated Runoff Volumes for Mill Creek Monitoring Station 14

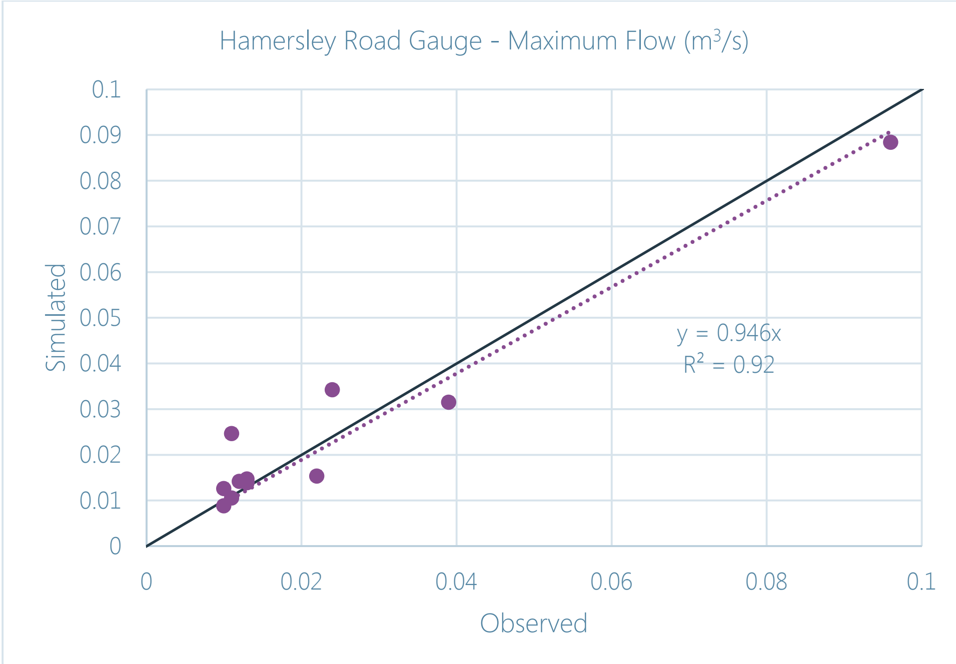


Figure 4.3.7: Comparison of Observed and Simulated Peak Flows for Mill Creek Monitoring Station 14

The detailed validation events are provided in Table 4.3.6. The Hanlon Creek flow monitoring commenced in 2017, therefore only 1 year (spring to fall) of flow data are available. In selecting validation events, groundwater discharge to both flow monitoring locations adds to the surface water response, as such peak flows and runoff volumes are influenced by the groundwater discharge. The Hanlon Creek monitoring site exhibits periods of significant groundwater discharge and groundwater response subsequent to storm events, based on the duration of the flow hydrographs. The Mill Creek flow monitoring site exhibits less groundwater response following storm events and provides better observed versus simulated runoff volumes and observed peak flows versus the Hanlon Creek flow monitoring site.

Table 4.3.6 Validation Event Detailed Results

Year	Date	Duration (hrs)	Rainfall (mm)	Observed Runoff Volume (m3)	Simulated Runoff Volume (mm)	Percentage Difference %	Observed Peak Flow (m^3/s)	Simulated Flow (m^3/s)	Percentage Difference %
Hanlon Creek Flow Monitoring Station 15									
2017	May 25	8.6	19.8	3204	2686	-16	0.055	0.030	-45
	June 23	3.2	39.4	3988	3037	-24	0.076	0.117	54
	Aug 11	0.66	12.6	3135	2748	-12	0.047	0.043	-9
	Nov 18	7.2	20.2	5148	5183	1	0.036	0.030	-17
Mill Creek Flow Monitoring Station 14									
2016	Aug 11	0.16	2.6	1220	1358	11	0.010	0.009	-10
	Aug 16	2.83	10.6	808	801	-1	0.012	0.014	17
	Aug 19	0.42	52.0	3245	2210	-32	0.096	0.088	-8
	Sept 7	2.92	33.6	1203	1241	3	0.024	0.034	42
	Nov 28	7.2	4.2	1463	1456	0	0.011	0.011	0
2017	Jun 23	3.16	39.4	2120	1328	-37	0.039	0.031	-21
	Aug 11	0.66	12.6	806	892	11	0.011	0.025	127
	Oct 9	1.75	7.6	663	816	23	0.010	0.012	20
	Oct 23	3.16	10.8	923	860	-7	0.013	0.014	8
	Nov 2	7.8	12.0	933	918	-2	0.013	0.015	15
	Nov 18	7.2	20.2	2220	1740	-22	0.022	0.015	-32

4.3.4.3 Hydrologic Analysis

Peak Flows

A continuous climate data set (precipitation, temperature, evapotranspiration) has been prepared for both the groundwater and surface water modelling. The precipitation dataset provided extends from 1950 to 2017 (67 years), and covers the full year for each year of the dataset (i.e. January to December inclusive). The climate data set has used the following information:

- 1950-2005: Guelph Turfgrass Institute (GTI) hourly and daily precipitation data, hourly temperature and daily evapotranspiration
- 2006: Combined GRCA Guelph Lake and Environment Canada (EC) Roseville and Elora stations hourly precipitation. GTI hourly temperature and daily evapotranspiration.
- 2007: Combined EC Roseville and Elora stations hourly precipitation. GTI hourly temperature and daily evapotranspiration
- 2008-2015: Combined GRCA Guelph Lake and Environment Canada (EC) Roseville and Elora stations hourly precipitation. GTI and Waterloo-Wellington hourly temperature and daily evapotranspiration
- 2016-2017: Monitoring Program and Waterloo-Wellington hourly precipitation data, GTI and Waterloo-Wellington hourly temperature and daily evapotranspiration

The validated PCSWMM hydrologic model has been executed for the continuous simulation, and simulated annual peak flows for the Hanlon Creek and Mill Creek monitoring sites have been extracted from the continuous simulation dataset, and frequency analyses using Consolidated Frequency Analysis (CFA) have been completed using the Three Parameter Lognormal, Log Pearson Type III Distribution, GEV and Wakeby Distributions with the Log Pearson Type III Distribution providing the best fit to the annual maximum peak flows. Full results of the frequency analyses are provided in Appendix 'D'. Frequency flows for both flow monitoring locations have been provided in Table 4.3.7. Frequency flows for both Mill Creek and Hanlon Creek are low (<1.5 m^3/s) for the 100 year, based on the significant influence of depressional features and the existing greenway systems, infiltrating most of the 100 year storm runoff.

In addition to frequency flows being determined using the 67 year data set, peak flows have been determined using the City of Guelph 3 hour Chicago design storms for the 2 to 100 year storm events, along with the Regional Storm (Hurricane Hazel), with peak flows provided within Table 4.3.8. The design event peak flows are dissimilar to the frequency flows based on continuous simulation, in that Hanlon Creek peak flows are lower. The Hanlon Creek monitoring site is downstream of the greenways which, as noted, have been designed to infiltrate the 100 year storm event, as such this result is not unexpected. That said, the Mill Creek design event peak flows for storm event less frequent than a 10 year return period, are significantly more than the frequency flows, which indicates that the local catchment contributing to the Mill Creek monitoring station, responds more to synthetic design storm events than actual precipitation.

Table 4.3.7 Frequency Peak Flows (m^3/s)

Location	Return Period								
	1.003	1.050	1.25	2	5	10	20	50	100
Hanlon Creek Monitoring Site[1]	0.008	0.036	0.100	0.250	0.530	0.760	0.990	1.310	1.550
Mill Creek Monitoring Site[1]	0.035	0.038	0.039	0.045	0.069	0.100	0.160	0.290	0.480

Note: [1.] Log Pearson Type III Distribution

Table 4.3.8 Design Storm Event Peak Flows (m^3/s)

Location	2	5	10	25	50	100	Regional
Hanlon Creek Monitoring Site	0.50	0.67	0.70	0.71	0.72	0.74	0.82
Mill Creek Monitoring Site	0.04	0.06	0.08	0.32	1.37	2.81	4.75

Water Balance

In addition to determining frequency flows and design event peak flows at the two (2) monitoring locations, the 1950-2017 climate data set has been used to determine an annual water balance (surface based water modelling) within the Clair-Maltby SPA and to the monitoring locations (flow and spot flow) within the Clair-Maltby Secondary Study Area (SSA) (ref. Drawing HYD2). The Clair-Maltby SPA is located at the headwaters of the Hanlon Creek, Torrance Creek and Mill Creek and with the significant number of the depressional features and lack of overland drainage routes and watercourses, surface runoff is predominantly infiltrated or evaporated.

The annual water balance assessment has been conducted for each subwatershed based on the subcatchments contributing to the monitoring locations within Mill Creek, Torrance Creek and Mill Creek (ref. Tables 4.3.9 to 4.3.11). In addition, the annual water balance has been conducted for the significant depressional features (ref. Table 4.3.12), with storage greater than 300 mm storage volume (ref. Figure HYD2). The significant depressional features, not including depressional wetlands have at this stage of the study been considered as potential locations for stormwater management facilities within the proposed land use framework.

As the annual water balance has been simulated for 67 years of climate data, detailed results have been provided within Appendix D. Based on the results in Tables 4.3.9 to 4.3.11, Hanlon Creek has the largest outflow. Each creek system annually has a loss (infiltration and evaporation) of 93% to 98% of the total precipitation, with Torrance Creek infiltrating the least, due to some existing development. Each creek system exhibits high annual infiltration, due to the depressional features and greenways, which will have to be replicated within the Clair-Maltby SPA.

The water balance results in Table 4.3.12 indicate that out of the forty-seven (47) significant depressional features with storage volume greater than 300 mm, only seven (7) incurred outflow during the 67 year continuous simulation period. The depressional features infiltrate most of the precipitation throughout the 67 year simulation period, with little outflow to downstream subcatchments or drainage systems.

The annual groundwater modelling has determined infiltration and evaporation to above 800 mm, which represents a reasonable corroboration between the surface water and groundwater modelling.

Table 4.3.9 Hanlon Subwatershed Annual Water Balance Summary

	Precipitation (mm)	Baseflow (mm)	Starting Snow Depth (mm)	Infiltration (mm)	Evaporation (mm)	Ending Snow Depth (mm)	Outflow (mm)	Net (mm)
Mean	856.46	115.20	19.88	842.98	26.94	19.82	115.49	-15.03
Median	846.34	115.12	9.18	828.41	26.34	9.18	115.21	-12.40
Min	543.18	115.10	0.00	532.00	19.26	0.00	114.73	-78.39
Max	1137.70	115.43	103.72	1127.13	38.38	103.60	121.18	5.07
Std Dev.	126.26	0.14	24.48	124.58	4.10	24.44	1.08	13.34

Table 4.3.10 Mill Creek Subwatershed Annual Water Balance Summary

	Precipitation (mm)	Baseflow (mm)	Starting Snow Depth (mm)	Infiltration (mm)	Evaporation (mm)	Ending Snow Depth (mm)	Outflow (mm)	Net (mm)
Mean	856.46	24.76	19.88	843.18	11.95	19.82	34.45	-8.30
Median	846.34	24.74	9.18	830.49	11.70	9.18	33.70	-5.90
Min	543.18	24.74	0.00	537.71	8.44	0.00	29.13	-59.80
Max	1137.70	24.81	103.72	1125.45	17.35	103.60	45.91	12.04
Std Dev.	126.26	0.03	24.48	122.88	1.87	24.44	2.94	12.75

Table 4.3.11 Torrance Subwatershed Annual Water Balance Summary

	Precipitation (mm)	Baseflow (mm)	Starting Snow Depth (mm)	Infiltration (mm)	Evaporation (mm)	Ending Snow Depth (mm)	Outflow (mm)	Net (mm)
Mean	856.46	0.00	19.88	804.64	41.74	19.82	29.38	-19.24
Median	846.34	0.00	9.18	792.55	40.44	9.18	27.99	-18.36
Min	543.18	0.00	0.00	507.78	30.07	0.00	13.76	-48.31
Max	1137.70	0.00	103.72	1069.55	58.40	103.60	58.85	2.94
Std Dev.	126.26	0.00	24.48	117.28	6.15	24.44	8.67	9.74

Table 4.3.12 Significant Depressional Features' Annual Water Balance Averages (1950 – 2017)

Depressional Feature ID	Precipitation (mm)	Starting Snow Depth (mm)	External Inflow (mm)	Infiltration (mm)	Evaporation (mm)	Ending Snow Depth (mm)	Outflow (mm)	Net (mm)
ST5	856.46	19.88	0.00	864.93	4.58	19.82	0.00	-12.99
ST7	856.46	19.88	0.00	865.46	4.36	19.82	0.00	-13.30
ST9	856.46	19.88	0.00	838.10	40.86	19.82	0.00	-22.44
ST11	856.46	19.88	0.00	854.90	13.83	19.82	0.00	-12.21
ST12	856.46	19.88	0.00	857.30	11.46	19.82	0.00	-12.24
ST13	856.46	19.88	0.00	844.32	22.49	19.82	0.00	-10.28
ST14	856.46	19.88	0.00	866.59	4.30	19.82	0.00	-14.37
ST17	856.46	19.88	0.00	833.79	27.44	19.82	0.00	-4.71
ST18	856.46	19.88	0.00	861.91	7.40	19.82	0.00	-12.78
ST19	856.46	19.88	0.00	862.75	7.29	19.82	0.00	-13.52
ST21	856.46	19.88	0.00	858.10	11.39	19.82	0.00	-12.97
ST24	856.46	19.88	0.00	856.61	11.83	19.82	0.00	-11.92
ST26	856.46	19.88	0.00	864.51	5.35	19.82	0.00	-13.34
ST27	856.46	19.88	0.00	856.35	12.73	19.82	0.00	-12.57
ST29	856.46	19.88	0.00	862.26	7.89	19.82	0.00	-13.63
ST30	856.46	19.88	0.00	865.01	4.87	19.82	0.00	-13.35
ST32	856.46	19.88	0.00	849.63	18.12	19.82	0.00	-11.22
ST33	856.46	19.88	0.00	850.62	17.41	19.82	0.00	-11.51
ST34	856.46	19.88	0.00	843.32	24.06	19.82	0.00	-10.86
ST37	856.46	19.88	0.00	859.10	9.57	19.82	0.00	-12.15
ST40	856.46	19.88	0.00	846.98	20.85	19.82	0.00	-11.30
ST42	856.46	19.88	0.00	845.72	14.49	19.82	0.22	-3.91
ST43	856.46	19.88	0.00	860.10	11.92	19.82	0.00	-15.50
ST44	856.46	19.88	0.00	844.48	23.08	19.82	0.00	-11.04
ST47	856.46	19.88	0.00	863.30	6.33	19.82	0.00	-13.11
ST48	856.46	19.88	0.00	865.55	4.36	19.82	0.00	-13.39
ST50	856.46	19.88	0.00	842.35	23.01	19.82	3.62	-12.46

Table 4.3.12 Significant Depressional Features' Annual Water Balance Averages (1950 – 2017)

Depressional Feature ID	Precipitation (mm)	Starting Snow Depth (mm)	External Inflow (mm)	Infiltration (mm)	Evaporation (mm)	Ending Snow Depth (mm)	Outflow (mm)	Net (mm)
ST51	856.46	19.88	0.00	855.69	11.28	19.82	0.00	-10.45
ST54	856.46	19.88	0.00	865.52	4.36	19.82	0.00	-13.36
ST58	856.46	19.88	0.00	843.60	23.63	19.82	0.00	-8.70
ST59	856.46	19.88	0.00	864.56	5.84	19.82	0.00	-13.88
ST71	856.46	19.88	0.00	827.13	38.88	19.82	0.00	-9.49
ST72	856.46	19.88	0.00	835.67	28.44	19.82	0.00	-7.59
ST79	856.46	19.88	0.00	866.51	4.31	19.82	0.00	-14.30
ST81	856.46	19.88	0.00	854.80	14.24	19.82	0.00	-12.52
ST82	856.46	19.88	0.00	836.77	29.83	19.82	0.00	-10.08
ST83	856.46	19.88	0.00	857.02	9.91	19.82	0.00	-10.41
ST88	856.46	19.88	0.00	865.11	4.91	19.82	0.00	-13.50
STU1	856.46	19.88	0.00	836.99	36.78	19.82	0.86	-18.12
STU6	856.46	19.88	0.00	821.47	59.07	19.82	0.28	-24.30
STU8	856.46	19.88	0.00	820.08	58.57	19.82	0.00	-22.13
STU15	856.46	19.88	0.00	822.45	57.40	19.82	0.19	-23.52
STU31	856.46	12.12	19.88	828.23	51.07	19.82	7.07	-17.73
STU38	856.46	19.88	0.00	784.83	22.31	19.82	60.74	-11.36
STU92	856.46	19.88	0.00	820.01	57.05	19.82	0.00	-20.53
STU95	856.46	19.88	0.00	818.89	55.69	19.82	0.04	-18.09
STU96	856.46	19.88	0.00	816.03	49.18	19.82	14.60	-23.29

The combined infiltration and evaporation values in table 4.3.9 to 4.312 provide a guide for water balance developing targets for the future land use condition. Based on the Clair-Maltby existing drainage system, the proposed drainage system for the future land use condition would have little annual outflow, based on most of the annual precipitation being infiltrated and evaporated.

4.4 Surface Water Quality

4.4.1 Importance/Purpose

The purpose of the water quality assessment has been to characterize the water quality health of the Clair-Maltby SPA based on the associated subwatershed studies and study data collection with respect to contaminant loadings under existing land use conditions, and to establish a baseline condition which can be used for the impact assessment during the next Study Phase. As most of the Clair-Maltby SPA does not drain overland to an open watercourse system, rather the area drains to depressional features that contribute to the groundwater system, impacts to the surface water quality through development are expected to become groundwater quality impacts. Surface water impacts could also impact natural features (i.e. wetlands and woodlands), which are often coincident with depressional features. Groundwater quality impacts may result in future implications for drinking source water protection, that said Guelph's water supply is not linked to the groundwater within the Clair-Maltby SPA. Guelph's Source Water Protection Plan Policies are part of the GRCA's Source Water Protection Plan Policies that restrict land uses that may impact ground water and require preventative measures such as stormwater management measures that protect groundwater.

4.4.2 Background Information

The following background information has been provided for reference to characterize the surface water quality within the Clair-Maltby area.

Reports

- Hanlon Creek Business Park 2009 -2011 Consolidated Monitoring Reports, City of Guelph, 2012-2013
- Westminster Woods East Subdivision 2009 Monitoring Report, Stantec Consulting Ltd., March 2010
- Hanlon Creek State-of-the-Watershed, Planning & Engineering Initiatives Ltd., September 2004
- Hanlon Creek Watershed Plan, Marshall Macklin Monaghan Limited et al., October 1993
- City of Guelph South Gordon Community Plan, Adopted by Guelph City Council on March 15, 1999, Administrative Update February 14, 2002
- Torrance Creek Subwatershed Study, Totten Sims Hubicki Associates et al., November 1998
- Mill Creek Subwatershed Plan, CH2M Gore & Storrie Limited, June 1996

Mapping

- 2012 Contours and DEM of the Clair-Maltby SPA (City of Guelph)
- Existing building, property, streets, and infrastructure (storm, watermain, wastewater) (City of Guelph)
- 2006, 2009 and 2012 Aerial imagery (City of Guelph)

- 2018 Official Plan Land use (City of Guelph)
- Existing roads, property and buildings (Puslinch Township)
- 2018 Official Plan Land use (Puslinch Township)
- GRCA approved mapping for the open watercourse systems
- Subwatershed boundaries (GRCA)
- Contour mapping (GRCA)
- Surficial soils and surficial geology mapping (Province)

Water Quality Data

Surface water quality monitoring has been previously conducted for each of the Mill Creek, Torrance Creek and Hanlon Creek Subwatershed studies and for the Heritage Green Community, therefore providing an indication of historic water quality conditions. The Torrance Creek water quality was indicated as reasonable water quality, apart from nitrates, total phosphorous and ecoli exceeded the PWQO. Hanlon Creek temperatures have been measured above 23°C due to a lack of canopy cover. Water quality for Mill Creek was noted as impaired due to Ecoli, Total Phosphorus, Aluminum, Copper, Lead Manganese and Zinc being above the PWQO.

4.4.3 Methods

In accordance with the Approved Terms of Reference for the Clair-Maltby CEIS and the CEIS Work Plan, a three (3) year monitoring program commenced as of June 2016. As part of the monitoring program, surface water quality monitoring has been conducted at key locations within the Clair-Maltby SPA and beyond to characterize the surface water chemistry under existing land use conditions. The locations for conducting the water quality monitoring have been established consultatively with members of the Technical Advisory Committee and field reconnaissance has been conducted to confirm the suitability of the locations for conducting the water quality monitoring. The water quality monitoring locations are presented in in Map SW-1 with details of the water quality chemistry and temperature results from both flow and standing wetland stations within Appendix E. The data from the 2018 monitoring is still being collected and will be included in the next CEIS report.

As part of the surface water quality monitoring program, water temperature has been recorded. The water level gauges include temperature sensors which provide a continuous scan of water temperature over the monitoring period.

In addition to water temperature, the CEIS Work Plan included water quality sampling as part of the surface water monitoring effort. The water quality parameters recommended by GRCA (ref.

Table 4.4.1) have been supplemented by metal and pesticides as agreed to by the City. Sampling has been as follows:

- Grab samples and in situ data were collected in both dry and wet periods in the summer and fall of 2016, and the spring, summer and fall of 2017 at each of the two (2) water gauge locations. This is being repeated in 2018.
- Grab samples and in situ data were also collected once in the summer and fall of 2016, and once in the spring, summer and fall of 2017 at each of the 12 wetland monitoring locations. Summer sampling was done during a "dry" period while spring and fall samplings were done in "wet" periods. This is being repeated in 2018.
- Due to the substantial expense of testing for pesticides, the Wood Team recommended more targeted testing. As agreed, single samples at six (6) locations across the PSA were collected in the fall of 2017.

For this study, the target was to conduct "wet" sampling within 24 hours of at least 10 mm of rainfall within the previous 48 hours, and "dry" sampling after no rain had fallen for at least 48 hours. Actual sampling parameters are documented in Table 4.4.1.

Water quality sampling was undertaken in 2016 at Station 7 (in the Hanlon Creek Subwatershed) and Station 14 (in the Mill Creek Subwatershed) over the summer and fall. In 2017, water quality sampling was undertaken at Stations 1 through 15, with the exception of Station 9 which was removed as a sampling location due to persistent lack of flows, for a total of 14 sampling locations (ref. Map SW-1, Appendix E). As noted in 2016, there are no creeks in the PSA as the area is essentially a headwater drainage area on the Paris Moraine where wetlands and ponds of various sizes provide the primary drainage. Therefore, wetland water sampling is considered central to this study.

In 2018, water level and quality sampling is being repeated as described above with the exception of the pesticide sampling which was scoped to 2017 only.

Table 4.4.1 Water Quality Parameters Assessed

Water Quality Parameter	Mechanism of Analysis	Comments
• **Total Suspended Solids (TSS)** • **Total Dissolved Solids (TDS)** • **Orthophosphate (P)** • **Total Phosphorus (TP)** • **Dissolved Sulphate (SO4)** • **Dissolved Chloride (Cl)** • **Total Kjeldahl Nitrogen (TKN)** • **Nitrite (NO2)** • **Nitrate (NO3)** • **Ammonia (NH3)**	• To be analyzed from grab samples sent to a laboratory	• Parameters suggested by GRCA in their comments on the Draft Clair-Maltby MESP Secondary Plan TOR (City of Guelph, 2015a).
• **Water temperature**	• To be measured continuously by the data logger and verified in situ three times over the season by field staff (with a water quality meter)	• Parameter suggested by GRCA in their comments on the Draft Clair-Maltby MESP Secondary Plan TOR (City of Guelph, 2015a).
• **pH** • **Conductivity, and** • **Dissolved oxygen (DO)**	• To be measured in situ by field staff (with a water quality meter)	• Parameters suggested by GRCA in their comments on the Draft Clair-Maltby MESP Secondary Plan TOR (City of Guelph, 2015a).
• **Metals** • **Pesticides***	• To be analyzed from grab samples sent to a laboratory	• Additional parameters suggested by the Consulting Team and agreed to by City.

Note: * Due to the additional cost, pesticide sampling had been targeted be sampled at only six of the 14 stations and only once in the fall of 2017.

Table 4.4.2 summarizes the water quality sampling events of 2016 and 2017. The rainfall amounts for the summer and fall wet weather water quality events, are considered to be on the low side (i.e. <15 mm), that said, only two (2) rainfall events of 15 mm or greater were recorded during the summer and fall seasons for 2017. For the 2018 monitoring program, a continued effort will be made to sample wet weather events of greater magnitude, as possible.

Water quality samples were collected in close proximity to the established wetland water level Stations. With the exception of November 3, 2017 sampling at Station 3, where only saturated soils existed within the immediate vicinity of the water level Station, and both sampling and in situ monitoring was completed approximately 2 m south of the station where standing water existed.

Table 4.4.2 Summary of 2016 and 2017 Water Quality Sampling Events

Date	Sites Sampled	Type of Event	Inter-Event Period (days)[1]	24-Hour Rainfall Total (mm)[2.]
August 4, 2016	Station 7, Station 14	Dry	10	0
August 17, 2016	Station 7, Station 14	Wet	5	10.6
September 22, 2016	Station 7, Station 14	Wet	6	6.0
October 20, 2016	Station 7, Station 14	Wet	12	7.0
April 28, 2017	Station 14, Station 15	Dry	8	4.4
May 1, 2017	Stations 1-8, Stations 10-15	Wet	0	20.4
August 10, 2017	Stations 1-8, Stations 10-15	Dry	6	0.0
September 5, 2017	Station 14, Station 15	Wet	0	8.6
October 3, 2017	Station 14, Station 15	Dry	29	0.0
November 3, 2017	Stations 1-8, Stations 10-15	Wet/Pesticides	12	6.8

Notes: " NA" indicates not applicable (dry weather samples)
[1] Between sampling time and end of last event exceeding 5 mm
[2] Rainfall depth for 24-hour period prior to sampling

4.4.3.1 Temperature

Flow Stations

Tables 4.4.3 and 4.4.4 summarize the temperature monitoring results for the Puslinch Channel (Station 14) in 2016 and 2017, and Hanlon Creek (Station 15) respectively in 2017. Based on a comparison of 2016 to 2017, the monthly daily maximums trend lower for 2017 based on it being a wetter year than 2016.

Table 4.4.3 Observed 2016 and 2017 Water Temperatures – Puslinch Channel (Station 14)

Month	Monthly Extremes		Monthly Averages		
	Daily Minimum	Daily Maximum	Daily Minimum	Daily Average	Daily Maximum
2016					
July	9.26	16.06	10.77	12.28	14.33
August	9.80	18.78	11.22	12.86	14.92
September	7.90	17.20	10.09	11.38	12.91
October	4.06	15.05	7.99	9.24	10.47
November	1.95	11.35	5.28	6.45	7.61
December	1.55	7.46	3.69	4.30	4.85
2017					
April	2.15	15.42	6.52	7.82	9.57
May	5.81	15.21	8.58	9.55	10.95
June	9.00	16.28	10.24	11.30	12.84
July	9.94	15.36	10.84	11.73	13.05
August	8.67	13.82	10.22	11.18	12.66
September	7.83	14.33	9.95	10.59	12.35
October	6.18	14.04	8.01	9.57	11.00
November	2.05	9.78	4.80	5.68	6.58

Table 4.4.4 Observed 2017 Water Temperatures – Hanlon (Station 15)

Month	Monthly Extremes		Monthly Averages		
	Daily Minimum	Daily Maximum	Daily Minimum	Daily Average	Daily Maximum
April	5.31	17.53	8.79	10.64	13.07
May	8.05	17.98	10.35	11.83	14.27
June	11.18	27.91	12.98	15.21	19.00
July	12.75	23.24	14.10	16.68	20.87
August	11.83	22.28	13.32	15.61	19.24
September	10.70	20.58	12.60	14.89	18.79
October	9.25	18.51	11.55	13.08	15.43
November	6.24	13.00	8.62	9.52	11.12

Water temperature graphs have been provided in Appendix E.

Wetland Stations

Overall, the wetland surface water temperatures in 2017 within the PSA all displayed a relatively consistent seasonal rise in temperatures from spring into summer, as air temperatures increased, and wetland water elevations fell (ref. Table 4.4.5 for a summary of each station's minimum, maximum and average monthly temperatures). At Station 10, however, the trend was different and surface water levels peaked in July but temperatures continued to rise despite the increase in recorded surface depths. Within wetlands where water elevations declined significantly, surface water temperatures began to show greater variability, likely coinciding with daily air temperature changes. This trend was most pronounced at Station 12, where wetland conditions were likely dry in mid-September and exposure to the sun was high. Notably, temperature fluctuations at the two stations located within Hall's Pond (Stations 5 and 7) began to fluctuate more in mid-August, as surface water levels dropped. These results are discussed in more detail in Section 4.4.5.

Table 4.4.5 2017 Wetland Surface Water Temperatures

Station No.	April*			May			June			July			August			September			October			November**		
	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max	Daily Min	Daily Avg	Daily Max
Stn 1	11.98	13.13	14.52	13.81	14.72	15.99	20.32	21.34	22.78	22.22	23.16	24.39	21.21	22.51	24.27	19.22	20.88	23.02	13.41	14.47	15.84	4.91	5.55	6.37
Stn 2	12.68	13.53	14.52	14.22	14.75	15.36	19.16	19.35	19.62	20.26	20.37	20.55	20.13	20.44	20.84	18.05	18.66	19.25	12.28	13.07	13.83	5.68	6.10	6.57
Stn 3	10.83	11.11	11.42	12.16	12.37	12.65	17.18	17.38	17.68	18.65	18.85	19.17	17.61	18.35	19.23	15.83	17.24	18.94	11.09	12.66	14.60	3.27	4.28	5.50
Stn 4	8.06	8.32	8.62	10.10	10.32	10.66	14.78	14.96	15.21	16.34	16.45	16.59	15.62	15.83	16.17	12.91	13.52	14.27	9.61	10.39	11.25	3.27	3.68	4.18
Stn 5	9.64	9.91	10.27	10.48	10.60	10.76	14.97	15.06	15.17	16.54	16.58	16.64	17.28	18.07	19.00	15.31	18.44	21.83	11.10	12.51	14.09	4.96	5.33	5.83
Stn 6	9.62	9.98	10.42	11.22	11.48	11.89	16.01	16.16	16.39	17.68	17.77	17.89	16.52	16.72	17.00	14.01	14.50	15.18	10.08	10.83	11.78	2.94	3.35	3.90
Stn 7	11.02	12.30	13.89	14.10	14.98	16.09	19.62	20.28	21.13	20.78	21.51	22.74	19.04	20.33	22.06	15.65	18.62	24.24	7.06	11.98	23.59	1.84	2.78	3.88
Stn 8	8.86	8.92	9.00	10.43	10.50	10.57	13.98	14.03	14.08	15.40	15.42	15.45	15.66	15.70	15.74	14.55	14.63	14.71	12.56	12.64	12.75	8.08	8.14	8.22
Stn 10	12.14	12.61	13.15	13.26	13.52	13.88	17.70	17.76	17.85	18.49	18.52	18.56	18.32	18.37	18.42	16.83	16.96	17.11	13.13	13.38	13.67	8.07	8.13	8.23
Stn 11	9.44	9.75	10.17	11.05	11.30	11.65	15.08	15.30	15.57	17.06	17.19	17.37	16.22	16.50	16.85	14.54	15.19	15.95	10.82	11.57	12.45	5.36	5.52	5.78
Stn 12	8.04	9.24	10.86	10.91	11.87	13.11	15.98	16.93	17.96	16.92	17.95	19.07	14.56	16.79	19.05	11.44	14.11	17.03	7.93	10.35	12.82	1.87	3.14	4.57
Stn 13* **	12.72	13.61	14.72	12.70	12.88	14.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.98	20.50	21.23	15.21	15.47	15.80	6.42	6.62	7.24

Notes: Stations 1 and 2 were removed on November 17, 2017
Stations 1 and 2 reflect 2017 temperature data that was recorded hourly
Station 7 reflects temperature from April 5 to Nov 29
* April temperatures include are the 18 to the 30, except Station 7 which began logging on April 5
** November Temperature logged until the 29, with the exception of Station 10 (Nov. 3), and Stations 1 & 2 (Nov. 17)
*** The Station 13 summer data was lost as a result of an accident with a vehicle going into Halligan's Pond and the logger being lost. A new logger was installed in September 2017.

In general, wetland temperatures in 2017 remained within the range to support cool or coldwater fish habitat (with the exception of Station 1 and, to a lesser extent, Station 7), even during the summer months. . These wetlands are not flowing features and the reasons for surface temperature conditions can relate to a number of factors which tend to vary over the course of a given year including wetland depth, extent to which the wetland (station) is shaded, air temperature and sources of water inputs (i.e., surface versus groundwater). That said, some wetlands could be receiving some localized shallow groundwater and/or interflow inputs to sustain their hydrology, with the exception of Stations 1 and 2. On average, Stations 1 and 2 maintained some of the highest average monthly temperatures of all wetlands sampled. This is presumed to be because, despite their relatively large size, as stated within the EIS (North-South Environmental Inc. 2015), these wetlands are maintained almost entirely by precipitation and surface runoff.

Graphed results of the wetland surface temperature collected over 2017 data by watershed in the PSA is presented in Figures 4.4.1 and 4.4.2. Graphed results of surface water temperature data collected in 2017 by individual station is provided in Appendix E1.

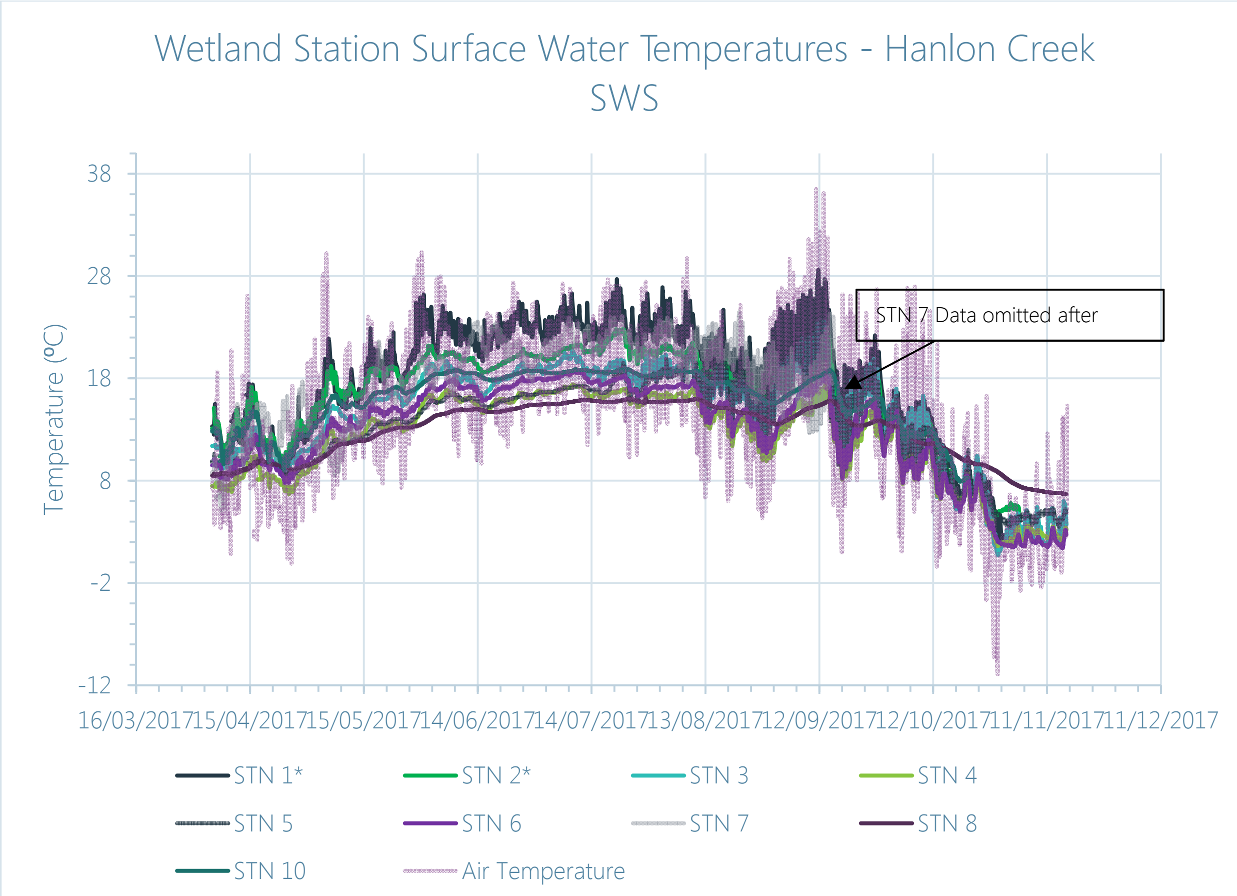


Figure 4.4.1: Surface water temperatures over 2017 in the wetland monitoring stations within the Hanlon Creek Watershed in the Primary Study Area.
(Note: The data for Station 7 were removed after mid-September due to a technical error).

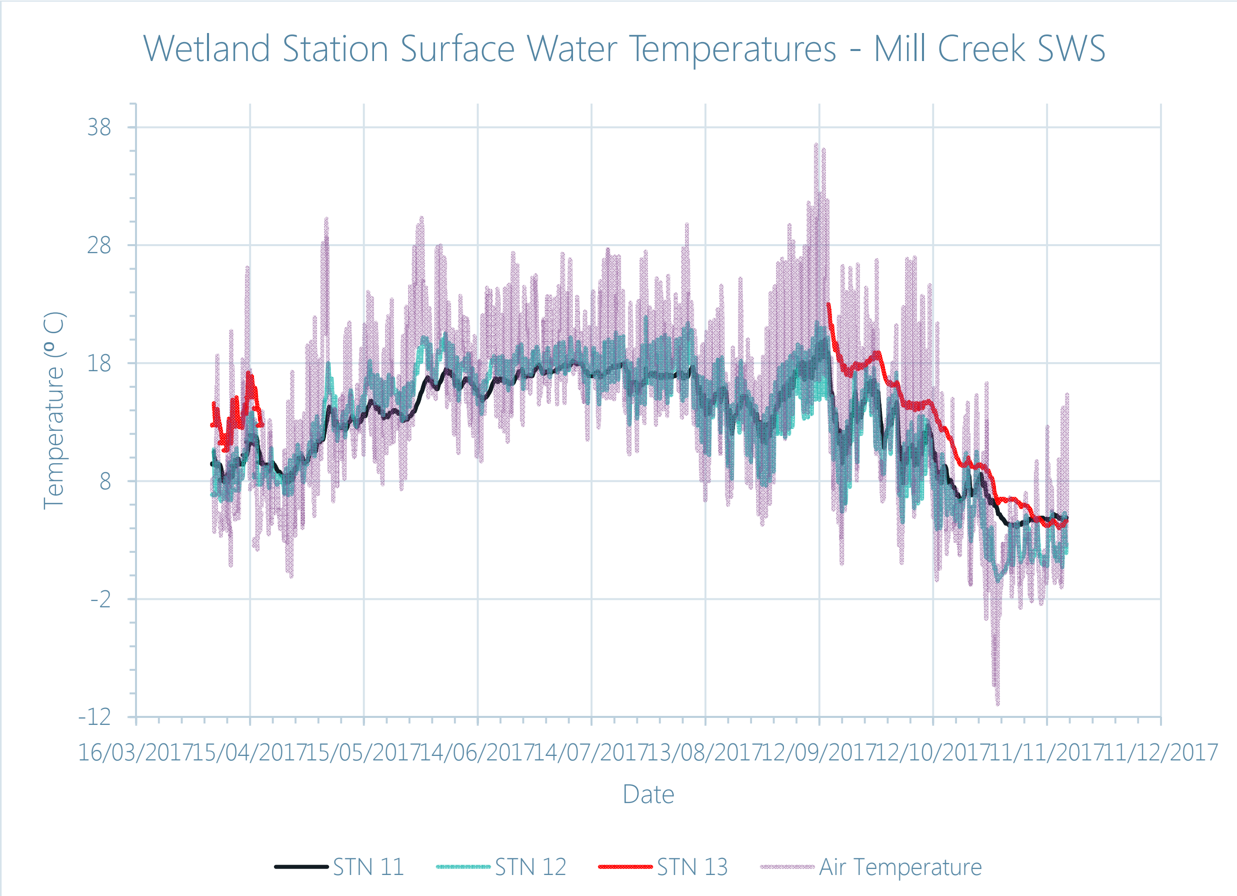


Figure 4.4.2: Surface water temperatures over 2017 in the wetland monitoring stations within the Mill Creek Watershed in the Primary Study Area.

(Note: The data for Station 13 were lost between late April 2017 and early September 2017 due to equipment loss).

4.4.3.2 Chemistry

Surface water quality parameters sampled and tested at the twelve wetlands and two flow stations (ref. Map SW-1, Appendix E), were assessed against three sets of established thresholds:

i. The Provincial Water Quality Objectives (PWQO);
ii. The Canadian Environmental Quality Guidelines (CEQG) for the Protection of Aquatic Life as prescribed by the Canadian Council of Ministers of the Environment; and
iii. The Canadian Drinking Water Quality (CDWQ) guidelines as prescribed by Health Canada.

PWQO and CEQG thresholds are intended to help manage water quality conditions for the protection of aquatic life. CDWQ guidelines base thresholds on the known human health effects associated with each contaminant, aesthetic qualities (taste, odour), and potential impairment to drinking water infrastructure (Health Canada 2014). CDWQ standards include two sub-sets of thresholds including (a) an aesthetic objective (AO) and (b) maximum acceptable concentrations (MAC). For this project, AO thresholds were applied, as they are generally more restrictive than MAC for the majority of parameters tested as part of the surface water sampling program.

These three sets of standards were used in combination to provide a more complete list of potentially relevant exceedances for the various surface water quality parameters of interest tested within the PSA. However, it is important to recognize that the data collected for this project are primarily intended to serve as a baseline reference for the pre-development conditions of a representative series of wetlands in the PSA, and that documented exceedances simply flag which parameters exceed provincial and federal thresholds established for flowing water, not wetlands *per se*. In addition, some of the exceedances relate to human health (i.e. CDWQ) while others are related to aquatic biota (i.e. PWQO and CWQG).

Key water quality parameter concentrations for nutrients and metals parameters for the one wetland (Station 7) and one flow (Station 14) locations sampled in 2016 are presented in Table 4.4.6. Key water quality parameter concentrations for nutrients and metals parameters for the twelve wetland and two flow stations sampled in 2017 are presented in Table 4.4.7 and Table 4.4.8 respectively. For levels of metals refer to Table 4.2.7. Table 4.2.9 provides a summary of the *in situ* water quality parameters tested for all stations surveyed over 2016 and 2017. Exceedances based on PWQO have been highlighted in yellow, CEQG in blue, and CDWQ guidelines in orange. Results that exceed more than one threshold are highlighted in red.

A summary of all water quality exceedances documented at each station sampled in 2017 and 2017 are presented in Table 4.4.10 and Table 4.4.11 respectively.

4.4.4 Water Quality Results

Historical Surface Water Quality Data

Surface water quality monitoring was completed for each of the Mill Creek, Torrance Creek and Hanlon Creek Subwatershed studies more than two decades ago. In the 1990's, the Torrance Creek (TSH *et al.,* 1998) water quality was assessed as reasonable, except for nitrates, total phosphorous and *Escherichia coli* (E. coli) which exceeded the PWQO standards. Hanlon Creek (MMM and LGL Ltd. 1993) temperatures were measured in the tributaries and, in some locations and some times of the year, reached above 23°C due to a lack of canopy cover. Water quality for Mill Creek (CH2M Gore & Storrie Ltd. *et al.,* 1996) was noted as impaired in the 1990's due to E. coli, total phosphorus, aluminum, copper, lead manganese and zinc being above the established PWQO standards.

Results from CMSP Surface Water Quality Monitoring

A summary of all water quality exceedances documented at each station sampled in 2017 and 2017 are presented in Table 4.4.10 and Table 4.4.11 respectively. The complete results for all parameters measured by station in 2017 are provided in Appendix E. Locations of the sampling stations are shown on Map SW-1 (Appendix E) and a photo log of the various stations at different times of the year is included in Appendix H2.

Table 4.4.6 Comparison of Measured Concentrations for Key Water Quality Parameters at a Wetland (7) and a Flow (14) Station in 2016 (Nutrients and Metals)

Location	Contaminant Concentration (mg/L)												
	TSS	TKN	Total P	Ammonia	Chloride	Alum	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Zinc
PWQO (Yellow)	n/a	n/a	0.03	0.02[1]	n/a	0.075	0.0005	n/a	0.005[2]	0.3	0.001[2]	n/a	0.02
CEQG (Blue)	n/a	n/a	n/a	n/a	n/a	0.005	0.00004	0.001	0.002	0.3	0.001	n/a	0.03
CDWQ (Orange)	n/a	n/a	n/a	n/a	120	0.1	0.005	0.05	1	0.3	n/a	0.05	5
Station 7	6.8	1.41	0.054	0.028	9.92	0.027	<0.000010	<0.00050	<0.0010	0.371	0.00038	0.111	0.0043
Station 14	<2.0	0.26	0.0056	<0.02	38.0	<0.010	0.000050	<0.00050	<0.0010	<0.050	<0.0001	0.0103	0.0890
Station 7	10.7	1.65	0.0742	<0.02	10.1	0.027	<0.000010	<0.00050	<0.0010	0.457	0.00053	0.0780	0.0032
Station 14	2.5	<0.15	0.0094	0.043	33.5	<0.010	0.000052	<0.00050	<0.0010	<0.050	<0.0001	0.0145	0.0760
Station 7	79.4	2.3	0.173	0.025	12.3	0.263	0.000022	<0.00050	<0.0010	0.491	0.00207	0.0317	0.0100
Station 14	<2.0	0.21	0.0069	0.032	36.7	<0.010	0.000042	<0.00050	<0.0010	<0.050	<0.0001	0.0101	0.0759
Station 7	15.8	1.68	0.0743	0.082	12.7	<0.010	<0.000010	<0.00050	<0.0010	<0.050	<0.0001	0.0150	<0.0030
Station 14	4.0	0.31	0.0075	0.074	33.6	<0.010	0.000075	<0.00050	<0.0010	<0.050	<0.0001	0.0248	<0.0030

Notes: [1] PWQO is for un-ionized Ammonia
[2] PWQO varies with hardness as $CaCO_3$, value presented is most stringent limit (lead) or based on initial PWQO (copper)
Yellow: Exceeds PWQO
Blue: Exceeds CEQG
Orange: Exceeds CDWQ
Red: Exceeds PWQO, CEQG and CDWQ

Table 4.4.7 Comparison of Measured Concentrations for Key Water Quality Parameters (Nutrients) 2017

Date	Location	Contaminant Concentration (mg/L)								
		TSS	Chloride	TKN	Ortho-P	Total P	Sulfate	Ammonia	Nitrate	Nitrite
	PWQO (Yellow)	**n/a**	**n/a**	**n/a**	**n/a**	**0.03**	**n/a**	**0.021**	**n/a**	**n/a**
	CEQG (Blue)	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**3**	**0.06**
	CDWQ (Orange)	**n/a**	**120**	**n/a**	**n/a**	**n/a**	**500**	**n/a**	**10**	**1**
April 28,2017	Station 14	<2.0	20.4	0.33	0.0035	0.008	10.7	<0.020	0.298	<0.010
	Station 15	3.5	246	0.49	<0.0030	0.0106	20.9	0.029	2.73	<0.010
1-May-17	Station 1	15.4	6.2	1.59	0.0055	0.0902	3.81	0.113	<0.020	<0.010
	Station 2	<2.0	2.31	0.52	<0.0030	0.0139	1.72	0.097	<0.020	<0.010
	Station 3	2.2	152	0.78	<0.0030	0.0247	5.54	0.045	<0.020	<0.010
	Station 4	<2.0	4.03	1.08	0.0043	0.0324	5.94	0.101	0.03	<0.010
	Station 5	<2.0	33.7	0.96	0.0103	0.0248	3.2	0.133	<0.020	<0.010
	Station 6	<2.0	9.8	0.76	<0.0030	0.0159	3.72	0.118	<0.020	<0.010
	Station 7	4.3	11.8	0.96	<0.0030	0.0303	1.41	0.077	<0.020	<0.010
	Station 8	2.2	2.58	1	<0.0030	0.0321	1.7	0.07	<0.020	<0.010
	Station 10	<2.0	1.5	0.66	<0.0030	0.0117	0.95	0.055	<0.020	<0.010
	Station 11	<2.0	96.9	1.06	0.0072	0.0311	3.59	0.067	0.02	<0.010
	Station 12	16.9	71.3	0.85	0.0108	0.129	3.7	0.035	0.059	<0.010
	Station 13	4.5	166	1.01	<0.0030	0.0316	2.08	0.059	<0.020	<0.010
	Station 14	4.5	12.3	0.38	0.0033	0.0103	7.6	0.159	0.153	<0.010
	Station 15	3.3	165	0.6	<0.0030	0.0087	14.7	0.065	2.03	<0.010
10-Aug-17	Station 1	56.7	5.78	1.85	<0.0030	0.131	1.95	<0.020	<0.020	<0.010
	Station 2	<2.0	1.41	0.69	<0.0030	0.015	0.91	0.18	<0.020	<0.010
	Station 3	38.3	120	1.2	0.0032	0.0651	1.87	0.066	<0.020	<0.010
	Station 4	<2.0	1.97	1.53	0.0105	0.0295	1.29	0.052	<0.020	<0.010
	Station 5	13.1	11.2	1.51	<0.0030	0.038	0.95	<0.020	<0.020	<0.010
	Station 6	<2.0	11.6	0.68	<0.0030	0.0163	0.79	0.038	<0.020	<0.010
	Station 7	4.1	12.6	0.93	<0.0030	0.0321	<0.30	0.066	<0.020	<0.010
	Station 8	19.2	2.83	1.93	<0.0030	0.0625	0.9	0.038	<0.020	<0.010
	Station 10	<2.0	1.65	0.73	<0.0030	0.0163	0.94	<0.020	<0.020	<0.010
	Station 11	24.1	351	3.75	0.0382	0.189	1.25	0.069	<0.020	<0.010
	Station 12	14.3	207	0.61	<0.0030	0.0216	2.27	<0.020	<0.020	<0.010
	Station 13	6.8	179	1.37	<0.0030	0.133	1.95	0.063	<0.020	<0.010
	Station 14	2.7	37.9	0.17	0.006	0.0067	18.7	<0.020	0.678	<0.010
	Station 15	2.9	184	0.61	0.0044	0.0065	18.3	<0.020	2.35	<0.010
5-Sep-17	Station 14	3.9	33.8	0.22	N/A	0.0105	15.5	0.194	0.551	<0.010
	Station 15	<2.0	196	0.41	N/A	0.0048	17.8	0.212	2.53	<0.010
3-Oct-17	Station 14	<2.0	38.7	<0.15	N/A	0.0042	18.2	0.067	0.689	<0.010
	Station 15	<2.0	194	0.21	N/A	0.0044	17.9	0.116	2.65	<0.010
3-Nov-17	Station 1	14	5.73	1.79	<0.0030	0.0842	2.51	0.036	<0.020	<0.010
	Station 2	7.7	1.42	0.72	<0.0030	0.0131	1.7	0.307	0.037	<0.010

Table 4.4.7 Comparison of Measured Concentrations for Key Water Quality Parameters (Nutrients) 2017

Date	Location	Contaminant Concentration (mg/L)								
		TSS	**Chloride**	**TKN**	**Ortho-P**	**Total P**	**Sulfate**	**Ammonia**	**Nitrate**	**Nitrite**
	PWQO (Yellow)	**n/a**	**n/a**	**n/a**	**n/a**	**0.03**	**n/a**	**0.021**	**n/a**	**n/a**
	CEQG (Blue)	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**n/a**	**3**	**0.06**
	CDWQ (Orange)	**n/a**	**120**	**n/a**	**n/a**	**n/a**	**500**	**n/a**	**10**	**1**
	Station 3	55	115	4.22	0.0128	0.242	8.72	2.52	0.054	0.013
	Station 4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Station 5	26.4	33.6	3.48	0.0031	0.0874	4.49	1.65	0.029	<0.010
	Station 6	277	16.3	1.17	0.0073	0.0805	0.94	0.12	0.089	<0.010
	Station 7	10	13.1	1.22	<0.0030	0.062	0.67	0.053	<0.020	<0.010
	Station 8	4.6	5.65	1	0.0054	0.0252	0.85	0.118	<0.020	<0.010
	Station 10	<2.0	2.35	0.65	<0.0030	0.0065	0.42	0.08	<0.020	<0.010
	Station 11	23.2	179	2.6	0.173	0.362	17.3	0.66	0.048	<0.010
	Station 12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Station 13	15.6	177	1.16	<0.0030	0.0363	1.28	<0.020	<0.020	<0.010
	Station 14	<2.0	29.5	0.36	0.0103	0.0389	13.4	0.036	0.431	<0.010
	Station 15	2.7	195	0.51	<0.0030	0.0099	19.6	0.194	2.77	<0.010

LEGEND: Exceedances based on PWQO have been highlighted in yellow, CEQG in blue, and CDWQ guidelines in orange. Results that exceed more than one threshold are highlighted in red

Notes:
[1] PWQO is for un-ionized Ammonia
[2] PWQO varies with hardness as $CaCO_3$, value presented is most stringent limit (lead) or based on initial PWQO (Aluminium)
n/a Not available
Yellow: Exceeds PWQO
Blue: Exceeds CEQG
Orange: Exceeds CDWQ
Red: Exceeds PWQO, CEQG and CDWQ

Table 4.4.8 Comparison of Measured Concentrations for Key Water Quality Parameters (Metals) 2017

Date	Location	Contaminant Concentration (mg/L)							
		Aluminum	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Zinc
	PWQO (Yellow)	0.075	0.0005	n/a	0.001[2]	0.3	0.0012	n/a	0.02
	CEQG (Blue)	0.005	0.00004	0.001	0.002	0.3	0.001	n/a	0.03
	CDWQ (Orange)	0.1	0.005	0.05	1	0.3	n/a	0.05	5
April 28,2017	Station 14	<0.0010	0.000028	<0.00050	<0.0010	<0.050	<0.000050	0.00635	0.0506
	Station 15	0.019	0.000034	<0.00050	<0.0010	0.143	0.000204	0.0417	0.0085
1-May-17	Station 1	0.019	<0.00001	<0.00050	<0.0010	0.174	0.000114	0.104	<0.0030
	Station 2	<0.010	0.000011	<0.00050	<0.0010	0.161	0.000117	0.0221	<0.0030
	Station 3	0.012	<0.000010	<0.00050	<0.0010	0.061	0.000103	0.0236	<0.0030
	Station 4	0.016	<0.000010	<0.00050	<0.0010	0.121	0.000097	0.0219	<0.0030
	Station 5	<0.010	0.000015	<0.00050	<0.0010	0.168	0.000121	0.0806	0.007
	Station 6	<0.010	<0.000010	<0.00050	<0.0010	0.06	0.000081	0.00361	<0.0030
	Station 7	<0.010	<0.000010	<0.00050	<0.0010	<0.050	0.000119	0.0223	<0.0030
	Station 8	0.022	<0.000010	<0.00050	<0.0010	0.248	0.000235	0.0254	<0.0030
	Station 10	<0.010	<0.000010	<0.00050	<0.0010	0.128	0.000152	0.00899	<0.0030
	Station 11	0.036	0.000011	<0.00050	<0.0010	0.313	0.000224	0.0247	0.0038
	Station 12	2.61	0.00019	0.00454	0.012	3.82	0.0204	0.246	0.0838
	Station 13	0.021	<0.000010	<0.00050	<0.0010	0.093	0.000365	0.0482	<0.0030
	Station 14	0.016	0.000064	<0.00050	<0.0010	0.063	0.000166	0.0173	0.0471
	Station 15	0.02	0.000029	<0.00050	<0.0010	0.149	0.000175	0.0444	0.0087
10-Aug-17	Station 1	0.0647	0.000014	<0.00050	<0.0010	0.416	0.000432	0.23	0.0058
	Station 2	0.0074	<0.000010	<0.00050	<0.0010	0.305	0.000109	0.0375	<0.0030
	Station 3	0.0074	<0.000010	<0.00050	<0.0010	0.493	0.000146	0.443	<0.0030
	Station 4	0.0085	<0.000010	<0.00050	<0.0010	0.155	0.0001	0.015	<0.0030
	Station 5	0.0199	<0.000010	<0.00050	<0.0010	0.289	0.000102	0.113	<0.0030
	Station 6	0.0065	<0.000010	<0.00050	<0.0010	0.066	0.000061	0.00643	<0.0030
	Station 7	<0.0050	<0.000010	<0.00050	<0.0010	0.081	<0.000050	0.0192	<0.0030
	Station 8	0.0052	<0.000010	<0.00050	<0.0010	0.415	0.000082	0.138	<0.0030
	Station 10	<0.0050	<0.000010	<0.00050	<0.0010	0.162	<0.000050	0.0192	<0.0030
	Station 11	0.0283	<0.000010	<0.00050	<0.0010	1.32	0.000183	1.69	0.004
	Station 12	0.0693	0.000018	<0.00050	<0.0010	1	0.000622	0.561	0.0088
	Station 13	0.0149	<0.000010	<0.00050	<0.0010	0.235	0.00015	0.145	<0.0030
	Station 14	0.0101	0.000075	<0.00050	<0.0010	<0.050	0.000112	0.0163	0.0871

Table 4.4.8 Comparison of Measured Concentrations for Key Water Quality Parameters (Metals) 2017

Date	Location	Contaminant Concentration (mg/L)							
		Aluminum	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Zinc
	PWQO (Yellow)	**0.075**	**0.0005**	**n/a**	**0.001[2]**	**0.3**	**0.0012**	**n/a**	**0.02**
	CEQG (Blue)	**0.005**	**0.00004**	**0.001**	**0.002**	**0.3**	**0.001**	**n/a**	**0.03**
	CDWQ (Orange)	**0.1**	**0.005**	**0.05**	**1**	**0.3**	**n/a**	**0.05**	**5**
	Station 15	0.0065	0.000018	<0.00050	<0.0010	0.139	0.000083	0.0179	0.0053
5-Sep-17	Station 14	0.0115	0.000076	<0.00050	<0.0010	0.056	0.00013	0.0501	0.0823
	Station 15	0.0058	0.000016	<0.00050	<0.0010	0.128	0.000116	0.0129	0.0055
3-Oct-17	Station 14	<0.0050	0.000057	<0.00050	<0.0010	<0.050	<0.000050	0.0133	0.0864
	Station 15	<0.0050	0.000022	<0.00050	<0.0010	0.113	0.000079	0.0279	0.0058
3-Nov-17	Station 1	0.0631	<0.000010	0.00055	<0.0010	0.179	0.000417	0.0982	<0.0030
	Station 2	0.0413	<0.000010	0.00056	0.0019	0.206	0.000477	0.0153	0.0377
	Station 3	0.0698	0.000021	0.00066	0.0014	0.328	0.00097	0.791	0.0101
	Station 4	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Station 5	0.0736	<0.000010	0.00053	<0.0010	0.648	0.00045	0.461	<0.0030
	Station 6	0.0091	<0.000010	0.00169	<0.0010	0.386	0.000135	0.192	<0.0030
	Station 7	0.0298	<0.000010	<0.00050	0.0013	0.084	0.000307	0.0278	0.0038
	Station 8	0.018	<0.000010	<0.00050	<0.0010	0.178	0.000162	0.027	<0.0030
	Station 10	0.0106	<0.000010	0.00051	<0.0010	<0.050	<0.000050	0.00123	<0.0030
	Station 11	0.0529	0.000025	0.0006	0.001	1.02	0.000408	0.688	0.0136
	Station 12	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
	Station 13	0.0327	<0.000010	0.00069	<0.0010	0.338	0.000557	0.126	<0.0030
	Station 14	0.0098	0.000061	<0.00050	<0.0010	<0.050	0.000099	0.0219	0.071
	Station 15	0.0238	0.000029	0.00055	<0.0010	0.184	0.000217	0.0518	0.0074

LEGEND: Exceedances based on PWQO have been highlighted in yellow, CEQG in blue, and CDWQ guidelines in orange. Results that exceed more than one threshold are highlighted in red.
Yellow: Exceeds PWQO
Blue: Exceeds CEQG
Orange: Exceeds CDWQ
Red: Exceeds PWQO, CEQG and CDWQ

Table 4.4.9 Comparison of Field Measured Parameters at a Wetland (7) and a Flow (14) Station in 2016 and 2017

Date	Air Temperature (deg C)	Location	Field Water Temperature (deg C)	Field Conductivity (mS/cm)	Laboratory Total Dissolved Solids (mg/L)	Field Dissolved Oxygen (mg/L)	Field pH
August 4, 2016	29.9	Station 7	23.01	0.214	178	4.44	7.12
		Station 14	10.97	0.441	388	13.51	7.52
August 17, 2016	25.4	Station 7	23.20	NA	170	2.97	8.13
		Station 14	12.30	NA	362	10.04	8.71
Sept. 22, 2016	27.6	Station 7	19.19	0.272	149	0.95	5.79
		Station 14	12.53	0.474	379	13.30	7.11
October 20, 2016	11.5	Station 7	13.394	NA	153	9.42	6.70
		Station 14	10.211	NA	350	9.59	7.46
April 28, 2017	16.3	Station 14	9.45	0.430	284	12.06	7.25
		Station 15	12.41	1.45	272	13.38	7.27
May 1, 2017	7.7	Station 1	10.76	0.332	189	9.89	7.45
		Station 2	11.01	0.260	156	9.88	7.42
		Station 3	10.88	0.591	435	7.68	7.26
		Station 4	8.07	0.370	189	4.10	6.85
		Station 5	9.47	0.369	257	9.76	7.22
		Station 6	9.61	0.308	205	9.18	7.66
		Station 7	11.85	0.195	135	9.00	7.33
		Station 8	10.4	0.171	117	4.05	6.84
		Station 10	10.54	0.234	153	9.71	7.40
		Station 11	8.97	0.549	393	9.30	7.27
		Station 12	10.60	0.400	347	9.91	7.81
		Station 13	11.66	0.868	440	9.66	7.47
		Station 14	8.09	0.347	242	10.87	7.34
		Station 15	10.07	0.936	613	12.08	7.40
August 10, 2017	24.5	Station 1	19.9	0.306	148	4.69	6.61
		Station 2	21.5	0.231	135	4.22	7.37
		Station 3	19.9	0.75	416	3.26	7.2
		Station 4	17.0	0.277	184	1.10	6.56
		Station 5	16.7	0.547	218	0.61	6.39
		Station 6	17.9	0.449	235	2.29	7.12
		Station 7	21.7	0.265	155	2.97	6.98
		Station 8	19.1	0.279	170	1.27	6.51
		Station 10	20.8	0.329	175	5.64	7.28
		Station 11	18.8	1.48	1070	1.26	7.00
		Station 12	17.8	1.13	803	2.02	6.01
		Station 13	26.2	0.77	392	5.59	8.20
		Station 14	12.2	0.649	364	9.78	7.66
		Station 15	20.8	1.11	626	10.7	7.61

Table 4.4.9 Comparison of Field Measured Parameters at a Wetland (7) and a Flow (14) Station in 2016 and 2017

Date	Air Temperature (deg C)	Location	Field Water Temperature (deg C)	Field Conductivity (mS/cm)	Laboratory Total Dissolved Solids (mg/L)	Field Dissolved Oxygen (mg/L)	Field pH
September 5, 2017	17.4	Station 14	11.2	0.613	360	9.17	7.84
		Station 15	17.4	1.127	654	12.06	7.56
October 3, 2017	24.6	Station 14	N/A	N/A	391	N/A	N/A
		Station 15	N/A	N/A	664	N/A	N/A
November 3, 2017	10.7	Station 1	7.98	0.293	163	13.97	7.89
		Station 2	8.39	0.233	108	13.47	8.01
		Station 3	10.27	0.799	386	9.17	7.25
		Station 4	N/A	N/A	N/A	N/A	N/A
		Station 5	9.70	0.575	271	5.22	6.84
		Station 6	8.72	0.423	175	7.94	6.90
		Station 7	8.24	0.252	156	8.04	7.33
		Station 8	8.28	0.237	148	9.73	7.25
		Station 10	7.58	0.298	164	12.21	7.70
		Station 11	9.43	1.009	631	2.90	6.85
		Station 12	N/A	N/A	N/A	N/A	N/A
		Station 13	8.63	0.820	399	12.23	7.98
		Station 14	8.26	0.557	292	12.24	7.82
		Station 15	12.57	1.133	661	13.01	7.74

Notes: NA. Not available

Notable water quality results from wetland and flow stations included frequent Ammonia exceedances and exceedances for Total Phosphorus, Aluminium, Copper, Iron, Lead, and Zinc at various sampling stations at different times of the year in both 2016 and 2017. The water quality exceedances may impact direct and indirect fisheries habitat and could wetland and riparian habitat. These findings are discussed further in the following text;

Nutrients

- For Ammonia, a threshold only exists under PWQO, not CEQG or CDWQ. Exceedances for Total Ammonia during the spring 2017 sampling were documented at all sampling stations except Station 14 in the dry sampling period, and at half of the stations (i.e. Stations 3, 4, 6, 7, 8, 11 and 13) during the summer sampling event, which was also under dry conditions. Regular Ammonia exceedances were also documented at Station 7 in 2016. Widespread exceedances of Ammonia may be attributed to runoff from adjacent agricultural or golf course nutrient applications in the spring. In addition, both the Hall's Pond subwatershed within the Hanlon Creek and the Mill Creek Subwatershed possess well-drained, hummocky headwater areas in the PSA which may facilitate leaching.
- Several exceedances for Total Phosphorus were documented in a number of the wetland stations (but not the flow stations) during the spring, summer and fall sampling events sampling events. In Station 1, the Neumann Pond Wetland, which is currently known to be maintained entirely by precipitation and surface runoff (NSE, 2015) phosphorus inputs are presumed to be from runoff from the adjacent agricultural lands. Comparable exceedances close to Station 1 were previously documented in the 2013/2014 Monitoring Report for the Bird Landing Subdivision (i.e., 0.074 mg/L) (BluePlan Engineering 2014). Other notable exceedances for Total Phosphorus were recorded at Stations 3 and 8 during the August sampling event, and Stations 5 and 6 during the November sampling event, and Station 7 in 2016. These Stations all exist within close proximity to lands currently used for agriculture or golf course uses where additional nutrients may be introduced to the groundwater and surface water through leaching and runoff.
- None of the reference documents provide specific thresholds for Total Suspended Solids (TSS), for background conditions within natural surface water systems. The majority of sites exhibited clear visual conditions, with the exception of Station 6 on November 3, 2017 which indicated a level of 277 mg/L.
- For Total Dissolved Solids (TDS) CDWQ standards provide a threshold of 500 mg/L (Health Canada 2014). Exceedances for TDS were documented at Station 15 (in Hanlon Creek outside the PSA) throughout 2017 with the exception the April 28, 2017 dry sampling event. Station 15 consists of an actively flowing system downstream of an online storm water management facility. Exceedances were also found at Station 11 and 12 (both adjacent to Maltby Road) during the August 10, 2017 sampling event with levels of 1070 mg/L and 803 mg/L, respectively. The exceedances were the highest recorded levels of

TDS for the 2017 monitoring season, while Station 15 had an average exceedance level of approximately 644 mg/L.

- PWQO, CEQG and CDWQ do not provide thresholds for Total Kjeldahl Nitrogen (TKN) or Orthophosphate:
  - For TKN, the majority of samples from 2017 resulted in levels between 0.3 to 2.0 mg/L, with the higher levels being found at Station 11 (3.75 mg/L) on August 10, and Stations 3 (4.22 mg/L), 5 (3.48 mg/L), and 11 (2.6mg/L) on November 3, 2017.
  - The highest levels of Orthophosphate were documented from Station 11 (0.0382 mg/L) on August 10, 2017. Notably, Orthophosphate results were not provided from the September 5 or October 3 sampling events due to laboratory error.
- Sulfate concentrations were relatively low at all stations in 2017 compared to the thresholds set by CDWQ of 500 mg/L (Health Canada 2014). The highest recorded measurement was 20.9 mg/L at Station 15 on April 28, 2017.
- Thresholds exist for both Nitrate and Nitrite in the CEQG and CDWQ. However, no exceedances were documented for either parameter during the 2017 monitoring season.
- Acceptable Chloride levels under CEQG are defined at up to 120 mg/L (CCME 1999). CWDQ sets a much higher limit of up to 250 mg/L (Health Canada 2014). Within Table 4.2.9, Chloride exceedances were documented at several stations throughout 2017, most notably during the August and November sampling events, primarily at stations close to roads (i.e. Stations 3, 11, 12 and 13) and at Station 15, downstream of a stormwater management facility.

Metals

- Widespread exceedances of Aluminium were observed in 2017 when compared to the CEQG standard of 0.005 mg/L (CCME 1999), while one such exceedance was documented at Station 7 in 2016. During the November 3, 2017 event all stations sampled exceeded this limit. For PWQO limits, only one (1) exceedance was recorded during the 2017 sampling events at Station 12 in spring. Station 12 is within a few metres of an active roadway which may influence the wetland’s water chemistry as a result of road runoff, but this would not explain the regular exceedances at stations further from roads.
- Sampling at Station 14 revealed repeated exceedances of Cadmium. Cadmium receives a restrictive limit of 0.00004 mg/L under the CEQG (CCME 1999). Only during the April sampling event did Station 14 not exceed the CEQG limit; Station 12 also exceeded CEQG standards once on May 1, 2017.
- Chromium exceeded the established thresholds on two occasions at two individual Stations during the 2017 monitoring season. Station 12 (0.00454 mg/L) on May 1 and Station 6 (0.00169 mg/L) on November 3, 2017.
- A few exceedances were documented for Copper in 2017. Mostly, exceedances occurred under the PWQO standards which are set at a more restrictive level of 0.001 mg/L (PWQO 1994). However Station 12 was found to exceed this limit as well as the CEQG limit of

0.002 mg/L (CCME 1999) on May 1. During November 2017, Stations 2, 3 and 7 were also found to have Copper levels slightly above the PWQO standard. All exceedances for Copper were recorded during sampling events that followed precipitation (i.e., wet events) which may indicate that surface runoff from surrounding lands may influence sample results.

- Thresholds for Iron are set at 0.3 mg/L for all three water quality criteria sets used in this study. Exceedances for Iron were recorded sporadically throughout the 2017 monitoring season at several different Stations, and at Station 7 in 2016. The highest Iron levels were recorded at Stations 11 and 12. Typically, high iron levels are a natural occurrence in areas where groundwater inputs exist as documented within the Mill Creek Subwatershed Plan (CH2M, Gopre & Storrie *et al.,* 1996).
- For Lead, one exceedance was recorded in 2017 at Station 12 during the May, 2017 sampling event and one was recorded at Station 7 in 2016. Again, close proximity to an active roadway and influence of road runoff is assumed to have been a factor. The threshold for Lead is 0.001 mg/L for both the PWQO and CEQG.
- Manganese has a threshold of 0.05 mg/L under the CDWQ criteria (Health Canada 2014). Exceedances were observed throughout the 2017 monitoring season at various Stations. An increased number of exceedances were observed during, and after, the August, 2017 sampling event.
- During some sample events in 2016 and all sample events in 2017, Station 14 was found to exceed the PWQO level for Zinc. The Mill Creek Subwatershed Plan (1996) groundwater quality samples documented high levels of Zinc. Due to the likelihood of groundwater inputs at Station 14 (as indicated by consistently low summer temperature readings in 2016 and 2017), it is possible that these exceedances are a natural occurrence. Zinc exceedances were also recorded at Station 12 (also in Mill Creek Subwatershed) during the May and November sampling events. All exceedances with the exception of Station 14 on April 28, exceeded both PWQO and CEQG thresholds.

Pesticides

- For pesticides, sampling was conducted in conjunction with the fall wetland water quality sampling on November 3, 2017. No exceedances occurred at any of the stations based on the available laboratory detection limits being higher than established standards. However Endosulfan, Endrin, Hexachlorobenzene, Hexachloroethane, and Methoxychlor were detected at limits that were higher than the established PWQO and CEQW standards.
- For pesticides, sampling was conducted in conjunction with the fall wetland water quality sampling on November 3, 2017. No exceedances based on the available thresholds were recorded at any of the stations. However, several pesticides (i.e., Endosulfan, Endrin, Hexachlorobenzene, Hexachloroethane, and Methoxychlor) could not be definitively tested for exceedances against the established PWQO and CEQW standards because the laboratory detection limits exceed the PWQO and CEQW thresholds for exceedances.

Comprehensive results of the scoped pesticide sampling conducted in 2017 are provided in Appendix E3.

Table 4.4.10 Summary of PWQO Exceedances for the 2016 Monitoring Program

Date	Total Number of PWQO/CEQG/CDWQ Exceedances by Location	
	Station 7	Station 14
August 4, 2016	3/1/1	1/2/0
August 17, 2016	2/1/1	2/2/0
Sept. 22, 2016	5/3/2	2/2/0
October 20, 2016	2/0/0	1/1/0

Table 4.4.11 Summary of PWQO, CEQG, CDWQ Exceedances for the 2017 Monitoring Program

Date	Station													
	1	2	3	4	5	6	7	8	10	11	12	13	14	15
April 28, 2017													1	3
May 1, 2017	4	1	3	3	2	1	2	3	1	4	9	4	3	4
August 10, 2017	3	2	5	2	3	2	2	5	0	6	5	4	3	3
September 5, 2017													4	3
October 3, 2017													2	2
November 3, 2017	3	3	4		4	5	3	1	1	6	1	5	4	4

Note: Data gaps in the table are explained by the fact that wetland Stations 1 through 13 (excluding 9, which had no standing water) were sampled once in the spring under wet conditions, once in the summer under dry conditions and once in the fall under wet conditions. Flow Stations 14 and 15 were each sampled under both wet and dry conditions in the spring, summer and fall.

4.4.5 Interpretation

The water quality monitoring conducted in 2016 and 2017 indicates that the existing surface water quality within the Clair-Maltby SPA and immediately downstream is generally of reasonable quality. Sampling is being repeated over 2018 to confirm if these results are consistent from year to year under different weather conditions.

That said, existing surface water quality has demonstrated PWQO, CEQB and CDWQ exceedances during wet weather conditions for Total Phosphorus, Aluminium, , Alum, Calcium, Cadmium, Iron, Manganese, Zinc and Ammonia. Exceedances occur for various reasons, such as untreated runoff from roadways, application of fertilizers on agricultural and the golf courses within the area.

The instream water temperature for the Mill Creek Station 14 during 2016 to 2017 did not get above 19°C, while the Hanlon Creek Station 15 got above 27°C. Water temperatures within Hanlon Creek flow monitoring station are impacted by runoff from existing residential development and the thermal impacts resulting from the permanent pool with the nearby stormwater management facility.

Wetlands are dynamic and surface water temperatures in wetlands will vary depending on a variety of factors including their size and depth, the extent to which the water levels in them vary over the year, air temperatures, the extent to which they have natural cover, and the source(s) of their water (i.e., surface water, groundwater or both). The larger wetlands sampled in the Hall's Pond subwatershed (as discussed in Section 4.2.7) have variable sources of water inputs other than direct precipitation depending on their location and the time of year. For example, while Neumann's Pond (Station 1) and Halligan's Pond (Station 13) appear to be largely surface water fed, Hall's Pond (Stations 6, 7 and 8) is being sustained by both groundwater and surface water contributions. In the Mill Creek Watershed, the so-called "Tim Horton's Pond" (Station 10) is also being sustained by both groundwater and surface water contributions and the relatively cool temperatures documented in the remaining wetlands assessed over 2017 in both Hall's Pond Subwatershed (i.e., Stations 3, 4 and 5) and Mill Creek Watershed (i.e., Stations 11 and 12) suggests that these smaller wetlands are also being sustained to some extent by a direct connection to the groundwater table. The relationship of these results to the fish community in the SPA is discussed in Section 4.5.5.

With respect to water chemistry, PWQO, CEQB and CDWQ repeated exceedances were documented at several stations and at different times of the year under existing conditions at both flow and non-flowing wetland stations for Total Phosphorus, Aluminium, Ammonia, Chloride, Cadmium, Iron, Manganese and Zinc. Exceedances can occur for various reasons, such as untreated runoff from roadways, application of fertilizers on agricultural and the golf courses within the area and, in some cases, (such as Zinc in Mill Creek watershed) due to naturally high occurrences. These exceedances are not being studied as part of the CMSP in order to be able to establish causal relationships, as this can be very complex. Exceedances are, however, being documented in order to contribute to a more complete picture of existing baseline conditions in the SPA to (a) guide management directions and objectives with respect to water quality in the SPA, and (b) provide generalized baseline information against which to assess site-specific findings as part of future development applications and related technical studies.

4.5 Fisheries

As already noted, the SPA is different from most other subwatershed and Secondary Plan areas in that there are no permanent watercourses due to the unique geology, topography, soils and drainage in the area. However, there are surface water features[1] (i.e., ponds and/or wetlands) that do and may support fish in the SPA and may qualify as fish habitat under the *Fisheries Act* (1985). Consequently, fisheries are considered in less detail than in most other subwatershed and Secondary Plan studies. Nonetheless, the area represents an important headwaters area of the Hanlon and Mill Creeks whose watercourses and associated fish communities in the broader SSA require consideration. In addition, as noted above, some of the isolated wetlands and ponds in the SPA are capable of supporting fish and benthic invertebrates.

4.5.1 Importance/Purpose

Characterization of the fish communities in the SPA, and in the broader SSA, is primarily needed to help assess aquatic sensitivities within the SPA and to help assess potential impacts to fisheries resources in the broader SSA as a result of development within the SPA. Consideration for the fish communities and habitats within the wetlands and ponds of the SPA is also required.

4.5.2 Background Information

The Staff Report to Council on the CMSP Terms of Reference (2015) specifically notes that the CMSP study should include consideration for a broader landscape area so that potential impacts of development within the SPA to the adjacent ecosystems is considered. Specifically, impacts that might result in decreases to base flow to either the Hanlon Creek system to the north or the Mill Creek system to the south were identified as a consideration.

Given the need to consider the broader landscape context, the goals and objectives related to fisheries from the relevant subwatershed studies should also be noted:

- The first of four goals in the Mill Creek Subwatershed Plan (GRCA 1996) is: "To restore, protect and enhance water quality and associated aquatic resources and water supplies". This goal includes the specific objective to: "Maintain/enhance cold water fisheries potential as subwatershed creeks".
- The second of three goals in the Hanlon Creek Watershed Plan (MMM Ltd. and LGL Ltd. 1993) is: "To restore, protect and enhance water quality and associated aquatic resources and water supplies". This goal also includes, among others. The specific objective of: "To enhance the fishery habitat, specifically to increase the quantity and quality of Brook Trout in the headwaters area and to extend their range downstream of the Hanlon Parkway to the Speed River".

[n] Notably. the City's Official Plan does not define "watercourse" but does define surface water feature (which includes ponds and other non-flowing aquatic habitats) and fish habitat.

However, the specific recommendations for both of these plans largely focussed on planned development outside of the SPA and did not specifically consider these headwater areas or their potential development. Therefore, reliance on the SPA-specific characterization in this report is more appropriate as the primary source of guidance.

The Hanlon Creek State of the Watershed Study (SOWS) (PEIL et al., 2004) reviewed the status of all resources, including fisheries, and made recommendations for ongoing monitoring. The Hanlon Creek SOWS (2004) confirmed the presence of brook trout (*Salvevelinus fontinalis*) in the watercourses both upstream and downstream of the Hanlon Creek Expressway from the 1970's through to the 1990's and again in 2001, although other species (such as mottled sculpin (*Cottus bairdi*), blacknose dace (*Rhinichthys atratulus*) and creek chub (*Semotilus atromaculatus*) were more abundant. Brook trout are described as being dependent on groundwater discharge to the creeks as they spawn exclusively in such areas.

Although the monitoring undertaken in 2001 confirmed the continued presence of brook trout in the upper portions of Tributary E, Tributaries C and D were dry that summer, and in general the numbers and species of fish documented was lower than in the 1990's.

The Hanlon Creek SOWS (2004) also recommended annual monitoring of fisheries and benthic invertebrates in the Hanlon Creek tributaries going forward, however no such work appears to have been undertaken east of the Hanlon Creek expressway since 2001.

4.5.3 Methods

4.5.4 Fish and Fish Habitat Data

The characterization of the fish and fish habitat within the study areas is based almost entirely on background data obtained from the Ministry of Natural Recourses and Forestry (MNRF) (1999 – 2012), Guelph District on March 3, 2017. Supplemental fisheries information was acquired from the following site-specific studies:

- 132 Clair Environmental Impact Study (EIS) (i.e., the Neumann Pond in the Hanlon Creek Watershed) at 132 Clair Road West (Aquafor Beech Limited 2012) in the SPA;
- Southgate Lands Environmental Implementation Report (EIR) including the ponds / ephemeral watercourse in the study area (385 Maltby Road West) (NRSI 2007) in the PSA and Mill Creek Watershed;
- Hanlon Business Park Consolidated EIS (NRSI 2004);
- Hanlon Business Park Environmental Implementation Report (NSRI 2009); and
- Hanlon Business Park Consolidated Monitoring Report (NRSI 2016).

As discussed in Section 4.4 of this report, the water level and water quality monitoring undertaken within the selected wetlands located in both the Mill and Hanlon Creek watersheds across the SPA also provides additional information related to aquatic ecology.

4.5.4.1 Headwater Drainage Features (HDFs) Assessment Methods

The only field work related to fish habitat undertaken with in the SPA was a scoped assessment using the current standard guidelines for the evaluation of headwater drainage features (HDFs) (CVC and TRCA 2014). The purpose of this assessment, which was undertaken between spring 2017 and spring 2018, was to identify any potential or actual drainage pathways, particularly those connected to wetland or ponds that may support fish. Field work was limited to those lands for which access had been provided in order to help assess the potential for such HDFs to support seasonal aquatic habitats.

A review of aerial imagery of the PSA available through Google Earth™ (2006-2017) and the City of Guelph (2006, 2009, 2012, 2016) was reviewed to identify any areas that exhibited evidence of saturation or concentrated surface flow that might indicate the presence of an HDF. Emphasis was placed on seasonal coverage (i.e., spring) and wet years. The results of this desktop review were then cross-referenced with 2016 and 2017 field data results from other disciplines, including wetland mapping (based on the Ecological Land Classification (ELC) (Lee *et al.*, 1998), observed seeps, surface water monitoring and shallow groundwater monitoring.

Field verification of the potential HDFs was undertaken on April 2, 2018 soon after significant rainfall by a Senior Fluvial Geomorphologist with extensive experience in the application of the CVC and TRCA HDFA Guidelines (2014). In addition to evaluating these potential features with respect to their form and function, the connectivity of these potential HDFs to other existing features, primarily wetlands, was assessed.

4.5.5 Interpretation

4.5.5.1 Fish and Fish Habitat Assessment

A review of the Natural Heritage Information Centre (NHIC) database for species occurrences and the MNRF data did not indicate the presence of any federally or provincially listed fish Species at Risk (SAR) occurring in the study areas. The fish species that are known or could be expected to occur in the study areas are common to Ontario, with an S-rank of S5 or S4 (NHIC 2017).

Hanlon Creek Watershed

There are fish records for one pond within the SPA. Neumann Pond is identified as a Provincially Significant Wetland (PSW) by MNRF and is an isolated pond not connected to any permanent or intermittent surface water drainage features. As per Section 4.2, Neumann Pond is entirely perched and reliant on precipitation and surface water contributions to sustain its hydrology. Existing fisheries data for the Neumann Pond historically found several Brown Bullhead (*Ameriurus* *nebulosus*) (Aquafor Beech 2012) (see Appendix G1). Brown Bullheads are warm water species which are tolerant of degraded water quality and can live in water with extremely low oxygen concentrations (North-South Environmental Inc. 2015). In addition, numerous Goldfish (*Carassius auratus*), an invasive species, were also reported within the pond.

The Hanlon Creek PSW located north of the SPA has several tributaries running through it as shown on Figure 4.5.1. As recorded by MNRF in 1999, portions of Branch E of the Hanlon Creek (PEIL et al., 2004) support cool and coldwater fish species including: brook trout, brook stickleback (*Culaea inconstans*), central mudminnow (*Umbra limi*) and northern redbelly dace. Brook trout is a native coldwater fish species that requires specialized habitat, is sensitive to increases in water temperatures and is vulnerable to environmental changes. All other fish species documented are identified as being common in Ontario and somewhat tolerant to changes and perturbations.

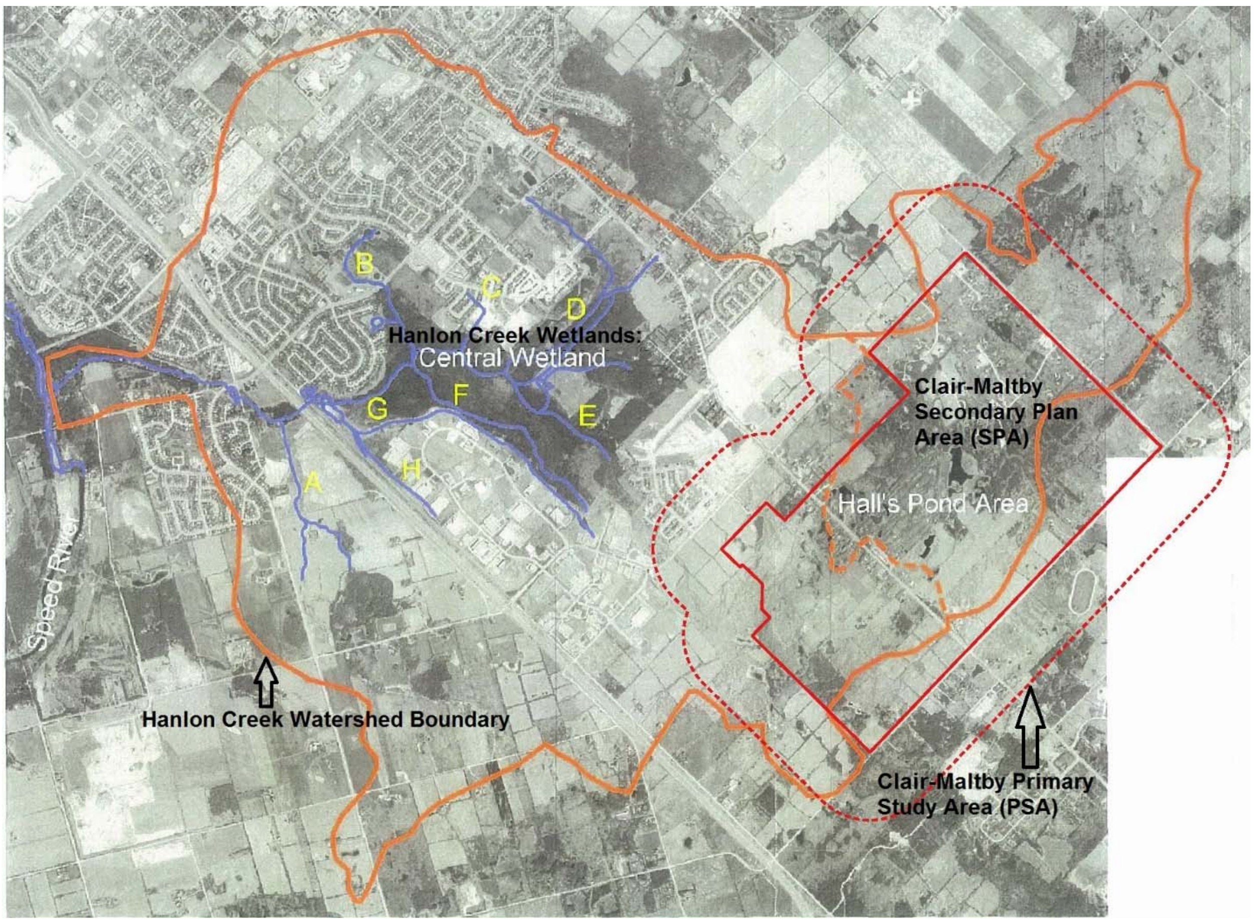


Figure 4.5.1: Tributaries in the Hanlon Creek PSWs and watershed area as mapped in 2004 [adopted from the Hanlon State of the Watershed Study, Figure A1.1 (PEIL et al., 2004)].

West of the Hanlon Expressway in the Hanlon Creek Business Park area (see Map NH-3, Appendix F), NSRI (2016) reported historical records of: blacknose dace (*Rhinichthys obtusus*), brook stickleback, creek chub, fathead minnow (*Pimephales promelas*), northern redbelly dace and white sucker (*Catostomus commersoni*). NSRI also captured four (4) brook trout as part of their environmental studies, confirming the presence of a cool / coldwater thermal regime in the creeks in this area.

Mill Creek Watershed

Mill Creek Watershed is located in the southern part of and south of the SPA as shown on Map G1. Existing fisheries information was obtained from MNRF (March 3, 2017) from 2012 and an older site-specific study (NRSI 2007). Fish species records are summarized in Appendix G1 and the results are illustrated on Map NH-3 found in Appendix F.

Fisheries sampling conducted within the PSA as part of the Southgate EIR documented no fish species observed within the two onsite ponds although incidental observations of goldfish within the area from 1998 were noted (NSRI 2007). The two (2) culverts passing under Maltby Road in this location were also identified as suitable for fish habitat (NSRI 2007) and MNRF records from 2012 identified Blacknosed Dace, Brook Stickleback, Central Mudminnow, Northern Redbellied Dace and Dace spp. in the area (see Map NH-3 in Appendix F and Table F-2 in Appendix G1). In July of 2016, field staff from the Consulting Team for this study observed this feature to be dry.

These records confirm the presence of intermittent coolwater fish habitat in this location. In addition, GRCA has indicated (T. Zammit, pers. comm. Aug. 13, 2018) that Brook Trout are known to spawn along the main branch of Mill Creek, and that Mill Creek and its tributaries (including tributaries downstream of the SPA) are currently classified as coldwater habitat by the MNRF. .

Fish Community in the SPA

No fish sampling was undertaken in any of the wetlands as part of this project, and background fisheries data was only available for two locations in the PSA – Neumann's Pond (surface water monitoring Station 1, as shown in Map SW-1, Appendix E) and from the intermittent watercourse running across Maltby Road West in the SPA. As discussed above, both of these locations have records of warm water fish species. The nature of fish communities in other wetlands and ponds in the PSA is unknown.

Irrespective of the fish habitat in the SPA, the recharge function provided by these wetlands is thought to contribute to baseflows in the broader SSA, particularly in Hanlon Creek to the northwest and Mill Creek to the south and southwest which, based on the available data, continue to sustain tributaries supporting cool water (in the case on Hanlon) and cold water (in the case of Mill Creek) fisheries respectively under existing conditions.

4.5.5.2 Headwater Drainage Features (HDFs) Assessment Findings

The desktop review process (described in Section 4.5.4.1) identified seven (7) potential HDFs, as shown in Map NH-4A. Field confirmation took place on April 2, 2018 within those lands for which access was provided (refer to Map NH-4B for extent of HDF assessed). A representative photo log of the field verified features is provided in Appendix H1.

The location of HDF reaches was confirmed using visual observations and GPS waypoint locations. Field-confirmed HDFs were delineated into reaches based on changes in any one of the following characteristics:

- Flow condition (dry/standing water to flowing)
- Riparian vegetation (within any riparian zone)
- Feature type

Delineated reaches were then identified based on the following naming convention from downstream to upstream:

Stream Code (HC) – HDF (H#) – Reach (R#) (see Map NH-4B, Appendix F)

Stream code referred to the Hanlon Creek watershed, HDF referred to the headwater drainage feature code identified in Map NH-4A. With the exception of HC-H3-R2, all HDF reaches were identified as a standing water or dry hydrologic condition. Reach HC-H3-R2 was observed to be flowing, providing a hydrologic connection between the two PSW units along the property line between Springfield Golf Course and the property to the south. As discussed in Section 4.6.4, this connection was also documented (as part of the vegetation community and wetland verification) as having flowing or standing water during the summer of 2017 and is being recommended as an addition to the MNRF's and the City's PSW mapping (as shown in in Maps NH-5 and NH-6). Field confirmation of HC-H7 determined that no discernible hydrologic connection could be observed between the Laneway wetland and Reach HC-H7-R1. On August 17, 2018 a site visit was undertaken to confirm the extent of wetland versus intermittent watercourse along H3 and the hydrologic function observed for HC-H3-R2 was dry.

Table 4.5.1 Headwater Drainage Feature Assessment Evaluation Matrix

Drainage Feature Segment	Step 1		Step 2	Step 3	Step 4	HDFA Guidelines Management Classification
	Hydrology	Modifiers	Riparian	Fish Habitat	Terrestrial Habitat	
HC-H3-R1	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**
HC-H3-R2	Valued Functions (Water is present in the spring as a result of seasonally high groundwater discharge or seasonally extended contributions from wetlands or other areas that support intermittent flow or water storage conditions)	Agriculture and Golf Course	Important Functions (Riparian corridor is dominated by forest or thicket/scrubland communities or wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**
HC-H3-R3	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**

Table 4.5.1 Headwater Drainage Feature Assessment Evaluation Matrix

Drainage Feature Segment	Step 1		Step 2	Step 3	Step 4	HDFA Guidelines Management Classification
	Hydrology	Modifiers	Riparian	Fish Habitat	Terrestrial Habitat	
HC-H3-R4	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**
HC-H3-R5	Limited Functions (Dry or standing water condition during first sample event)	Agriculture	Limited Functions (Riparian corridor is dominated by cropped land)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Limited Functions (No terrestrial habitat present)	**No Management Required**
HC-H5-R1	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**
HC-H5-R2	Limited Functions (Dry or standing water condition during first sample event)	Agriculture	Important Functions (Riparian corridor is dominated by forest or thicket/scrubland communities or wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Contributing Functions (Provides wildlife movement opportunities)	**Maintain/ Replicate Terrestrial Linkage**
HC-H6-R1	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**

Table 4.5.1	Headwater Drainage Feature Assessment Evaluation Matrix					
Drainage Feature Segment	Step 1		Step 2	Step 3	Step 4	HDFA Guidelines Management Classification
	Hydrology	Modifiers	Riparian	Fish Habitat	Terrestrial Habitat	
HC-H7-R1	Limited Functions (Dry or standing water condition during first sample event)	N/A	Important Functions (Feature type is wetland)	Contributing Functions (Indirect contributions of flow and allocthonous materials)	Important Functions (Wetlands with breeding amphibians)	**Protection**

Results of the HDFA are presented in Table 4.5.1, which includes a detailed breakdown of each drainage feature on a reach basis for each of the four assessment steps outlined in the 2014 (CVC and TRCA) HDF Guidelines (i.e., Step 1 – hydrologic function, Step 2 - riparian function, Step 3 - fish habitat function and Step 4 - terrestrial habitat function), as well as a management classification (Step 5A). With the exception of HC-H4-R1, which was identified as No Management Required, and HC-H5-R2, which was identified as Maintain/Replicate Terrestrial Linkage, all other evaluated HDFs were identified as Protection.

HDF management recommendations, as taken directly from the CVC and TRCA (2014) HDF Guidelines, are summarized below:

Protection – Important Functions: e.g. swamps with amphibian breeding habitat; perennial headwater drainage features; seeps and springs; SAR habitat; permanent fish habitat with woody riparian cover

- Protect and/or enhance the existing feature and its riparian zone corridor, and groundwater discharge or wetland in-situ;
- Maintain hydroperiod;
- Incorporate shallow groundwater and base flow protection techniques such as infiltration treatment;
- Use natural channel design techniques or wetland design to restore and enhance existing habitat features, if necessary; realignment not generally permitted;
- Design and locate the stormwater management system (e.g. extended detention outfalls) are to be designed and located to avoid impacts (i.e. sediment, temperature) to the feature.

Maintain or Replicate Terrestrial Linkage – Terrestrial Functions: e.g. features with no flow with woody riparian vegetation and connects two other natural features identified for protection.

- Maintain the corridor between the other features through in-situ protection or if the other features require protection, replicate and enhance the corridor elsewhere;
- If the feature is wider than 20 m, it may need to be assessed separately through an Environmental Impact Study to determine whether there are other terrestrial functions associated with it.

No Management Required – Limited Functions: e.g. features with no or minimal flow; cropped land or no riparian vegetation; no fish or fish habitat; and no amphibian habitat.

- The feature that was identified during desktop pre-screening has been field verified to confirm that no feature and/or functions associated with headwater drainage features are present on the ground and/or there is no connection downstream. These features are generally characterized by lack of flow, evidence of cultivation, furrowing, presence of a seasonal crop, and lack of natural vegetation. No management recommendations required.

4.5.5.3 Preliminary Targets and Objectives

In addition to the management objectives for HDFs as described in the 2014 Guidelines, the following preliminary targets and objectives for wetlands and ponds within the SPA have been identified:

- Protect fish habitat found in wetlands and ponds within the SPA in accordance with the applicable legislation and policies.
- Ensure development in the SPA does not result in negative impacts to baseflow or water quality in the broader SSA (see related groundwater targets and objectives).

4.6 Terrestrial

As noted in Section 1.0, the SPA already has an identified Natural Heritage System (NHS) (see Map NH-1, Appendix F) which was incorporated into the City's Official Plan in 2010 through OPA 42, refined through the OMB settlement process, and finalized through the OMB's approval of OPA 42 in June 2014.

The fisheries and aquatic resources in the SPA are limited to the isolated ponds and/or wetlands in this area due to the absence of flowing surface water features (as discussed in Section 4.5), and therefore significant terrestrial habitats (including wetlands) in conjunction with Significant Landform areas (discussed in Section 4.7) form the basis for most of the natural areas and functions incorporated into the NHS. Specifically, the NHS in the SPA includes the following components falling under the category of Significant Natural Areas or Natural Areas which are each discussed in more detail in this section of the report. Notably, minimum buffers are to be applied to but are separate from the protected natural feature (e.g., Significant Wetland, Significant Woodland) and are not defined as part of the feature but are part of the minimum requirement regarding mitigation, where established in the Official Plan. Minimum and/or established buffers are also mapped as part of the land use designation in the City's Official Plan (2014).

- Significant Natural Areas
  - significant habitat for Provincially Endangered and Threatened species
  - Significant Wetlands (i.e., Provincially Significant Wetlands (PSWs) (as identified by MNRF) plus minimum 30 m buffers and Locally Significant Wetlands (LSWs) -which include non-PSW and unevaluated wetlands of at least 0.5 ha - plus minimum 15 m buffers

  - Significant Woodlands (i.e., woodlands as defined in the Official Plan of at least 1.0 ha and rare or uncommon woodland types – as defined in the Official Plan - of at least 0.5 ha) plus minimum 10 m buffers
  - Significant Landform (discussed in Section 4.7)
  - Significant Wildlife Habitat (SWH) (including Ecological Linkages), and
  - Restoration Areas
- Natural Areas
  - Other Wetlands (i.e., non-PSWs between 0.2 and 0.5 ha that meet the established criteria for protection) plus minimum 15 m buffers
  - Cultural Woodlands (i.e., Cultural Woodlands as defined in the Official Plan of at least 1.0 ha not dominated by non-indigenous, invasive species) plus minimum 10 m buffers
  - Habitat of significant Species (i.e., habitat of locally significant species not already captured as Provincially Endangered or Threatened or as SWH), and
  - Established buffers (where applicable)

Significant Landform, a key component of the NHS in the SPA, is discussed in more detail in Section 4.7 below.

There are no Areas of Natural and Scientific Interest (ANSIs) in the SPA or significant valleylands in the SPA, although these features do occur elsewhere in the City. There is also an earth science ANSI just outside the SPA to the east which has been identified as a representative potion of the Paris Moraine, as discussed in conjunction with Significant Landform in Section 4.7.

As part of the CMSP process the consulting team was specifically asked to: (a) review the existing NHS in the context of the current and applicable environmental legislation, policies and guidelines and (b) make refinements to the NHS based on new information gathered through the CMSP process based on the direction set out in the approved City Official Plan (2014). Therefore, this Characterization Report builds on the data and assessments presented in the 2017 Monitoring Report to provide:

- Review of the status of Species at Risk (SAR) (in particular Provincially Endangered and Threatened species) as well as locally significant species (i.e., in the County) (see Section 4.6.4.1 and Appendices G2 and G3);
- Recommended refinements to wetlands mapping in the SPA, including refinements to both MNRF wetlands mapping and the City's NHS wetlands mapping (see Section 4.6.4.2 and Maps NH-5 and NH-6 in Appendix F);
- Recommended refinements to Significant Woodlands and Cultural Woodlands mapping in the SPA (see Section 4.6.4.3 and Maps NH-7 and NH-8 in Appendix F);
- Recommendations for Candidate and Confirmed Significant Wildlife Habitat (SWH) in the SPA (see Section 4.6.4.4 and Maps NH-9 and NH-10 in Appendix F);

- Review of Ecological Linkages in the SPA as well as consideration for connectivity to NHS and Wellington County Greenlands outside the SPA (see Section 4.6.4.5 and Map NH-11 in Appendix F); and
- Discussion of opportunities for enhancement and restoration of the NHS (see Section 4.6.4.6).

These assessments and refinements are discussed in the context of the applicable Provincial legislation and City Official Plan and GRCA policies in Section 4.6.1. Representative photos of wetlands and other natural heritage elements documented in the PSA are provided in Appendix H2 and Appendix H3.

4.6.1 Importance/Purpose

Characterization of the terrestrial communities in the SPA (including wetlands) is needed to identify refinements and updates to the NHS and to help assess potential impacts to terrestrial resources as a result of development within the SPA. The recommended NHS that emerges from the CMSP will form the basis for the NHS in the SPA and will inform the ultimate land use patterns and infrastructure networks associated with the Secondary Plan.

Although it is understood that there will still need to be some verification of NHS components and boundaries as part of site-specific Environmental Impact Studies (EIS) or Environmental Assessments (EAs), the refined and updated NHS developed through the CMSP will provide a sound basis for guiding land uses and associated infrastructure in the SPA.

4.6.2 Background Information

The SPA includes portions of the Hanlon Creek, Mill Creek and Torrance Creek watersheds. It also contains a well-defined NHS which was first identified in draft form through the City's Natural Heritage Strategy, revised through a series of public consultations and through the OMB process, and was ultimately approved and incorporated into the City's current Official Plan (2014 Consolidation).

The Hanlon Creek Watershed and the Mill Creek Watershed each cover almost half of the SPA, with the northeastern corner captured by the Torrance Creek Watershed (ref. Figure HYD, Appendix D). The studies done for these subwatersheds are dated and did not focus on the SPA lands but still include some relevant guidance and information related to terrestrial habitats.

- The second of four goals in the Mill Creek Subwatershed Plan (CH2M et al., 1996) is: "To *conserve, protect, and restore natural land, water, forest and wildlife resources*". The two objectives supporting this goal are: "*Protect natural area functions/features form development*" and "*Enhance natural features and functions in the long term*". However, the SPA is only a very small component of this large watershed and the specific management recommendations are directed to areas outside the SPA.

- The Hanlon Creek Watershed Plan (MMM Ltd. and LGL Ltd. 1993) identifies of a system of core areas, buffers, corridors and linkages intended to preserve and enhance the natural areas as development in the watershed progresses. These core areas and a number of the associated buffers and linkages have been carried forward into the City's NHS in the SPA.
- The Hanlon Creek State of the Watershed Study (PEIL et al., 2004) includes portions of the watershed in the SPA, but the review focussed on the portion of the watershed north of Clair Road under development. Findings related to terrestrial habitats included the following.
  - Agricultural lands, cultural meadows and plantations were the primary land cover types converted to built-up uses between 1991 and 2001 in the portions of the watershed north of Clair Road. More than 220 ha of deciduous forest had also been removed, while small increases in cultural woodlands, cultural thicket and mineral marsh were documented.
  - The proportion of native to non-native plant species in the watershed was about 1:3.
  - Although core areas (e.g., Significant Wetlands and woodlands) had been generally well-protected through the development process between 1991 and 2001, buffers, linkages and corridors recommended through the original Plan had been encroached upon.
  - Linkages between core areas had generally been retained but had been reduced in width in many locations.
- The Torrance Creek Subwatershed Study Management Strategy (TSH et al., 1998) also identifies a series of cores, linkages and corridors for protection. However, the original subwatershed boundaries did not include any lands within the SPA and the reports did not include any recommendations directly related to the terrestrial habitats in the SPA except for the identification of a linkage (for coyotes and other species) across Clair Road towards the Hall's Pond Wetland Complex.

These subwatershed studies, and others, were considered through the City's Natural Heritage Strategy (Dougan & Associates 2009a,b) along with other sources of site-specific information where available. Field work undertaken in support of the Strategy included high-level assessments of natural areas outside of PSWs using the Ecological Land Classification (ELC) system (as per Lee et al., 1998), breeding bird surveys and amphibian surveys. These surveys were undertaken between 2004 and 2008 and included good coverage of the SPA as the largest greenfield area remaining in the City. Deliverables from this Strategy included: City-wide ELC mapping, draft criteria for identification of different components of the NHS and recommended buffers, draft mapping of the various NHS components, a significant plant list for Wellington County and a significant wildlife list for Wellington County.

The final Natural Heritage Strategy (Dougan & Associates 2009a,b) was received by Council on July 27, 2009 and staff were directed to use the report as the basis for new NHS policies and mapping to be incorporated into the Official Plan update. New NHS policies and mapping were presented in draft format between March and May 2010 and presented in final format in Official Plan Amendment (OPA) 42 which was passed by Council July 27, 2010 and by MMAH on February 22, 2011.

As part of this process, the significant plant and wildlife lists for Wellington County were adopted by the City as working documents subject to periodic review and updates as resources permit. These lists (City of Guelph 2012) were used as the basis for screening locally significant species in the SPA.

OPA 42 provides policies and supporting mapping for identification and implementation of a City-wide NHS which replaced the City's former system of Core and Non-Core Greenlands with a new system comprised of the NHS components listed in the introductory text above. The purpose of the NHS, as stated in OPA 42, is to:

- protect natural features and areas for the long-term;
- maintain, restore and, where possible, improve the biodiversity, connectivity and ecological functions of natural features and areas; and
- recognize and maintain Ecological Linkages between and among natural heritage, surface water features and groundwater features.

The natural features and areas comprising the NHS are discussed in more detail in Section 4.6.4 and Section 4.7. These features and areas were identified to provide: (a) explicit conformity with the NHS components in the PPS and (b) support protection of Guelph's unique biophysical context in a manner consistent with other Provincial guidance.

A number of site-specific appeals were made to the OPA 42 NHS (2010), including a number within or immediately adjacent to the SPA (see Maps NH-1 and NH-2, Appendix F). Site-specific settlements were made for each of these properties. As part of these settlements, specific agreements were made with respect to the mapping of Significant Woodlands and in some cases Significant Landform, Ecological Linkages and wetlands. These refinements were incorporated into the City's Official Plan (2014 Consolidation) and approved by the OMB on June 4, 2014. This NHS is shown in Map NH-1 (Appendix F) and is referred to herein as the "current" 2014 NHS.

The site-specific agreements made on each parcel through the OPA 42 process with respect to these features are being respected and carried forward into the CMSP NHS. However, refinements to the NHS on these properties have been identified where new information has been brought forward as part of the CMSP. For example, identification of Candidate and Confirmed SWH based on field work undertaken for this project or background information provided to the City since

June 2014 (as documented in the 2017 Monitoring Report for this project) has resulted in some refinements to the NHS across the SPA, as discussed in more detail in Section 4.6.4.

In addition, there is one property (also identified on NH-2) that is before the courts on matters related to the City's Tree Protection By-law. On this property the vegetation classification (i.e., Ecological Land Classification, or ELC) mapping in place at the time of approval of the City's NHS (2014 Consolidation) has been retained as the basis for verification of the NHS, as directed by the City.

4.6.3 Methods

The terrestrial assessments completed for the CMSP relied on a synthesis of information from background data, background documents (see Appendix A), desktop analysis of air photos and scoped field studies. Supplemental natural heritage field studies undertaken as part CMSP process to inform the terrestrial characterization have included:

- vegetation assessments and botanical surveys;
- calling amphibian surveys and amphibian / reptile movement surveys over roads;
- basking turtle surveys;
- breeding bird surveys;
- winter wildlife surveys (including deer and raptors); and
- incidental surveys for seeps, springs, terrestrial crayfish burrows and other wildlife in conjunction with other targeted surveys.

Surveys were scoped according to the presence of suitable habitats and were limited to City-owned lands and private lands where access was provided.

Details of the access provided, locations of where surveys were conducted and methods employed for conducting the surveys are provided in the 2017 Monitoring Report along with summaries of the data collected. The 2017 Monitoring Report also includes the updated ELC mapping for the SPA and PSA.

An overview of the methods used to review and, where appropriate, identify refinements to the NHS, are presented below.

Refinements to NHS Mapping

As part of the CEIS work in support of the CMSP, the City's ELC mapping from 2014 has been updated (see Map NH-5 as well as NH-5A through NH-5D in the 2017 Monitoring Report). These updates were based on:

- A review of current aerial photography (spring 2017) with reference to older aerial photography (i.e., going back to 2012) where appropriate[2];
- Integration of ELC mapping from current site-specific EIS in the PSA and SPA (i.e., Aquafor Beech 2012, NRSI 2012a,b, Dance Environmental 2014, North-South Environmental 2014, and North-South Environmental 2015);
- A review of current wetlands mapping from MNRF (2017) and the City's significant and Cultural Woodlands mapping (from the Official Plan, 2014 Consolidation); and
- Field verification from the road and on site where access was provided (i.e., 2162 Gordon Street; 1, 5 and 12 Kilkenny Place and 24 Serena Lane) (see Map G-2 from the 2017 Monitoring Report). Notably access to 1968 and 1992 Gordon St. was obtained for the 2018 season.

Based on this information, distinct vegetation communities using ELC (as per Lee at al., 1998) were delineated on aerial photos to the finest level possible with the existing information. In the ELC system there are three nested levels of detail: Community Series (e.g., Coniferous Forest, FOC), Ecosite (e.g., Dry-Fresh Pine Coniferous Forest Ecosite, FOC1) and Vegetation Type (e.g., Dry-Fresh White Pine-Red Pine Coniferous Forest Type, FOC1-2). In general, ELC was mapped to the Community Series or Ecosite Level except where field verification has been completed within the last decade.

The ELC mapping includes areas in the PSA within the City of Guelph where access and/or data was available, however the refinements have been focussed within the SPA.

The City and Consulting Team met with MNRF and GRCA on January 11, 2017 to discuss, among other things, the approach to updating the wetland mapping through the CMSP. The outcome of these discussions and the agreed to approach are described in Section 4.6.4.2 with an overview of the findings.

The SWH Criteria Schedules for Ecoregion 6E (OMNR 2015) have been used as the basis for screening for the various types of SWH in the PSA. The approach and criteria in the overarching Significant Wildlife Habitat Technical Guide (MNRF 2000) have also been used as the source of guidance for identifying Candidate and Confirmed SWH in the PSA.

The Consulting Team also obtained direction from the City and their legal counsel in the spring of 2018 as to the approach to be taken with respect to the properties with site-specific settlements from the OPA 42 OMB process within the SPA, as well as the property currently before the courts

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[2] The most current available aerial photography (i.e., spring 2017) was used in all cases except on one property (i.e. 2021 Gordon) where the City has instructed the Consulting Team to revert to the 2012 aerial photography as these lands are currently before the courts for adjudication related to NHS issues.

on matters related to the NHS. The Consulting Team was advised that for parcels with site-specific agreements made through the OPA 42 OMB process:

- specific agreements made with respect to the mapping of Significant Woodlands, Significant Landform, Ecological Linkages and/or wetlands would be respected and carried forward into the CMSP NHS, and
- refinements to the NHS would be applied where new information has been brought forward as part of the CMSP based on field work undertaken for this project (as documented in the 2017 Monitoring Report) or background information provided to the City since June 2014.

In addition, there is one property (also identified on Maps NH-1 and NH-2, Appendix F) that is before the courts on matters related to the City's Tree Protection By-law. On this property NHS mapping based on the City's ELC from 2014 has been retained and refinements have been applied based on the 2014 ELC as applicable.

4.6.4 Interpretation

In terms of terrestrial natural heritage, the SPA contains a mix of cultural communities, natural forests and wetlands that support a range of significant species. This diversity of natural features and areas sits above the generally well-drained, hummocky topography of the Paris Moraine. Many NHS, including the NHS in the City of Guelph north of the SPA, are linked along river valleys. However, in the absence of such features in these headwaters to the Hanlon Creek, Mill Creek and Torrance Creek watersheds, portions of the Paris Moraine (see Map NH-13, Appendix I) were identified for protection (as described in Section 5.2.6) to help build a connected system that captures some of the topographic uniqueness of this part of the City.

The NHS in the SPA is comprised of the following components:

- Habitat of Provincially and locally significant species (discussed in Section 4.6.4.1);
- Significant Wetlands and Other Wetlands (discussed in Section 4.6.4.2);
- Significant Woodlands and Cultural Woodlands (discussed in Section 4.6.4.3);
- Significant Landform (discussed in Section 4.6.5);
- Significant Wildlife Habitat (SWH) (discussed in Section 4.6.4.4), including Ecological Linkages (discussed in Section 4.6.4.5); and
- Restoration areas (discussed in Section 4.6.4.6).

These are each discussed in the context of the applicable policies and the approach taken to refining the NHS as it relates to each of these components in Section 4.6.4.1.

4.6.4.1 Habitat of Provincially and Locally Significant Species

Habitat of significant species is divided into two categories in the SPA in accordance with the City's Official Plan (2014 Consolidation): (a) significant habitat of provincially Endangered and Threatened species and (b) habitat for (locally) significant species, both described below.

Species that are Provincially significant but not listed as Endangered or Threatened (i.e., listed as S1, S2 or S3 by the Ontario's Natural Heritage Information Centre (NHIC)) and species considered Species at Risk (SAR) but that not listed as Provincially Endangered or Threatened (i.e., species that are only listed as Endangered or Threatened Federally or are considered Special Concern Provincially or Federally) are addressed under SWH in Section 4.6.4.4.

Habitat of Provincially Endangered and Threatened Species

Habitat of Endangered and Threatened species is protected under the Provincial Policy Statement (2014) which prohibits development and site alteration in such habitat except in accordance with provincial and federal requirements. Species listed as Endangered and Threatened on the Species at Risk (SAR) list for Ontario are specifically protected under the Endangered Species Act (ESA) (2007) which is implemented and enforced by the MNRF. Nonetheless, the City and development proponents are required to be compliant with the ESA and therefore these species are considered and addressed through the CMSP.

The specific locational data relating to such habitat is considered sensitive and is generally retained by MNRF, although mapping for certain species (e.g., Spiny Softshell Turtle, *Apalone spinifera*) is considered more sensitive than others (e.g., Butternut trees, *Cinerea juglans*). No such habitats have been mapped in the City of Guelph's Official Plan to date, and none is proposed to be mapped in the SPA through this process, although several records are known in the area (see Appendix G2). These are discussed below.

A list of twenty-four (24) wildlife SAR species that could potentially occur in the City of Guelph was provided for this project by the Guelph District MNRF on February 27, 2017, thirteen (13) of which are provincially Endangered or Threatened. Of these 13, six (6) species have been confirmed as occurring in the SPA or PSA as part of the field work done by Beacon or in site-specific studies completed over the last decade:

- Butternut: To date, only one plant SAR has been documented in the PSA. Butternut, a provincially and federally Endangered species, was documented by Beacon in 2017 and previously through the Natural Heritage Strategy (Dougan & Associated 2009 a, b). It is possible that additional Butternuts occur in the SPA as suitable habitat exists.
- Yellow-breasted Chat (*Icteria virens*) is a provincially and federally Endangered and confirmed as breeding relatively recently in the southwestern portion of the PSA on 385

Maltby Road West (NRSI 2012b, NRSI 2012c, NRSI 2007). It may occur elsewhere in the PSA as suitable habitat exists.

- Barn Swallow (*Hirundo rustica*) is Provincially and Federally Threatened and has been confirmed as nesting in barns/sheds in both the SPA and PSA (e.g., near 2162 Gordon Street by Beacon, on 424 Maltby Road (Dance Environmental Inc. 2014) and 331 Clair Road (NRSI 2012a)). Barn Swallow was also observed foraging in the west section of the SPA on the 132 Clair Road West lands (NSEI 2015), the 385 Maltby Road West lands (NRSI 2012c, NRSI 2007), north of SPA at the 1897 Gordon Street property (Aboud and Associates Inc. 2010) and on 1858 Gordon Street (former Pergola Lands) (Stantec 2014) and so is a relatively prevalent SAR in the SPA.
- Bobolink (*Dolichonyx oryzivorus*) is provincially and federally Threatened and confirmed as breeding in grasslands in both the SPA and PSA in the west section of the SPA in the vicinity of the 132 Clair Road West lands (NSEI 2015), and north of the SPA near Dallan Drive (Stantec 2009) and former Pergola Lands (Stantec 2014).
- Eastern Meadowlark (*Sturnella magna*) is provincially and federally Threatened and confirmed as breeding in grasslands in both the SPA and PSA west of the SPA on the 950 Southgate Drive property and east of the SPA on the 1825 Victoria Road South property during the breeding bird surveys conducted by Beacon in 2017 (outside the City limits), in the west section of the SPA in the vicinity of the 132 Clair Road West lands (NSEI, 2015), west of the SPA on the 385 Maltby Road West lands (NRSI 2012c, NRSI 2007) and north of the SPA on the Former Pergola lands (Stantec 2014).
- Eastern Small-footed Myotis (*Myotis leibii*), provincially Endangered, a bat species confirmed as breeding in the southwestern portion of the PSA within treed habitats on 424 Maltby Road West (Dance Environmental Inc. 2014).

The seven (7) other Provincially Endangered and Threatened species for which suitable habitat exists in the SPA or PSA but have not been recently confirmed in the area are:

- Jefferson Salamander (*Ambystoma jeffersonianum*): MNRF staff have reviewed Guelph District data and although the SPA, particularly in the Maltby Road West area, is known to support other species of salamanders, they are of the opinion that there is a very low likelihood of there being any regulated habitat for this species within the SPA. Based on the information available, it appears that the area has been extensively surveyed and no recent records of have been documented[3]. Based on this information, MNRF did not require surveys for this species as part of the CMSP (T. McKenna, September 29, 2015).

[3] As part of previous studies in the Maltby Road West area, tail samples had been collected to verify if species were Jefferson/Jefferson dominated polyploid Salamanders (*Ambystoma jeffersonianum /Ambystoma laterale (2) jeffersonianum*), but all the results came back negative for Jefferson Salamander (Dance Environmental Inc. 2014, NRSI 2012b, c).

However, the status of this species and related species with which it hybridizes is under review and MNRF should be consulted for future site-specific studies.

- Blanding's Turtle (*Emydoidea blandingii*): Blanding's Turtles live in shallow water, usually in large wetlands and shallow lakes with abundant water plants. Suitable habitat is present within the PSA and SPA within larger wetlands and ponds with abundant vegetation (e.g., Hall's Pond). The surveys undertaken by Beacon in 2017 recorded substantial numbers of Midlands Painted (*Chrysemys picta marginata*) and Snapping Turtles (*Chelydra serpentine*) in various ponds within and adjacent to the SPA (discussed in Section 4.5.4.4), but no Blanding's Turtle. Nonetheless, future surveys should screen for this species where suitable habitat occurs.
- Chimney Swift (*Chaetura pelagica*): Before European settlement Chimney Swifts mainly nested on cave walls and in hollow trees or tree cavities in old growth forests. However, they have adapted to urbanization and now are more likely to be found in and around urban settlements where they nest and roost (rest or sleep) in chimneys and other manmade structures. They also tend to stay close to water as this is where the flying insects they eat congregate.
- Three bat species - Little Brown Myotis (bat) (*Myotis lucifugus*), Northern Myotis (Bat) (*Myotis septentrionalis*) and Tri-Coloured Bat (*Perimyotis subflavus*): Guidance with respect to identification of habitat for SAR bats is evolving as more is known about these species, but at present MNRF's focus is on the identification of roosting habitats which requires screening all coniferous, deciduous and mixed forest ELC communities and may include screening of cultural woodlands and plantations in some cases (MNRF 2017).
- Rusty-patched Bumble Bee (*Bombus affinis*): The habitat for this species is widespread but the last sightings in Canada were in 2002 at the Pinery Provincial Park on Lake Huron. This species, like other bumble bees, is associated with open habitat such as mixed farmland, urban settings, savannah, open woods and sand dunes.

Details about the current status, preferred habitats and known ranges of all the species listed above is provided in Appendix G2 of the 2017 Monitoring Report.

Habitat of Locally Significant Species

The City of Guelph's Official Plan includes a specific set of policies (Policy 6A.3.4) to capture plant and wildlife species considered locally significant (i.e., listed as rare or significant in the County of Wellington (City of Guelph 2012) but not listed as Provincially Endangered or Threatened, or meeting the criteria for SWH. Although it is anticipated that habitat for the majority of such species would already be captured within other identified NHS components, some may not. This policy basically requires proponents to: (a) make reasonable efforts to protect the habitat *in situ*, (b) if (a) is not feasible, to consider alternatives to *in situ* protection (e.g., habitat restoration or transplanting).

In the City of Guelph, "locally significant" species are those listed in the significant plant and wildlife species lists for Wellington County (City of Guelph 2012) that are not already captured as provincially Endangered or Threatened, or as conservation concern under SWH. These are considered working lists and the detailed methods as to how they were developed are included in the Natural Heritage Strategy Phase 2 Volume 2 Report (Dougan & Associates with Snell & Cecile 2009b).

Based on the review environmental studies prepared for various properties within and adjacent to the SPA (see Appendix G1), as well as site visits conducted by Beacon in 2017 a total of 20 locally significant plant species and 54 locally significant wildlife species were confirmed in the SPA and/or PSA.

The locally significant plant species are predominantly wetland species and include: Black Maple (*Acer nigrum*), Awned Sedge (*Carex atherodes*), Hop Sedge (*Carex lupulina*), Fireweed (*Chamerion angustifolium* ssp. *angustifolium*), Hairy Swamp Loosestrife (*Decadon verticillata*), Downy Willowherb (*Epilobium strictum*), Marsh Horsetail (*Equisetum palustre*), Meadow Horsetail (*Equisetum pratense*), Rough Avens (*Geum laciniatum*), Butternut, Interrupted Fern (*Osmunda claytoniana*), Canada Clearweed (*Pilea pumila*), Yellow Water Crowfoot (*Ranunculus flabellaris*), Small Yellow Water Buttercup (*Ranunculus gmelinii*), Rough-leaved Goldenrod (*Solidago patula*), Freshwater Cordgrass (*Spartina pectinatus*), Heart-leaved Aster (*Symphyotrichum cordifolium*), Highbush Blueberry (*Vaccinium corymbosum*), Wood Lily (*Lilium philadelphicum*), and Buttonbush (*Cephalanthus occidentalis*).

The 54 significant wildlife species (i.e., 42 species of birds, six amphibian species, three species of reptile, one mammal, two Odonates and one butterfly species) include a mix of wildlife species reflective of the diversity of natural and cultural vegetation communities in the PSA, as well as the mix of meadow, woodlands and wetlands.

- Examples of the types of birds documented in the PSA and/or SPA include: Pied-billed Grebe (*Podilymbus podiceps*), Broad-winged Hawk (*Buteo platypterus*), Least Flycatcher (*Empidonax minimus*), Magnolia Warbler (*Setophaga magnolia*), Scarlet Tanager (*Piranga olivacea*), Eastern Towhee (*Pipilio erythrophthalmus*) and Grasshopper Sparrow (*Ammodramus savannarum*).
- Six (6) locally significant amphibian species have been recorded in the SPA and/or PSA as follows:
  - Bullfrog (*Rana catesbeiana*) was recorded during the Natural Heritage Strategy Surveys (Dougan & Associates 2005) and was also recorded in 2017 by Beacon;
  - Pickerel Frog (*Rana palustris*) was recorded as breeding in the PSA in previous field studies (Dougan & Associates 2005) but has not been documented since;
  - Two Blue-spotted Salamanders/Blue-Spotted Dominated Polyploid Salamanders (identified as *Ambystoma laterale* or *Ambystoma (2) laterale - jeffersonianum* based

on visual observation) were recorded by Beacon near the eastern culvert under Maltby Road West in spring 2017 (see Photos 4 and 6 in Appendix H2);
  - Yellow-spotted Salamanders (*Ambystoma maculatum*) and Red-spotted Newt *Notophtalmus viridescens viridescens*) were recorded in several previous studies in the SPA and PSA over the past decade or so, but not as part of the CMSP field studies: Yellow-spotted Salamander has been recorded on the 365 Maltby Road West lands (NRSI 2007, NRSI 2012c) and in Hall's Pond wetlands (Timmerman et al., 2010) and Red-spotted Newt has been recorded on the 365 Maltby Road West lands (NRSI 2012c, Dougan & Associates 2005).
- Three (3) locally significant snake species have been recorded in the SPA and/or PSA as follows:
  - Northern Water Snake (*Nerodia sipedon sipedon*) was noted once along Maltby Road East in 2017 and is the first record for this area
  - Brown Snake (*Storeria dekayi dekayi*) was noted once along Maltby Road West in 2017 and has also been previously documented in the PSA and SPA by others (NSEI 2016, NSEI 2015, NSEI 2014, Dance Environmental Inc. 2014, McEachren 2012, NRSI 2012b, NRSI 2012c, NRSI 2011, NRSI 2010, NRSI 2007, Black et al., 2005, NSEI 2001).
  - Previous field studies documented Redbelly Snake (*Storeria o. occipitomaculata*) (NSEI 2016, NSEI 2015, NSEI 2014, Dance Environmental Inc. 2014, McEachren 2012, NRSI 2012c, NRSI 2011, NRSI 2010, NRSI 2007, Black et al. 2005, NSEI 2001).
- Two (2) locally significant mammals – Long-tailed Weasel (*Mustela frenata*) and Jumping Mouse (*Napaeozapus insignis*)– have been recorded in the PSA by others.

A complete list of locally significant wildlife species documented in the SPA and/or PSA is included in the 2017 Monitoring Report (see Table 4.4.13).

No refinements to the City's mapping is provided based on the locations of locally significant species as this information is incomplete and will, irrespective, need to be verified as part of site-specific studies. Specific locations were not available for species drawn from background sources, and those identified during field studies were limited to the properties where access was provided and surveys in the rights-of-ways. These lists help characterize the current species diversity in the SPA and also provide the range of locally significant species that could be encountered at the site-specific level.

4.6.4.2 Significant Wetlands and Other Wetlands

One of the most prevalent natural heritage features in the SPA are its wetlands and ponds. Many of these features are identified as Provincially significant and captured within the Hall's Pond Provincially Significant Wetland Complex (in the Hanlon Creek Watershed) or the Mill Creek Provincially Significant Wetland Complex (within the Mill Creek Watershed). The SPA also includes a number of wetlands and ponds, generally units smaller than 0.5 ha and in a number of cases smaller than 0.2 ha, which are currently mapped as unevaluated or "other" wetlands and have not been identified as Provincially significant. The process and outcomes of reviewing the mapping and status of these features is described in this section.

Review of and refinements to both the Province's and the City's wetlands mapping was undertaken as part the updates to the City's NHS. As noted in the methods above, refinements were: (a) based on the updated ELC mapping (provided in the 2017 Monitoring Report), (b) informed by the guidance provided by MNRF and GRCA (described in more detail below) and (c) ultimately based on an approach that considered the local conditions, context and area-specific precedents.

Overview of Applicable Policies

The City of Guelph Official Plan (2014 Consolidation) includes the following categories of wetlands to be included within the NHS:

1. Provincially Significant Wetlands (PSWs): as identified by MNRF plus minimum 30 m buffers;
2. Locally Significant Wetlands (LSWs): non-PSWs and unevaluated wetlands of at least 0.5 ha plus minimum 15 m buffers; and
3. Other Wetlands: unevaluated wetlands between 0.2 and 0.5 ha that meet one or more of the established criteria for protection plus minimum 15 m buffers, with the criteria being: (i) located within a floodplain or riparian community, (ii) identified as a bog or fen, (iii) providing habitat for locally significant species, (iv) part of an ecologically functional corridor or linkage between Significant Natural areas, or (v) part of a seep or spring or is hydrologically linked to a Significant Wetland.

Minimum buffers are to be applied to but are separate from the protected natural feature (e.g., Significant Wetland, Significant Woodland) and are not defined as part of the feature but are part of the minimum requirement regarding mitigation, where established in the Official Plan. Minimum and/or established buffers are also mapped as part of the land use designation in the City's Official Plan (2014).

Under the City's policies, no new development is permitted within a PSW (as per the PPS 2014) or LSW and activities within their established buffers are limited to essential linear infrastructure and stormwater management facilities (restricted to the outer half of the buffer). The same restrictions apply to Other Wetlands confirmed as meeting the criteria for protection, although trails may also be permitted within their buffers. The City's policies for "Other Wetlands" also require wetland units between 0.2 and 0.49 ha to be screened against the criteria in the Official Plan under Policy 6A.3.2 (cited above) to determine whether or not they require protection.

In addition, GRCA regulates all wetlands[4] (and their defined adjacent lands or "areas of interference") in their jurisdiction and therefore their policies also apply (GRCA 2015) to the SPA (see Map NH-4A, Appendix F). Development is generally not permitted in wetlands but may be permitted in accordance with the GRCA's consolidated policies for the administration of Ontario Regulation 150/06 (2015). For example, development may be permitted within naturally occurring wetlands less than 0.5 ha in size and within anthropogenic wetlands less than 2 ha in size, subject to the criteria outlined in Policies 8.4.4 and 8.4.5, respectively. In addition, public infrastructure may be permitted within a wetland in accordance with Policies 8.4.6 and 8.4.7.

Guidance from MNRF and GRCA

The City and Consulting Team met with MNRF and GRCA on January 11, 2017 and with the GRCA once again on August 13, 2018 to discuss, among other things, the approach to updating the wetland mapping in the SPA through the CMSP process. MNRF (M. Thompson) indicated that going forward decisions relating to PSWs would be guided by the current Ontario Wetland Evaluation System (OWES) Guidelines (MNRF 2014a) and additional guidance from their office regarding complexing units smaller than 0.5 ha. In addition, GRCA indicated that they would accept minor refinements and additions to GRCA-mapped wetlands (i.e., identification of wetlands not previously identified by GRCA) based on information collected through the CMSP, but that any proposed removals from GRCA mapping (i.e., recommendations that areas mapped as wetlands be removed based on field verification that these areas are not, in fact, wetlands) would need to be field verified by GRCA.

Current guidance regarding the OWES as it relates to complexing wetlands in Southern Ontario from MNRF (2014) states that: "In general, wetlands smaller than 2 ha (5 acres) are not evaluated. However very small wetlands can provide habitat for wildlife or serve other ecological, hydrological, hydrogeological or social functions. This is particularly true in wetland complexes". The rules for complexing wetlands have been simplified and made more specific as follows (adapted from MNRF 2014a):

1. Wetlands must not be complexed across watersheds except in rare circumstances as in major headwater areas, such as the Oak Ridges Moraine.
2. The maximum distance between units of a complex must not exceed 0.75 km straight line distance.
3. Lacustrine wetlands (often occurring at the mouths of streams entering the lake) may be considered as units of a complex as long as units meet the 0.75 km distance criterion, although lacustrine wetlands connected to one another by bands of submergent vegetation will not necessarily be complexes.

[4] "Notably, "wetlands" are defined slightly differently under the Conservation Authorities Act and by MNRF, however in 2005 the GRCA, MNRF and Ducks Unlimited published a guidance document intended to resolve differences in GRCA;s and MNRF's approach to wetland identification and protection (GRCA *et al.*, 2005) which remains in effect.

In addition, the OWES guide (MNRF 2014a) states that: "wetland units less than 2 ha in size may be included as part of the complex … when, in the opinion of the evaluator, the small wetland pocket may provide important ecological benefit. Some examples of such benefits would be: a grassy area used by spawning pike; an area containing a community or specimen of a rare or unusual plant species; a seepage area in which a regionally or provincially significant plant or animal species is found; or a wetland which strengthens a corridor link between larger wetlands or natural areas".

Additional guidance provided by MNRF Guelph District (M. Thompson, January 11, 2017) regarding the inclusion of wetlands less than 0.5 ha in wetland complexes is as follows:

- Wetlands under 0.5 hectares can be included in an existing PSW complex if they fulfil one or more of the following criteria:
  1. Occur in site districts where wetlands are very rare or rare (i.e., score of 60 or 80 points in the rarity within the landscape category see Table 4, Section 4.1 in the Wetland Manual. In these site districts, wetlands are so rare that small wetlands take on added importance and in some parts of the district may constitute the majority of wetlands).
  2. Support wetland types not well represented elsewhere in a wetland complex, covering 10% or less of the total wetland area (i.e., open water wetlands in a wetland complex that largely supports deciduous swamps, a graminoid marsh wetland in a wetland complex that is largely cattail marsh, etc.). These less frequent wetland types will add to the biodiversity of the wetland complex and will support flora and fauna not in the more dominant wetland types in the wetland complex.
  3. Sustain significant species/communities (i.e., rare or uncommon species/communities at the local, regional or provincial/national level based on species lists noted in the Wetland Evaluation Manual or approved by MNRF District office and NHIC lists for fauna, flora and communities; conservation priority bird species as defined by Bird Studies Canada; or species tracked by the Natural Heritage Information Centre).
  4. Function as amphibian breeding areas.
  5. Function as migratory waterfowl stopovers, summer feeding areas or waterfowl breeding areas.
  6. Are headwater source areas or contribute base flows to watercourses.
  7. Are hydrologically connected to larger wetlands.
  8. Provide intervening wetland habitat between larger wetlands thereby acting as wildlife stepping stones.
  9. Are part of a larger wetland divided by a road, driveway, trail, or utility corridor.
  10. Are kettle wetlands, an uncommon wetland, restricted to moraines (most kettle wetlands are small and on some parts of a moraine constitute the majority of wetlands).
  11. Occur along corridors.

The Grand River Watershed Wetland Evaluation Protocol (MNRF *et al.,* 2005) which was developed jointly between GRCA, MNRF and Ducks Unlimited Canada (DUC) also includes some guidance in Appendix B that clarifies when open water bodies are or are not considered wetlands. Specifically, Scenario 6 indicates that: "*The test to determine if open water bodies should be considered to be wetlands is the presence of wetland function. Open water areas that are presumed not to perform some wetland function should not be considered to be wetland. Open water bodies that do not contain wetland vegetation because of turbidity caused by intrusion of livestock or annual draw-down of waterbody by the landowner should not be considered to be wetlands. Similarly, storm water ponds, irrigation ponds and golf course ponds should not be included. Naturalized dug or dammed ponds may be considered to be wetlands [if they meet the established criteria]*".

Approach for the CMSP

At the meeting with MNRF and GRCA on January 11, 2017 the Consulting Team presented a draft map showing that: (a) the current MNRF PSW mapping does not align in all locations with the City's PSW mapping, and (b) some smaller (i.e., under 2 ha) wetland units had been included as part of either the Hall's Pond or Mill Creek PSW complexes in the SPA, while others had not even though all mapped wetlands/ponds are less than 750 m from a PSW unit. In addition, discussions with GRCA in August 2018 have also identified some discrepancies between wetlands mapped and regulated by GRCA (see Map 5A, Appendix F) with those identified by MNRF (see Map 5B, Appendix F) and with the consolidated wetland map developed by the City as part of its NHS.

MNRF (M. Thompson) indicated that the most recent wetland mapping by MNRF in this area had been done by A. Timmerman using the guidelines applicable at the time combined with his professional judgement. Going forward, she indicated MNRF's decisions would be guided by the current OWES Guidelines (MNRF 2014a) and additional guidance from their office regarding complexing units smaller than 0.5 ha (cited above).

Based on the state of the current wetland mapping and consideration for the guidance provided by both MNRF and GRCA it was agreed that, for confirmed PSWs, the Consulting Team should:

a) update the vegetation community mapping for the SPA and, where more current Ecological Land Classification (ELC) mapping is available, for the PSA; and
b) use this updated ELC base to refine and reconcile the identified PSW boundaries, as well as confirm or identify any additional wetland units not currently identified as PSW.

Although it is recognized by the Consulting Team that ELC wetland boundaries do not always correspond to wetland boundaries mapped based on the application of the Ontario Wetland Evaluation System (OWES) guidance, it was agreed with GRCA that for the purposes of the Secondary Plan refinements this approach would suffice with the understanding that final wetland boundaries would still need to be staked and confirmed in the field with GRCA as part of each development application or process.

As the GRCA regulates all wetlands in its jurisdiction, it was further agreed in consultation with them (August 13, 2018) that:

1. Proposed minor revisions to existing wetland boundaries mapped by the GRCA would be acceptable with supporting data or information;
2. Proposed wetland "additions" (i.e., new wetlands not currently mapped by the GRCA – error of omission) would be acceptable with supporting data or information; and
3. Proposed wetland "removals" (i.e., currently mapped as wetland by the GRCA but possible error of commission) could only be removed from the mapping if verified in the field by the GRCA and confirmed as not being wetland.

Wetland mapping updates and refinements undertaken for the CMSP to date have been based on desktop assessments supplemented by drive-by and field assessments on the properties where access has been provided. These refined boundaries (as shown in Maps NH-5B and NH-6, Appendix F) are being further reviewed and refined over the summer and fall of 2018 where additional information and site access are being provided. Once this process has been completed, refined and updated wetland mapping will be shared with the MNRF and GRCA for their review and approval.

For wetlands not currently identified as part of PSW complexes (i.e., unevaluated wetlands), it was recognized that despite the relatively small size of some of these units that given the criteria for complexing provided by MNRF that any feature meeting the definition of "wetland"[5] within the SPA could potentially be complexed within one of the existing PSWs. However, it was also recognized that in many cases the Consulting Team did not have sufficient site-specific information to confirm whether or not the feature was in fact a "wetland" (as opposed to an open water feature lacking wetland functions). In addition, in a recent site-specific case within the PSA just outside the SPA (i.e., 1888 Gordon), MNRF had determined that based on site-specific information the small wetland on site did not warrant complexing with the adjacent Hall's Pond PSW complex.

[5] "Wetlands" are defined by MNRF (2014) as: "Lands that are seasonally or permanently flooded by shallow water as well as lands where the water table is close to the surface: in either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic or water tolerant plants" but are defined by the Conservation Authority Act (1990) somewhat more restrictively as land that: "(i) is seasonally or permanently covered by shallow water or have a water table close or at the surface, (ii) directly contributes to the hydrological function of a watershed through connection with a surface watercourse, (iii) has hydric soils, the formation of which have been caused by the presence of abundant water, and (iv) has vegetation dominated by hydrophytic plants or water tolerant plants, the dominance of which has been favoured by the presence of abundant water but does not include periodically soaked or wet land that is used for agricultural purposes and no longer exhibits wetland characteristics

Therefore, for the non-PSW and unevaluated wetlands the approach taken by the Consulting Team (as agreed with the City) was that they would recommend the following unevaluated wetland units be complexed with the existing PSW with the same watershed:

1. units physically connected to a PSW unit by being immediately adjacent or connected through a surface water connection (thereby meeting MNRF criterion #7 above); and/or
2. units contained within the current NHS (thereby meeting MNRF criterion #11 above and strengthening "a corridor link between larger wetlands or natural areas" as per the OWES guidance in MNRF 2014a).

The remaining unevaluated wetlands, all less than 0.5 ha and in a number of cases well under 0.2 ha, have been retained on the map as Other Wetlands ha with the intent that their status would be reviewed as part of the site-specific assessment process and subject to the applicable policies.

Wetland Refinement Mapping

Based on the approach outlined above, wetland mapping refinements were undertaken in two stages:

- Stage 1: Identification of proposed changes to the Province's mapping of PSWs and unevaluated wetlands (shown in Map NH-5B in Appendix F); and
- Stage 2: Incorporation of proposed changes to the Province's wetland mapping into the City's framework for wetlands, and identification of any further changes to the City's wetlands mapping based on the applicable City policy framework, including the applicable of applicable buffers (shown in Map NH-6 in Appendix F).

The results included both proposed addition to and removals form PSW units, as well as a number of transitions of unevaluated wetlands to PSW units and a few additions to and removals of unevaluated wetlands. Notably, proposed "additions" and "removals" in the SPA so not imply actual wetland creation or removal, but simply reflect corrections to the accuracy of the existing mapping (e.g., removal of features mapped as wetland that are not in fact wetland, and addition of features currently not mapped as wetland that were found to qualify as wetlands in the field). Most of the changes are attributable to refinements in the ELC mapping. Most changes to wetlands also fall within the boundaries of the current NHS (2014), although some do not particularly once the minimum buffers[6] are applied to the refined features (as shown in Map NH-6 in Appendix F). All wetlands, irrespective of size, were included.

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[6] Minimum buffers to be applied to but are separate from the protected natural feature (e.g., Significant Wetland, Significant Woodland) and are not defined as part of the feature but are part of the minimum requirement regarding mitigation, where established in the Official Plan. Minimum and/or established buffers are also mapped as part of the land use designation in the City's Official Plan (2014).

One unevaluated wetland shown on Map NH-6 (on 360 Maltby Road East) identified in the ELC mapping and the MNRF mapping is being recommended for removal from the City's NHS mapping in accordance with the site-specific OMB agreement. However, based on the available information, this feature is still considered a wetland feature and will still be subject to review and the applicable policies as part of site-specific studies.

It is also worth noting that the City's 2014 NHS, as shown in Maps NH-1, NH-5A and NH-5B includes minimum buffers for wetlands identified for protection in this system. A minimum buffer of 30 m is applied to all PSWs and a minimum buffer of 15 m is applied to all LSWs and protected Other Wetlands, as per the City's approved NHS policies. Refinements to the wetland mapping, including related refinements to the associated buffers to these wetlands, is presented in Map NH-6 (Appendix F).

Going forward, finalizing the wetland refinements for the CMSP will involve integration of additional refinements based on new information and/or field verification undertaken over 2018 as well as consideration for the GRCA's wetlands layer (see Map NH-5A, Appendix F).

4.6.4.3 Significant Woodlands and Cultural Woodlands

Based on the current ELC mapping (see the 2017 Monitoring Report): "natural" woodlands and forests comprise about 16% of the SPA and include coniferous, mixed and deciduous forest types. Cultural woodland types comprise an additional 15.4% (i.e., 8% of the SPA is covered by cultural woodland communities as defined by the ELC system and plantations cover an additional 7.4%). Wooded wetlands, also known as swamps, provide an additional 1.9% of coverage. This results in a total of more than 30% of the SPA covered in some type of woodland or forest community.

In the current NHS (2014), some of these wooded features are identified as Significant Woodlands, some are identified as Cultural Woodlands (as defined in the Official Plan), some overlap with other NHS components (e.g., Significant Wetlands and their associated buffers, Significant Landform), and some are outside of the identified NHS. The process and outcomes of reviewing the mapping and status of these features is described in this section.

Review of and refinements to the City's woodlands mapping was undertaken as part the updates to the City's NHS. As noted in the methods above, refinements have been based on the updated ELC mapping (provided in the 2017 Monitoring Report) except where site-specific OMB settlements related to OPA 42 (2014) or current litigation (see Maps NH-1 and NH-2, Appendix F) require "defaulting" to the Significant Woodlands and Cultural Woodlands mapping as approved in 2014 (City of Guelph 2014).

Overview of Applicable Policies

The City of Guelph Official Plan (2014 Consolidation) includes the following categories of woodlands to be included within the NHS:

1. Significant woodlands identified for protection include:
    a. Woodlands (not identified as Cultural Woodlands or plantations) of 1 ha or greater in size, plus a 10 m minimum buffer.
    b. Woodlands 0.5 ha in size or greater consisting of Dry-Fresh Sugar Maple Deciduous Forest plus a 10 m minimum buffer, or
    c. Woodland types ranked as S1 (critically imperilled), S2 (imperilled) or S3 (vulnerable) by the NHIC plus a 10 m minimum buffer.
2. Cultural woodlands (as defined in the Official Plan) identified for protection must meet the description provided in the Official Plan, be at least 1.0 ha and not be dominated by non-indigenous, invasive species plus minimum 10 m buffers.

The City's Official Plan (2014 Consolidation) further defines the following:

WOODLANDS: treed areas that … includes an area of land at least 0.2 ha size with at least:
i) 1000 trees of any size, per hectare;
ii) 750 trees measuring over 5 centimetres diameter at breast height, per hectare;
iii) 500 trees measuring over 12 centimetres diameter at breast height, per hectare;
iv) 250 trees measuring over 20 centimetres diameter at breast height, per hectare,

But does not include a cultivated fruit or nut orchard, a plantation established for the purpose of producing Christmas trees or nursery stock. For the purposes of defining woodland, treed areas separated by more than 20 metres will be considered a separate woodland.

CULTURAL WOODLAND: a woodland with tree cover between 35% and 60% originating from, or maintained by, anthropogenic, influences and culturally based disturbances (e.g., planting or agriculture, clearing, recreation, grazing or mowing); often having a large proportion of introduced (i.e., non-indigenous) species (as per the Ecological land Classification System for southern Ontario) and with shrubs, grasses, and/or herbaceous ground cover…

PLANTATIONS: where tree cover is greater than 60% and dominated by canopy trees that have been planted:
I. managed for production of fruits, nuts, Christmas trees or nursery stock; or

II. *managed for tree products with an average rotation of less than 20 years (e.g. hybrid willow or poplar); or*
III. *established and continuously managed for the sole purpose of tree removal at rotation, as demonstrated with documentation acceptable to the planning authority or the MNR, without a forest restoration objective.*

These policies, as currently implemented by City staff, result in the identification of any wooded areas of at least 1 ha meeting the established tree densities as being considered as Significant Woodland except for: (a) plantations that are being actively managed (as described above) and (b) wooded units less than 1 ha separated by more than 20 m from the larger wooded area. Notably, there is currently no definition or policies for wooded areas that meet the first part of the definition for plantations (i.e., "where tree cover is greater than 60% and dominated by canopy trees that have been planted") but that are not being managed in accordance with one of the three methods described in the remainder of the definition. Therefore, under the current policies, such areas fall into the category of "woodlands" by default.

In general, development or site alteration is not permitted within a confirmed Significant Woodland or Cultural Woodland or its buffers, although there are some exceptions with respect to some types of infrastructure and trails if these elements meet the established criteria

Approach for the CMSP

The current Significant Woodland and Cultural Woodland mapping in the City's approved Official Plan (2014 Consolidation) is based on the ELC mapping in place at the time and the mapping as approved through site-specific settlements of the OPA 42 OMB process.

The proposed refinements to the City's Significant Woodland and Cultural Woodland mapping are based on:

a) carrying forward the mapping approved through site-specific settlements of the OPA 42 OMB process (as identified in Map NH-1 in Appendix F); and
b) updating the mapping on the remaining parcels based on:
    i. the updated ELC mapping (as provided in the 2017 Monitoring Report), and
    ii. application of the current City policies, as described above.

Mapping updates have been based primarily on desktop assessments supplemented by drive-by assessments and field assessments on the properties where access has been provided. The refinements (as shown in Maps NH-7 and NH-8, Appendix F) even once approved and incorporated into the Secondary Plan, will still be subject to field verification and staking with City staff as part of site-specific studies in the future.

Woodland Refinement Mapping

Based on the approach outlined above, woodland mapping refinements include (outside of the OPA 42 settlement properties):

- proposed additions to Significant Woodlands;
- proposed transitions from Cultural Woodlands to Significant Woodlands;
- proposed transitions from Significant Woodlands to Cultural Woodlands; and
- proposed additions to Cultural Woodlands.

No refinements involving removals to woodland areas were identified.

It is also worth noting that the City's 2014 NHS, as shown in Maps NH-1 and NH-8, includes minimum buffers for woodlands identified for protection in this system. A minimum buffer of 10 m is applied to all Significant Woodlands and Cultural Woodlands to be protected, as per the City's approved NHS policies. These refinements are illustrated independently on Map NH-7 (Appendix F) for clarity, and in the context of the existing NHS and with the applicable 10 m minimum buffers on Map NH-8 (Appendix F).

As shown on Map NH-8, many refinements fall within the existing NHS but a number that extend beyond the current NHS have been identified east of Gordon Street, particularly in the Rolling Hills area at the corner of Clair Road and Victoria Road, and in the parcels along Maltby Road East.

4.6.4.4 Significant Wildlife Habitat (SWH)

SWH is the most complex natural heritage feature category in the PPS (2014) and, in many municipalities, the one that is the most challenging to implement. One of the primary challenges is that SWH is meant to be identified on a comprehensive, jurisdiction-wide basis so that SWH areas that are "*ecologically important in terms of features, functions, representation or amount*" (MMAH 2014) can be identified across a given planning area. However, identification of most types of SWH requires site-specific, and in some cases very intensive, field assessments which is often not possible for a jurisdiction-wide study.

No SWH had previously been mapped in the SPA as part of the City's NHS (2014) in part due to the absence of site-specific data and in part due to the fact that specific Ecoregional criteria had not yet been developed. Therefore, the SWH assessments and mapping developed through the CMSP is new.

Overview of Applicable Policies

SWH is an umbrella for a wide range of unique and specialized habitat types that are often, but not always, captured within other significant natural heritage features and areas. The applicable Provincial guidance documents (MNRF 2015, MNRF 2000) divide SWH into the following four categories, with a total of thirty-seven (37) specific SWH types identified for Ecoregion 6E (MNRF 2015):

- seasonal concentration areas (15 types);
- rare vegetation communities or specialised habitats for wildlife (15 types);
- habitats of species of conservation concern (excluding the habitats of Endangered and Threatened species) (5 types); and,
- animal movement corridors (2 types).

SWH may be identified as "Candidate" areas where suitable habitat is present but actual species or species numbers required to meet the established criteria have not been confirmed, or "confirmed" once an area meeting the established criteria has been field-verified.

Although guidance for identifying SWH is provided by MNRF, it is ultimately the municipal planning authority (in this case, the City of Guelph) who is responsible for confirming SWH. The criteria for designation of SWH in the City of Guelph (policy 6A.2.9) are as follows:

> *1. Wildlife Habitat that is the most ecologically important in terms of function, representation or amount in contributing to the quality and diversity of the natural heritage system, and falls into one or more of the following categories:*
>
> > *i) seasonal concentration areas, including deer wintering and waterfowl overwintering areas identified by the MNR;*
> > *ii) rare vegetation communities or specialized habitat for wildlife;*
> > *iii) habitat for species of conservation concern (excluding significant habitat of endangered and threatened species), specifically: globally significant species, federally significant species and provincially significant species.*
>
> *2. Ecological linkages.*

Notably, the "Ecological Linkages" category was included as part of the SWH feature in recognition of primary function of these areas being animal movement corridors, as per the Provincial guidance. However, given their distinct function and policy framework, ecological Linkages within and adjacent to the SPA are discussed separately in Section 4.6.4.5 below.

The City's policies with respect to SWH (City of Guelph 2014) provide a higher level of protection to confirmed SWH than is required in the PPS (2014) in that no development or site alteration is permitted within confirmed SWH (irrespective of whether or not the test of no net impacts can be met). Therefore, the City generally tries to capture the best quality and/or most representative SWH (as per the provincial guidance, MNRF 2000) as opposed to any features or areas that may meet the Ecoregional criteria in the City's boundaries.

Approach for the CMSP

The SWH assessment resulted in the following categories of SWH being assigned:

- Confirmed SWH (mapped): Confirmed SWH was only identified where both the suitable habitat and the suggested criteria were considered to be met based on: (a) data collected by Beacon in 2017 (i.e., one seepage area, amphibian breeding habitats (woodland), and turtle wintering areas)) (as detailed in the 2017 Monitoring Report) or (b) SWH identified by others in the PSA that would have been based on data unlikely to have changed since the time of the original identification (i.e., rare vegetation community, NRSI 2007).
- Candidate SWH (mapped): Candidate SWH was identified where suitable habitat could be fairly confidently mapped based on the available information, but data was insufficient to determine if the specific criteria were met or species listed were present. In these cases, site-specific studies should screen for this category of SWH where suitable habitat occurs.
- In the case of raptor wintering habitat and shrub/early successional breeding bird habitat, Candidate SWH areas have been identified approximately with asterisks with the understanding that these areas will need to be screened at the site-specific level to assess the presence and extent of habitat.
- SWH type may occur but is not mapped: In some cases, neither confirmed nor Candidate SWH could be mapped based on the available data but may still occur within the SPA based on known conditions. In these cases, site-specific studies will need to screen for this category of SWH where suitable habitat exists.
- Not Applicable: Finally, some types of SWH are considered not applicable within the PSA based on the absence of suitable habitat. These would presumably not need to be screened as part of future site-specific studies.

Summary of SWH Findings and Application in the SPA and PSA

The findings of the SWH analyses are summarized in Table 4.6.1 below and presented in more detail (including the applicable criteria) in Appendix G4. Candidate and confirmed SWH that could be mapped are illustrated in Maps NH-9 and NH-10 (Appendix F).

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment

SWH Type* (ref. Appendix G4 for more details)	Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)**	Assessed SWH Status in the SPA
Seasonal Concentration Areas		
Waterfowl Stopover and Staging Areas (Terrestrial)	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment

SWH Type* (ref. Appendix G4 for more details)	Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)**	Assessed SWH Status in the SPA
Waterfowl Stopover and Staging Areas (Aquatic)	All marshes with open water where incidental observations of migratory waterfowl have been recorded that could potentially support the required aggregations to be considered Confirmed SWH in the SPA are considered suitable habitat and have been mapped as Candidate SWH. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	Candidate SWH is mapped (ref. Map NH-9) in Appendix F
Shorebird Migratory Stopover Area	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Raptor Wintering Area	Extensive potentially suitable habitat is present within the PSA due to the relatively abundant areas of cultural meadows and thickets adjacent to deciduous, coniferous or mixed forests. Two listed species (Red-tailed Hawk and Northern Harrier) have been confirmed in the PSA. However, no observations were within the SPA and observations in the adjacent PSA were not in adequate numbers or frequency to meet the suggested criteria (i.e., 10 individuals from at least 2 species of hawk or owl for 20 days of use). Site-specific study will be needed to capture the best and most representative area(s) in the SPA, assuming more than one of the Candidate areas meets the established criteria.	Several Candidate SWH areas are shown approximately (ref. Map NH-9 in Appendix F) with an asterisk
Bat Hibernacula	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Bat Maternity Colonies	All deciduous forest (FO-) and swamp (SW-) communities in the SPA are considered suitable habitat and have been mapped as Candidate SWH. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	Candidate SWH is mapped (ref. Map NH-9 in Appendix F)
Turtle Wintering Areas	Midland Painted Turtles and Snapping Turtles have been documented in ponds throughout the SPA and PSA. Not all ponds were assessed as part of the Clair-Maltby Secondary Plan study. Suitable habitat for wintering is presumed to be present within the PSA and SPA in ponds where these turtles have been observed.	Candidate and Confirmed SWH are mapped (ref. Map NH-9 in Appendix F)

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment

SWH Type* (ref. Appendix G4 for more details)	Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)**	Assessed SWH Status in the SPA
	Confirmed SWH has been mapped in ponds where at least five Painted Turtles and/or at least one Snapping Turtle were documented in 2017. Candidate SWH includes Other Wetlands or ponds with permanent open water in the SPA. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	
Reptile Hibernaculum	Suitable habitat may be present within the SPA and/or PSA (e.g. in animal burrows, old housing foundation and wetlands that go below the frost line) but has not been mapped. While a number of individual listed snake species (i.e., Northern Water Snake, Northern Brownsnake, Eastern Ribbonsnake, Northern Red-bellied Snake and Eastern Gartersnake) have been documented in the PSA, no concentrations (i.e., >5 individuals) of reptiles have been recorded. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped
Colonially-Nesting Bird Breeding Habitat (Bank and Cliff)	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Colonially-Nesting Bird Breeding Habitat (Tree/Shrubs)	Suitable habitat may be present within the PSA in treed wetlands (i.e., swamps) and ponds. Great Blue Heron has been observed in the SPA), but nests were not found. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped
Colonially-Nesting Bird Breeding Habitat (Ground)	Only one of the listed species has been recorded in the PSA (Brewer's Blackbird) and none of the listed species would be expected to occur in the PSA in sufficient numbers to meet the criteria.	Not Applicable
Migratory Butterfly Stopover Areas	No suitable habitat identified in the SPA or PSA due to its distance from Lake Ontario and Lake Erie.	Not Applicable
Landbird Migratory Stopover Areas	No suitable habitat identified in the SPA or PSA due to its distance from Lake Ontario and Lake Erie.	Not Applicable

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment

SWH Type* (ref. Appendix G4 for more details)	Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)**	Assessed SWH Status in the SPA
Deer Yarding Areas	This SWH type is determined by MNRF, typically in areas with higher levels of snowfall. No suitable habitat has been identified in the SPA or PSA by MNRF.	Not Applicable
Deer Winter Congregation Areas	White-tailed deer are known to be common in the PSA, but this SWH type is determined by MNRF and no suitable habitat has been identified in the PSA by MNRF. It typically applies to woodlands and/or swamps that are at least 100 ha but may also apply to smaller coniferous plantations. Verification should occur through site-specific study.	This type of SWH may occur but has not been mapped
Rare Vegetation Communities		
Cliffs and Talus Slopes	No suitable habitat identified in the PSA, and none would be expected to occur.	Not Applicable
Sand Barren	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Alvar	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Old Growth Forest	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Savannah	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Tallgrass Prairie	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Other Rare Vegetation Communities	In 2006, NRSI identified a small Buttonbush Mineral Deciduous Thicket Swamp Type (SWT3-4) community within the southwestern PSA, which is considered rare in Ontario (with an S-rank of S3). Additional provincially rare communities may be identified through site specific study.	One confirmed SWH is mapped (ref. Map NH-9 in Appendix F); other rare communities may be identified
Specialized Habitat for Species		
Waterfowl Nesting Area	Suitable habitat may be present within the SPA and/or PSA in the vicinity of ponds, but surveys conducted as part of the Clair-Maltby Secondary Plan studies did not document adequate numbers of listed species. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment

SWH Type* (ref. Appendix G4 for more details)	Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)**	Assessed SWH Status in the SPA
Bald Eagle and Osprey Nesting, Foraging and Perching Habitat	Suitable habitat is present within the SPA and/or PSA in the vicinity of ponds and wetlands. No evidence for Bald Eagle has been documented in the PSA. One active Osprey nest was located on the lighting posts around the baseball diamonds in the northwestern PSA in 2017, but is on a man-made object, so it is not SWH. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped
Woodland Raptor Nesting Habitat	No suitable habitat identified in the SPA or PSA, and none would be expected to occur.	Not Applicable
Turtle Nesting Areas	Potential suitable habitat is present within the PSA and SPA in areas surrounding marshes and open aquatic ecosites, particularly adjacent to ponds where Midland Painted Turtles and /or Snapping Turtle have been documented by Beacon (see Section 4.4.3.3 and SWH Type #7). Two Snapping Turtle nests were documented on the 132 Clair Road lands (North-South Environmental Inc. 2015) but the specific locations are unknown. Snapping Turtle was also observed nesting within areas of marshes located in the northern central PSA in the vicinity of Dallan Drive. North-South Environmental (2016) noted Snapping Turtle basking and nesting close to the SWM Pond and wetland just east of Hawkins Drive, while Stantec (2007) observed nesting Snapping Turtle in a wetland south of Dallan Drive within the SPA. Additional turtle nesting areas may be identified through site specific study.	This type of SWH occurs and is to be mapped through site-specific study
Seeps and Springs	Suitable habitat occurs within the SPA and PSA. One seep was confirmed by Beacon in 2017 within the SPA on the 2162 Gordon Street property. Additional seepage areas may be identified through site specific study.	One Confirmed SWH is mapped (ref. Map NH-9 in Appendix F); additional seeps or springs may occur

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment		
SWH Type* (ref. Appendix G4 for more details)	**Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)****	**Assessed SWH Status in the SPA**
Amphibian Breeding Habitat (Woodland)	Suitable habitat occurs within wetlands in the SPA and PSA, and as documented in the amphibian surveys over 2017, these areas support very healthy levels of Spring Peepers, Gray Treefrogs and Wood Frogs with Eastern Newt, Blue-spotted Salamander and Western Chorus Frog documented in the area as well. All wetlands greater than 500 m^2 located in, or within 120 m of, a woodland (i.e., FOC, FOD or FOM) or swamp in the SPA have been identified as Candidate SWH for this category. Wetlands meeting the suggested criteria based on data collected in 2017 have been identified as Confirmed SWH for this category. Additional areas may be confirmed through site specific study. Candidate areas should be verified through site-specific study. Additional areas may also be identified through site specific study.	Candidate and Confirmed SWH is mapped (ref. Map NH-9 in Appendix F)
Amphibian Breeding Habitat (Wetland)	Suitable habitat occurs within wetlands in the SPA and PSA, as do the listed species (see SWH Type #28). All wetlands greater than 500 m^2 located more than 120 m from a woodland (i.e., FOC, FOD or FOM) or wooded swamps in the SPA have been identified as Candidate SWH for this category. Wetlands meeting the suggested criteria based on data collected in 2017 have been identified as Confirmed SWH for this category. Candidate areas should be verified through site-specific study. Additional areas may also be identified through site specific study.	Candidate SWH is mapped (ref. Map NH-9 in Appendix F)
Woodland Area-Sensitive Bird Breeding Habitat	No suitable habitat has been identified in the SPA or PSA due to the lack of interior forest, although a few of the listed species have been documented.	Not Applicable
Habitat for Species of Conservation Concern		
Marsh Bird Breeding Habitat	Limited suitable habitat occurs within the PSA and SPA, but most of the listed species have not been documented in the area and would not be expected to occur, with the exception of Sora, Pied-billed Grebe and Green Heron.	This type of SWH may occur but has not been mapped

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment		
SWH Type* (ref. Appendix G4 for more details)	**Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)****	**Assessed SWH Status in the SPA**
	Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	
Open Country Bird Breeding Habitat	No suitable habitat has been identified in the SPA or PSA due to the absence of large enough contiguous meadow / grassland habitats, although a few of the listed species have been documented.	Not Applicable
Shrub/Early Successional Bird Breeding Habitat	Potentially suitable habitat is present within the SPA and PSA due to the presence of cultural thickets of at least 10 ha. Several of the listed species were documented in the SPA and PSA, particularly west of Victoria., by Beacon in 2017 and in previous studies. Site-specific study is needed to refine the mapping and capture the best and most representative area(s) in the SPA.	Several Candidate SWH areas are shown approximately with an asterisk (ref. Map NH-9 in Appendix F))
Terrestrial Crayfish	Suitable habitat occurs within the PSA and SPA, and this type of SWH has been confirmed elsewhere in the City. No evidence of Terrestrial Crayfish was documented during field studies within the PSA and SPA. However, surveys for this species were incidental and not targeted and access was limited, therefore they may occur. Site specific study may be required where suitable habitat exists to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped
Special Concern and Rare Wildlife Species	Suitable habitat occurs within the SPA and PSA for a number of Special Concern species as well as some species list provincially as S1, S2, S3 or SH. These were documented by Beacon in 2017 and in other background studies (ref. Appendix G3). Site specific studies should include screening for these species to confirm the status of this SWH type.	This type of SWH may occur but has not been mapped
	Animal Movement Corridors	
Amphibian Movement Corridors	The amphibian movement documented through the Clair Maltby Secondary Plan studies, and through previous work (Dougan & Associates with Snell and Cecile 2009a), has been primarily across existing roads. The City has identified several Ecological Linkages which are intended to, among other functions, support amphibian movement. Other portions of the NHS which connect Candidate or Confirmed amphibian	This type of SWH may occur but has not been mapped

Table 4.6.1 Overview of Significant Wildlife Habitat (SWH) Assessment		
SWH Type* (ref. Appendix G4 for more details)	**Application to the Secondary Plan Area (SPA) and Primary Study Area (PSA)****	**Assessed SWH Status in the SPA**
	breeding habitats with summer foraging or wintering habitats may also provide linkage functions. One or more of these areas may meet the criteria for amphibian movement corridors. Site specific studies should include screening for amphibian movement where suitable habitat exists to confirm the status of this SWH type.	
Deer Movement Corridors	No deer movement corridors meeting the SWH criteria have been identified by MNRF to date in the SPA. However, the City has identified Ecological Linkages that, based on the available information, are in appropriate locations to support deer movement in an urbanized context.	Not Applicable

Notes: * Adapted from the listed species and habitat criteria provided in the Significant Wildlife Habitat Criteria Schedules for Ecoregion 6E (MNRF 2015) but updated to reflect any relevant changes in species status. For example, Tri-coloured Bat (*Perimyotis subflavus*) is now listed as Threatened so needs to be addressed as a Species at Risk under the Endangered Species Act (2007) and not under SWH. Descriptions of suitable habitat and the applicable criteria for each type is included in Appendix G4

** The SWH assessment considered the broader PSA (i.e., a 500 m zone surrounding the SPA) where contiguous or adjacent natural and semi-natural areas occur in this zone. The SPA was included in the assessment in two ways: (a) to screen for suitable habitat and (b) to screen for data from background studies (ref. Appendix A) that may inform the assessment. However, ultimate refinements to the SWH mapping will be restricted to within the City's boundaries and will be focussed within the SPA.

In summary, of the 37 types of SWH have been confirmed or may occur in the SPA and/or adjacent PSA:

1. Waterfowl Stopover and Staging Areas (Aquatic)
2. Raptor Wintering Area
3. Bat Maternity Colonies
4. Turtle Wintering Areas
5. Reptile Hibernaculum
6. Colonially-Nesting Bird Breeding Habitat (Tree/Shrubs)
7. Deer Winter Congregation Areas
8. Other Rare Vegetation Communities
9. Waterfowl Nesting Area

11. Bald Eagle and Osprey Nesting, Foraging and Perching Habitat
12. Turtle Nesting Areas
13. Seeps and Springs
14. Amphibian Breeding Habitat (Woodland)
15. Amphibian Breeding Habitat (Wetland)
16. Marsh Bird Breeding Habitat
17. Shrub/Early Successional Bird Breeding Habitat
18. Terrestrial Crayfish
19. Special Concern and Rare Wildlife Species
20. Amphibian Movement Corridors

SWH category #19 above includes a wide range of species. The following species that have been confirmed in the SPA and/or PSA by Beacon or other studies are Provincially or Federally significant but not Provincially Endangered or Threatened SAR and would be considered under this SWH category:

- Western Chorus Frog (*Pseudacris triseriata*) is Federally Threatened and was confirmed in the western portion of the SPA and PSA by Beacon in 2017 along Transect W3 (ref. Map NH-2 in the 2017 Monitoring Report), by Dougan & Associates (2005) on 201 Maltby Road West and by NRSI (2012b and 2007) on the 385 Maltby Road West property, and near 161, 205 and 253 Clair Road East (NRSI 2016, Stantec 2009, Stantec 2007). Dougan & Associates (2005) also recorded Western Chorus Frog within the ponds east and west of Gordon Road in the SPA.
- Eastern Ribbon Snake (*Thamnophis sauritus sauritus*) is a species of Special Concern Provincially and Federally and was confirmed in the "Tim Horton's" pond (Basking Turtle Monitoring Station T1 ref. Map NH-2 in the 2017 Monitoring Report) behind the baseball diamonds south of Bishop MacDonell High School by Beacon in 2017, and also within ponds on the 385 Maltby Road West property by others (NRSI 2012b, NRSI 2012c, NRSI 2007).
- Snapping Turtle (*Chelydra serpentine*) is a species of Special Concern Provincially and Federally. Midland Painted Turtle (*Chrysemys picta*) was also recently listed as Special Concern Federally. Both species were confirmed basking by Beacon in 2017 in various ponds in the SPA and PSA (see Figure 4.6.1 and Table 4.4.10 in the 2017 Monitoring Report) and Snapping Turtle also observed nesting within wetlands located in the northern central PSA in the vicinity of Dallan Drive. North-South Environmental (2016) also noted Snapping Turtle basking and nesting close to the SWM Pond and wetland just east of Hawkins Drive, while Stantec (2007) observed nesting Snapping Turtle in a wetland south of Dallan Drive within the SPA. Additionally, Snapping Turtle was confirmed in the Halls' Pond Wetland Evaluation (Timmerman et al. 2010) and on the 385 Maltby Road West Lands (NRSI 2007).

- Wood Thrush (*Hylocichla mustelina*) is a species of Special Concern Provincially and Federally Threatened, confirmed in the forested mid-northern portion of the PSA in close proximity to Dallan Drive (NSEI 2014, Stantec 2007);
- Eastern Wood-pewee (*Contopus virens*) is a species of Special Concern Provincially and Federally, was confirmed in various forested habitats in the SPA and PSA by Beacon in 2017, including Breeding Bird stations B2, B5, B6, B8, and B10, north of the SPA near Dallan Drive (NSEI 2014, Stantec 2007), and west of SPA at the 424 Maltby Road property (Dance Environmental Inc. 2014) and the 385 Maltby Road West lands (NRSI 2007); and
- Monarch (*Danaus plexippus*) is a species of Special Concern provincially and federally and was confirmed in the SPA and PSA in some meadow habitats in the following locations: 132 Clair Road West (NSEI 2015), 161, 205 and 253 Clair Road East (NSEI 2014, Stantec 2007), 424 Maltby Road (Dance Environmental Inc. 2014), Westminster Wood East (Stantec 2009, 2007), along Victoria Road (McCormick Rankin Corporation, and Gamsby and Mannerow Limited 2003) and 385 Maltby Road West. Additionally, Monarch was noted dead on the side of the road twice during the amphibian movement surveys on Transect W3 and W6 (see Map NH-2 in the 2017 Monitoring Report).

Yellow Banded Bumble Bee (*Bombus terricola*) identified as Special Concern Federally has also been confirmed in the City although there have been no searches within the PSA to date. There are no other wildlife species considered Provincially significant confirmed in the SPA and/or PSA by Beacon or other studies other than those listed above.

SWH Refinement Mapping

As noted above, SWH was not previously mapped in the SPA as part of the City's NHS (2014) and so all SWH mapping in this area is new. Maps NH-9 and NH-10 in Appendix F illustrate all of the Confirmed and Candidate SWH identified through the assessment process. SWH has been mapped, as per the Provincial guidance, according the ELC polygon(s) in which it has been documented or in which suitable habitat occurs. The ELC base mapping is provided in the 2017 Monitoring Report.

The two exceptions to the use of ELC for mapping Candidate SWH are: raptor wintering areas (SWH category #2 above) and shrub/early successional bird breeding habitat (SWH category #17 above). According to the established criteria (MNRF 2015), suitable habitat for raptor wintering needs to be >20 ha with a combination of forest and upland, while suitable habitat for shrub/early successional bird breeding is at least 10 ha. Protection of such large areas in the SPA that may be outside of the current NHS (2014) presents a substantial challenge given all of the other competing land uses and the need to accommodate certain densities in the SPA overall. Given this challenge, Candidate areas have been flagged with asterisks based on general habitat suitability (see Maps NH-9 and NH-10 found in Appendix F) and the City is seeking to identify at least one area of habitat suitable for both SWH functions within the SPA.

Map NH-10 (Appendix F) lumps all of the Confirmed and all of the Candidate SWH to illustrate these areas in relation to the current NHS (2014). As with the wetland and woodland refinements, most proposed refinements fall within or immediately adjacent to the current NHS. Notably, no minimum buffers are prescribed for SWH in the City's NHS policies due to the range of habitat types, however buffers to confirmed SWH are to be determined based on site-specific studies.

4.6.4.5 Ecological Linkages

Ecological linkages – also known as wildlife corridors – are recognized in both Provincial and City policies as key components to a functional NHS. Ecological linkages, as well as wildlife crossing locations across existing roads, have been defined, identified and mapped in the City's current NHS (2014 Consolidation). As part of the CMSP, these linkages and crossing locations have been reviewed in the context of the SPA and the surrounding PSA, based on current background and field data.

Overview of Applicable Policies

In Ontario, the PPS (2014) states: "*The diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features*" (policy 2.1.2). The Province also recognizes the importance of corridors for wildlife movement through its SWH types which include "animal movement corridors" as noted in Section 4.6.4.4.

The City of Guelph also recognizes the importance of ecological connectivity in its Official Plan (2014 Consolidation) and has identified and developed policies for both Ecological Linkages and wildlife (amphibian and deer) crossings as part of the NHS.

Ecological linkages are defined in the Official Plan as follows:

> *Ecological Linkage means areas identified based on the principles of conservation biology that connect Significant Natural Areas and/or protected Habitat for Significant Species and along which wildlife can forage, genetic interchange can occur, and populations can move from one habitat to another in response to life cycle requirements. Ecological Linkages provide or enhance connectivity where it is otherwise lacking, ensuring a systems based approach, and supporting natural connections between Significant Natural Areas and/or protected Habitat for Significant Species. Ecological Linkages can also include those areas currently performing, or with the potential to perform linkage functions through restoration measures. Although linkages help to maintain and improve the Natural Heritage System and related ecological functions, they can also serve as habitat in their own right.*

In general, the Official Plan policies for Ecological Linkages (Section 6A.2.9 policies 8 through 13) support connectivity in the NHS but do include provisions for accommodating essential infrastructure and stormwater management facilities, as do some of the other NHS components. The policies also allow for the mapped linkages, which are generally 100 m wide in the SPA, to be modified or refined in terms of location and width as long as the established criteria (e.g., maintaining connectivity) are met.

In addition, linkages that are known or expected to support wildlife movement across existing roads are shown as wildlife crossings (see Map NH-11 in Appendix F) so that mitigative measures can be considered and implemented as opportunities arise (see the City's Official Plan policies under 6A.4).

Review of Ecological Linkages and Wildlife Crossings

Map NH-11 in Appendix F illustrates the identified Ecological Linkages and wildlife crossings within and adjacent to the SPA as per the current NHS (2014), and also illustrates and numbers these connections both with the SPA and extending outside the SPA to the County's Greenlands System and to other NHS components in the City.

The Ecological Linkages and wildlife crossings in Schedule 10 of the current NHS (2014 Consolidation) were identified based on consideration of suitable habitat (e.g., the presence of a combination of woodlands and/or wetlands on both sides of the road) supplemented with field data related to amphibian populations (Dougan & Associated 2005) and incidental observations of deer activity collected as part of the City's Natural Heritage Strategy (Dougan & Associated 2009a,b). Ecological linkage mapping was also, in some cases, refined through site-specific mapping changes agreed to through the OMB settlement process which was finalized on June 4, 2014.

In general, the wildlife movement information collected through the CMSP amphibian movement studies (detailed in the 2017 Monitoring Report) confirms that the current NHS captures or flags most of the locations where movement of amphibians has been documented, with some of those areas appearing to support more movement than others. However, lack of access to a number of the properties meant that amphibian movement within some of the large properties (where future roads may be located) where linkages are identified could not be assessed as part of the CMSP.

Both the 2017 studies by Beacon and the site-specific studies undertaken on certain properties in and adjacent to the CMSP over the past decade have identified several locations where amphibians migrate between Candidate / Confirmed breeding habitats and summer / wintering areas, with the greatest activity documented across Maltby Road West just west of the SPA. In order of apparent significance, amphibian crossing locations include, as shown on Map NH-11 in Appendix F:

- Maltby Road West in the vicinity of linkages C and D;
- Maltby Road East in the vicinity of linkages E and F, as well as where the “other” crossing is noted on Map NH-11 between these two arrows;
- Victoria Road in the vicinity of linkage H; and
- Gordon Street between the complexes of wetlands and woodlands on either side in two areas corresponding to linkages 6, 2 and 4.

Figure 4.6.1 below illustrates the total number of amphibians documented during the four movement surveys undertaken by the Consulting Team in the spring and fall of 2017 (in green circles) as well as the ponds in which the largest numbers of turtles were documented in 2017 (in blue call-out boxes). Amphibian movement has also been documented across Clair Road East in other monitoring work (NSE 2015) which is ongoing. Details of the results of these surveys in terms of numbers, species and dates recorded are provided in the 2017 Monitoring Report. Although the vast majority of the records were for frogs, there were also a few records of salamanders, newts, snakes and turtles.

These observations suggest that the Ecological Linkages already identified in the NHS are in appropriate locations, and also show that the deer crossing and other wildlife crossing locations previously identified in the City’s NHS are also locations that support substantial amphibian movement with the exception of linkage G.

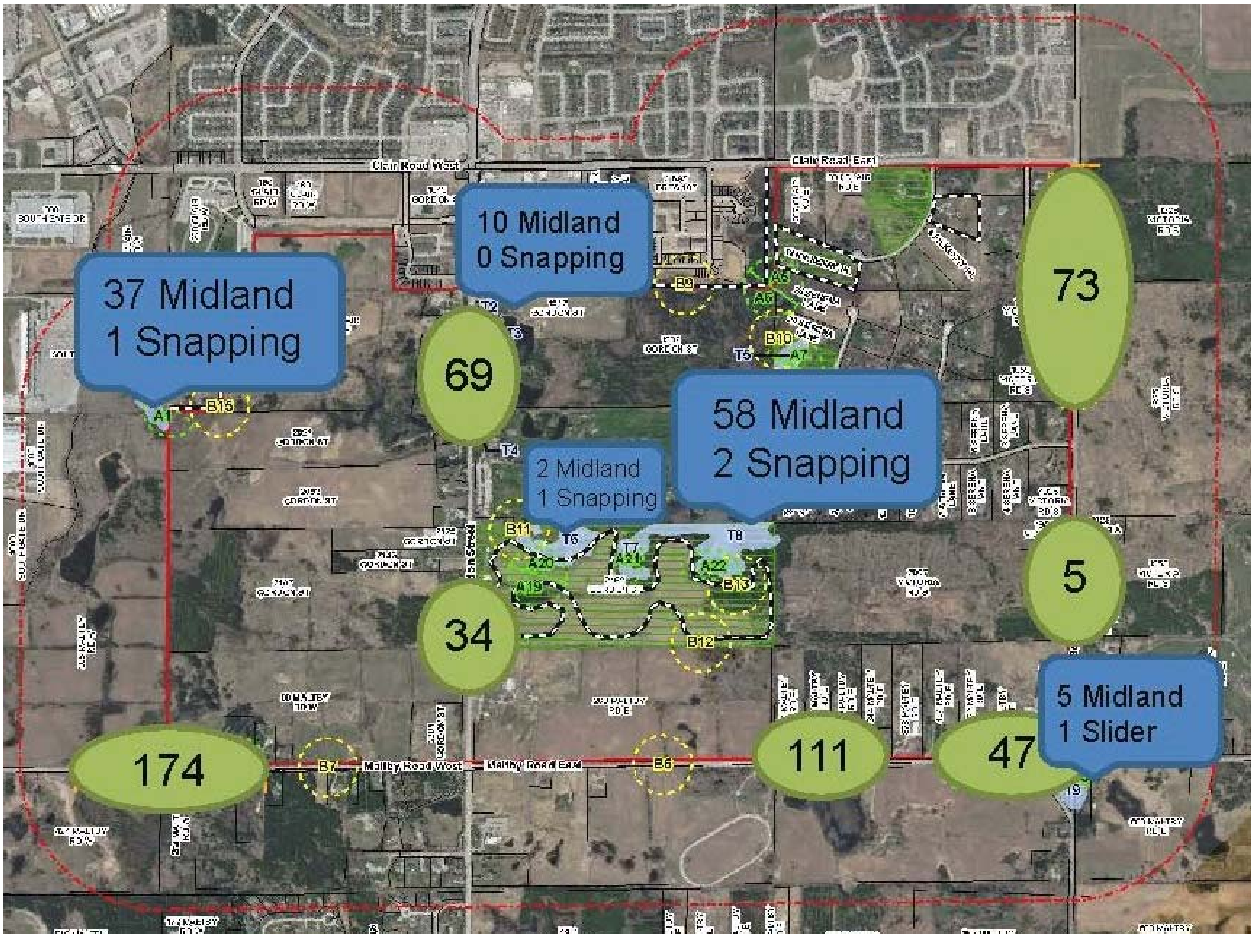


Figure 4.6.1. Total number of amphibians documented during movement surveys (in green circles) and ponds in which the largest numbers of turtles were documented in 2017 (blue call-out boxes).

As noted and illustrated above, the greatest concentration of movement documented over 2017 was on Maltby Road West, followed by Maltby Road East, Victoria Road close to Clair Road and Gordon Street in the vicinity of the Hall's Pond PSW Wetland Complex. Previous amphibian movement surveys along Maltby road West across from 385 Maltby Road West undertaken between 2009 and 2012 (McEachren 2012, NRSI 2012b, c) also documented significant amphibian movement in this area.

In the SPA, the EIS and EIR for the Dallan Lands (east of the Cineplex on Clair Road) (Stantec 2009, NSEI 2014) and subsequent wildlife movement monitoring (NSEI 2016) confirmed amphibian movement in linkages I and J, as well as across Clair Road.

With respect to white-tailed deer movement, the 2017 winter wildlife survey (see Section 4.4.3.6 in the 2017 Monitoring Report) documented an abundance of deer tracks in the agricultural fields and forested features of 2162 Gordon Street. There were also deer tracks within the forested features in proximity to Dallan Drive, Kilkenney Place and Serena Lane in the Rolling Hills subdivision in the northeast corner of the SPA. However, no large concentrations or specific deer movement locations were documented in 2017, although the results are limited to the properties on which access was provided. This nonetheless suggests that linkages 2 / 6 and 4 in the current NHS are in locations that could support deer movement in an urbanized context. Deer movement between the City and the County / Puslinch Township along linkages H and G along Victoria Road, and along linkages C, D, E and F across Maltby Road also likely occurs.

The majority of background data from the PSA and SPA (ref. Appendix A) also noted the presence of deer, but no specific concentration areas.

4.6.4.6 Opportunities for Restoration and Naturalization

Opportunities for restoration and naturalization in the City exist (a) through the formal designation of Restoration Areas as defined in the City's Official Plan, (b) though the restoration and naturalization of other NHS components (e.g., Ecological Linkages, buffers and Significant Landform not already naturalized), and (c) through the identification of additional restoration and/or naturalization opportunities outside identified NHS components.

Restoration Areas are a specific and defined component of the City's NHS and, as stated in the Official Plan (policy 6A.2.10), they "*are generally located on public lands, and identify potential areas where restoration may be directed*". Designated Restoration Areas in the City must meet one or more of the following criteria (City of Guelph Official Plan 2014, policy 6A.2.10):

1. *Existing and new stormwater management areas abutting the Natural Heritage System.*
3. *Areas within City parkland (including portions of the Eastview Community Park) and GRCA lands which are not intended for active uses.*
4. *Isolated gaps within the Natural Heritage System.*

The need for this land use designation arose from the recognition that the City's NHS is a valued community asset that is continually under threat from competing land uses, as well as stressors introduced from the environment (e.g., climate change, invasive pests and plants) and stressors associated with urbanization (e.g., encroachments from adjacent land uses, disturbances associated with artificial noise and lighting). In addition to protecting valued natural areas and establishing appropriate buffers and setbacks, formally designated Restoration Areas provide an additional means of enhancing the NHS).

Currently identified Restoration Areas in the City outside of the SPA include stormwater areas / corridors that abut and connect the NHS (e.g., in Westminster Woods), areas in City parkland or open space not intended for active use (e.g., Eastview Park, the Lafarge lands park) and isolated gaps in the NHS (e.g., areas within and around Hanlon Creek Wetlands). Restoration Areas have not yet been identified in the SPA but may be identified once the Preferred Community Conceptual Plan has been determined. Opportunities for identification of such areas through the EIS and EIR process also exist in the current Official Plan policies.

Although the identification of both formally designated Restoration Areas and potentially informally identified restoration and naturalization areas are feasible and desirable from a natural heritage perspective, consideration must also be given to balancing such opportunities with other land uses that must be accommodated within the City, and within the SPA in particular. Furthermore, some types of restoration and/or naturalization (e.g., Restoration Areas that provide SWM or LID functions, and those outside identified NHS components) may be better identified at the site-specific stage when the details of a given development are known. Going forward, opportunities to ensure various types of restoration and naturalization areas are integrated into the SPA either through mapping and/or policies and/or management strategies.

4.7 Significant Landforms

The Paris Moraine is a significant landform complex of southern Ontario which dominates the landscape of south Guelph. Chapman and Putnam (1966, p. 200) noted that this moraine complex is particularly well displayed in the area between Guelph and Puslinch. Section 4.2.4.3 above provides a complete description of the surficial geology associated with this moraine.

The City of Guelph formally defined portions of the Paris Moraine complex as one of several natural heritage components ("Significant Landform") of its Natural Heritage System (NHS) in OPA 42 and mapped this component in Schedule 10D of the Official Plan (2014 Consolidation). The criterion used to identify this component is as follows:

> "*Hummocky Topography* of the *Paris Galt Moraine* that exhibits slope concentrations where the slope is 20% or greater, and located in association with closed depressions identified by the GRCA, and in close proximity to other Significant Natural Areas of the Natural Heritage System."

Further, hummocky topography is defined in the City's Official Plan (2014 Consolidation) as:

> "…the character of the land as displayed by the *Paris Galt Moraine* consisting of a topography highlighted by concave and convex slopes connecting a high diversity of slope classes…and generally incorporating closed depressions, ridges and/or hilltops."

Hummocky moraines are also often referred to as a type of "ice-contact" deposit because of the significant role of glacial ice in their formation. The closed depressions are kettle landforms that formed by the melting of buried ice blocks (see Section 4.2.4.3). As the ice melts, sand gravel material in contact with the ice becomes unstable, slumping downward and creating slopes typically greater than 20%. Hence, both closed depressions and steep slopes are critical in defining the significance of the Paris Moraine within the SPA.

4.7.1 Importance/Purpose

The Paris Moraine dominates the landscape of south Guelph and forms the substrate for other significant natural heritage features. For example, closed depressions create opportunities for wetland formation. In addition, the northeast-southwest linear nature of the moraine provides a natural connecting function that contributes to critical ecological linkages. The Natural Heritage Reference Manual (MNRF 2010) recommends jurisdictions include landform, particularly moraines, as both a significant feature and a connection element when developing natural heritage strategies. This approach was adopted in the identification of the NHS in Guelph's south end where the Paris Moraine is such a prominent feature.

The City's Official Plan (2014 Consolidation) includes specific objectives for the designation and protection of significant landform within the NHS:

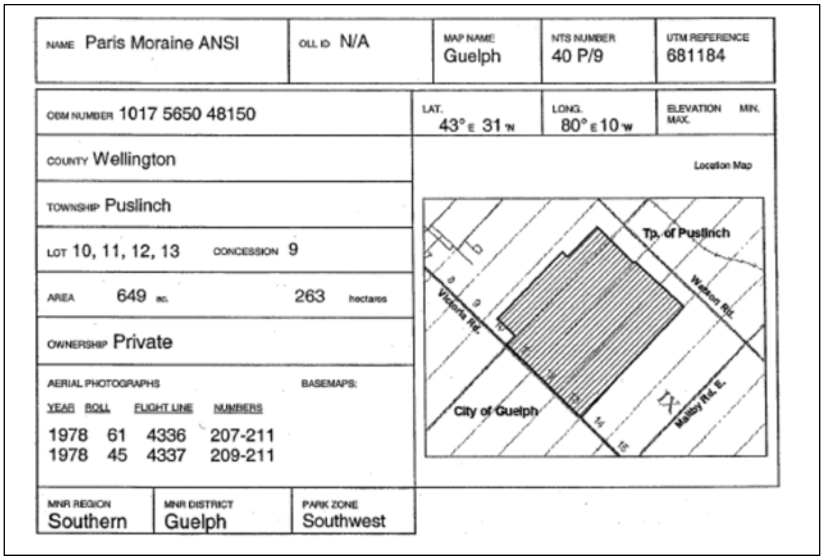
- The first refers to the need to identify and protect significant portions of the Paris Galt Moraine as it: a) contributes important environmental services ("including, surface water features and groundwater resources, providing wildlife habitat and linkages, and supporting biodiversity") and b) contributes to the "City's geologic and aesthetic uniqueness."
- The second focuses on the protection of vulnerable surface and groundwater resources by maintaining and enhancing linkages and connectivity of related functions amongst other natural heritage features and the hydrological functions of the moraine.

Significant landform was identified in the SPA, and throughout the City south of Clair Road, as a stand-alone component with the intent of meeting these objectives. Consideration for significant landform through the CMSP process will be important to ensure that any potential impacts that may compromise these objectives be addressed and mitigated.

4.7.2 Background Information

Considerable technical work has been undertaken to describe and understand the Paris Moraine. Many of these are referenced in Section 4.2.4.3 including Chapman and Putnam (1966, 1984), Karrow (1968), OGS (2003), and McGill (2012).

As noted, the South Guelph – Puslinch area provides some of the best examples of the Paris Moraine and its associated functions (Chapman and Putnam 1966). This local significance is underscored by the designation of a portion of the moraine east of Victoria Road just outside the City limits in Wellington County as the core area for Provincial significance. The Paris Moraine Provincially Significant Area of Natural and Scientific Interest (ANSI) lies immediately east of the SPA (Figure 4.7.2.1).


NAME Paris Moraine ANSI | OLL ID N/A | MAP NAME Guelph | NTS NUMBER 40 P/9 | UTM REFERENCE 681184

OBM NUMBER 1017 5650 48150 | LAT. 43° E 31 N | LONG. 80° E 10 W | ELEVATION MIN. MAX.

COUNTY Wellington

TOWNSHIP Puslinch

LOT 10, 11, 12, 13 CONCESSION 9

AREA 649 ac. 263 hectares

OWNERSHIP Private

AERIAL PHOTOGRAPHS BASEMAPS:

YEAR	ROLL	FLIGHT LINE	NUMBERS
1978	61	4336	207-211
1978	45	4337	209-211

MNR REGION Southern | MNR DISTRICT Guelph | PARK ZONE Southwest

Figure 4.7.2.1. Location of the Paris Moraine Provincially Significant ANSI in Wellington County (Kor 2005).

Kor (2005) describes the significance of the Paris Moraine at this location as follows:

> "The Paris Moraine is an end moraine that represents a major still-stand of the retreating Port Bruce ice mass from the region, and the farthest extent of the Ontario lobe in its final stages. The moraine is a massive feature, and is composed of the stony and sandy Wentworth Till…Given its excellent preservation in a populated but generally rural setting, the Paris Moraine as defined here is considered to be provincially significant. The moraine is important to the interpretation of the deglacial events in the region and exhibits a wide range of landform features typical to this moraine, notably: multiple ridge topography; small irregular kames; intensely kettled topography; and, crevasse fillings."

The presence of this Provincially significant ANSI just outside the SPA boundaries, lends support to the City's inclusion of portions of this unique topographic and geologic feature within the City itself. This direction formed the rationale for identification and designation of significant landform within the City's boundaries, south of Clair Road.

4.7.3 Methods

Significant Landform mapping for OPA 42 employed the available surficial geology mapping interpreted in order to identify characteristic features of the moraine. This employed the use algorithms within the City's GIS to evaluate essential characteristics of ice-contact moraines in combination with the location of other natural heritage features as follows:

- slopes of 20% and greater;
- concentrations of slopes;
- slopes located in association with closed depressions greater than 1 m deep (as mapped by the GRCA); and
- close proximity to other significant natural heritage features or areas.

A number of site-specific refinements and adjustments were made to the significant landform mapping approved by Council in 2010 based on site-specific agreements[7] made through the OMB settlement process between 2011 and 2013. The approved significant landform mapping (as approved by the OMB June 4, 2014) in the SPA is shown in the context of the slope classes present in the study area under existing conditions on Map NH-12 (Appendix I). The approved significant landform mapping is also shown in the context of the NHS (also approved by the OMB June 4, 2014) on Map NH-13 (Appendix I).

The City's Official Plan (2014 Consolidation) also flags a 50 m "adjacent lands" area around identified significant landform in the City in which potential development impacts to the feature must be considered (shown in Map NH-13, Appendix I). The OPA 42 policies did not include any specific policies in regards to guide development within the adjacent lands to ensure no negative impacts to identified significant landform but require that an EIS be prepared and submitted as part of the development application process. Further guidance with respect to integration of significant landform (and related NHS features) into the Secondary Plan Area as it becomes developed is to be developed through the CMSP.

4.7.4 Interpretation

No additional work is being undertaken as part of the CMSP process to review or further refine the designated significant landform. However, requests for refinements brought forward through the CMSP consultation process will be considered as long as they can be undertaken in a manner that is consistent with the current applicable City policies (specifically Policy 6A.2.8(10)).

The emphasis of the CMSP work, as it relates to significant landform will be to develop policies and/or development guidelines to direct development with the adjacent lands areas so that potential impacts to the significant landform areas are mitigated. These guidelines will be based on the protection of both visual and functional elements of the associated significant landform. Guidelines will be developed as part of the CMSP process.

Preliminary targets related to significant landform must be consistent with the established City policies and should include:

- consideration for no net loss of significant landform area;

7 Properties that appealed OPA 42 over issues including significant landform are identified in Maps NH-1 and NH-2, Appendix F.

- protection of the visual form and functional characteristics of the significant landform areas, including any associated drainage and linkage characteristics; and
- integration of the landform into the community such that its visual uniqueness and natural heritage functions are not compromised.

5.0 INTEGRATION – CHARACTERIZATION THE SPA

5.1 Integration Approach

In order to better understand the fundamental elements of the Clair-Maltby SPA, in terms of the environmental features, attributes and associated functions, it is necessary to integrate the respective disciplines and associated characterization assessments, into a cohesive framework. Not all disciplines affect all environmental features, however each is principally linked by the hydrologic water cycle (surface water and groundwater), as the primary integrating mechanism. The focus of the approach adopted in this assessment, has been to identify key features on the landscape which require an integrated assessment, and based on CEIS Team consultation, develop an enhanced understanding of significance and sensitivity of the respective units. This perspective will then be used in subsequent CEIS phases to assess impacts and establish management and protection approaches associated with the future land use condition (Phases 2 and 3).

Primary environmental elements stemming from the discipline-specific characterization work described in the previous report sections include:

- Wetland/Woodlot Features
- Significant Landform Features (Depressional Features)
- Recharge and Discharge Areas

Absent from the foregoing list are watercourses which typically provide conveyance of drainage, provide riparian corridors and connect wetland and woodlot features. As the Clair-Maltby SPA does not include typical open watercourse systems, the CEIS Team has included significant landform features (depressional features), as the key environmental element that is integrated to the hydrologic cycle (topographic feature). It does however, include some ponds and/or wetlands that support fish, as well as a few small drainage features that provided intermittent surface flows between wetlands (see Section 4.5.5).

Each of the three (3) environmental elements to varying degrees requires an integrated assessment in order to establish the significance and associated sensitivity of the features, particularly in the context of the urbanizing setting; the following provides some associated guidance in this regard:

1. Wetland/Woodland Units
    - diversity and significance of species (flora and fauna)
    - potential for corridor linkage and benefits to key biota
    - presence/absence of fluvial unit
    - local catchment area (size and land use)
    - groundwater influence to sustainability of habitats and functions

- feature size, plant community diversity, and proximity to other features

2. Significant Landform Features (Depressional Features)
   - presence/absence of form/stability
   - storage volume (stage/storage relationship) – surface water capture
   - groundwater discharge/ recharge
   - presence/absence of riparian vegetation
   - water quality and temperature
   - sediment transport

3. Recharge and Discharge Areas (Non depressional)
   - rate of infiltration/recharge
   - location of functional recharge areas
   - functional relationship to wetland or terrestrial feature
   - quantity of groundwater flux

The foregoing factors/considerations (and others) have been summarized as they relate to the respective environmental units or features. The following sections provide insight regarding these units or features, which have been and will continue to be used in subsequent study stages to inform the land use and infrastructure (road and services) planning process in an iterative manner (i.e. MESP).

5.2 Principles of Integration

The fieldwork and accompanying assessments, associated with the Clair-Maltby characterization, have been used to establish various principles, unique to the overall study area. These principles reflect certain properties and characteristics of the Clair-Maltby SPA, which depending on their nature lead to certain implications for (to) management associated with proposed future land use changes.

The following sections provide insights related to integration principles and the implications for (to) management where relevant. It should be noted that by their very nature there are overlaps between the respective disciplines, which essentially lead to the integrated understanding of how the Clair-Maltby SPA's function. ***Text in bold italics is representative of recommendations and future considerations.***

5.2.1 Groundwater Characterization and Functions

i. The characterization, Conceptual Model of Groundwater Flow and MIKE SHE integrated numerical model results presents the significant hydrogeological characteristics related to recharge and its functional connection to groundwater discharge and connection to the underlying municipal aquifer. This then provides the context for associated groundwater constraints and opportunities for future development.

The permeable nature of the surficial sediments, as well as the interconnected permeable nature throughout the thickness of overburden allows for significant infiltration, subsequent recharge to the water table and potential hydraulic connections within the groundwater flow system to surface water features and the deeper bedrock. The conceptual model flow system subsequently quantified by the integrated groundwater model indicate recharge within and adjacent to the PSA contribute groundwater flow to the Mill Creek and Hanlon Creek watersheds as well as the municipal aquifer.

Infiltration should be maintained to provide for existing recharge and the opportunity exists to enhance infiltration without creating unacceptable increases in groundwater levels. Infiltration practices must consider Source Water Protection Policies.

ii. Groundwater flow tends to radiate out from the SPA to contribute groundwater flow to the Mill Creek and Hanlon Creek watersheds.

The larger scale groundwater flow divided associated with the SPA should be considered for maintaining recharge associated with contributing discharge areas.

iii. Closed depressional features are shown to provide enhanced infiltration and recharge.

These features should be maintained if functionally significant on a local scale (ie related to an adjacent wetland). Depressional features may provide opportunities for storm water management.

iv. The hydrogeological characterization, related groundwater modelling and associated water budgets for Neuman's Pond, Hall's Pond and Halligan's Pond indicate these features are predominantly maintained by direct precipitation and minor overland flow and minor groundwater contribution to these features which reflects the lower groundwater levels in the vicinity of these wetlands. Groundwater discharge appears to be derived locally and during spring melt or longer-term precipitation events. Wetlands within the SPA can exhibit perched conditions such as Neuman's Pond (ie unsaturated zone beneath the pond) or be connected to the water table such as Hall's Pond, Halligan's Pond (ie saturated zone beneath the pond) and a number of other wetland/pond features within the SPA (ie western portion of SPA).

Maintenance of the overall hydrologic function within the localized subcatchments to these features to preserve the water levels associated with these features.

v. A large portion of the SPA has a thick unsaturated zone and the depth to water is greater 9 metres. There are areas where groundwater is closer to surface typically within and adjacent to the wetland features previously described.

   Infrastructure trenches should be designed using best management practices to minimize water table lowering and redirection of shallow flows.

vi. A portion of the recharge water within the SPA provides a local contribution of recharge to the lower municipal aquifer.

   Infiltration should be maintained to provide for existing recharge and the opportunity exists to enhance infiltration without creating unacceptable increases in groundwater levels.

vii. There is limited groundwater quality protection within the overburden from potential contaminant sources particularly those species that are considered conservative (i.e. those that do not biodegrade or are not adsorbed such as chloride). The Vinemount aquitard provides greater protection for the municipal aquifer.

   Best management practices to maintain infiltrating water quality should be applied.

5.2.2 Surface Water Characterization and Functions

i. Although most of the wetland areas are groundwater fed, surface water from local subcatchments also contributes to the wetlands features. Terrestrial units (not necessarily in depressional areas) receive overland drainage, which contributes to the features water balance. Drainage catchments located within or adjacent to terrestrial units may also contribute sediments and nutrients, important for sustainability.

   Flood protection (stormwater quantity controls) for the Clair-Maltby SPA to be integrated with planning of the NHS terrestrial units, based on the existing unit water balance.

ii. Woodlots located within depressional areas and wetlands provide temporary flood storage. The temporary storage of overland surface runoff results in infiltration (within woodlots), evaporation and reduced overland runoff volumes and the attenuation of peak flows.

The existing flood storage function of wetlands and woodlots should be appropriately managed within the terrestrial units for the proposed land use, by replicating the existing contributing overland drainage conditions.

iii. If unmitigated, the conversion of agricultural lands to urban land uses will increase the rate and volume of storm runoff locally within the Clair-Maltby SPA, and potentially further downstream within the Clair-Maltby SSA. The Clair-Maltby SPA provides a significant infiltration function at the headwaters of the Mill Creek, Torrance Creek and Hanlon Creek subwatersheds, with minimal definable surface water features existing.

Stormwater management and drainage systems should be implemented to appropriately manage the increased rate and volume of runoff from future development resulting in no increase in peak flows and runoff volume to Mill Creek, Torrance Creek and Hanlon Creek. As part of the stormwater management system, source, conveyance and end-of-pipe measures that promote infiltration, should be implemented.

iv. Significant groundwater recharge areas are located within the Clair-Maltby depressional features. There are forty-seven (47) significant depressional features with over 300 mm of storage, resulting in mostly infiltration of the contributing surface runoff. The significant infiltration that occurs within Clair-Maltby contributes to baseflow and cool surface water temperatures within the creek systems downstream of the Clair-Maltby SPA.

The significant infiltration function of the depressional features should either be preserved or replicated within stormwater management measures including source, conveyance and end-of-pipe controls, including low impact development (LID) best management measures. The stormwater management system should appropriately maintain and if possible augment baseflows, and mitigate thermal impacts from future development. Depressional wetlands are not to be considered for stormwater management.

v. The limited number of headwater drainage features contribute and convey sediment to the downstream drainage system (wetlands, depressional features) while also removing contaminants, and are therefore an integral component of the existing drainage system.

The limited headwater drainage features function of "natural" sediment contribution to downstream drainage systems (wetlands, depressional features) should be replicated by using innovative drainage systems and BMP's (i.e. replication of lost headwater drainage features within appropriate land uses).

5.2.3 Water Quality Characterization and Functions

i. The water quality monitoring conducted in 2016 and 2017 indicates that the existing surface water quality within the Clair-Maltby SPA and immediately downstream is generally of reasonable quality. Existing surface water quality has demonstrated PWQO, CEQB and CDWQ exceedances during wet weather conditions; for Total Phosphorus, Aluminium, Ammonia, Chloride, Cadmium, Iron, Manganese and Zinc. Exceedances occur for various reasons, such as untreated runoff from roadways and application of fertilizers on agricultural and the golf courses within the area, as well as naturally occurring exceedances (as is the case with Zinc in Mill Creek Watershed).

Based on the existing subwatershed studies, historic water quality conditions can be reported. The Torrance Creek water quality was indicated as reasonable water quality, apart from nitrates, total phosphorous and Ecoli exceeded the PWQO. Hanlon Creek temperatures have been measured above 23oC due to existing development, a lack of canopy cover and stormwater management facility with a permanent pool. Water quality for Mill Creek was noted as impaired due to Ecoli, Total Phosphorus, Aluminum, Copper, Lead Manganese and Zinc being above the PWQO based on land uses and natural high metal concentrations.
Based on historic data collected as part of the respective subwatershed studies, a number of exceedances were previously documented. Torrance Creek's water quality was reported as reasonable apart from Nitrates, Total Phosphorous and E. coli exceeding the PWQO (TSH *et al.,* 1998). Hanlon Creek temperatures measured above 23^{o}C in certain tributaries and certain times of the year, reportedly due to a lack of canopy cover (MMM and LGL Ltd. 1993). Water quality for Mill Creek was noted as impaired due to PWQO exceedances of E. coli, Total Phosphorus, Aluminium, Copper, Lead, Manganese and Zinc based on existing land uses and naturally high metal concentrations.

Based on future land use conditions within the study area, stormwater management infrastructure should be designed to maintain the current water quality conditions to the greatest extent possible*, and improve them where possible.*

ii. Existing land use within Clair-Maltby is primarily agricultural and terrestrial units, resulting in reasonable water quality. The existing soils, particularly the sand and loams, provide a water quality function as filtration mediums based on the significant infiltration within the Clair-Maltby SPA.

Adequate pre-treatment of surface runoff from paved surfaces should be provided prior to infiltration measures. Stormwater management measures within existing depressional features outside of protected woodlands and wetlands or replicating depressional features should have adequate pre-treatment of surface water drainage

to protect groundwater quality, as per the City's Stormwater Protection policies. Infiltration stormwater quality management measures that filter contaminants from runoff should be implemented within the study area. Treatment of surface water from paved surfaces should also be provided to runoff entering wetlands, wooded areas and ponds to maintain the water quality entering those features.

iii. Wetland temperatures within most wetlands in the Mill Creek watershed support cool or coldwater temperature ranges, even during the summer months, suggesting most or all of them may be receiving some groundwater inputs to sustain their hydrology.

Where significant in sustaining fish habitat, groundwater contributions to wetlands in the PSA need to be maintained and surface water temperatures impacts from development need to be mitigated. Stormwater management practices that mitigate thermal impacts from urban development should be implemented within the study area.

5.2.4 Aquatic Characterization and Functions

Within the SPA

i. The SPA contains no permanent or intermittent watercourses due to the unique geology, topography, soils and drainage in the area. However, the SPA represents an important headwaters area to the Hanlon and Mill Creeks which are known to support coolwater and cold water fish habitat respectively.

Water balance and quality is to be maintained to Hanlon Creek and Mill Creek to continue supporting the coolwater and cold water fish habitats that exist in those respective watersheds.

ii. Some of the isolated wetlands and ponds in the SPA are capable of supporting fish and benthic invertebrates. Based on the available temperature data for the wetlands, it can be generally hypothesized that entirely perched systems (like the Neumann Pond / PSW (Aquafor Beech 2012)) that support fish are likely to provide warmwater conditions, while other ponds / wetlands that support fish and sit within the groundwater table for extended periods (like the Tim Horton's or portions of Hall's Pond) may support cooler temperature regimes.

Site-specific studies will be required to confirm the presence or absence of fish, and the nature of the fish communities, in these features. Temperature regimes within the wetlands and ponds are to be maintained through appropriate stormwater

management measures, including quality treatment (i.e. Level 1, Enhanced water quality treatment for areas draining to wetlands).

iii. Most surface water simply drains directly down except in depressions where organics have accumulated over time and wetlands have formed. The desktop HDF assessment found only a few potential HDFs in the SPA, and the scoped field verification confirmed two flowing for a short distance between established PSW units.

The hydrologic connection of the HDF (ref. Map NH-4, Feature HDF6) is to be maintained and is to be protected in addition to the PSW complex.

Outside the SPA

i. Outside the SPA, the available fisheries data indicates that watercourses immediately north of the SPA in the Hanlon Creek system historically supported, and appear to continue to support, a coolwater thermal regime. In addition, the available fisheries data indicates that watercourses immediately south of the SPA in the Mill Creek system historically supported, and appear to continue to support, a coldwater thermal regime. The Regional groundwater flow that emerges from the SPA is thought to provide for groundwater discharge to both the Hanlon and Mill Creek systems. This discharge is key to supporting baseflows and maintaining the coolwater and coldwater regimes in these systems.

Maintaining this groundwater discharge as development proceeds in the SPA is an identified target (as noted in Section 5.3).

5.2.5 Terrestrial Characterization and Functions

i. The NHS in the SPA is within the headwaters of three subwatersheds (Hanlon Creek to the north, Mill creek to the south and Torrance Creek to the northeast). This landscape is very well drained with no surface water features except for the ponds and wetlands. The SPA provides baseflow to the Hanlon Creek Tributaries and the Mill Creek tributaries that continue to support cool and coldwater fisheries respectively in their upper reaches.

ii. The NHS in the SPA and the surrounding PSA are characterized by a patchwork of wetlands of various shapes and sizes, upland woodlands and plantations, and successional meadows and thicket communities that support a diverse range of plant and wildlife species.

iii. The SPA is known to support a moderate level of plant diversity, although few species are considered significant at the Provincial or local level. A total of 467 plant species have been documented in the SPA and PSA including one Provincially Endangered species (i.e., Butternut) and 20 locally significant species (City of Guelph 2012) which are primarily associated with the wetland habitats.

iv. The PSA and SPA also supports a range of wildlife species including a robust amphibian population, numerous ponds supporting turtles and a diverse range of bird species.

v. A range of common mammals have also been recorded in the SPA and PSA including White-tailed Deer (*Odocoileus virginianus*) and Coyote (*Canis latrans*), as well as some les common records of Northern Short-tailed Shrew (*Blarina brevicauda*), Woodchuck (*Marmota monax*), Muskrat (*Ondatra zibethicus*) and Mink (*Mustela vison*) (see Appendix NH-5 in the 2017 Monitoring Report for details).

The City has policies and mapping for a Natural Heritage System (NHS) throughout the City, including the SPA, which was approved in 2014. This NHS has been reviewed and, where appropriate, recommendations are being made for refinements to this system based on information collected through the CMSP through background information and field studies. Future refinements to the wetland and woodland components of the NHS and the identification of Candidate and Confirmed SWH areas in the SPA will be finalized with input from the City of Guelph, GRCA, MNRF, landowners, stakeholders and public. This NHS will then be used as the basis for the Secondary Plan as well as the impact assessment and the related recommendations for management and monitoring.

An overview of the recommendations for implementation of each of the NHS components going forward is provided below.

Habitat of Provincially and Locally Significant Species

Habitat of Provincially and locally significant species relates to:

- significant habitat for Provincially Endangered and Threatened species (City of Guelph Official Plan policy 6A.2.3); and
- habitat of significant species (i.e., habitat of locally or Regionally significant species not already captured as Provincially Endangered or Threatened or as SWH) (City of Guelph Official Plan policy 6A.3.4).

i. The SPA and adjacent PSA provide habitat for more than a dozen Provincially Endangered and Threatened species (see Appendices G2 and G3) as well as dozens of locally significant plant and wildlife species.

ii. There is confirmed suitable habitat for a total of thirteen (13) Provincially Endangered or Threatened species in the SPA and/or PSA:

- six of these species have been confirmed in the SPA and/or PSA either through field work undertaken in 2017 or site-specific studies in the area undertaken over the past decade (i.e., one plant – Butternut; four bird species – yellow-Breasted Chat, Barn Swallow, Bobolink and Eastern Meadowlark; and one mammal – Eastern Small-footed Bat); and
- suitable habitat exists in the SPA or PSA for the seven (7) other Provincially Endangered and Threatened species but their presence not been recently confirmed in the area (i.e., one amphibian species - Jefferson Salamander; one turtle species - Blanding's Turtle; one bird species - Chimney Swift; Three Bat Species - Little Brown Myotis, Northern Myotis And Tri-coloured bat; and one insect species - Rusty-patched Bumble Bee).

iii. No habitats for Provincially Endangered or Threatened have been mapped as part of the CMSP process due to: the sensitivity of mapping their locations, the fact that presence needs to be confirmed on a site-specific basis in consultation with MNRF, and the fact that in some cases in situ protection of the habitat may not be required. Notably, a number of the SAR listed above have species-specific regulations under the ESA that allow for the removal of their habitats if specific conditions (e.g., for habitat net gain, compensation and monitoring) are met.

Screening for all SAR listed above should be undertaken, in consultation with MNRF at the EIS or EA stage for all properties with or adjacent to suitable habitat.

iv. The City of Guelph's Official Plan also provides some protection for locally significant species (City of Guelph 2012) that are not Provincially Endangered or Threatened or SWH. This policy basically requires proponents to: (a) make reasonable efforts to protect the habitat *in situ*, (b) if (a) is not feasible, to consider alternatives to *in situ* protection (e.g., habitat restoration or transplanting).

v. Based on the review environmental studies prepared for various properties within and adjacent to the SPA (see Appendix A), as well as site visits conducted by Beacon in 2017 a total of 20 locally significant plant species and 54 locally significant wildlife species were confirmed in the SPA and/or PSA. Most of the significant plant species have wetland affinities. The significant wildlife species include a mix reflective of the diversity of natural and cultural vegetation communities in the PSA and include species (and particularly birds) associated with meadow, woodland and wetland habitats respectively.

vi. Although records of locally significant plant species have been linked to certain properties or, for field work completed as part of the CMSP, with specific ELC polygons (see the 2017 Monitoring Report), SPA-wide mapping of locally significant species was not developed. Lists of species documented in the area (see the 2017 Monitoring Report) can serve as guidance when locally significant species are screened for as part of the EIS or EA process.

Significant Wetlands and Other Wetlands

i. In the City of Guelph Official Plan (2014 Consolidation) wetlands within the NHS fall into the following categories:

- Significant Wetlands: Provincially Significant Wetlands (PSWs) (as identified by MNRF) plus minimum 30 m buffers and Locally Significant Wetlands (LSWs) which include non-Provincially Significant Wetlands and Unevaluated Wetlands of at least 0.5 ha plus minimum 15 m buffers (policy 6A.2.4); and
- Other Wetlands: non-PSWs between 0.2 and 0.5 ha that meet the established criteria for protection plus minimum 15 m buffers (policy 6A.3.2).

ii. Wetlands and open water make up about 10% of the SPA (see the 2017 Monitoring Report), including treed swamps, thicket swamps, marshes, and shallow aquatic communities. Most of these areas are captured within the existing NHS (2014) with a few more areas proposed to be added through the recommended refinements.

iii. In some cases, these features are connected to each other through temporary or permanent surface water connections, and in other cases these wetland units are hydrologically isolated (i.e. no surface water connection to other wetlands).

iv. An approach for reviewing and refining wetland mapping in the SPA was determined in consultation with GRCA, MNRF and the City (described in Section 4.6.4.2). This process resulted in the identification of some proposed refinements of mapped wetlands as shown in Maps NH-5B and NH-6 (Appendix F). Refinements are primarily related to new information collected through the CMSP process whereby areas previously mapped as wetland have been verified as not being wetlands, or whereby areas not previously mapped as wetlands have been identified as wetlands.

This mapping is to be finalized through the CMSP process with all identified PSWs having a 30 m buffer and Other Wetlands outside the NHS having a 15 m buffer applied and being flagged for further study at the site-specific stage. The NHS mapping to be used as a basis for the Secondary Plan will have PSWs shown as Significant Natural Areas and Other Wetlands shown as Natural Areas Overlays.

Once the Secondary Plan is finalized and approved, all mapped wetlands and ponds (as well as any unmapped wetlands and ponds) will still be subject to review, the applicable policies and boundary verification and staking with the GRCA and the City (where the feature is being protected) and may also be subject to further review by MNRF as part of site-specific studies.

Significant Woodlands and Cultural Woodlands

i. In the City of Guelph Official Plan (2014 Consolidation) woodlands within the NHS fall into the following categories:

- Significant Woodlands: woodlands of at least 1.0 ha and rare or uncommon woodland types – as defined in the Official Plan - of at least 0.5 ha) plus minimum 10 m buffers; and
- Cultural Woodlands: Cultural Woodlands as defined in the Official Plan of at least 1.0 ha not dominated by non-indigenous, invasive species plus minimum 10 m buffers.

ii. An approach for reviewing and refining woodland mapping in the SPA was determined in consultation with the City (described in Section 4.6.4.3). This process resulted in the identification of proposed additions to both Significant Woodlands and Cultural Woodlands as well as some transitions form one designation to the other as shown in Maps NH-7 and NH-8 (Appendix F). This mapping is to be finalized through the CMSP process with all identified Significant Woodlands and Cultural Woodlands having a 10 m buffer applied to them to be mapped separately but included in the overall NHS mapping.

The NHS mapping to be used as a basis for the Secondary Plan will have Significant Woodlands shown as Significant Natural Areas and Cultural Woodlands shown as Natural Areas.

Once the Secondary Plan is finalized and approved, all mapped woodlands will be subject to review, the applicable policies and boundary verification and staking with the City (where the feature is being protected) as part of site-specific studies.

Significant Landform

See discussion in Section 5.2.6 below**.**

Significant Wildlife Habitat (SWH)

i. An assessment of SWH in the SPA was undertaken for the first time through the CMSP. This assessment found that of the 37 types of SWH, 20 of them have been confirmed or may occur in the SPA and adjacent PSA. Where possible, these areas have been mapped as shown in Maps NH-9 and NH-10 (Appendix F) and as summarized in Table 5.2.5.1 below.

Table 5.2.5.1 Summary of Candidate and Confirmed Significant Wildlife Habitat (SWH) in the PSA

SWH Type* (ref. Appendix G4 for more details)	Confirmed and/or Candidate or Potential SWH, Both or Neither	Mapped or Not Mapped (see Maps NH-9 and NH-10, Appendix F)
Seasonal Concentration Areas		
1. Waterfowl Stopover and Staging Areas (Aquatic)	Candidate	Mapped
2. Raptor Wintering Area	Several Candidate SWH areas are shown approximately	Mapped with asterisks[1]
3. Bat Maternity Colonies	Candidate	Mapped
4. Turtle Wintering Areas	Candidate and Confirmed	Mapped
5. Reptile Hibernaculum	This type of SWH may occur	Not mapped
6. Colonially-Nesting Bird Breeding Habitat (Tree/Shrubs)	This type of SWH may occur	Not mapped
7. Deer Winter Congregation Areas	This type of SWH may occur	Not mapped
Rare Vegetation Communities		
8. Other Rare Vegetation Communities	One Confirmed; others may be identified	Mapped
Specialized Habitat for Species		
9. Waterfowl Nesting Area	This type of SWH may occur	Not mapped
11. Bald Eagle and Osprey Nesting, Foraging and Perching Habitat	This type of SWH may occur	Not mapped
12. Turtle Nesting Areas	This type of SWH occurs	Not mapped
13. Seeps and Springs	One seep Confirmed; others may be identified	Mapped
14. Amphibian Breeding Habitat (Woodland)	Candidate and Confirmed	Mapped
15. Amphibian Breeding Habitat (Wetland)	Candidate	Mapped
Habitat for Species of Conservation Concern		
16. Marsh Bird Breeding Habitat	This type of SWH may occur	Not mapped
17. Shrub/Early Successional Bird Breeding Habitat	Several Candidate SWH areas are shown approximately	Mapped with asterisks[1]
18. Terrestrial Crayfish	This type of SWH may occur	Not mapped
19. Special Concern and Rare Wildlife Species	This type of SWH may occur	Not mapped

Table 5.2.5.1 Summary of Candidate and Confirmed Significant Wildlife Habitat (SWH) in the PSA		
SWH Type* (ref. Appendix G4 for more details)	**Confirmed and/or Candidate or Potential SWH, Both or Neither**	**Mapped or Not Mapped (see Maps NH-9 and NH-10, Appendix F)**
Wildlife Corridors		
20. Amphibian Movement Corridors	This type of SWH may occur	Not mapped but may be captured, at least in part, through mapped Ecological Linkages

Note: [1] Site-specific study will be needed to capture the best and most representative area(s) in the SPA, assuming more than one of the Candidate areas meets the established criteria.

ii. An approach for SWH assessment and mapping in the SPA was determined based on the applicable MNRF guidance (MNRF 2015, MNRF 2000) and in consultation with the City (described in Section 4.6.4.4). This process resulted in the identification of potentially suitable habitat for more than 13 SWH types and of confirmed areas for seven (7) SWH types. As expected, most mapped SWH areas fall within the current NHS (see Map NH-10, Appendix F), but some areas do extend outside.

SWH mapping in the SPA is to be finalized through the CMSP process with Confirmed SWH being mapped as a designation and Candidate SWH being mapped as an overlay for future assessment. Buffer requirements vary for different types of SWH and will not be applied at this stage but will be determined at the EIS or EA stage as appropriate.

The NHS mapping to be used as a basis for the Secondary Plan will have Confirmed SWH shown as Significant Natural Areas and Confirmed SWH shown as overlays for further study.

Once the Secondary Plan is finalized and approved, all mapped and unmapped SWH listed above will need to be assessed as part of site-specific studies in the context of the applicable policies. Feature boundary verification may also be required with the City and, where appropriate, GRCA (where the feature is being protected).

Ecological Linkages

i. It is recognized in both natural heritage theory and policy that it is important to maintain and possibly improve connections between and among protected natural features and areas, particularly within urbanizing areas (such as the SPA).

ii. Both aquatic and terrestrial ecological connections (often referred to as corridors or linkages) can support the movement of native plants and wildlife between natural areas and provide critical pathways for genetic exchange at various geographic scales.

iii. These connections can also support the movement of some undesirable natural elements (e.g., invasive species, plant pathogens). However, the risk is generally considered outweighed by the benefits and arguably the need to support the movement of species between natural areas, which for many species is critical to their annual life cycles as well as their long-term meta-population persistence. This is particularly true of certain groups like amphibians and reptiles which, unlike birds, cannot fly over intervening built-up landscapes.

iv. In general, both the background and field data collected in support of the CMSP indicates that both the Ecological Linkages and Significant Natural Areas identified in the current NHS (2014), as shown in Map NH-11 (Appendix F), provide connectivity in the locations where amphibian and reptile movement is occurring.

v. In recognition of the need to facilitate safe movement of amphibians, reptiles and small mammals across roads the City has begun to install wildlife culverts in locations known for movement of these species. In the PSA but outside the SPA three relatively large culverts were installed in 2013 along Maltby Road West and, more recently, several culverts were installed across Poppy Drive East.

The effectiveness of these mitigation efforts and opportunities to introduce these, and other types, of mitigation to minimize impacts to local amphibian, reptile and small mammal populations in other suitable locations will need to be considered moving forward.

Restoration Areas

i. Restoration Areas are a defined component of the City's NHS. In the SPA, although appropriate locations for such areas are currently being contemplated, no specific areas have been mapped to date. Mapping of restoration areas is typically a last step in the process and is not undertaken until the mapping of other components of the NHS has been resolved. In the case of the SPA, the NHS refinements presented in this Characterization Report are still draft. I

Identification of at least some restoration and/or enhancement areas is best deferred to the site-specific study stage when opportunities in relation to a specific development proposal can be identified.

ii. In the SPA, it is recognized that some trees outside of the NHS will need to be removed and replaced within the SPA.

Buffers, Ecological Linkages and Restoration Areas are all recognized as potentially appropriate locations for tree replacements. There is also, as noted in Section 4.6.4.4, the need to accommodate and maintain some unforested areas in the City able to support species with life cycle needs in more open, successional habitats. Going forward, these different requirements will need to be balanced against other land use needs in the SPA.

5.2.6 Significant Landforms Characterization and Functions

i. The prominent topography of the Paris Moraine complex – both positive and negative relief – dominates the character of the SPA. The portions of this complex formally designated as Significant Landform in the City's Official Plan (Schedule 10D, 2014 Consolidation) capture some of the most representative and striking elements of the moraine contributing both visual and functional values.

ii. Physically, Significant Landform provides the backbone of the NHS in the City as expressed by prominent ridges in combination with marked closed depressions. Further, the northeast-southwest linearity of the moraine provides a natural connecting element completely crossing the NHS, literally tying the SPA together (see Map NH-13, Appendix I).

Hence, as development proceeds, it will be important to maintain the visual elements of the landform as well as its associated hydrologic and ecological functions.

iii. Functionally, the Significant Landform in the SPA provides:

- a variety of slopes, aspects and moisture regimes;
- hydrological conditions enhancing infiltration and groundwater recharge;
- Ecological Linkages between natural features and areas within the NHS and beyond; and
- tying together the various Significant Natural Areas composing the NHS.

The long-term protection of Significant Landform will ensure the on-going function and integrity of the City's NHS. This should include adjacent lands strategies to guide appropriate transitions between protected significant landform areas and adjacent development and infrastructure.

5.3 Preliminary Targets and Objectives

Preliminary working targets and objectives have been provided in Table 5.3.1 based on the existing conditions disciplines findings and previously documented objectives and targets. Objectives and targets are considered preliminary, based on the on-going monitoring plan and associated field work being conducted in 2018. Objectives and targets will be confirmed, refined and made more prescriptive subsequent to completion of the 2018 monitoring program and through input received from stakeholder agencies.

Table 5.3.1 CEIS Study Working Targets

Integration Context	Discipline	Goal	Objective	Working Targets
Water	Groundwater	Groundwater of sufficient quantity and quality to support ecological functions, aquatic habitats, native fish communities and sustainable human needs, including drinking water, agricultural, industrial, and commercial uses.	1. Protect, Restore and enhance groundwater recharge and discharge	• Work toward maintaining pre-development groundwater recharge and groundwater discharge
			2. Protect, restore and enhance groundwater quality.	• Provide stormwater quality treatment for infiltrated surface water.
			3. Ensure sustainable rates of groundwater use.	• Work toward maintaining pre-development groundwater recharge to support groundwater supply function of local aquifers.
	Surface Water	Surface waters of a quality, volume and naturally variable rate of flow to: • Protect aquatic and terrestrial life and ecological functions; • Protect human life and property from risks due to flooding; • Protect and contribute to the local groundwater system within Guelph, and the domestic drinking water source; • Support sustainable agricultural, industrial, and commercial water supply needs	4. Protect and restore the natural variability of infiltration to significant depressional features (or surrogates).	• Work toward maintaining pre-development water budget.
			5. Maintain and restore natural levels of baseflow.	• Work toward maintaining pre-development water budget
			6. Maintain surface and groundwater flows to terrestrial features	• Work toward maintaining pre-development water budget
			7. Eliminate or minimize risks to human life and property due to flooding and erosion.	• Provide post-to-pre-development flood control for all events up to the Regional Storm event.
			8. Protect and restore surface water quality, with respect to toxic contaminants and other pollutants, to ensure protection of aquatic life, ecological functions, human health, and water supply needs.	• Meet or exceed stormwater quality control for future development in accordance with Provincial (MOECC – TSS based or updates to MOECC Guidelines) standards.
Nature	Aquatic System	A healthy aquatic system that supports a diversity of aquatic habitats and communities.	9. Protect, restore and enhance the health and diversity of native aquatic habitats, communities and species.	• Meet or exceed stormwater quality control for future development in accordance with Provincial (MOE CC – TSS based or updates to MOECC Guidelines) standards. • Work toward maintaining pre-development groundwater discharge at key locations. • Net gain or no net loss in fish productive capacity. • Meet or exceed guidelines contained in Guidance for Development Activities in Redside Dace Protected Habitat V1.2 (OMNRF, March 2016)
			10. Ensure development within the SPA does not negatively impact the health and diversity of coolwater and cold fish habitats in the SSA.	• Development in the SPA does not result in negative impacts to baseflow in the SSA. • Development in the SPA does not result in negative impacts to water quality in the SSA.
		Maintain, restore and enhance the Natural Heritage System including linkages between and	11. Protect Significant Landforms and their associated functions	• No net loss of Significant Landform area.

Table 5.3.1 CEIS Study Working Targets				
Integration Context	**Discipline**	**Goal**	**Objective**	**Working Targets**
Nature	Terrestrial System	among Significant Natural Areas, Natural Areas, surface water and groundwater features.		• Protect the functional characteristics of the Significant Landform areas including any associated drainage and natural heritage functions. • Integrate Significant Landform into the community such that its visual uniqueness is not negatively impacted.
			12. Maintain, restore and enhance native biodiversity by protecting Habitat for Significant Species.	• Protect habitat for Provincially Endangered and Threatened species in accordance with the Endangered Species Act (2007) and in consultation with MNRF. • Protect habitat for locally significant species in accordance with the City of Guelph's Official Plan. • Protect the Significant Natural Areas and Natural Areas of the NHS that provide habitat for these species, including the Ecological Linkages within the City of Guelph and connections to Greenlands in the adjacent Wellington County. • Use native species for all naturalization and compensation plantings in the SPA. • Restore meadow, wetland and woodland habitats through the planning process for the CMSP.
			13. Maintain, restore and enhance wetlands identified for protection	• Protect all Significant Wetlands and their established buffers • Where studies confirm the identified wetland or pond warrants protection, protect Other Wetlands with their established buffers • Ensure the feature-specific water balance to protected wetlands is maintained • Ensure the water quality of all protected wetlands is maintained or improved • Pursue opportunities to enhance local biodiversity through invasive species management, where appropriate, and naturalization of wetland buffers with native species
			14. Maintain, restore and enhance woodlands identified for protection	• Protect all Significant Woodlands and their established buffers. • Where studies confirm the identified Cultural Woodlands warrant protection, protect Cultural Woodlands with their established buffers • Ensure the feature-specific water balance to protected woodlands is maintained. • Pursue opportunities to enhance local biodiversity through invasive species management and naturalization of woodland buffers (and in some cases of the woodlands themselves) with native species.
			15. Maintain, restore and enhance Significant Wildlife Habitat (SWH) identified for protection	• Protect all Confirmed SWH and their established buffers. • Pursue opportunities to enhance local biodiversity through naturalization of SWH buffers with native species.
			16. Maintain, restore and enhance ecological connectivity in the NHS	• Protect identified Ecological Linkages in accordance with City policies. • Maintain connections between and among Significant Natural areas and protected Natural Areas.

Table 5.3.1 CEIS Study Working Targets				
Integration Context	**Discipline**	**Goal**	**Objective**	**Working Targets**
Nature	Terrestrial System			• Pursue opportunities to enhance local biodiversity and connectivity through the restoration and naturalization of Ecological Linkages with native species.
			17. Maintain a diversity of habitat types within Restoration Areas	• Identify Restoration Areas where compensation tree plantings can be directed. • Identify at least one Restoration Area for to be maintained as meadow/shrub habitat to support, ideally adjacent to some upland woodland, to provide SWH or both raptor wintering and shrub/early successional breeding birds.

Appendix A: List of Background Sources Reviewed

Appendix B: Hydrogeology (Groundwater)

Appendix C

Groundwater Quality

Appendix D
Hydrology (Surface Water)

Appendix E
Surface Water Quality (Temperature and Chemistry)

Appendix F

Natural Heritage Mapping

Appendix G

Natural Heritage Species and Habitat Analyses (Aquatic and Terrestrial)

Appendix H
Natural Heritage Photo Logs

Appendix I
Significant Landform Mapping

wood.