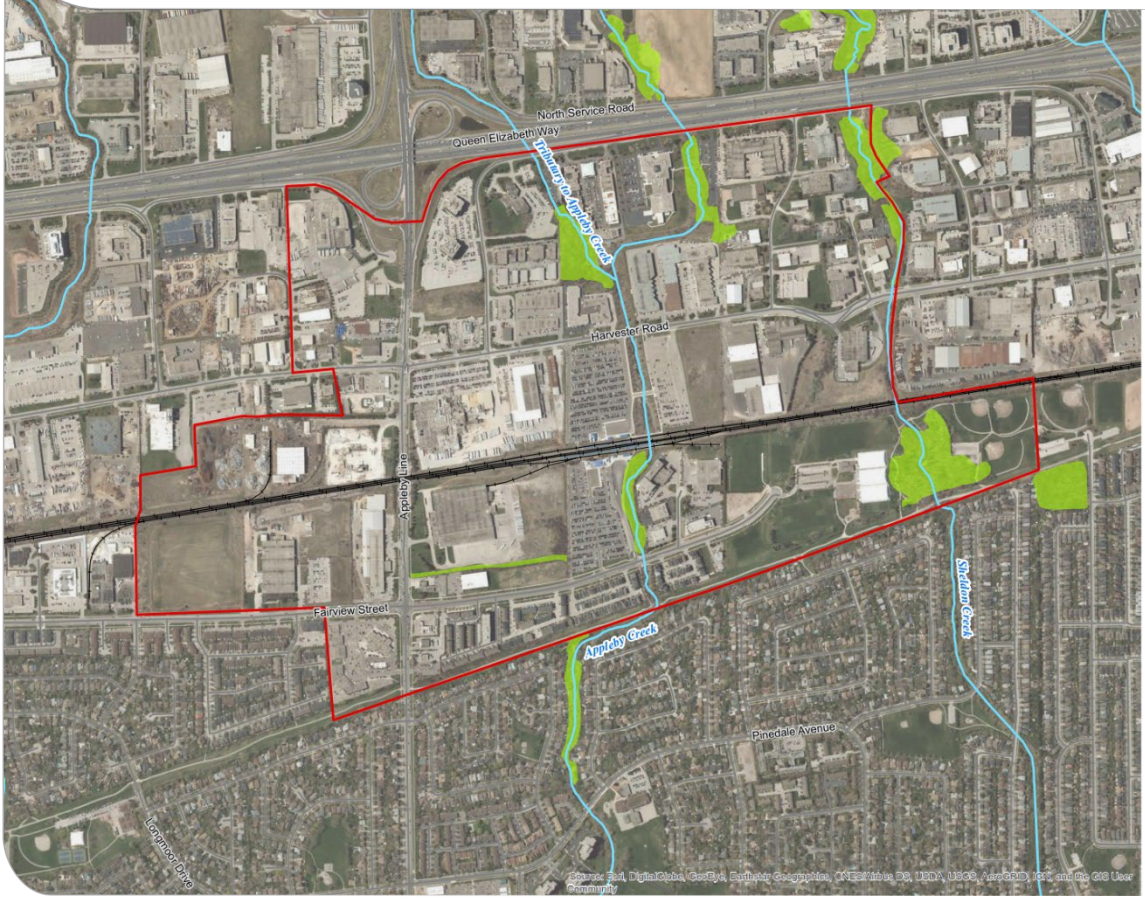
DILLON CONSULTING

BURLINGTON MOBILITY HUB

Scoped Environmental Impact Study

Appleby Mobility Hub



August 2022 – 17-5015

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1.0 Introduction

Dillon Consulting Limited ("Dillon") was retained to complete a Scoped Environmental Impact Study ("EIS") for the City of Burlington (the "City") in support of future redevelopment and intensification in association with the City's four Mobility Hubs (i.e. Downtown, Burlington, Aldershot and Appleby). This Scoped EIS was prepared specifically for the Appleby Mobility Hub. The limits of the Appleby Mobility Hub Planning Area (herein referred to as the "Study Area") are delineated in **Figure 1**.

The purpose of the Scoped EIS is to document existing conditions of the natural environment; determine the potential limits of development; evaluate the potential for environmental impacts associated with the proposed development; and recommend mitigation, restoration, and enhancement measures to preserve and/or restore natural features. The Scoped EIS has been prepared in general accordance with the following environmental guidelines:

- Conservation Halton ("CH") Environmental Impact Statement Guidelines (November 2005);
- Halton Regions ("Halton") Environmental Impact Assessment Guidelines (2016);
- CH's Guidelines for Ecological Studies (March 2017);
- Regional Official Plan Amendment Number 38 ("ROPA 38"); and
- Regional Official Plan Policy 77(5) study requirements for an Area-Specific Plan (2015); as well as,
- The Guidelines following the Terms of Reference ("TOR") established in consultation with the CH, Halton Region, the City, the City's consultants, and agreed to through correspondence on May 31, 2017 (**Appendix A**).

CITY OF Burlington

APPLEBY
BURLINGTON HUB MOBILITY STUDY

STUDY AREA
FIGURE 1

- Study Area
- Road
- Railway
- Watercourse
- MNRF Wooded Area

0 50 100 200 Metres

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-12

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig1_StudyArea.mxd

2.0 Overview of Policy Framework

The Appleby Mobility Hub Area is subject to three levels of planning policies: Provincial, Regional, and Municipal. Recent updates to Provincial policies (effective July 1, 2017) will be reflected in upcoming updates to Regional and Municipal policies. For purposes of the following discussion, the most recent updated version of the applicable documents has been reviewed. The context provided relates to issues pertinent to the Study Area and does not represent the full spectrum of applicable planning related considerations contained within these governing plans. Refer to **Appendix B** for Schedules referenced within **Section 2.0**.

2.1 Provincial Framework

2.1.1 Provincial Policy Statement (2020)

The Provincial Policy Statement, 2020 (PPS) provides overall policy direction on matters of provincial interest related to land use planning and development in Ontario. The PPS sets forth a vision for Ontario's land use planning system by managing and directing land use to achieve effective development and land use patterns, wise use and management of resources, and protecting public health and safety. This report deals specifically with Policy 2.1, Natural Heritage, and Policy 2.2, Water, which provides for the protection and management of natural heritage and water resources, which include the following:

- significant wetlands;
- significant coastal wetlands;
- significant woodlands;
- significant valleylands;
- significant wildlife habitat;
- significant areas of natural and scientific interest (ANSIs);
- fish habitat;
- sensitive surface water features; and
- sensitive groundwater features.

The PPS defines "significant" to mean:

- *in regard to wetlands, coastal wetlands and areas of natural and scientific interest, an area identified as provincially significant by the Ontario Ministry of Natural Resources using evaluation procedures established by the Province, as amended from time to time;*
- *in regard to woodlands, an area which is ecologically important in terms of features such as species composition, age of trees and stand history; functionally important due to its contribution to the broader landscape because of its location, size or due to the amount of forest cover in the planning area; or economically important due to site quality, species composition, or past management*

history. These are to be identified using criteria established by the Ontario Ministry of Natural Resources; and,

- *in regard to other features and areas in Policy 2.1, ecologically important in terms of features, functions, representation or amount, and contributing to the quality and diversity of an identifiable geographic area or natural heritage system".*

The PPS defines "sensitive" to mean:

- *in regard to surface water features and groundwater features, means areas that are particularly susceptible to impacts from activities or events, including, but not limited to, water withdrawals, and additions of pollutants.*

This report deals specifically with Policies 2.1.1 and 2.1.2 which provides for the long-term protection, management and connectivity of natural features in an area. Policy 2.1.2 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*.'

The potential significance of natural heritage features may be evaluated based on size, age, the presence of rare or sensitive species, species diversity, and linkage functions, taking into consideration factors such as adjacent land use and degree of disturbance. Criteria for determining significance follow the guidance outlined in the Natural Heritage Reference Manual (MNRF, 2010) and the Significant Wildlife Habitat Technical Guide Eco-Region 7E Criterion Schedules (MNRF, 2015), where applicable.

2.1.2 Growth Plan for the Greater Golden Horseshoe (2020)

Pursuant to the Places to Grow Act, 2005, the Growth Plan for the Greater Golden Horseshoe, 2019 (Growth Plan) was approved on June 16, 2006. The Growth Plan has been amended four times since its release in 2006. The first amendment was released in January 2012 and contains policies, schedules and definitions that apply in the Simcoe Sub-area. The second amendment was released in June 2013 to update and extend the Growth Plan's population and employment forecasts. The third amendment took effect on July 1, 2017, which effectively replaced the 2006 Growth Plan. Following the third amendment (July 1, 2017); the fourth amendment came into effect on May 16, 2019. Lastly, the fifth and final amendment was issued August 28, 2020.

The Growth Plan requires the identification of water resource systems and the protection of key hydrologic features and key hydrologic areas, similar to the level of protection provided in the Greenbelt (MMAH, 2017). This provides a consistent framework for water protection across the Greater Golden Horseshoe (GGH) and builds on existing plans and policies. The Growth Plan also provides for the identification and protection of natural heritage systems in the GGH outside of the Greenbelt Area and settlement areas in order to provide consistent and long-term protection for natural heritage systems across the GGH (MMAH, 2017).

Section 4.2.2 of the Growth Plan states that the NHS mapping will exclude lands within settlement area boundaries that were approved and in effect as of May 16, 2019. As per Section 4.2.2(6), beyond the NHS, including within settlement areas, the municipality will continue to protect any other natural heritage features in a manner that is consistent with the PPS (2020).

As per Schedule 4 of the Greater Golden Horseshoe Growth Plan (**Appendix B**), the Study Area is designated as "*Built-Up Area*". Policies regarding *Built-Up Areas* are listed under Section 2.2.2 of the GPGGH, speak to minimum intensification targets for residential development in delineated *Built-Up Areas*.

2.1.3 Greenbelt Plan (2017)

Pursuant to the Greenbelt Act, 2005, the Greenbelt Plan was introduced in 2005 (MMAH) as a sub strategy to the original 2005 Growth Plan and the PPS (2020) to define growth and development within the GGH along with the Oakridge's Moraine Conservation Plan (ORMCP), and the Niagara Escarpment Plan (NEP). The Greenbelt Plan was recently updated in 2017; the update to the Greenbelt Plan was approved by the Lieutenant Governor in Council, Order in Council No. 1025/2017 as an amendment to the Greenbelt Plan on July 1, 2017.

The Study Area falls within the area designated as '*Settlement Areas Outside the Greenbelt*', just outside of the Greenbelt lands (see Schedule 1 and detailed Map 99 of the Greenbelt Plan). As such, in accordance with Policy 1.3 of the Greenbelt Plan, this Plan does not apply to lands designated as being outside the Greenbelt. The Greenbelt Plan defers to municipal official plans for detailed delineation of settlement boundaries and to govern land use and manage development within non-Greenbelt areas.

2.2 Regional Framework

2.2.1 Region of Halton Official Plan

The Region of Halton Official Plan is based on The Regional Plan [1995], which was adopted by Council of the Corporation of the Regional Municipality of Halton on March 30, 1994, through By-law 49-94. There have been a number of revisions and amendments to the Plan in addition to subsequent appeals to the changes in the years since this original Official Plan was adopted. Most recently, Regional Official Plan Amendment No. 38 (ROPA 38) to the Halton Region Official Plan was adopted by Regional Council on December 16, 2009, and modified and approved by the Minister of Municipal Affairs and Housing (MMAH) on November 24, 2011. An appeal of the Amendment was launched with the Ontario Municipal Board (OMB), and following a series of decisions portions of ROPA 38 have since received OMB approval. The most up-to-date version of the Regional Official Plan (ROP) reviewed in support of the Scoped EIS is the September 28, 2015, Interim Office Consolidation, published on January 13, 2016.

Policies within the ROP direct a significant portion of new growth to the Built-up Areas of the community through intensification, to preserve the surrounding protected countryside of the Greenbelt. The ROP structure includes provisions of applicable Provincial plans, namely the PPS, the Greenbelt Plan, and the Growth Plan. The Natural Heritage System designation includes both Regional Natural Heritage System and Greenbelt Natural Heritage System. The Regional Natural Heritage System is defined in the ROP as "a system of connected natural areas and open space to preserve and enhance the biological diversity". The Study Area lies inside of the Built Boundary identified in Map 1 of the ROP.

The Appleby Study Area contains the following designations, as shown on Map 1 of the ROP:

- *Urban Area*: Policies 72 – 77(21) of the ROP addresses the Urban Area designation and contains provisions for environmental protection and undertaking environmental studies within the urban area.
- *Regional Natural Heritage System*: The general Natural Heritage System policies that apply to the Study Area are outlined in Policies 113 to 114.2 of the ROP. Specific to the Regional Natural Heritage System are Policies 115.2 through 118.
- *Major Transit Station*: The Appleby Station is shown as a Major Transit Station and is subject to intensification polices outlined in the ROP.
- *Employment Area*: Policy 77.1-77.4(6) of the ROP addresses the Employment Area designation and contains provisions for environmental protection and undertaking environmental studies within the employment area.

Additional policies relating to the protection of environmental quality as a result of development are outlined in policies 140 through 149 of the ROP. These policies also outline specific provisions for development occurring adjacent to an active rail network and have been considered as part of this EIS.

The proposed Study Area is located on lands that are partially within Halton's Natural Heritage System and partially designated Regional Natural Heritage System on Map 1 of the Regional Official Plan (ROP) consolidated June 19 2018. Additionally, the Study Area contain or is adjacent to:

Features identified as Key Features as Illustrated on Map 1G of the ROP including:

- unmapped significant woodlands;
- candidate significant wildlife habitat (SWH);
- candidate habitat of endangered or threatened species (SAR); and,
- fish habitat.

Conservation Halton (CH):

- Areas identified as Highly Vulnerable Aquifer Area within the April 2015 Halton-Hamilton Source Protection Region Assessment Report; and,
- Areas regulated by CH such as watercourses and floodplains.

2.3 Municipal Framework

2.3.1 City of Burlington Official Plan

The City's Official Plan came into effect in 1994 through By-law No. 78-1994 and was subsequently approved by the Region of Halton with modifications in 1997. Since that time the Official Plan has been systematically reviewed and amended in order to ensure it reflects changing community needs and dynamics, address external influences, and to respond to new Regional and Provincial planning policies and legislation. The Office Consolidated version of the Plan used for this review was published by the City in July 2015. On April 26, 2018, the City of Burlington Council adopted a new Official Plan through By-law 24-2018, titled '*Grow Bold: Burlington's Official Plan'.* This new Official Plan document is currently under review by the Region of Halton, and is therefore not yet in full effect. As the intent is for the Secondary Plans under development for the Burlington Mobility Hub to be integrated into the new Official Plan, the following sections provide a review of the current Official Plan and the Grow Bold Plan in turn.

2.3.1.1 Current Official Plan (July 2015 Consolidation)

Sustainable environment policies described in Part II, Section 2 of the Official Plan apply to all areas of the City unless otherwise noted. These policies also contain provisions for the protection of natural heritage features and assets.

The Study Area falls within the Urban Area Boundary as depicted on Schedule B of the Official Plan. The land uses in the Study Area include:

- *General Employment* and *Business Corridor*: These land uses make up the two Employment designations in the City. Developments in these areas are subject to the Employment policies outlined in Part III, Section 3.1 to Section 3.2 of the Official Plan. Policies specific to the *General Employment* designation are outlined in Section 3.3, and those specific to the *Business Corridor* are outlined in Section 3.4 of the Official Plan.
- *Greenlands:* The objective of the Greenlands designation is to observe the long-term preservation of lands that form a permanent natural resources base consisting of ecologically sensitive natural areas. Developments are subject to the general policies outlined in Section 6.1 through Section 6.2.2. Section 6.2.3 provides policies for the *Greenlands* Protection and Acquisition of Natural Features Policies.
- *Mixed Use Corridors - General, Commercial Corridor* and *Employment*: Policies pertaining to Mixed Use areas in the City are outlined in Part III, Section 5 of the Official Plan. General policies pertaining to all Mixed Use areas are outlined in Section 5.1 to Section 5.3.2. Section 5.3.3 provides policies for the *Mixed Use Corridor – Commercial Corridor* designation, with policies for the *Mixed Use Corridor – Employment* designation outlined in Section 5.3.4.

The relevant policies pertaining to the Study Area as indicated in the City's Official Plan were considered in the development of this Scoped EIS.

2.3.1.2 Grow Bold: Burlington's Official Plan (Adopted by City Council April 26, 2018)

Environment and Sustainability policies that apply to all areas of the City (unless otherwise noted) are described in Chapter 4 of the City's new Official Plan, adopted by Burlington City Council on April 26, 2018 (the Grow Bold Plan). Pursuant to the Growth Plan (2017), the City has identified a Natural Heritage System as part of its Natural Heritage System, Major Parks, and Open Space designation under the Urban Structure of the new Official Plan (Section 2.3.5).

The policies corresponding to the Natural Heritage System, Parks, and Open Space designation are defined in Section 8.4 of the Grow Bold Plan. Policies state that the City's Natural Heritage System is designated on Schedule C. The Natural Heritage System in the Urban Area is part of a broader city-wide Natural Heritage System, which in turn is part of a much larger system outside of city boundaries. Schedule A of the Grow Bold Plan designates the majority of the Study Area as Urban Area, with the exception of a few small scattered parcels identified as Green System.

The Study Area is designated on Schedule B of the Grow Bold Plan as predominantly Employment Land (to be added to the Region of Halton Employment Area) north of the Rail Line. South of the Rail Line, the western segment is designated as Mixed-Use Nodes and Intensification Corridors, and the eastern portion is identified as Natural Heritage System, Major Parks and Open Space. A thin spine of the Natural Heritage System layer also carries on north of the Rail Line through the Study Area. Schedule B-1 of the Grow Bold Plan indicates that the large majority of the Study Area falls within a Primary Growth Area, with the southeast portion of the Study Area designated as part of the Natural Heritage System and Major Parks and Open Space designation.

Schedule C identifies the portions of the Study Area south of the QEW as a Business Corridor or General Employment Land. The policies pertaining to the Business Corridor designation are provided in Section 8.2.4 of the Grow Bold Plan, with the General Employment Land policies provided in Section 8.2.3. The area closest to the tributaries of Appleby Creek and Sheldon Creek have been designated as part of the City's Natural Heritage System. South of the Rail Line to Fairview Street, land has been designated as an Urban Corridor or Urban Corridor - Employment Lands. On the northeast portion of the Study Area, where Fairview Street ends, there are lands designated for Major Parks and Open Space.

Schedule M of the Grow Bold Plan identifies the City's Key Natural Features including tributaries such as Appleby and Sheldon Creek that flow through the Study Area southward to Lake Ontario.

2.4 Endangered Species Act, 2007

In June 2008, the *Endangered Species Act*, 2007 (ESA) came into effect in Ontario. The purpose of the ESA is to identify Species at Risk (SAR) based on the best available scientific information; to protect SAR

and their habitats, to promote the recovery of SAR; and to promote stewardship activities to assist in the protection and recovery of SAR in Ontario. There are two applicable regulations under the ESA; *Ontario Regulation 230/08* (the SARO List); and, *Ontario Regulation 242/08* (General). These regulations serve to identify which species and habitat receive protection and provide direction on the current implementation of the ESA by the Ministry of Natural Resources and Forestry (MNRF).

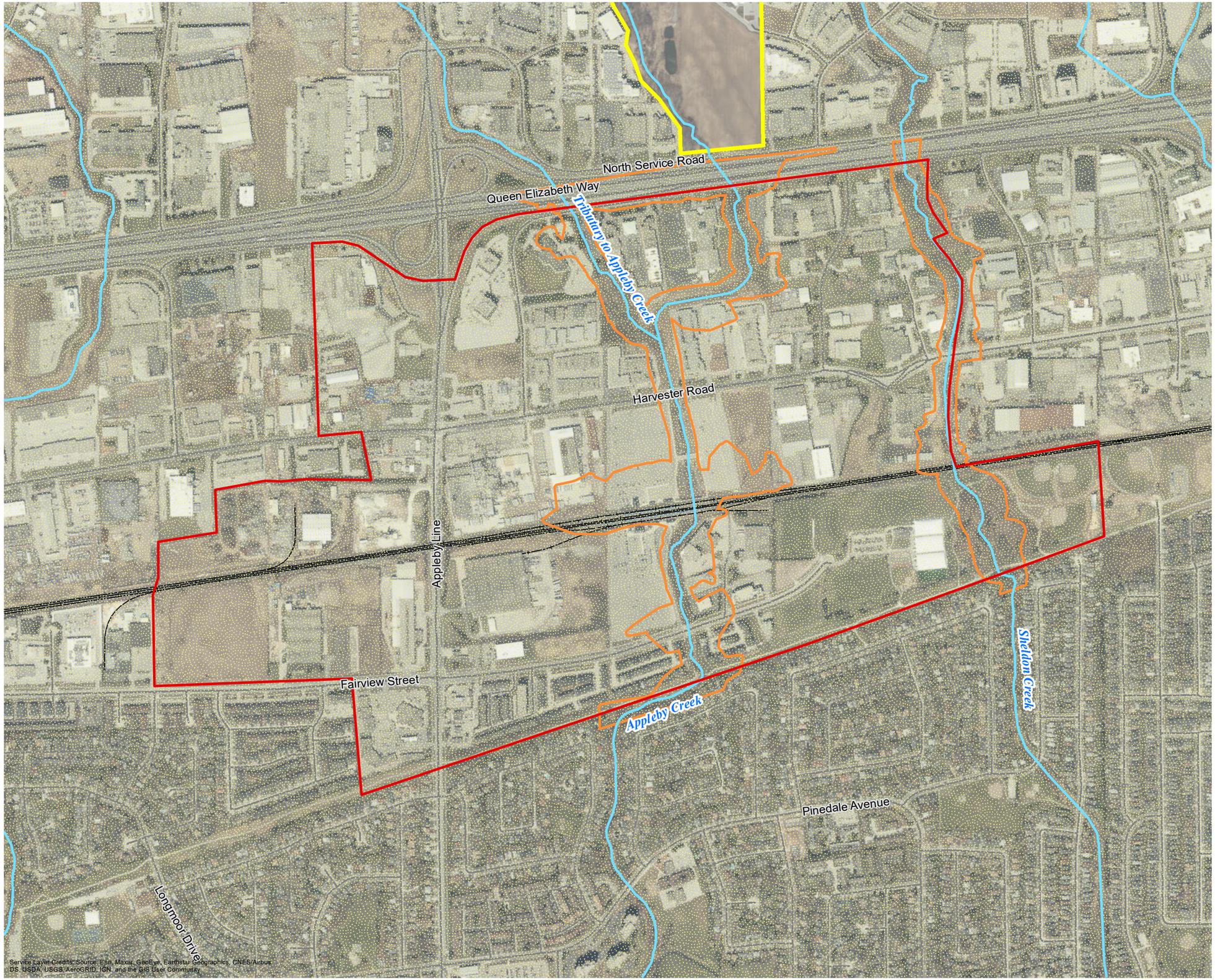
The potential for SAR and SAR habitat to be present within the Study Area is discussed further in **Section 3.4** and **Section 5.5** of this report.

2.5 Conservation Halton (Ontario Regulation 162/06)

In accordance with Section 28 of the Conservation Authorities Act, 1990, CH is authorized to implement and enforce the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation (*Ontario Regulation 162/06*). Section 2(1) of this Regulation lists areas within CH's jurisdiction where development is prohibited without proper permissions from CH. Such areas include, but are not limited to, river or stream valleys, hazardous lands, and wetlands.

In participating in the review of applications under the Planning Act and Environmental Assessment Act(s), CH ensures that applicants and approval authorities are aware of Section 28 Regulation requirements under the Conservation Authorities Act, where applicable. Further, CH assists in the coordination of these applications to avoid ambiguity, conflict and unnecessary delay or duplication in the process.

The tributaries of Appleby Creek and Sheldon Creek within the Study Area are located within CH Regulated Area (**Figure 2**).



CITY OF Burlington

APPLEBY
BURLINGTON HUB MOBILITY STUDY

PROVINCIAL AND AGENCY LAND USE DESIGNATIONS
FIGURE 2

- Study Area
- Road
- Railway
- Watercourse
- Built Boundary for the Growth Plan for the Greater Golden Horseshoe (2020)
- Conservation Halton Regulation Limit within Study Area (2012-05-14)

0 50 100 200 Metres

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF, CONSERVATION HALTON

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-12

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig2_LU_Designations.mxd

3.0 Results of Background Review

The following sections provide a brief summary of the existing environmental conditions within the Study Area. This information provides the background information upon which the EIS was based.

3.1 Landforms, Soils, and Geology

The Study Area is located within the Iroquois (Sand) Plains physiographic region of southern Ontario, which is a lowland region bordering Lake Ontario. Lake Iroquois formed following the formation of Lake Peel, as the ice receded farther from the Lake Ontario Basin. Lake Iroquois occupied a larger area than the current Lake Ontario and had higher water levels. Shoreline cliffs, sandbars and beaches are located approximately three kilometres (km) inland and mark the edge of the former lake. The physiographic region, known as the Iroquois Plains, extends around the shore of Lake Ontario from Niagara River to the Trent River spanning a distance of approximately 300 km (Chapman and Putnam, 1984). The plain is covered in layers of fine silty sands which formed the former lake bottom and beaches (Halton-Hamilton Source Protection, 2012).

The surficial bedrock east of the Niagara Escarpment is primarily the Queenston Formation. The Queenston Formation overlies the Georgian Bay Formation and comprises easily weathered, red shale with siltstone. The formation is approximately 150 meters (m) thick. The ice movement and water flow has eroded the shale over hundreds of thousands of years. This erosion has left an irregular bedrock surface and an unpredictable thickness of overlying soils (Halton-Hamilton Source Protection, 2012).

The old sandbars in this region are considered good aquifers that supply water to farms and villages. The gravel bars are quarried for road and building material, while the clays of the old lake bed have been used for the manufacture of bricks (Chapman and Putnam, 1984). This narrow strip is the most densely inhabited area because of its proximity to Lake Ontario and its climatic influences, as well as its favourable soil conditions.

3.2 Aquatic Environment

3.2.1 Watershed Summary

The Study Area lies within the Urban Creeks watershed, which consists of fourteen small watersheds located along the north shore of Lake Ontario within urban areas. The Urban Creeks watershed all originate at or below the Niagara Escarpment and flow either into the north shore of Burlington Bay/Hamilton Harbour or directly into Lake Ontario. The drainage area of the Urban Creeks is quite small, ranging in size from 2.7-20.9 km^2, which are small in comparison to other watersheds within CH's jurisdiction. The Urban Creeks Watershed has been delineated further, and the Appleby Study Area is located within the Burlington Urban Creeks Subwatershed. The watersheds are mostly urbanized and

predominately enclosed except for small portions of open, altered channel. Storm sewer flows add significantly to the natural drainage within the watercourse. Drainage for the watershed is directed to Lake Ontario (Halton-Hamilton Source Protection, 2012).

Urban Creeks Watershed in one of the watersheds involved in CH's Long-Term Environmental Monitoring Plan (LEMP). The LEMP was developed in 2005 to assess the long-term health of the CH'S watershed. The results of the program will assist in verifying whether CH'S mission to "help protect the natural environment from the lake to escarpment for the benefit and enjoyment of future generations" is being fulfilled (CH, 2013). Reports issued in 2009 and 2013 document the monitoring progress and results of environmental assessments during the 2008 and 2012 assessment years (e.g. fish community sampling, benthic invertebrate sampling, channel morphology, ecological land classifications, marsh monitoring, etc.; CH, 2013).

3.2.2 Fish Habitat

3.2.2.1 Appleby Creek

Degraded conditions and low water levels continued to be large factors affecting stream health in Appleby Creek as per the 2012 CH LEMP (CH, 2013). Stations surveyed during the 2012 LEMP were located outside of the Study Area, further upstream, and were considered to be in poor condition with respect to aquatic habitat.

3.2.2.2 Sheldon Creek

One of the Sheldon Sampling Locations from the CH LEMP is within the Study Area (**Figure 3**). Results of the aquatic assessment suggested that portions of Sheldon Creek were considered poor, fair and even good, which was quite different than what was documented in Appleby Creek (CH, 2013). A single indicator species [White Sucker (*Catostomus commersoni*)] was observed at the Sheldon Creek CH LEMP monitoring station (**Figure 3**). Upstream reaches of Sheldon Creek had a high number of native species, a moderate number of indicator species and a high catch per unit effort resulting in a classification of good.

Previous fish community sampling within Halton Region by CH has been performed. CH provided Dillon with terrestrial and aquatic records for the watershed. Information was filtered to fish observed within the Study Area as well as adjacent to the Study Area if the water feature supplied a watercourse within the Study Area (**Table 1**).

Table 1: Fish Species Identified throughout CH Assessments and Surveys

Scientific Name	Common Name	SARA[1]	ESA[2]	S-RANK[3]
Within the Study Area				
Rhinichthys atratulus	Blacknose Dace	---[4]	---	S5
Culaea inconstans	Brook Stickleback	---	---	S5
Semotilus atromaculatus	Creek Chub	---	---	S5
Pimephales promelas	Fathead Minnow	---	---	S5
Carassius auratus	Goldfish	---	---	SNA
Catostomus commersoni	White Sucker	---	---	S5
Associated with Lake Ontario				
Rhinichthys atratulus	Blacknose Dace	---	---	S5
Culaea inconstans	Brook Stickleback	---	---	S5
Semotilus atromaculatus	Creek Chub	---	---	S5
Pimephales promelas	Fathead Minnow	---	---	S5
Carassius auratus	Goldfish	---	---	SNA
Catostomus commersoni	White Sucker	---	---	S5
Lepomis gibbosus	Pumpkinseed	---	---	S5
Etheostoma caeruleum	Rainbow Darter	---	---	S4

As per comment from the CH, it is noted that watercourses are a migratory corridor for fall-spawning salmonids such as Coho and Chinook salmon.

3.2.3 Invertebrate Biotic Index

Invertebrate sampling stations do not exist within the tributaries associated with the Study Area (CH, 2013).

3.3 Natural Heritage Features

As mentioned in **Section 2.1**, natural heritage features as defined under the PPS require consideration within the Scoped EIS, discussed in subsequent sections. Note that consideration of fish habitat and habitat for *endangered* and *threatened* species has been included in **Section 3.4**, **Section 4.5** and **Section 5.5**, respectively.

[1] Federal Species at Risk Act (SARA)
[2] Provincial Endangered Species Act (ESA)
[3] S-Rank is an indicator of commonness in the Province of Ontario. A scale between 1 and 5, with 5 being very common and 1 being the least common
[4] "---" denotes no information or not applicable

3.3.1 Wetlands

Wetlands provide habitat for fish and wildlife and have important hydrological functions. A variety of wetland habitat types, significant locally and provincially, exists primarily above the escarpment due to poor drainage.

No Provincial Significant Wetland (PSW), locally significant wetlands or Unevaluated Wetland units were identified within or adjacent to the Study Area.

3.3.2 Woodlands

The woodland cover is generally concentrated above the Niagara Escarpment with patches of forest cover below. This distribution reflects the agricultural history of the area. In the 1800s and early 1900s, the extent of forest cover in the Burlington Region declined considerably as people settled in the area (CH, 2006).

The Study Area occurs in the Urban Land Cover area of Halton Region. Land covers in the urban areas include impervious surfaces such as asphalt, concrete and rail tracks on transportation routes. It also includes buildings of various sizes and densities that are used for a variety of purposes. Pervious surfaces are primarily limited to parklands and lawns (CH, 2013).

No significant woodlands were specifically identified within or adjacent to the Study Area; however, within the Study Area there are three unevaluated woodlands associated with Appleby Creek and two associated with Sheldon Creek (**Figure 1**).

3.3.3 Valleylands

No significant valleylands were identified within or adjacent to the Study Area.

3.3.4 Areas of Natural and Scientific Interest

No ANSIs were identified within or adjacent to the Study Area.

3.3.5 Significant Wildlife Habitat

The Significant Wildlife Habitat Technical Guide (MNRF 2000) defines Species of Conservation Concern as globally, nationally, provincially, regionally, or locally rare (S-Rank of S1 to S3) but does not include SAR (listed as *endangered* or *threatened* under the ESA). A review of the MNRF background data provided in support of the Scoped EIS does not suggest the presence of significant wildlife habitat in association with the woodland communities within the Study Area. However, several Species of Conservation Concern have the potential to occur within or adjacent to the Study Area (**Table 2**).

Table 2: Species of Conservation Concern with the potential to occur within the Study Area

Scientific Name	Common Name	SARA[5]	ESA[6]	S-RANK[7]	Info Source[8]
Vascular Plants					
Asplenium scolopendrium var. americanum	Hart's-tongue Fern	SC	SC	S3	MNRF SAR in Area
Sphenopholis nitida	Shiny Wedge Grass	---[9]	---	S1	NHIC
Crataegus brainerdii	Brainerd's Hawthorn	---	---	S2	NHIC
Crataegus pruinosa var. dissona	Northern Hawthorn	---	---	S3	NHIC
Phegopteris hexagonoptera	Broad Beech Fern	---	SC	S3	MNRF SAR in Area
Birds					
Falco peregrinus	Peregrine Falcon	SC	SC	S3B	MNRF SAR in Area
Ammodramus savannarum	Grasshopper Sparrow	---	SC	S4B	OBBA
Melanerpes erythrocephalus	Red-headed Woodpecker	THR	SC	S4B	OBBA
Hylocichla mustelina	Wood Thrush	---	SC	S4B	OBBA
Contopus virens	Eastern Wood-pewee	---	SC	S4B	OBBA
Herpetozoa					
Chelydra serpentina	Snapping Turtle	SC	SC	S3	MNRF SAR in Area, OHA
Thamnophis sauritus	Eastern Ribbonsnake (Great Lakes population)	SC	SC	S3	MNRF SAR in Area, OHA
Graptemys geographica	Northern Map Turtle	SC	SC	S3	MNRF SAR in Area, OHA
Sternotherus odoratus	Eastern Musk Turtle	THR	SC	S3	MNRF SAR in Area, OHA
Lepidoptera					
Danaus plexippus	Monarch	SC	SC	S2N,S4B	OBA
Pieris virginiensis	West Virginia White	---	SC	S3	OBA
Mammals					
Microtus pinetorum	Woodland Vole	SC	SC	S3?	MWH, MNRF SAR in Area

The potential for significant wildlife habitat to be present within the Study Area is discussed further in **Section 4.4.3** and **Section 5.4.3**.

[5] Federal Species at Risk Act (SARA)
[6] Provincial Endangered Species Act (ESA)
[7] S-Rank is an indicator of commonness in the Province of Ontario. A scale between 1 and 5, with 5 being very common and 1 being the least common
[8] Information sources include: MNRF = Ministry of Natural Resources and Forestry; OBBA = Ontario Breeding Bird Atlas; ON = Ontario Nature: Ontario Reptile and Amphibian Atlas; SARA = Species at Risk Act; TEA = Toronto Entomologists' Association; MWH = Mammals of the Western Hemisphere
[9] "---" denotes no information or not applicable

3.4 Species at Risk

3.4.1 Species at Risk and Species at Risk Habitat

A SAR information request was submitted to the MNRF Aurora District Office in order to obtain SAR records to help narrow our focus on potential SAR and/or SAR habitat within the Study Area. The MNRF identified the following *endangered* and *threatened* species with the potential to occur within and/or adjacent to the Study Area:

- Chimney Swift (*Chaetura pelagica*) listed as *Threatened* under the ESA;
- Eastern Small-footed Myotis (*Myotis leibii*) listed as *Endangered* under the ESA;
- Little Brown Myotis (*Myotis lucifugus*) listed as *Endangered* under the ESA;
- Northern Myotis (*Myotis septentrionalis*) listed as *Endangered* under the ESA; and,
- Tri-coloured bat (*Perimyotis subflavus*) listed as *Endangered* under the ESA.

These species are discussed further in **Section 5.5**.

3.5 Incidental Wildlife

A review of aerial imagery and local knowledge suggests that there are several common wildlife species found within the general area with potential to occur in the Study Area.

Incidental wildlife occurrences are discussed further in **Section 4.6** and **Section 5.6**.

4.0 Methodology of Biophysical Inventory

The results of the background review were used to assist in scoping the 2017 field program. Fieldwork conducted for the Scoped EIS occurred between May and August when weather conditions and timing were deemed suitable based on the survey protocols being implemented (**Table 3**). Fieldwork consisted of Ecological Land Classification (ELC) of vegetation communities, botanical surveys, aquatic surveys, and breeding bird surveys. The aforementioned surveys were completed in predetermined locations which were approved and confirmed in consultation with CH during the establishment of the TOR. Incidental wildlife observations made during the surveys were also documented. The following sub-sections outline the survey methodologies used in support of the Scoped EIS.

Table 3: Dates and Times of Field Surveys

Date (2017)	Weather Conditions	Air Temp (°C)	Purpose of visit
May 23	Mostly clear, light breeze, <1mm precipitation	11	Breeding Bird Survey #1
June 22	Overcast & periods of rain	18	Stream Assessment
June 28	Mostly clear, light breeze, no precipitation	15	Breeding Bird Survey #2, ELC Survey, Botanical Survey

4.1 Ecological Land Classification

Vegetation communities were assessed using ELC as a first step to identify and assess potential natural heritage features within the Study Area. During the field investigations, vegetation was characterized using the ELC System for Southern Ontario (Lee et al., 1998) in order to classify and map ecological communities to the vegetation level. The ecological community boundaries were determined through the review of aerial imagery and then further refined during site visits. In addition to the vegetation survey, a basic soil assessment was conducted to identify the soil moisture class within the ecosystem.

The ELC protocol recommends that a vegetation community be a minimum of 0.5 ha in size before it is defined. Based on the composition of vegetation communities within the Study Area, patches of vegetation less than 0.5 ha or disturbed/planted vegetation were described, provided they clearly fit within an ELC vegetation type.

Results of the ELC survey are included in **Section 5.1**.

4.2 Vegetation Inventory

Summer botanical surveys were completed in conjunction with the detailed ELC survey in June. Surveys consisted of wandering transects and/or area searches to determine the presence, richness and

abundance of floral species within the Study Area. Species nomenclature is based on the Ontario Plant List (Newmaster *et al.,* 1998).

Results of the botanical surveys are discussed in **Section 5.2**.

4.3 Aquatic Assessment

4.3.1 Stream Assessments

A stream assessment was conducted on June 22 to investigate the portions of Appleby Creek, Tributary to Appleby Creek and Sheldon Creek mapped within the Study Area. Information collected for the watercourses included (where applicable): channel form, presence/absence of flow, substrate type, channel dimensions (e.g. width and depth), and riparian vegetation. Methodologies used to collect this information was akin to the Ontario Stream Assessment Protocol (OSAP). This information was then used to help determine the overall health and sensitivity of each watercourse.

The locations of stream assessments are shown on **Figure 3**, and results are discussed in **Section 5.3**.

4.3.2 Fluvial Geomorphology Assessment

In addition to the aquatic stream assessments, a fluvial geomorphology assessment was completed by GeoProcess Research Associated within the Study Area. Refer to **Appendix E** for detailed methods as they relate to the fluvial geomorphology assessment.

A summary of the results as it pertains to bank and stream stability as well as aquatic/riparian habitat is summarized in **Section 5.3**.

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APPLEBY
BURLINGTON HUB MOBILITY STUDY

2017 FIELD SURVEY LOCATIONS
FIGURE 3

- Study Area
- Conservation Halton Fish Records
- Breeding Bird Survey Location
- Stream Assessment Locations
- Conservation Halton 2012 LEMP
- Road
- Railway
- Watercourse

0 50 100 200 Metres

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF, CONSERVATION HALTON

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-12

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig3_SurveyLocations.mxd

4.4 Natural Heritage Features

4.4.1 Wetlands

No PSW and/or unevaluated wetland units were identified within or adjacent to the Study Area.

4.4.2 Woodlands

Woodlands within the Study Area were investigated as part of the ELC and vegetation inventory.

Results of field studies relating to woodlands are discussed in **Section 5.4.2**.

4.4.3 Significant Wildlife Habitat

Based on the presence of the woodland within the Study Area, breeding bird surveys were conducted to establish baseline conditions, and to determine whether significant wildlife habitat exists within the Study Area as defined in the *Eco-region 7E Criterion Schedules* (MNRF, 2015).

4.4.3.1 Breeding Bird Survey

Diurnal breeding bird surveys conducted within the Study Area followed the methods outlined in the Ontario Breeding Bird Atlas Guide for Participants (Cadman et al 2007) and were completed in late-May and late-June (two surveys) in an effort to document both early season and late season breeders. Specifically, surveys consisted of point counts generally conducted between dawn and five hours after sunrise to establish quantitative estimates of bird abundance in suitable habitat types within the Study Area. During the surveys, evidence of breeding behaviour was recorded which generally includes, but is not limited to, males singing, nest building, egg incubation, territorial defence, carrying food, and feeding their young.

To supplement the surveys, area searches of the habitat were completed using binoculars to observe species presence and breeding activity. Area searches involved noting individual bird species observations and their corresponding breeding evidence while traversing the habitat on foot. Point count locations are displayed in **Figure 3**.

Results of breeding bird studies within the Study Area are included in **Section 5.4.3.1**.

4.5 Species at Risk

Surveys for Butternut were completed in conjunction with ELC surveys within the Study Area. With respect to birds, since no specific habitat for SAR birds identified by the MNRF is present within the Study Area, general surveys for Chimney Swift were completed in conjunction with diurnal breeding bird surveys outlined above.

Given that the woodlands within the Study Area will be protected and no vegetation removal is anticipated in association with the woodlands, specific snag/cavity tree searches in support of bat habitat were not conducted.

Results relating to SAR within the Study Area are included in **Section 5.5**.

4.6 Incidental Wildlife

A general wildlife assessment was completed within the Study Area through incidental observations while on site. Incidental observations of wildlife were noted, as well as other wildlife evidence such as dens, tracks, and scat. For each observation, notes, and when possible, photos were taken. These observations helped to determine potential ecological functions, linkages, etc. within the Study Area.

Results relating to incidental wildlife within the Study Area have been included in **Section 5.6**.

5.0 Results of Biophysical Inventory

A biophysical inventory of natural features within the Study Area was completed in accordance with the methods detailed in **Section 4.0**. The analysis of data collected from secondary source information and during field studies in 2017, was used to evaluate the significance of natural heritage features within the Study Area.

5.1 Ecological Land Classification

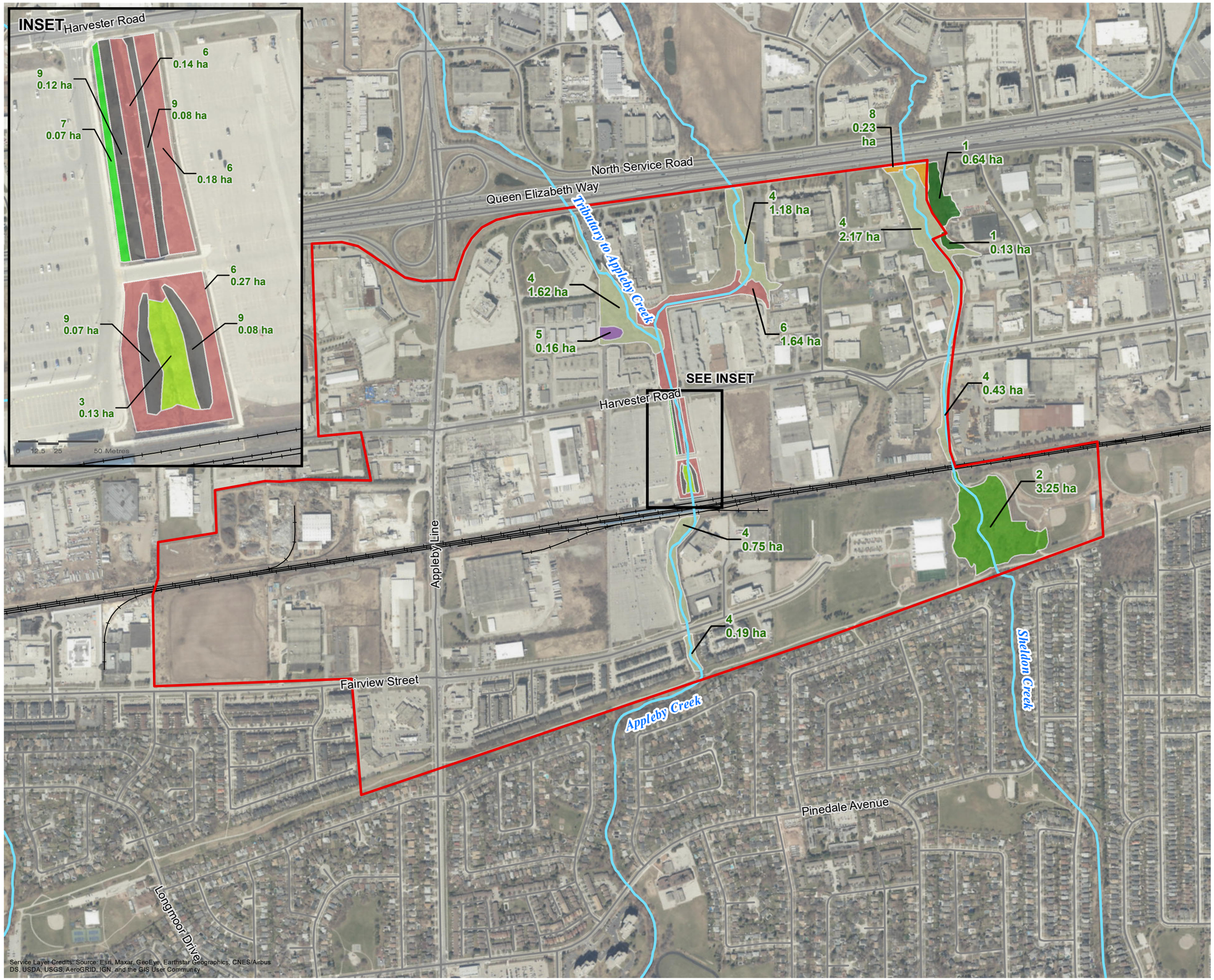
Six natural vegetation communities, as well as three anthropogenic communities, were observed within the Study Area during the ELC survey. The location, type, and boundaries of the communities are delineated in **Figure 4.** The natural vegetation communities surveyed within the Study Area are considered common in Ontario. **Table 4** outlines the communities documented during ELC surveys and summarizes the dominant vegetation cover. Reference photos of the natural vegetation communities are provided in **Appendix C**.

The natural communities within the Study Area have been disturbed due to anthropogenic uses (i.e., trails, dumping, etc.) and contained the presence of invasive species.

Table 4: Ecological Land Classification

ELC	Classification	Area (ha)	Vegetation	Comments	Photo Appendix C
FODM7-4	Fresh – Moist Black Walnut Lowland Deciduous Forest Type	6.34	The canopy and sub-canopy consists of Black Walnut (*Juglans nigra*) as the dominant species, with Green Ash (*Fraxinus pensylvanica*), Manitoba Maple (*Acer negundo*), Crack Willow (*Salix fragilis*), Lombardy Poplar (*Populus nigra cv. italica*), Sugar Maple (*Acer saccharum*), Norway Maple (*Acer platanoides*), American Basswood (*Tilia americana*), Red Oak (*Quercus rubra*), and Shagbark Hickory (*Carya ovata*) associates. Understory species consist of Green Ash, Manitoba Maple, Norway Maple, Choke Cherry (*Prunus virginiana*), English Hawthorn (*Crataegus monogyna*), Rose species (*Rosa* sp.), Riverbank Grape (*Vitis riparia*), Black Walnut, Black Raspberry (*Rubus occidentalis*), Staghorn Sumac (*Rhus hirt*a), Tartarian Honeysuckle (*Lonicera tatarica*) and Multiflora Rose (*Rosa multiflora*). Ground layer species present consists of Common Red Raspberry (*Rubus idaeus* ssp. *idaeus*), White Avens (*Geum canadense*), Spotted Jewelweed (*Impatiens capensis*), Sugar Maple, Common Motherwort (*Leonurus cardiaca*), Garlic Mustard (*Alliaria petiolata*), Dame's Rocket (*Hesperis matronali*s), Rose species, Bull Thistle (*Cirsium vulgare*), Eastern Late Goldenrod (*Solidago altissima ssp. altissim*a), Fuller's Teasel *(Dipsacus fullonum*), Wild Chervil (*Anthriscus sylvestris*), Purple Slender Stinging Nettle (*Urtica dioica* ssp. *gracilis)*, Common St. John's-wort (*Hypericum perforatum*), Tall Buttercup (*Ranunculus acris*), Philadelphia Fleabane (*Erigeron philadelphicus*), Canada Thistle (*Cirsium arvense*), Herb-robert (*Geranium robertianum*), Wild Garlic (*Allium vineale*), Goldenrod species (*Solidago* sp.), Poison Ivy (*Toxicodendron rydbergii*), Kentucky Bluegrass (*Poa pratensis* ssp. *pratensis*), Fowl Managrass (*Glyceria striata*) and Reed Canary Grass *(Phalaris arundinacea*).	This community is associated with watercourse features and separated by anthropogenic features. The community contained sparse occurrences of invasive species (i.e. Garlic Mustartd). The northern patch between the QEW and Harvester Road to the northeast contained several informal trails and meeting places. The patch between QEW and Harvester Road to the northwest contained informal trails and was adjacent to recent restoration works.	Photo 1
THDM2-11	Hawthorn Deciduous Shrub Thicket	0.16	This community was dominated by Hawthorn (*Crataegus sp.*), Common Buckthorn (*Rhamnus cathartica)* and Sweet Cherry (*Prunus avium*) associates. The understory consisted of Thicket Creeper (*Parthenocissus inserta*) and Common Burdock (*Arctium minus*). Ground layer species present consists primarily of Canada Thistle, Philadelphia Fleabane, Canada Goldenrod (*Solidago canadensis*), Aster species (*Aster* sp.), Wild Parsnip (*Pastinaca sativa*), and Garden Asparagus (*Asparagus officinalis*).	This community is present along the western edge of the FODM7-4 north of Harvester Road and west of the Tributary to Appleby Creek.	N/A
MEMM4/ THDM2	Fresh - Moist Mixed Meadow Ecosite/Dry - Fresh Deciduous Shrub Thicket Ecosite	2.23	The canopy and sub-canopy consists of Black Walnut with rare occurrences of Black Locust (*Robinia pseudoacacia*). Understory species consist of rare occurrences of Black Walnut, Staghorn Sumac and Black Locust. Ground layer species present consists primarily of Wild Chamomile (*Matricaria chamomilla*), Garden Bird's-foot Trefoil (*Lotus corniculatus*), Canada Thistle, Philadelphia Fleabane, Canada Goldenrod (*Solidago canadensis*), Aster species (*Aster* sp.), Blunt-leaved Bedstraw (*Galium obtusum*) and Brome species (*Bromus* sp.); with rare occurrences of Fuller's Teasel, Curly Dock (*Rumex crispus*), Wild Parsnip (*Pastinaca sativa*), Garden Asparagus, Sunflower species (*Helianthu*s sp.), Canada Bluegrass (*Poa compressa*), Sulphur Cinquefoil (*Potentilla recta*), Reed Canary Grass and Creeping Wildrye (*Briza* sp.).	This community is divided by anthropogenic features into three separate areas in the north central portion of the Study Area. The community contains mostly riparian vegetation with patches of upland thicket as the community transitions into forest communities.	Photo 2
FODM6-5	Fresh – Moist Sugar Maple – Hardwood Deciduous Forest Type	3.25	The canopy and sub-canopy consists of Sugar Maple, American Beech (*Fagus grandifolia*) and Eastern Hop-hornbeam (*Ostrya virginiana*) as the dominant species, with Scotch Pine (*Pinus sylvestris*), Silver Maple (*Acer saccharinu*m), Crack Willow, American Basswood, Northern Red Oak, Wild Black Cherry (*Prunus serotina*), Green Ash and Eastern Hemlock (*Tsuga canadensis*) associates. Understory species consist of Sugar Maple, and American beech, with rare occurrences of Eastern Hop-hornbeam, American Basswood, Black Walnut, Choke Cherry, Red-berried Elderberry (*Sambucus racemosa* ssp. *pubens*), Norway Maple and Green Ash. Ground layer species present consists primarily of Garlic Mustard, Virginia Creeper (*Parthenocissus quinquefolia*), Broad-leaved Enchanter's Nightshade (*Circaea canadensis*) and Common Buckthorn, with rare occurrences of White Avens, Riverbank Grape, Red Osier Dogwood (*Cornus sericea ssp sericea*), Euonymus species (*Euonymus* sp.), European Swallow-wort (*Cynanchum rossicum*), Poison Ivy, Spotted Jewelweed, Jack-in-the-pulpit (*Arisaema triphyllum*), May-apple (*Podophyllum peltatum*), Common Burdock, Blunt-leaved bedstraw, False Solomon's-seal (*Maianthemum racemosum*), Rosy Sedge (*Carex rosea*), Woodland Sedge (*Carex blanda*), Canada Bluegrass, Canada Managrass (*Glyceria canadensis* var. *canadensis*), Orchard Grass (*Dactylis glomerata*), Herb-robert and Common St. John's-wort.	This community is located in the southeast portion of the Study Area and contains abundant occurrences of non-native species. The forest is located within Sherwood Forest park and contains a number of recreational trails that appear to receive extensive use.	Photo 3

ELC	Classification	Area (ha)	Vegetation	Comments	Photo Appendix C
FODM7	Fresh – Moist Lowland Deciduous Forest Ecosite	0.13	The canopy and sub-canopy consists primarily of Green Ash (*Fraxinus pennsylvanica*), Manitoba Maple and Crack Willow (*Salix fragilis*), with Paper Birch (*Betula papyrifera*), Northern Catalpa (*Catalpa speciosa*), Eastern Cottonwood, Black Cherry (*Prunus serotina*), Black Walnut and American Elm (*Ulmus americana*) associates. Understory species are dominated by Green Ash, with rare occurrences of Common Buckthorn (*Rhamnus cathartica*), European Alder (*Alnus glutinosa*) and Staghorn Sumac. Ground layer species present consist of Thicket Creeper, Colt's-foot (*Tussilago farfara*), Goldenrod species (*Solidago isp.*), Poison Ivy and Field Horsetail (*Equisetum arvense*), with rare occurrences of Riverbank Grape, Purple-flowering Raspberry (*Rubus odoratus*), Blunt-leaved bedstraw, White Avens, Fox Sedge (*Carex vulpinoidea*), Reed Canary Grass, Orchard grass (*Dactylis glomerata*), Day Lily species (*Hemerocallis* spp.) and Vetchling Peavine (*Lathyrus palustris*).	This community is located centrally within the Study Area and contains occasional occurrences of invasive species (i.e. Common Buckthorn). The community is associated with Appleby Creek.	N/A
FODM5	Dry-Fresh Sugar Maple Deciduous Forest	0.77	The canopy and sub-canopy consist primarily of Sugar Maple with Red Oak, Eastern Hop-hornbeam, Wild Black Cherry and American Beech. Understory species consist mostly of Common Buckthorn, with rare occurrences of Choke Cherry, Red-berried Elderberry and Sugar Maple. Ground layer species consist primarily of White Avens, Broad-leaved Enchanter's Nightshade, Garlic Mustard and Poison Ivy, with rare occurrences of Herb-Robert.	This community is in the northwest end of the Study Area and has occasional occurrences of invasive species.	Photo 4



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SITE INVESTIGATION RESULTS
FIGURE 4

- Study Area
- Road
- Railway
- Watercourse

Ecological Land Classification

1. FODM5: Dry-Fresh Sugar Maple Deciduous Forest
2. FODM6-5: Fresh-Moist Sugar Maple-Hardwood Deciduous Forest
3. FODM7: Fresh-Moist Lowland Deciduous Forest
4. FODM7-4: Fresh-Moist Black Walnut Lowland Deciduous Forest
5. THDM2-11: Hawthorn Deciduous Shrub Thicket
6. MEMM4 / THDM2: Fresh-Moist Mixed Meadow / Dry-Fresh Deciduous Shrub Thicket
7. Manicured Lawn
8. Active Restoration
9. Gabion Basket Area

0 50 100 200 Metres

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-12

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig4_ELC.mxd

5.2 Vegetation

A total of 76 botanical species were documented during 2017 field studies. Of the 76 species, 39 are listed as native species considered to be common (SRank of S4) to very common (SRank of S5) in the province of Ontario. The remaining species are listed as introduced species; therefore, a status ranking is not applicable as the species is not a suitable target for conservation activities (SRank of SE or SNA).

The Co-efficient of Conservatism (CC) provides additional information on the nature of the vegetation communities within the Study Area. The CC values range from 0 to 10 and represent an estimated probability that a plant is likely to occur in a landscape that is relatively unaltered or is in a pre-settlement condition. For example, a CC of 0 is given to plants such as Manitoba Maple (*Acer negundo*) that demonstrate little fidelity to any remnant natural community, i.e. may be found almost anywhere. Similarly, a CC of 10 is applied to plants like Shrubby Cinquefoil (*Potentilla fructicosa*) that are almost always restricted to a pre-settlement remnant (i.e. a high-quality natural area). Introduced plants were not part of the pre-settlement flora, so no CC values have been applied to these species.

Of the 76 species identified in the Study Area, three have a CC value of 7 or greater; Canada Managrass (7), Eastern Hemlock (7), and Purple Bladderwort (10). The mean CC value for the site was 1.77, indicating an altered landscape. This is typical of an urban environment as compared to naturally occurring environments. A full list of the vegetation species observed within the Study Area has been included in **Appendix D**.

Potential impacts related to vegetation within the Study Area are included in **Section 8.1.1**.

5.3 Aquatic Assessment

5.3.1 Stream Assessments

The tributary to Appleby Creek flows south to its confluence with Appleby Creek. These watercourses were assessed from their upstream limits within the Study Area; south of the South Service Road crossing. The tributary to Appleby Creek was assessed to its confluence with Appleby Creek, and Appleby Creek was assessed to the Study Area's southern limit. Sheldon Creek was also assessed within the Study Area and it was observed to flow south from the South Service Road crossing to its southern extent within the Study Area. The areas of assessment are shown in **Figure 3**.

5.3.1.1 Tributary to Appleby Creek

Within the Study Area, the Tributary to Appleby Creek was characterized as a permanent creek, observed to be flowing on the day of the assessment and contained direct habitat for fish. The tributary was linear with minor instances of meandering (**Appendix C**; Photo 5). The morphology of the creek was dominated by run and flat habitat. The limited meandering of the tributary contained flat habitat with

less flow velocity observed. The average wetted width was observed to be approximately 2 m while the average depth was observed to be approximate 0.13 m. Unstable banks were observed along the upper portion of the reach despite a deciduous thicket riparian area. Gabion baskets, historically installed for bank stabilization, were observed in the lower portion of the watercourse (**Appendix C**; Photo 6).

Substrates within the creek were dominated by gravel and shale, with clay also present. Limited instream vegetation was observed, predominantly in the form of cattails located at the South Service Road crossing outlet. No barriers to fish migration or limiting critical habitat were observed during the assessment.

5.3.1.2 Appleby Creek

Within the Study Area, Appleby Creek was characterized as permanent, observed to be flowing on the day of the assessment and contained direct habitat for fish. The creek was linear with an indication of bank stabilization in the area of the Go Station (**Appendix C**; Photo 7). The morphology of the watercourse was diverse and contained riffle, run, pool, flat and glide habitat throughout. The substrate was sorted instream, which is a measure of the spread of particle sizes in the substrates, and consisted primarily of shale, cobble, silt and gravel. The wetted width averaged approximately 3 m with an average depth of approximately 0.14 m. No instream aquatic vegetation was observed while the dense riparian cover was provided by mixed deciduous trees and shrubs. Numerous gabion baskets and armour stone were observed instream, many of which presented likely barriers to fish migration (**Appendix C**; Photo 8)

5.3.1.3 Sheldon Creek

Within the Study Area, this watercourse was characterized as permanent, direct fish habitat and was flowing on the day of assessment. The watercourse meandered within a defined channel and the morphology consisted of runs, riffles, pools and flats. The substrate was observed to be dominated by cobble and gravel throughout with sand and clay present as well. The wetted width averaged approximately 3 m and the average depth was approximately 0.13 m. Instream vegetation was not observed within the study area; however, recent riparian plantings were observed south of South Service Road (**Appendix C**; Photo 9). The mixed deciduous forest (FODM7-4) provided a dense riparian cover along with a significant portion of the banks.

The banks were observed to be unstable in many areas and recent bank stabilization efforts have failed in the area of the Sherwood Forest Park (**Appendix C**; Photo 10). No limiting sensitive fish habitat was observed within the Study Area. A seasonal barrier to fish migration was observed upstream of the Harvester Road crossing in the form of an instream, concrete footing containing an approximate 1 m drop at a steep angle with no low flow channel present (**Appendix C**; Photo 11).

5.3.2 Fluvial Geomorphology Assessment

The upper portion of Sheldon Creek was observed to have a natural channel design which provides good energy dissipation by creating floodplain access. The regraded banks, grade-control structures and cobble/boulder bed/bank material make this creek more resilient to future changes. However, downstream of the railroad tracks, the previous attempts to mitigate erosion on Sheldon Creek have been unsuccessful, therefore less resilient to future change. The downstream reaches are bedrock-dominated reaches, and are expected to adjust at a much slower rate that non-bedrock reaches. Overall, the Appleby reach is currently in a much more degraded state with previous erosion mitigations compromised by river adjustments and water flowing through channelized, confined corridors. Additionally, the observed debris within the channel is expected to further amplify the erosion and sediment processes.

Rehabilitation opportunities should be prioritized based on erosion risk to existing infrastructure and potential degradation to the aquatic environment. Erosion risk rehabilitation solutions vary based on location and include but are not limited to the following measures:

- Modifications to the bankfull channel (e.g. width-depth improvements and naturalized erosion protection)
- Removal of woody debris present at select locations throughout the reach
- Removal of all failed concrete grade control structures
- Gabion baskets can be replaced with naturalized erosion protection measures (e.g. vegetated buttresses and riffle-pool morphology bed features).
- Floodplain benches can be added to reconnect the frequent flow regime to the floodplain
- Naturalized erosion protection such as armour stone or boulder steps.

In addition to the solutions provided above, site specific mitigation measures for specific reach locations within Appleby Creek are summarized in **Table 5** below, based on the fluvial geomorphology assessment by GeoProcess (**Appendix G**).

Table 5: Appleby Creek Rehabilitation Opportunities Based on Reach Locations

Reach	Rehabilitation Opportunities
APC01A	Rehabilitation opportunities consist of incorporating naturalized erosion protection of the bed and banks, removing existing gabions and riprap, and employing floodplain benches.
APC01B	Mitigation measures within APC01B focus on the strategic removal of woody debris accumulation within the midpoint of the reach.
APC02	Rehabilitation of a concrete spillway at the upstream end to a series of steps and pools is recommended as well as the removal of all failed concrete grade control structures and gabion baskets.
APC03	Recommendations for this reach include revegetation of the corridor, along with the replacement of the concrete grade control structures with naturalized erosion measures such as armourstone or boulder steps.
APC04	Rehabilitation opportunities here include the removal of existing gabion bank protection with naturalized bed and bank protection such as vegetated buttresses and riffle-pool morphology bed features.

For detailed results as they relate to the fluvial geomorphology assessment, refer to the Preliminary Fluvial Geomorphology Assessment Results Report prepared by GeoProcess in **Appendix E**. Reach specific stream rehabilitation opportunities for Appleby Creek have been evaluated by GeoProcess and are provided under separate cover in **Appendix G**.

5.4 Natural Heritage Features

5.4.1 Wetlands

No PSW or unevaluated wetland units were identified within or adjacent to the Study Area.

5.4.2 Woodlands

The woodlands within the Study Area were investigated in association with ELC surveys. In accordance with the policies of the Halton Regional Official Plan Amendment Number 38 (ROPA 38 Section 277):

> ***SIGNIFICANT WOODLAND*** *means a Woodland 0.5 ha or larger determined through a Watershed Plan, a Sub-watershed Study or a site-specific Environmental Impact Assessment to meet one or more of the four following criteria:*
>
> *(1) The Woodland contains forest patches over 99 years old;*
> *(2) The patch size of the Woodland is 2 ha or larger if it is located in the Urban Area, or 4 ha of larger if it is located outside of the Urban Area but below the Escarpment Brown, or 10 ha or larger if it is located outside the Urban Area but above the Escarpment Brow;*
> *(3) The Woodland has an interior core area of 4 ha or larger, measured 100m from the edge; or*
> (4) *The Woodland is wholly or partially within 50 m of a major creek or certain headwater creek or within 150 m of the Escarpment Brow.*

Below, **Table 6** lists each of the woodlands identified within the Study Again against the aforementioned evaluation criteria for woodland significance. **Table 6** should be ready concurrently with **Figure 5.**

Table 6: Woodland Evaluation Table for Appleby Study Area

Woodland	Attributes		Evaluation Criteria				
			Size	Age	Patch Size	Interior Area	Proximity to Water
	Size (ha)	Interior Forest (100 m from the edge)	Woodland 0.5 ha or larger	Woodland contains forest patch over 99 years old	Patch size of woodland is 2 ha or greater if located in the Urban Area	Woodland contains 4 ha of interior core area measured 100m from the edge	Woodland is wholly or partially within 50 m of a major creek or certain headwater creek
A *	0.19	0	---	---	---	---	---
B	0.75	0	√	---	---	---	√
C *	0.13	0	---	---	---	---	---
D	1.62	0	√	---	---	---	√
E	1.18	0	√	---	---	---	√
F	3.25	0	√	---	√	---	√
G *	0.43	0	---	---	---	---	---
H	2.95	0	√	---	√	---	√

** woodland does not meet minimum criteria of 0.50 ha to be evaluated for significance under ROPA 38 Section 227; therefore, the woodland will be evaluated for significant under the Natural Heritage Assessment Guide (2012).*

Woodland B, D & E are greater than 0.50 ha and are located within 50 m of a major creek or headwater feature (Appleby Creek) in an Urban Area; therefore, they meet the criteria for significance under ROPA 38, Section 277.

Woodland F & H are greater than 2.0 ha within an Urban Area and are located within 50 m of a major creek or headwater feature (Sheldon Creek); therefore, they meet the criteria for significance under ROPA 38, Section 277.

Although Woodlands A, C & G do not meet the minimum requirement for significance under ROPA 38, they were also assessed under the Natural Heritage Assessment Guide (MNRF 2012). As outlined in the Natural Heritage Reference Manual (MNRF 2010), for a woodland feature to be significant it must first meet minimum standards for tree crown cover (minimum 60%). If these minimum standards are met, it is then evaluated based on size criterion, ecological function criteria, and uncommon characteristics criteria. Many of the criteria have minimum size thresholds that are based on the percentage of woodland cover in the municipality where the project has been proposed (City of Burlington). Woodlands that meet the minimum standard for any one of the criteria are considered significant.

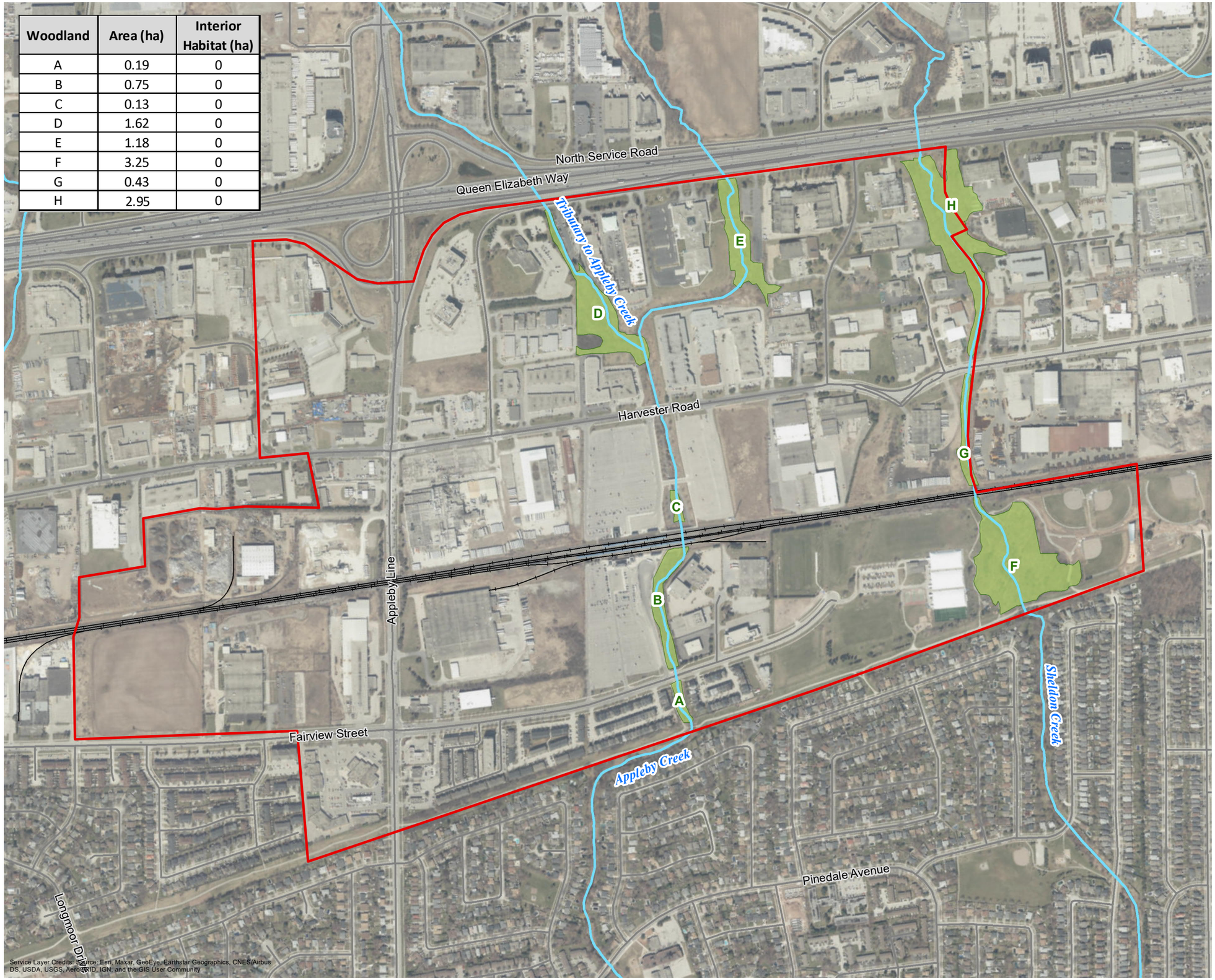
The estimate of woodland cover within the City of Burlington is 23%; comprising 17% in the urban areas and 28% in the rural areas (City of Burlington, 2010). For the purposes of determining significance, the woodland cover within the urban areas (17%) is used. In order for a woodland to be considered significant, it must be greater than or equal to 20 ha in size. If the woodland fails to meet that criterion, it is considered significant if it meets any one of the following criteria:

a) Interior habitat of 2 ha is present, with a 100 m interior buffer on all sides;
b) Proximity to other woodlands (within 30 m of another significant woodland) and greater than 4 ha in size;
c) Overlap with other natural heritage features (provincially significant wetlands, ANSI's, etc.) and is greater than 4 ha in size;
d) Within 50 m of a sensitive groundwater discharge, watercourse or fish habitat and is greater than 2.0 ha in size; or
e) Contain certain representative native woodland species and is 4.0 ha in size.

Woodlands A, C & G within the Study Area are 0.19 ha, 0.13ha and 0.43 ha, respectively. They do not contain interior habitat and they are not located within 50 m of a sensitive groundwater discharge. Therefore, the woodlands are determined to be not significant under the Natural Heritage Reference Manual (MNRF 2010).

Potential impacts related to woodlands within the Study Area are included in **Section 8.1.1** and **Section 8.1.3**.

Woodland	Area (ha)	Interior Habitat (ha)
A	0.19	0
B	0.75	0
C	0.13	0
D	1.62	0
E	1.18	0
F	3.25	0
G	0.43	0
H	2.95	0



CITY OF Burlington

APPLEBY
BURLINGTON HUB MOBILITY STUDY

WOODLANDS
FIGURE 5

- Study Area
- Road
- Railway
- Watercourse
- Dillon Delineated Woodlands

0 50 100 200 Metres

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

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PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-12

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig5_Woodlands.mxd

5.4.3 Significant Wildlife Habitat

The results of the field surveys as they apply to wildlife habitat are detailed below. Based on the results of the 2017 field investigations, no Significant Wildlife Habitat (SWH) pertaining to Rare Vegetation Communities, Specialized Habitat for Wildlife or Animal Movement Corridors as defined in the *Eco-region 7E Criterion Schedules* (MNRF, 2015) were identified within the Study Area. However, SWH for Special Concern and Rare Wildlife Species was confirmed based on the observations of Eastern Wood-peewee (*Contopus virens*) during the 2017 breeding bird surveys (**Figure 6**).

Given that the 2017 field investigations were limited to ELC, botanical, breeding bird and aquatic surveys, it is recommended that the need to undertake additional terrestrial surveys (e.g. amphibians, bats, etc.) be evaluated during the site specific development applications. However, given the presence of woodlands within the Study Area, candidate SWH for Bat Maternity Colonies has the potential to occur in association with the woodland features identified during ELC (**Figure 6**).

5.4.3.1 Breeding Bird Survey

A total of 31 bird species were observed during breeding bird surveys in 2017 (**Table 7**). Of the 31 species observed, one SAR (Barn Swallow (*Hirundo rustica*)), and one SCC (Eastern Wood-pewee) were identified. The remaining 29 species are considered secure (SRank of S4) to very common (SRank of S5) in the province of Ontario based on the provincial conservation rankings assigned by the NHIC.

Table 7: Breeding Bird Survey Results 2017 Field Investigations

Scientific Name	Common Name	GRank[10]	SRank[11]	SARA[12]	ESA[13]	Breeding Evidence[14]
Turdus migratorius	American Robin	G5	S5B	---	---	S
Corvus brachyrhynchos	American Crow	G5	S5B	---	---	S
Carduelis tristis	American Goldfinch	G5	S5B	---	---	F/O
Tachycineta bicolour	Tree Swallow	G5	S4B	---	---	H
Contopus virens	Eastern Wood-peewee	G5	S4B	---	SC	S
Sturnus vulgaris	European Starling	G5	SNA	---	---	FY, S, CF
Hirundo rustica	Barn Swallow	G5	S4B	---	THR	F/O
Zenaida macroura	Mourning Dove	G5	S5	---	---	S
Seiurus aurocapilla	Ovenbird	G5	S4B	---	---	S
Setophaga ruticilla	American Redstart	G5	S5B	---	---	S
Setophaga magnolia	Magnolia Warbler	G5	S5B	---	---	H

[10] Glabl conservation status is an indicator of commonness across the species entire rang
[11] S-Rank is an indicator of commonness in the Province of Ontario. A scale between 1 and 5, with 5 being very common and 1 being the least common
[12] Federal Species at Risk Act (SARA)
[13] Provincial Endangered Species Act (ESA)
[14] Breeding Bird Codes from Breeding Bird Atlas of Ontario (Cadman *et al.* 2007)

Scientific Name	Common Name	GRank[10]	SRank[11]	SARA[12]	ESA[13]	Breeding Evidence[14]
Cardinalis cardinalis	Northern Cardinal	G5	S5	---	---	S
Dumetella carolinensis	Gray Catbird	G5	S4B	---	---	S, A
Pipilo erythrophthalmus	Eastern Towhee	G5	S4B	---	---	S
Quiscalus quiscula	Common Grackle	G5	S5B	---	---	H
Picoides villosus	Hairy Woodpecker	G5	S5	---	---	S
Picoides pubescens	Downy Woodpecker	G5	S5	---	---	S
Passer domesticus	House Sparrow	G5	SNA	---	---	S
Stelgidopteryx serripennis	Northern Rough-winged Swallow	G5	S4B	---	---	H
Charadrius vociferus	Killdeer	G5	S5B,S5N	---	---	S
Agelaius phoeniceus	Red-winged Blackbird	G5	S4	---	---	S, NB
Melospiza melodia	Song Sparrow	G5	S5B	---	---	S
Cardellina pusilla	Wilson's Warbler	G5	S4B	---	---	H
Mniotilta varia	Black-and-white Warbler	G5	S5B	---	---	S
Poecile atricapillus	Black-capped Chickadee	G5	S5	---	---	S
Anas platyrhynchos	Mallard	G5	S5	---	---	H
Petrochelidon pyrrhonota	Cliff Swallow	G5	S4B	---	---	F/O
Setophaga petechia	Yellow Warbler	G5	S5B	---	---	S, A
Vireo gilvus	Warbling Vireo	G5	S5B	---	---	S
Molothrus ater	Brown-headed Cowbird	G5	S4B	---	---	A
Larus delawarensis	Ring-billed Gull	G5	S5B,S4N	---	---	F/O

Observed

X Species observed in its breeding season (no breeding evidence)

Possible

H Species observed in its breeding season in suitable nesting habitat

S Singing male(s) present, or breeding calls heard, in suitable nesting habitat in breeding season

Probable

P Pair observed in suitable nesting habitat in nesting season

T Permanent territory presumed through registration of territorial song, or the occurrence of an adult bird, at the same place, in breeding habitat, on at least two days a week or more apart, during its breeding season.

D Courtship or display, including interaction between a male and a female or two males, including courtship feeding or copulation

V Visiting probable nest site

A Agitated behaviour or anxiety calls of an adult

B Brood Patch on adult female or cloacal protuberance on adult male

N Nest-building or excavation of nest hole, except by a wren or a woodpecker

Confirmed

NB Nest-building or excavation of nest hole by a species other than a wren or a woodpecker

DD Distraction display or injury feigning

NU Used nest or egg shells found (occupied or laid within the period of the survey)

FY Recently fledged young (nidicolous species) or downy young (nidifugous species), including incapable of sustained flight

AE Adult leaving or entering nest sites in circumstances indicating occupied nest

FS Adult carrying fecal sac

CF Adult carrying food for young

NE Nest containing eggs

NY Nest with young seen or heard

Woodlands within the Appleby Study Area are greater than 2 km of Lake Ontario and do not meet the minimum criteria of ≥5.0 ha; therefore, woodlands within the Study Area are not considered candidate Landbird Migratory Stopover Area SWH.

5.5 Species at Risk

As indicated in **Section 5.4.3.1**, a Barn Swallow was observed during breeding bird surveys. The observation was made associated with Appleby Creek north of the railway and south of Woodland D (**Figure 5**). Although Barn Swallow nests were not observed during the 2017 field investigations, suitable habitat for this species exists within the Study Area.

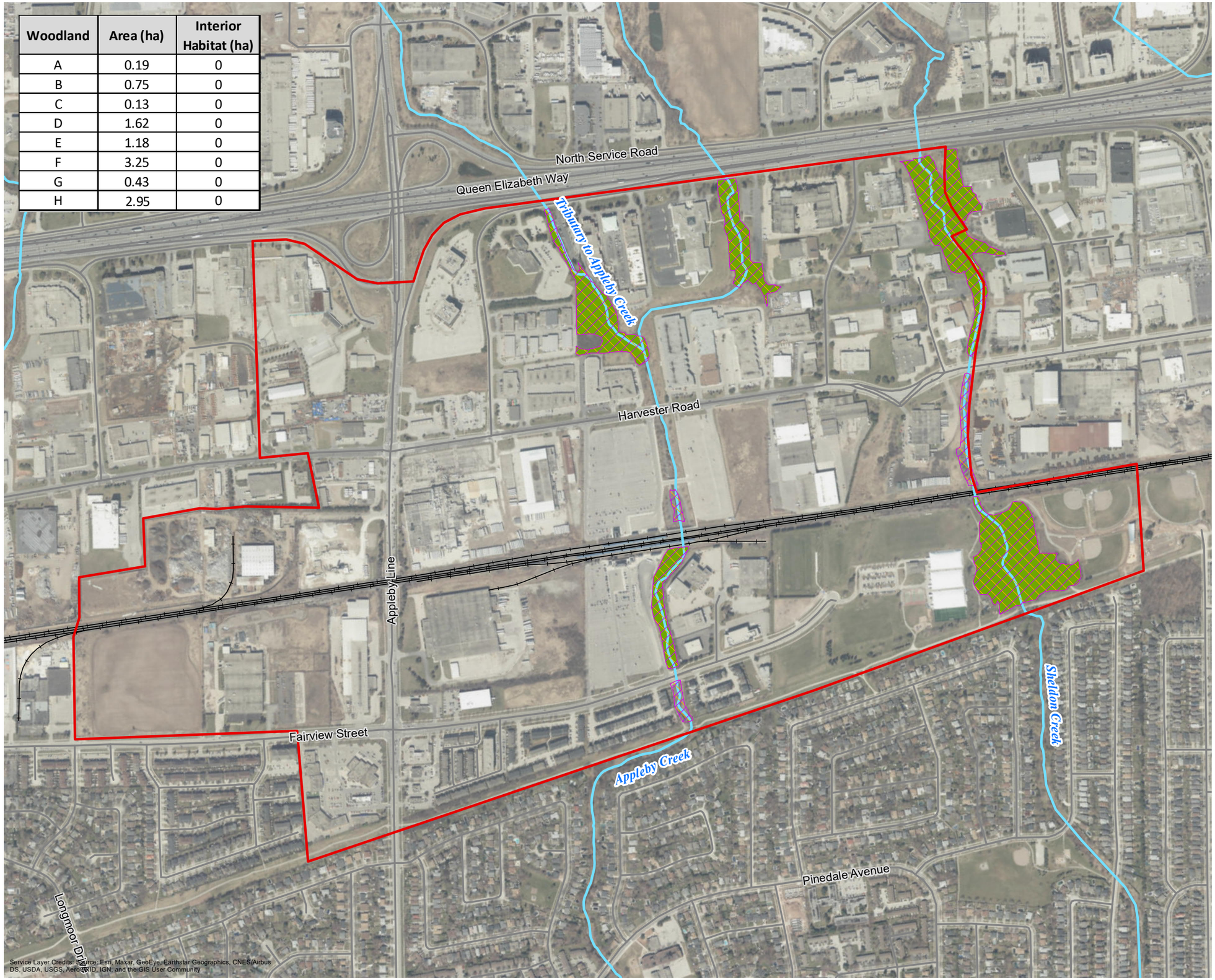
Although Chimney Swift individuals were not observed during the 2017 field investigations, there is potential for chimneys and/or stacks associated with buildings located with the Study Area to provide habitat for Chimney Swift. It is recommended that potential Chimney Swift habitat be evaluated during the development application stage.

With respect to SAR bats, the candidate SWH for Bat Maternity Colonies identified in **Figure 6** also has the potential to serve as habitat for SAR bats. The natural features associated with the candidate SWH will be protected as part of the future developments and are further discussed in **Section 9.1**.

5.6 Incidental Wildlife

During field investigations, no incidental wildlife species were observed within the Study Area.

Woodland	Area (ha)	Interior Habitat (ha)
A	0.19	0
B	0.75	0
C	0.13	0
D	1.62	0
E	1.18	0
F	3.25	0
G	0.43	0
H	2.95	0



CITY OF Burlington

APPLEBY
BURLINGTON HUB MOBILITY STUDY

SIGNIFICANT NATURAL FEATURES
FIGURE 6

- Study Area
- Road
- Railway
- Watercourse

Significant Natural Feature

- Woodland

Significant Wildlife Habitat

- Special Concern and Rare Wildlife Species (Eastern Wood Pewee)

Candidate Significant Wildlife Habitat

- Bat Maternity Colony

0 50 100 200 Metres

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

DILLON CONSULTING

PROJECT: 17-5015
STATUS: DRAFT
DATE: 2018-08-20

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig6_SignificantNaturalFeatures.mxd

6.0 Ecological Function

Natural features within and adjacent to the Study Area were analyzed to determine their ecological function. As the majority of the Study Area is comprised of urban, recreational, industrial and educational land uses, the potential ecological functions within the Study Area are minimal.

Woodlands B, D, E, F & H met the significance requirements outlined in ROPA 38. The aforementioned woodlands along with Appleby and Sheldon Creek represent the few natural areas within the highly urbanized Burlington City with a high percentage of tree cover. Appleby Creek, Tributary to Appleby Creek and Sheldon Creek were each documented as having the potential to provide permanent, direct fish habitat. Although dense riparian cover is provided by mixed deciduous trees and shrubs throughout significant portions of the watercourses, no instream aquatic vegetation was observed. Barriers to fish migration were observed along Appleby Creek and Sheldon Creek in the form of gabion baskets and concrete footing. General ecological functions associated with significant woodlands include prevention of erosion and runoff, facilitating hydrological and nutrient cycling, and improving localized soil, water and air quality.

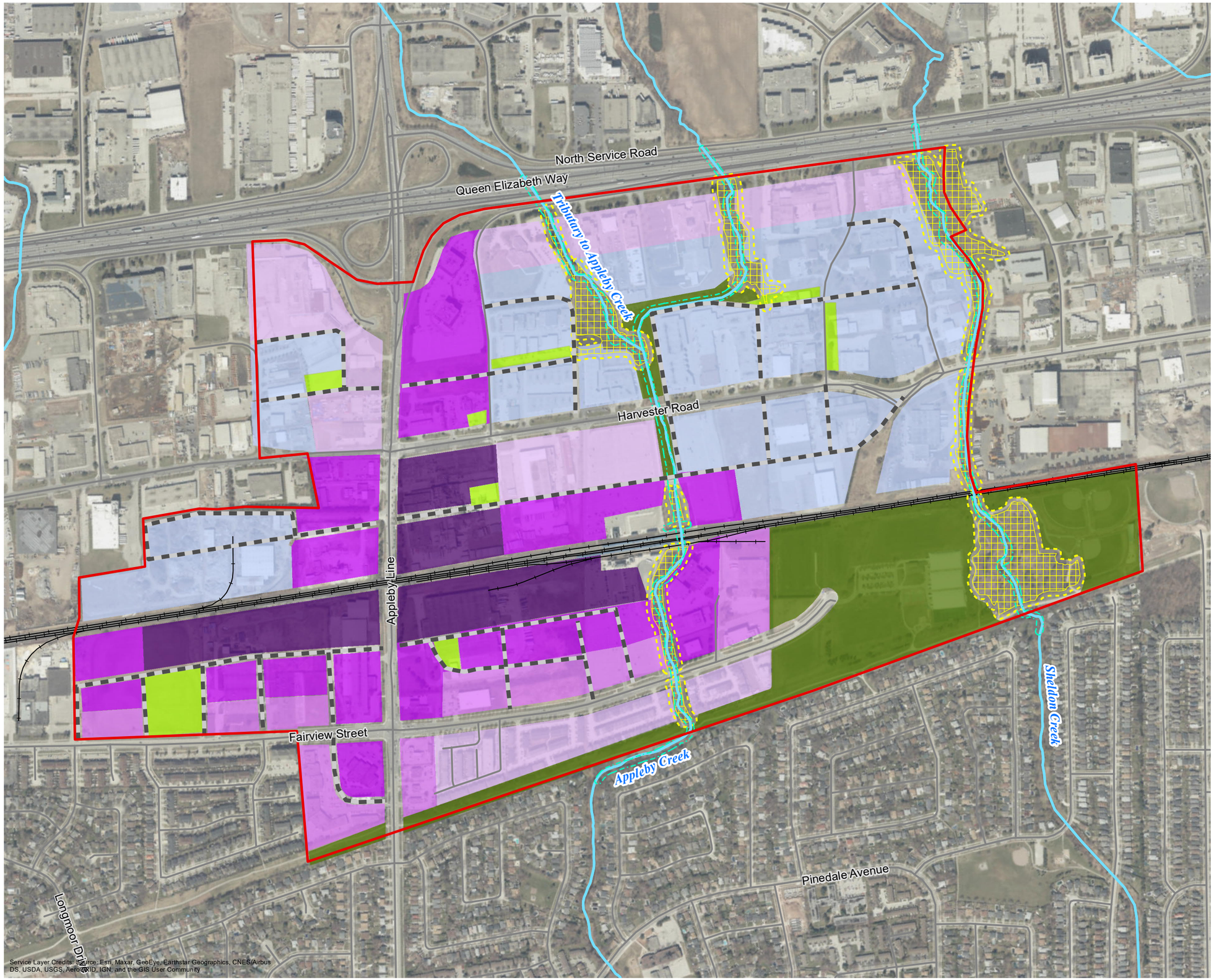
From a terrestrial perspective, the significant and non-significant woodland features provide cover, foraging, refuge and nesting habitat for terrestrial wildlife (though limited). In addition, the woodlands have also been designated as SWH for Special Concern and Rare Wildlife Species (i.e. Eastern Wood-peewee) and candidate SWH for Bat Maternity Colonies, of which each of the woodlands has the potential to support SAR bats. However, due to the surrounding urbanized area and the disturbed nature of the Study Area, the creek corridors (including the woodlands) provide limited habitat function for urban tolerant flora and fauna.

7.0 Description of Proposed Development

The City is embarking on an ambitious program to complete a comprehensive intensification planning framework. Conceptualizing Area Specific Plans for the Appleby Mobility Hub is an important step to ensure the City continues to 'Grow Bold' in the face of increasing development pressures. The goal is to promote intensification in a number of strategic locations, providing opportunities for mixed-use redevelopment, employment growth, reinvigorating community infrastructure and improved transportation networks to support growth. The near built-out status of the City's urban area was a central factor for the Conceptualized Area Specific Plans and was required in order to manage future growth within strategic existing urban areas through infill and intensification. The City's Appleby Mobility Hub will act as the eastern gateway to the City and an important industrial and employment destination.

The Conceptualized Plan for the Appleby Mobility Hub is illustrated in **Figure 7** along with the assessed natural heritage features with their associated recommended buffers. Changes to the concept plan and potential densities are not expected to have a significant impact on the natural environment, so long as the recommended setbacks are respected. The Appleby Burlington Mobility Hub streetscapes will continue to foster new prestige employment uses. At strategic locations, privately-owned public spaces will provide further opportunities to enhance pedestrian experiences while providing a direct connection to the Appleby GO Station and nearby Sherwood Forest Park. Key considerations implemented in the Downtown Hub Conceptualized Plan are:

- Protect and enhance existing and stable employment uses;
- Locate new prestige office uses along Fairview Street and Harvester Road, and light industrial uses along internal streets near the rail corridor;
- Redevelop underutilized and vacant sites to create a continuous and high-quality streetscape;
- Enhance pedestrian and vehicle connections to downtown along New Street, and via the Centennial Trail;
- Locate mid-rise buildings near the Appleby GO Station and the highest density along the rail corridor and the area at Appleby Line and Fairview Road;
- Enhance access and views to Sherwood Forest Park; and
- Extend existing connections and create new ones within the mobility hub area to maximize permeability of large blocks.



CITY OF Burlington

APPLEBY
BURLINGTON HUB MOBILITY STUDY

CONCEPTUALIZED PLAN
FIGURE 7

- Study Area
- Road
- Railway

Assessed Natural Heritage Features

- Watercourse
- 7.5 m Setback from CH Watercourse
- Natural Heritage System
- 10 m Setback from Natural Heritage System

Concept Plan Features

- Low Rise (1-3 Stories)
- Mid Rise (4-6 Stories)
- Mid Rise (7-11 Stories)
- Tall (12-19 Stories)
- Tallest (20+ Stories)
- Proposed Parks / Open Space
- Existing Parks / Open Space
- Proposed Street

0 50 100 200 Metres

N W E S

MAP DRAWING INFORMATION:
DATA PROVIDED BY MNRF

MAP CREATED BY: LK
MAP CHECKED BY: DL
MAP PROJECTION: NAD 1983 UTM Zone 17N

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PROJECT: 17-5015
STATUS: DRAFT
DATE: 2021-11-16

FILE LOCATION: G:\cad\GIS\175015\Mapping\EIS_Appleby\Appleby_Fig7_ConceptPlan.mxd

8.0 Impact Assessment

8.1 Direct Impacts

Direct impacts are those that are immediately evident as a result of development. Typically, the adverse effects of direct impacts are most evident during the site preparation and construction phase of a development. Potential direct impacts of the proposed intensification of redevelopment within the Appleby Mobility Hub may include the following:

- Tree and vegetation removal;
- Diversion of surface water flows;
- Erosion and sedimentation into natural features (woodlands, Sheldon Creek, and Appleby Creek); and
- Loss of/ disturbance to wildlife and general wildlife habitat.

The majority of intensification of redevelopment activities are proposed outside of the recommended 10 m woodland buffer. Potential direct impacts would generally be limited to pre-existing disturbed areas which currently consist of residential, business and asphalt parking lots (**Figure 7**).

8.1.1 Tree and Vegetation Removal

Potential tree and ground vegetation removal would be limited to the intensification and redevelopment area as shown on the Conceptualized Plan in **Figure 7** to facilitate grading and construction of the infrastructure.

Potential tree removal may result in a reduction in tree cover, marginal wildlife habitat loss, and alteration of soil conditions. On a site level, the impacts of tree and vegetation removal may include:

- Direct loss of trees;
- Decreased floral species richness and abundance;
- Negative edge effects, including altered soil conditions and water availability;
- Alteration of microclimate;
- Loss of native seed banks; and
- Physical injury, root damage, and compaction of trees not intended for removal that may result from construction operations.

As previously stated in this report, the proposed intensification of redevelopment area provides minimal ecological function and thus, the potential removal of select isolated trees and other vegetation (with exception to the woodlands) may result in minimal habitat loss, minimal reduction of natural cover in the area, and minimal reduction in ecological function. We do propose through the Landscape and Planting Plan discussed further in Section 9.2 below, that the re-planting following the re-intensification

will the off-set proposed tree and vegetation removal as well as provide enhancements and/or restoration function to natural areas and their associated setbacks/buffers, where possible.

Refer to **Section 9.0** for mitigation and enhancement opportunities.

8.1.2 Diversion of Surface Water Flows

The Appleby and Sheldon Creek corridors within the Study Area contribute as "natural" conveyance infrastructure (i.e. drainage system), riparian habitat (though limited), and socially by preserving and enhancing open space. In order to preserve these functions for the long term, the current ecological function has been determined, and mitigation and enhancement in the context of future intensification of redevelopment have been proposed (**Section 9.0**).

8.1.2.1 Riverine Flooding Hazard

The Appleby Mobility Hub includes portions of three watersheds; Shoreacres Creek, Appleby Creek and Sheldon Creek. Of these, two contain sections of open channel, with an associated potential riverine flood hazard.

Approximately seven parcels of land have been identified within the Study Area as being within the limits of the Appleby Creek floodplain, to varying degrees. Generally, only a portion of these parcels are affected by the floodplain. The most vulnerable area to riverine flooding was noted to be the Appleby Go station north parking lots, north of the CNR tracks. Under the Regional Storm Event, spill is simulated in both directions (east and west) which could potentially impact a greater number of properties than the seven parcels noted previously.

For Sheldon Creek, the Harvester Road crossing has the potential to be overtopped during the Regional Storm Event. Only one parcel of land in this area has been noted to be affected by the Regional Floodplain extents.

8.1.2.2 Urban Flooding Hazard

No detailed modeling has been prepared as the current hydrologic/hydraulic modelling focused on the riverine systems only. As such, the hazard from these features is currently unknown.

Refer to **Section 9.3**and **Section 9.6** for mitigation measures related to surface flows. For detailed results as they relate to diversion of surface water flows, refer to the Flood Hazard and Scoped Stormwater Management Assessment Report prepared by Wood Environmental & Infrastructure Solutions (Wood) in **Appendix F**.

8.1.2.3 Potential Development Impacts

Changes in land cover associated with development (increased imperviousness) has the potential to generate impacts to downstream receivers, both with respect to water quantity (increased peak flows and erosion potential) and water quality (increased contaminants due to paved surfaces in particular). As noted in the Flood Hazard and Scoped Stormwater Management Assessment Report, the City of Burlington's current Stormwater Management Design Guidelines would be applied for any new development. This would require post to pre-peak flow control at a minimum (2 through 100-year storm events) and over-control (100-year post to 5-year pre) for more constrained areas. Erosion control measures (extended detention storage) would also be required, potentially in combination with LID BMPs (City now recommends the retention and on-site infiltration of the first 5 mm of rainfall). Enhanced water quality controls (80% average annual TSS removal) would also be required.

With respect to hydraulic impacts, no development would be permitted within the Regulatory Floodplain (or within the associated additional buffer width), thus no off-site impacts would be expected. Development within spill areas could potentially be considered, however such areas are now regulated by Conservation Halton. As noted within the Flood Hazard and Scoped SWM Assessment Reporting, further study in such areas would need to be completed to confirm no off-site impacts and safe conveyance of flood flows (including a cut/fill balance and additional overland hydraulic modelling). Additional floodproofing measures would also be required for the development site itself.

8.1.3 Erosion and Sedimentation of Natural Features

Due to the anticipated reduction in infiltration rates post intensification of redevelopment, there is the potential for the woodlands and watercourses to be impacted as a result of the redevelopment if construction best management practices are not implemented. Potential impacts to the aforementioned features may include, but are not limited to:

- Reduced water quality and degradation of downstream aquatic habitat (e.g. surface water flow into Lake Ontario); and
- Disturbance to or loss of, additional vegetation due to the deposition of dust and/or overland mobilization of soil.

Refer to **Section 9.0** for mitigation measures related to erosion and sedimentation within the Study Area.

8.1.4 Loss of and/or Disturbance to Significant Wildlife Habitat

Marginal habitat for flora and fauna may be impacted due to potential vegetation clearing within the proposed intensification of the redevelopment area. Habitat for flora and fauna may be impacted by construction in the following ways:

- Displacement, injury, or death resulting from contact with heavy equipment during clearing and grading activities;

- Disturbance to wildlife as a result of noise associated with construction activities, particularly during breeding periods; and
- Loss of general wildlife habitat.

Significant wildlife habitat for Eastern Wood-pewee was identified within forested communities as a result of species observations made during breeding bird surveys. In addition, there is potential for SWH Bat Maternity Colonies to be present within the woodlands. Since development activities are proposed wholly outside of the woodlands, and its associated 10 m buffer, the potential for impacts to bats or Species of Conservation Concern utilizing the woodland is limited. As previously mentioned, vegetation communities within the Study Area were found to have species composition indicating an altered landscape, with existing disturbances and adjacent development activities and recreational uses. Therefore, impacts to SWH and general wildlife within adjacent natural features are not anticipated.

Although habitat for Barn Swallow is not limited within the Study Area and individuals were observed foraging along Appleby Creek, the potential for impacts to Barn Swallow foraging habitat within the Study Area is limited. However, since there is potential for Barn Swallow to be nesting within structures, it is recommended that structures proposed for removal with vertical facings are assessed for the presence of Barn Swallow nests prior to removal. In the event Barn Swallow nest(s) are observed and their removal is required in support of the development, the removal of the next can be registered through the MNRF registry process. Timing windows do, however, apply with respect to when a Barn Swallow nest can be removed and, subsequently when compensation habitat is required to be in place.

In addition to the aforementioned, the development of buildings upwards and outwards in close proximity to Lake Ontario increases the number of hazards found in cities and may result in bird strikes day or night due to the confusing effects of glass and light pollution. This is particularly harmful to nocturnal and migratory animals in flight. Avian building strikes are the results of confusing optical illusions for birds. Light inevitably attracts avian species to urban environments where they subsequently get trapped, which is commonly known as “fatal light attraction”. Glass poses a danger as birds cannot perceive glass as a solid object and will strike clear glass while attempting to reach the reflected habitat and sky.

Accordingly, wildlife impact mitigation measures have been recommended for the development area and are included in **Section 9.4**.

8.2 Indirect Impacts

Indirect impacts are those that do not always manifest in the core development area but in the lands adjacent to the development. Indirect impacts can begin in the construction phase; however, they can continue post-construction. Potential indirect impacts of the proposed intensification of redevelopment include anthropogenic disturbance and colonization of non-native and/or invasive species.

8.2.1 Anthropogenic disturbance

Disturbance to local wildlife communities due to potential indirect impacts on the lands adjacent to the proposed intensification of redevelopment could result if left unmitigated. Noise, light, vibration and human presence are indirect impacts that can adversely influence the population size and breeding success of local wildlife. These effects are more pronounced when new development is introduced in non-urban areas. Lands within the development area are already disturbed by adjacent recreational areas. Therefore, the proposed intensification of redevelopment is not anticipated to cause a negative impact on surround natural areas.

8.2.2 Colonization of Non-native and/or Invasive Species

Physical site disturbance may increase the likelihood that non-native and/or invasive flora species will be introduced to the surrounding vegetation communities. Invasive flora can establish in disturbed sites more efficiently than native flora. This type of colonization is currently occurring within the woodland and creek corridors as shown in **Figure 4**. The field investigation results determined that the woodlands within the study area contained presence of invasive species such as Bittersweet Nightshade (*Circaea Canadensis)*, Black Locust (*Robinia pseudoacacia*), Garlic Mustard (*Alliaria petiolate)* and Common Buckthorn (*Rhamnus cathartica*). In order to maximize ecological function within the Study Area, removal of invasive species paired with the planting of native tree and shrub species is recommended.

Mitigation measures related to control of invasive species are addressed in **Section 9.2**.

9.0 Mitigation and Opportunities for Enhancement

Mitigation involves the avoidance or minimization of developmental impacts through good design, construction practices and/or restoration and enhancement activities. The feasibility of mitigation options has been evaluated based on the natural features within and adjacent to the Study Area. The impact assessment highlighted four potential direct impacts, which include potential tree and vegetation removal, diversion of surface water flows, potential loss of wildlife and wildlife habitat, and erosion and sedimentation of natural features.

A variety of mitigation techniques can be used to minimize or eliminate the above-mentioned impacts. These measures include enhancement of the buffer area through a Landscaping and Planting Plan, a Stormwater Management Plan, Wildlife Impact Mitigation Plan, Erosion and Sediment Control Plan and an Environmental Monitoring Plan; each of which is introduced below. Detailed mitigation measures will be finalized in consultation with the City, CH and Halton Region as part of the preliminary and site-specific development applications.

9.1 Natural Heritage Feature Buffers

Recommended buffers are illustrated in the Conceptualized Plan for the Appleby Mobility Hub (**Figure 7**). As discussed in **Section 5.4.2**, Woodlands B, D, E, F & H met the criteria to be considered significant under Section 277 of the ROPA 38. As a result, and in consideration of the existing development adjacent to the woodlands and tributaries within the Study Area, we have applied a recommended 10 m buffer to each of the woodlands within the Study Area. As illustrated in **Figure 7,** there are pre-existing disturbances such as residential housing, parking lots and buildings within the recommended buffer. As such, the buffers apply to areas without pre-existing disturbance in order to prevent potential adverse effects to habitat and ecological function (though limited) that the woodlands and creek corridors provide in the urban setting.

Appleby Creek, the Tributary to Appleby Creek and Sheldon Creek are each subject to CH regulation. New development adjacent to watercourses will be subject to a setback from the stable top of bank, the flooding hazard and/or meaderbelt allowance (whichever is greater) that are associated with the watercourses. A 7.5 m buffer (as per CH policy) from the watercourses is required from future development (**Figure 7**). It is recommended that the stable top of bank, flooding hazard and/or meaderbelt allowance be confirmed with the City and CH at the site specific development application stage. For the current delineation of flooding hazards, refer to the Flood Hazard and Scoped Stormwater Management Assessment prepared by Wood in **Appendix F**.

Similar to the woodlands, the 7.5 m minimum recommended buffer applies to areas without pre-existing disturbances or restoration and enhancements areas identified during the site specific development stage in order to prevent potential adverse effects to habitat and ecological function (though limited). It should be noted that the buffer recommendations will be further assessed at the site specific development application stage.

In its current state, the buffer areas consist of low-quality habitat and contain invasive species as a result of pre-existing disturbances within the Study Area. Enhancement activities within the buffer areas will generally have the effect of increasing the amount of available habitat and overall wildlife corridor. In addition, this naturalized, vegetated buffer will provide protection to adjacent natural features through filtration of overland flows for each of the watercourses, and protection from edge effects to the woodlands. As the proposed buffer enhancements will not only increase the overall quality of available habitat within the buffer areas, but also the quality and protection of both aquatic and terrestrial habitat within the adjacent natural features, the intensification of redevelopment limit as shown, with minimal encroachment into the buffer areas should not result in negative impacts to the adjacent natural features.

Buffer enhancement plantings are to be detailed in the preliminary Landscaping and Planting Plan, described below.

To improve the aquatic function of the watercourses within the Study Area, the following enhancements with associated ecological benefit should be considered during the site-specific development application stage:

- Native Riparian Plants
    - Improves corridor function and linkage between existing areas of natural cover;
    - Improves natural cover for wildlife and plant movement and dispersal;
    - Contribution of recourses to stream biota (i.e. nutrients and shade);
    - Moderation of water temperatures and flow;
    - Sediment load buffering;
    - Bank stabilizations; and
    - Removal of invasive species.
- Implement habitat structures such as basking logs, brush piles, raptor poles etc.:
    - Promotes wildlife diversity by implementing several habitat elements; and,
    - Maximizes potential for wildlife passage, forage, residency, hibernation, and breeding habitat.

Furthermore, buffer recommendation should be further assessed at the detailed design stage to ensure their extent (width) is sufficient and that they can perform their intended function in light of the likely negative impacts resulting from adjacent development or site alteration (before, during and after construction) add to determine other mitigation measures as needed (i.e. enhancement plantings in the buffer, permanent fencing, sediment and erosion control measures).

9.2 Landscaping and Planting Plan

The proposed intensification of redevelopment plan may require the potential removal of select trees, shrubs, wildflowers and wild grasses and are limited to the Conceptualized Plan illustrated in **Figure 7.**

As a result, a Landscaping and Planting Plan is required to off-set proposed vegetation removal and propose enhancements to natural areas where possible. Compensation plantings of trees are generally based on the number of removals required to facilitate construction of the development. The exact number of compensation plantings and locations is generally determined at the site-specific development applications. It was identified by the City that, given the densities and urban nature of the development on many sites, it may be difficult to achieve compensation plantings on site for many developments. The Landscaping and Planting Plans should include, but is not limited to:

- Identifying strategic areas on publicly owned lands and recommended approaches to improving overall tree canopy in urban areas;
- A mix of native deciduous and coniferous trees and shrubs throughout the development and buffer area;
- Sodding within the residential portions of the development; and
- A native seed mix recommended by suppliers for enhancement within the buffer area and/or publicly owned lands.

The following monitoring and maintenance measures may also be recommended for both the buffer and enhancement areas:

- Removal of invasive trees and shrubs (i.e. Bittersweet Nightshade, Black Locust, Garlic Mustard and Common Buckthorn), where applicable.
- Watering and weeding of newly planted areas as required for proper establishment of plantings.
- Replacement of dead material from previous year's planting.

Conservation Halton's Landscaping and Tree Preservation Plan Guidelines (2010) is recommended to be consulted for further information and direction at the detail design stage.

9.3 Integrated Stormwater Management Plan and Low Impact Design

Effective stormwater management (SWM) measures are required for all Environmental Impact Studies within the City. For detailed results as they relate to the Integrated Stormwater Management Plan and Low Impact Design (LID), refer to the Flood Hazard and Scoped Stormwater Management Assessment prepared by Wood in **Appendix F**. A summary of the aforementioned as it relates to the Integrated Stormwater Management Plan and LID is provided below.

Riverine flood management strategies are expected to be minimal. CH would be expected to restrict or prevent development within floodplain areas of both Appleby Creek (including its tributary) and Sheldon Creek.

Urban flooding hazards (overland flow and storm sewer surcharging) are currently unknown for the Appleby Mobility Hub, given that the existing modeling tools applied for the current study do not include these features. Notwithstanding, storm sewer capacity and potential surcharging would need to be considered in the design of basement foundation drainage systems.

Consistent with the approach employed for each of the four Mobility Hubs, it is expected that each development requiring an increase in impervious coverage would incorporate on site quantity controls to observe that there is no increase in peak flows to downstream receivers. Opportunities for shared communal quantity control features would need to be reviewed in conjunction with proposed area plans.

The currently proposed land use plan for the Appleby Go Mobility Hub indicates the use of "Green Streets" for area roadways. Green Streets provide the opportunity to incorporate LID Best Management Practices (BMPs) as part of the overall streetscaping design, including surface features (bioswales and bioretention areas, soil retention cells/tree planters) and sub-surface features (exfiltration pipes and storage chambers). These measures would benefit both water quality, quantity, and water budget, infiltration and erosion.

The following recommendations for SWM quality and quantity control to be considered during the site-specific development application stage are:

- Post to pre-peak flow control (2-year through 100-year) for areas discharging directly to creek systems;
- Over-control (100-year post to 5-year pre) of peak flows for areas connecting to storm sewers or where major system is constrained, additional over control may be warranted where a known capacity constraint exists in the trunk storm sewer system;
- Consider erosion control measures where feasible, potentially in combination with LID BMPs for the overall SWM strategy;
- Enhanced (80% average) annual TSS for all impervious areas; and,
- Review opportunities for synergies with other studies and road reconstruction projects in particular ("Green Streets").

It is also recognized that the City is currently in the process of reviewing and update Stormwater Management Design Policies and Guidelines. As a result, additional stormwater management requirements, particularly with respect to climate change, erosion control, and water balance/infiltration should be considered for future developments.

9.4 Wildlife Impact Mitigation Plan

Strategies to mitigate impacts to general wildlife prior to and during construction are proposed. These may include (but are not limited to):

- Clearing trees and vegetation outside the breeding bird season (April 1 to August 31). Should any clearing be required during the breeding bird season, nest searches conducted by a qualified person should be completed 48 hours prior to clearing activities. If nests are found, work within 10 m of the nest should cease until the nest has fledged. If no nests are present, clearing may occur. This is in accordance with the federal *Migratory Birds Convention Act*;
- Schedule vegetation clearing and grading activities to avoid disturbance to breeding amphibians and other sensitive wildlife species where possible;
- Where possible, maximize the distance of construction equipment used from the woodland edge to avoid disturbing wildlife;
- Limit the use of lighting where possible. Avoid light effects entering the woodland (eliminate light trespass) where possible;
- Installation of wildlife exclusion fencing and escape routes, which direct wildlife away from the construction area and to more suitable habitat (e.g. Appleby and Sheldon Creek corridors);
- Visual monitoring for wildlife species and avoidance where encountered if possible;
- If necessary, have a qualified biologist monitor construction in the areas of potential wildlife habitat. If wildlife is found within the construction area they will be relocated to an area outside of the development into an area of appropriate habitat, as necessary;
- Construction crews working on site should be educated on local wildlife and take appropriate measures for avoiding wildlife; and
- Should an animal be injured or found injured during construction they should be transported to an appropriate wildlife rehabilitation centre.

Following the construction of buildings, mitigation measures that can be incorporated into the design of a proposed building in an attempt to reduce potential bird strikes have been identified in the City of Toronto's Bird-friendly Development Guidelines. Examples of such measures recommended for incorporation into the design of the proposed building to make glass more visible to avian wildlife include:

- Applying films or decals on glass;
- Installing internal screens in windows;
- Voiding the use of internal lights when commercial operations are not active;
- Directing external lights downwards and turning them off when not in use (except for security and safety purposes); and
- Using motion sensors on the safety and security lighting.

While collisions cannot be avoided entirely, it is not anticipated that bird strikes will significantly impact bird populations in the area. Through the implementation of measures such as those listed above, the potential for bird strikes can be reduced through building design and operational control measures. The City is currently developing Bird Friendly Guidelines to require that buildings are designed to incorporate bird friendly design options versus this being a post construction requirement. In keeping with the MNRF EcoRegion Criteria Schedule 7E, the City's guidelines will also require buildings within

five (5) kilometres (km) of the Lake Ontario Shoreline to implement bird friendly designs in order to protect migratory birds (MNRF 2015).

Some of the many enhancements options to bird habitat to be considered during the site-specific development application stage are:

- Providing Species at Risk habitat to support life processes (e.g. nest boxes, perches, etc.); or,
- Provide an Organic Growers Supply (OGS) approved seed mix for pollinators to enhance and support life processes which, in turn, will serve as a mechanism to create habitat for other taxon (i.e. Odonata).

Enhancements should be designed and discussed in consultation with the City during the site-specific development application stage.

9.5 Erosion and Sediment Control Plan

Construction activity, especially operations involving the handling of earthen material, dramatically increases the availability of sediment for erosion and transport by surface drainage. In order to mitigate the adverse environmental impacts caused by the release of sediment-laden runoff into receiving watercourses, measures for erosion and sediment control are required for construction sites. This is an extremely important component of land development that plays a large role in the protection of watercourses and aquatic habitat.

Control measures that are appropriate for the erosion potential of the site should be selected. These control measures should also be implemented and modified on a staged basis to reflect the site activities. Furthermore, their effectiveness decreases with sediment loading and therefore, inspection and maintenance are recommended.
In addition, an Erosion and Sediment Control Plan should be developed as part of the site specific development applications for the proposed redevelopments. The plan may include, but is not limited, installation of geotextile silt fences, rock check dams, ditch checks, mud mats, temporary sediment ponds, designated topsoil stockpile areas, and cut-off swales and ditches to divert surface flows to the appropriate sediment control area; with provisions for re-vegetating the area as soon as construction is completed. More specifically, the plan may include the following measures:

- Standard duty silt fencing (OPSD 219.110) and/or other equivalent erosion and sediment controls should be installed around the perimeter of the work area to clearly demarcate the development area and prevent erosion and sedimentation into adjacent habitats. Erosion and sediment control measures should be monitored regularly to observe they are functioning properly and if issues are identified they should be dealt with promptly;
- Stockpiling of excavated material should not occur outside the delineated work area. If stockpiling is to occur outside of this area, silt fencing should be used to contain spoil piles to prevent

sedimentation into adjacent areas. Further, stockpiling of excavated materials will not occur within 30 m of watercourses; and
- A spill response plan should be developed and implemented as required.

As discussed previously in **Section 8.1**, the proposed development may result in diversion of surface water flows as well as increased erosion and sedimentation into regulated watercourses, potentially affecting water quality. Changes in land cover associated with development has the potential to generate impacts to watercourse, both with respect to water quantity (increased peak flows and erosion potential) and water quality (increased contaminants due to paved surfaces in particular). The following mitigation measures are recommended to help mitigate negative impacts post-development:

- Implementation of Low Impact Development Best Management Practices (LID BMPs) for roadway reconstructions
- Vegetation planting of watercourse banks with native riparian species
- Surface features such as bio swales and bio retention areas, soil retention cells, tree planters
- Sub surface features such as exfiltration pipes and storage chambers
- End of pipe (EOP) measures (i.e. plunge pools, velocity reducers)

Implementation of these measures would benefit both water quantity, quality and water budget, infiltration, and erosion. Additional, site specific in-stream mitigation measures include the following:

- Vegetated buttresses and riffle-pool morphology bed features
- Naturalized erosion protection such as armour stone or boulder steps
- Cobble bed and bank material for erosion protection.
- Floodplain benches can be added to reconnect the frequent flow regime to the floodplain

As discussed previously in **Section 5.3.2** site specific stream rehabilitation opportunities and mitigation measures for Appleby Creek have been evaluated by GeoProcess and are provided under separate cover in **Appendix G**.

9.6 Environmental Monitoring Plan

The Environmental Monitoring Plan (EMP) should be carried out through the duration of construction activities on-site to observe that the erosion and sediment control measures operate effectively and to monitor the potential impact, if any, upon the natural environment. The duration of construction is defined as the period of time from the beginning of earthworks until the site is stabilized. Site stabilization is defined as the point in time when the roads have been paved, buildings have been built, lawns have been sodded and restoration plantings have been completed.

The EMP should consist of monitoring the erosion and sediment measures and the restoration/compensation plantings. Erosion and sediment control measures should be regularly monitored and may require periodic cleaning (e.g. removal of accumulated silt), maintenance and/or re-construction. Inspections of the erosion and sediment controls on the construction site should be

undertaken by a certified sediment and erosion control monitor. If control measures are damaged and/or not functioning as originally intended they should be repaired and/or replaced promptly. Site inspection staff and construction managers should refer to the Erosion and Sediment Control Inspection Guide (2008) prepared by the Greater Golden Horseshoe Area Conservation Authorities. This guide provides information related to the inspection reporting, problem response and proper installation techniques. The EMP should be implemented during active construction periods in the development area with the following frequency:

- On a bi-weekly basis; and/or
- After every 10 mm or greater rainfall event.
- Monitoring will begin once each SWM facility has been substantially completed and will continue until 80% of the facility's contributing catchment is built out. If possible, staff gauges will be installed in each SWM facility during construction to support ESC inspections

Restoration planting and protected vegetation areas will require periodic monitoring to observe that they are not impacted by adjacent development. Should impacts be observed, necessary steps should be taken to observe that the impacted vegetation is either restored or replaced. Monitoring of vegetation will take place every other year (i.e. years 2, 4, 6, 8, and 10) for a minimum of 10 years or 80% build-out (whichever comes sooner) subject to the results of the Adaptive Management Plan.

Vegetation communities should be monitored for vegetation compositions and spatial boundaries. This monitoring data will be useful in detecting changes resulting from natural succession, maintenance, restoration & enhancement activities, as well as impacts from development activities.

The ELC system is a standardized vegetation classification system for monitoring vegetation community composition, spatial boundaries and impacts from humans. This approach to mapping vegetation communities should form part of the EMP and can be completed through field surveys and/or aerial imagery interpretation, with the purpose of documenting:

- NHS-Urban Interface Integrity;
- Ecosite Description;
- Boundary Integrity;
- Canopy Health;
- Native Communities & Species Diversity; and
- Invasive Plant Species.

Wildlife monitoring is also recommended and would be conducted concurrently with vegetation monitoring activities. As a result, it is recommended that the EMP include, at a minimum, a commitment to undertake breeding bird and amphibian call surveys (where appropriate). These two wildlife groups are easily monitored and sensitive to human disturbances and changes in habitat.

The purpose of the recommended vegetation and wildlife monitoring is to detect potential changes in habitats, plants and wildlife species compositions over time. Acknowledging a natural system is dynamic, and will vary over time, the monitoring program should seek to document a range of changes in the system; including:

- Existing natural habitat maintenance requirements (e.g. invasive species removal, etc.);
- Successional changes in habitat composition; and
- The success of restoration and enhancement activities.

As part of the site-specific development application stage, it is recommended that the applicant work with the City (and other agencies as determined by the City) to develop an approved site-specific EMP.

10.0 Summary

This Scoped EIS was prepared in support of future redevelopment and intensification in association with the City's Appleby Mobility Hub. The TOR for this Scoped EIS was developed in consultation with CH, the Region and the City. The findings of the biophysical inventory, which consisted of secondary source reviews and comprehensive field studies, are presented in this Scoped EIS.

The majority of the Study Area consists of pre-existing developed land uses. As a result, the 2017 natural heritage inventories were limited to Sheldon Creek, the Tributary to Appleby Creek and Appleby Creek and their adjacent woodlands. Each of the aforementioned watercourses were documented as permanent and provide direct fish habitat. Although erosion mitigation measures were generally observed throughout, the downstream reaches within the Study Area are less resilient to future changes.

Woodlands B, D, E, F & H were assessed as significant under the ROPA 38 (Section 277), while woodlands A, C & G were assessed as not significant under both ROPA 38 as well as the Natural Heritage Reference Manual (MNRF 2010). A total of 31 common bird species were observed during field studies, include one SAR (i.e. Barn Swallow) and one SCC (i.e. Eastern Wood-pewee). Significant wildlife habitat for Eastern Wood-pewee was identified within the Study Area as well as candidate SWH for Bat Maternity Colonies. A total of 71 botanical species were observed, eight of which are native and considered *Secure* of *Apparently Secure* in Ontario (SRank of S5 and/or S4).

Potential impacts of development may include potential tree and vegetation removal, diversion of surface water flows, sedimentation, and loss of potential wildlife habitat. These potential impacts can be avoided or minimized by implementing the mitigation, restoration, and management measures described in this report.

As there are a number of Species at Risk in the lands within or adjacent to the Study Area or that may be impacted by the proposed works. It is recommended that engagement with the Ministry of Environment, Conservation and Parks (MECP) at the detail design stage is initiated to determine if there are requirements under the Endangered Species Act (2007).

Appendix A

Terms of Reference

March 6, 2017 (Updated April 25, 2017)
Our File: TPB178008-04

City of Burlington
426 Brant Street
Burlington, ON L7R 3Z6

Attention: Phillip Caldwell, MCIP RPP, Senior Planner

Dear Sir:

Re: Scoped Environmental Impact Studies Work Plan, Mobility Hubs Planning

Brook McIlroy Inc.'s (BMI) proposal for Consulting Services for the City of Burlington Mobility Hub Planning (December 12, 2016) outlined a Work Plan that included departures from the Terms of Reference (TOR) agreed to between the City and Conservation Halton and Region of Halton and outlined in RFP-239-16 (November 17, 2016). The changes to the TOR were proposed by Amec Foster Wheeler and Dillon Consulting in order to provide cost efficiencies to accommodate the City's project budget, and related specifically to the *Scoped Environmental Impact Studies* as defined in Appendix G *Environmental Impact Study Preliminary Guidance For Study Components and Technical Requirements* in the RFP. The intent of this letter is to more clearly communicate the changes to the TOR for the Environmental Impact Study presented in BMI's December 12, 2016 proposal. It is intended that this letter and attachments are read in conjunction with BMI's December 12, 2016 proposal.

On February 14, 2017 staff from the City of Burlington, Conservation Halton, Amec Foster Wheeler and Dillon Consulting met to discuss the Work Plan for the Scoped Environmental Impact Study. The discussion focused on identifying the changes proposed to the TOR and the objective was to obtain agreement between the City, Conservation Halton and the BMI Team on the proposed Work Plan such that there was a consensus moving forward. In an effort to clearly and concisely summarize the proposed changes to the TOR, the original TOR have been modified and changes have been tracked. The changes proposed by Amec Foster Wheeler to *Section 6.0 Stormwater Management and Riverine Hazards* and by Dillon Consulting to *Section 5.0 Environmental Studies and Analysis* and *Section 7.0 Supplementary Information* have been integrated in Attachment A. As noted above, it is intended that this letter and Attachment A are read in conjunction with BMI's December 12, 2016 proposal. Further, Attachment A is intended to clarify our original proposal, not replace it – if the City perceives an inconsistency between the December 12, 2016 proposal and Attachment A, please bring it to the attention of the BMI Team.

Five (5) key study gaps related to *Stormwater Management and Riverine Hazards* have been identified and are summarized below. The proposed gap-filling approaches and study-risks related to potential out-of-scope work are discussed in Attachment A to this letter.

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Amec Foster Wheeler Environment & Infrastructure
Registered office: 2020 Winston Park Drive, Suite 700, Oakville, Ontario L6H 6X7
Registered in Canada No. 773289-9; GST: 899879050 RT0008; DUNS: 25-362-6642

1. Uncertainties remain on policy perspectives related to Regulatory flood control and specifically the Hager-Rambo Flood Control System. Conservation Halton agreed to review this matter further and advise on how the Authority will seek to apply policy. Background related to this issue is discussed in Section 6.3 a) x).

2. Flood risk in the Burlington and Downtown Mobility Hubs related to a potential breach of the Freeman Pond and/or West Hager Pond, two of the three flood control facilities that are part of the Hager-Rambo Flood Control System, is a potential gap. Amec Foster Wheeler has outlined preliminary assessments that are proposed and is expected to determine if additional study is required as part of the Mobility Hub Planning.

3. Flood spills have been identified in several locations along the Hager-Rambo Diversion Channel however the associated spill path(s) through the Burlington and Downtown Mobility Hubs and the potential impact on future development is a gap. Amec Foster Wheeler has outlined preliminary assessments that are proposed to be completed and are expected to provide 'high-level' guidance on the flood hazard associated with the spill(s). The level of flood risk prescription that can be obtained within the existing Work Plan scope is uncertain and additional study will be required. The limitations of the assessment are discussed in Section 6.3 a) x).

4. The Work Plan proposes a high-level risk assessment for erosion potential related to future development in the Mobility Hubs. Where erosion potential is determined to be 'low' and the Technical Advisory Committee (TAC) agrees that no further study is required, the proposed Work Plan will meet study objectives. If erosion potential cannot be satisfactorily screened by proposed Work Plan, study gaps may exist. Gaps relate to the potential need to establish erosion thresholds downstream of the Mobility Hubs, and the potential need to undertake continuous hydrologic simulations to complete an erosion duration analysis in support of establishing the criteria for future erosion control requirements. Section 6.2 e) (2) provides additional detail on the proposed approach.

5. Conservation Halton staff have noted they will consider regulating Lower Hager and Lower Rambo Creeks; staff to advise. No implications to the Work Plan are expected.

Additional comments from Conservation Halton (received via e-mail March 23, 2017, secondary comments received via e-mail April 20, 2017) have also been updated into the current revised work plan. To summarize the changes resulting from this additional round of comments:

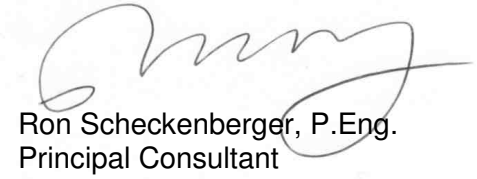
1. Page 6 of PDF (5.0 - Table A) – Aldershot has been revised to a "Yes*", based on the qualifiers and conditions outlined under the "*".
2. Page 10 of PDF (5.0 – Water Quality/Benthic Invertebrates) – Asteriks added for Burlington and Appleby Line.
3. Page 11 of PDF (5.0 – Stream/Drainage Corridor and Storm Sewer Outfall Assessment) Falcon Creek and Glen Wood Creek have not been included in the Table. Falcon Creek is not located within the Aldershot Mobility hub area, and Glenwood Creek has only a minor amount within the area. Qualifying wording has been added to the text that an assessment may be required if it is determined that there is any expected hydrologic impact to these features; if necessary this work would be beyond the current scope. Table B within Section 6.0 (Hydrologic Modelling Requirements) has been similarly updated.

4. Page 17 of PDF (6.2 e) 3) – Proposed Hydrology/Stormwater Management) – Revised wording to include assessment of *preliminary potential* flood mitigation controls in the event of spill. Any detailed measures or assessments would be beyond the scope of the current study and are therefore not included.
5. Page 22 of PDF (6.3 a) x) – Hager-Rambo Diversion Channel & Flood Control System) – wording has been revised to clarify that the system to be assessed will include the channels between the ponds and the diversion channel (although spills will only be assessed at a high level, as noted in the revised terms of reference). This also assumes that the hydraulic models are readily available for these reaches in a usable state. Reference has also been included to the East Rambo Pond (it has been assumed that this is what was being referred to, rather than the East Hager Pond, as no such feature is known to exist beyond the QEW/North Service Road drop structure, which has no storage or attenuation function).

We trust the foregoing is consistent with our discussion on February 14, 2017 and provides an adequate basis upon which to advance the Work Plan for the Scoped Environmental Impact Studies.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited



Per: Ron Scheckenberger, P.Eng.
Principal Consultant

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

AB/ls/MJS/RBS

c.c. David Sajecki, Brook McIlroy Inc.
Daniel Bourassa, Dillon Consulting
Allen Benson, Dillon Consulting
Justine Giancola, Dillon Consulting
Jeff Hirvonen, GeoProcess

APPENDIX G

ENVIRONMENTAL IMPACT STUDY
PRELIMINARY GUIDANCE FOR STUDY COMPONENTS AND TECHNICAL REQUIREMENTS

DISCLAIMER

Please note that information contained in this Appendix has been provided by partner agencies to the City of Burlington. Given the urban context of the Mobility Hub study areas, additional scoping/elimination of study requirements identified within this Appendix will be explored with the chosen project consultant to ensure study's focus is less on characterization of existing features and more on restoration and enhancement opportunities.

The chosen project consultant will be required to submit a work plan for the Environmental Impact Studies upon awarding of the project contract which will identify an environmental scope of work reflective of the existing urban context of the Mobility Hub study areas and based on the consultant's own past experience as well as other best practices for similar studies. The project consultant's proposed work plan will be evaluated by the City of Burlington and partner agencies through a technical advisory committee (TAC)

1.0 STUDY PURPOSE

The purpose of Environmental Impact Studies in each Mobility Hub area is generally to:

- Inventory, characterize, and assess existing environmental conditions including natural hazards, natural heritage and water resource features and areas;
- Provide recommendations for the protection, restoration, and enhancement, where feasible, of natural heritage, and water resource features and areas;
- Provide recommendations for management and mitigation of natural hazard and other constraints, where feasible;
- Provide sufficient detail to support the designation of the Natural Heritage System (NHS), through refinement of the Regional Natural Heritage System (RNHS), as well as identifying areas for future development;
- Refinement of the Regional Natural Heritage System for the Study Area and development of a Natural Heritage System Restoration and Enhancement Plan to be implemented through redevelopment and private and public land stewardship as part of an innovative Environmental Management Strategy for each study area;
- Conformity with applicable Provincial, Regional, and City land use planning policies, including Section 145(9) of the Regional Official Plan, and applicable Conservation Halton Policies;

- Establish procedures for monitoring water quality and quantity before, during and after development; and
- Other objectives and goals as proposed by the project consultant in their final work plan.

2.0 STUDY PROCESS/PHASING

The Environmental Impact Studies should be broken into the following phases to allow for feedback from relevant technical reviewers/agencies:

- Phase 1 – Background Review and Characterization
- Phase 2 – Analysis
- Phase 3 – Management Strategy Development
- Phase 4 – Implementation and Monitoring

The Environmental Impact Studies will both inform and be informed by the land use scenarios developed as part of the Area Specific Planning process. As a result, study phases should be prioritized based on the information required to inform the delivery of stage 1 and stage 2 project deliverables as established in the Terms of Reference and may include the undertaking certain phases concurrently.

The final Environmental Impact Studies should be completed prior to the approval of Area Specific Plans.

3.0 ADVISORY COMMITTEES/MEETINGS

Work undertaken as part of the Environmental Impact Studies will be reviewed by a technical advisory committee (tac) with representation from the project consultant, the City of Burlington, Region of Halton and Conservation Halton.

4.0 STUDY CONSIDERATIONS

Urban Context – Environmental Impact Studies/Sub-Watershed Studies such as those required within each Mobility Hub area are typically conducted in undeveloped greenfield settings. The existing urban nature of all four Mobility Hub study areas should be considered when undertaking the Environmental Impact Studies.

Innovative Implementation Strategy – Given the urban nature of the Mobility Hub study areas, the Environmental Management Strategy prepared at the conclusion of the Environmental Impact Studies should consider innovative implementation tools not typically considered in relation to Area Specific/Secondary Plans in greenfield areas. As greenfield development will not be the primary mechanism relied on for implementation, policies targeted primarily at guiding future development will not be the best way to fulfill the majority of the recommendations. Redevelopment, public land stewardship, public works relating to natural hazard mitigation and stormwater infrastructure "greening", targeted ecological restoration projects and community education and stewardship may be

more relevant tools in these studies. As a result, the studies should explore utilizing a broadened set of implementation tools to reflect the urban context of these areas.

5.0 ENVIRONMENTAL STUDIES AND ANALYSIS

Table A Environmental Studies and Analysis

Required Environmental Studies/Analysis	Aldershot	Burlington	Downtown	Appleby
Hydrogeologic Assessment following CH Requirements for Completion of hydrogeological studies to facilitate Conservation Halton's reviews http://www.conservationhalton.ca/policies-and-guidelines	Yes*	No*	No*	No*
Identification of the extent of Hazard lands within the hub study area in accordance with MNRF guidelines and Conservation Halton policy and guidelines http://www.conservationhalton.ca/policies-and-guidelines.	Yes*	Yes*	Yes*	Yes*
Flooding Hazard Assessment	Yes	Yes	Yes	Yes
Erosion Hazard Assessment	Yes	Yes	Yes	Yes
Coastal hazard assessment			Yes	
Natural Heritage Studies/ System (see Table D in 7.0)	Yes*	Yes*	Yes*	Yes*
Species at Risk Consultation with the Ministry of Natural Resources and Forestry (MNRF)	Yes	Yes	Yes	Yes
Hydrologic/hydrogeologic evaluation and water balance for the wetlands	Yes*			
Stream classification, fish community inventory and fish habitat assessment	Yes	Yes	Yes	Yes
Water quality evaluation (including water chemistry and benthic invertebrates)	Yes	Yes	Yes	Yes
Stormwater management mitigation plans	Yes	Yes	Yes	Yes

Please note that where **Yes*** is indicated please refer to the proceeding Notes section below.

Table A Notes:

- Hydrogeologic Assessment: For the Burlington Mobility Hub, Downtown Mobility Hub and Appleby Mobility Hub the hydrogeologic assessment will rely on available borehole information to screen for the feasibility and provide future design guideance (where

proposed) for subsurface green infrastructure (LID's). The basic information collected from existing available borehole data would include groundwater levels, soils types, infiltration rates, etc. For the Aldershot Mobility Hub, the following is included in the Work Plan:

- Review CH information including regulations mapping
- Review 1200 King Road data (spring and summer)
- Conduct a field reconnaissance to observe any changes and possible points of water discharge (either surface and / or groundwater)
- Establish micro-topography to define surface water catchment zone
- Develop details of a future monitoring assessment program

With regard to the foregoing, it is expected that following the execution of this scoped investigation there would be a better understanding of the composition and function of the wetland including its possible zone of influence on surface water contribution. This understanding will then inform the potential extent of the constraint, while providing direction on water management strategies and also the form of future studies.

- Identification of Natural Hazard lands: To determine the hazard limit associated with valleys (defined and undefined), both the flooding and erosion hazards are to be considered. The hazard limit is set by the greater of the flood or erosion hazard, plus the applicable development setback based on the appropriate policy and regulatory requirements. It should be noted that additional buffers and/or corridor widths may be needed in consideration of other factors introduced by the study assessment including, but not limited to, the protection of ecological and hydrologic functions such as critical function zones and impacts to adjacent lands.

- Natural Heritage Studies/ System: Natural heritage studies are completed in order to identify and further delineate the existing Regional Natural Heritage System (RNHS). Natural heritage investigations/studies will be conducted while using the guiding policy framework of the RNHS within the Regional Official Plan Amendment No. 38 (ROPA 38). They will provide an appropriate level of detail for the planning analyses such that the components of the RNHS (Key Features; Enhancement Areas and Linkages) can be identified and associated functions characterized. Once the RNHS and its key features are identified and delineated potential impacts of the proposed Secondary Plan and restoration or enhancement opportunities can be presented. Standard field studies include, but are not limited to, Ecological Land Classification (ELC), wetland delineation (using ELC), vegetation surveys, breeding bird surveys, and amphibian breeding surveys. It is noted that for the next stage of study OWES will be required.

Understanding the urban nature of the Mobility Hub study areas and the importance of interconnecting the core areas and key features of the RNHS, there will be a focus on identifying opportunities to use a combination of ecological restoration, natural hazard mitigation (excluding structural technicques), stormwater infrastructure, parks, etc. to establish both active and passive City of Burlington - Mobility Hub Planning Brook McIlroy/ connections with the natural environment. Where this may not be possible, other options such as community education and stewardship programs will be proposed, to establish this connection between residents and the environment.

A Natural Heritage study for the Aldershot GO Train Station lands as well as those lands immediately adjacent has recently been initated. Therefore, the study requirements for those portions of the study area with the Aldershot Mobility Hub area may already be underway and could inform/suppliment additional environmental work required in the study area. Please note that there are additional natural areas within the study area that will need to be assessed using the same criteria.

Based on consultation with CH Planning Ecologists, the following terrestrial field studies will be required for each of the Mobility Hubs. The table below should be read concurrently with ***Attachment A***, Figures 1 through 4, which illustrate the portions within each of the Mobility Hub study areas where field studies will occur.

Terrestrial Field Studies	Aldershot	Burlington	Downtown	Appleby
Ecological Land Classification	✓	✓	✓	✓
Wetland Delineation	✓*			✓*
Vegetation Inventory	✓	✓	✓	✓
Breeding Bird Surveys	✓	✓	✓	✓

**Presence of wetlands to be confirmed through ELC.*

A more fulsome list of the terrestrial and aquatic natural heritage studies that may be considered has been included in Section 7.0, Table D of this Appendix.

- Species at Risk: Species at Risk (SAR) listed as Endangered or Threatened under *Ontario Regulation 242/08* are afforded both species and habitat protection under the Ontario *Endangered Species Act* (ESA), 2007. The MNRF will be consulted to request relevant SAR occurrence records pertaining to each of the four Mobility Hub study areas. This information will be used to help identify potential SAR and SAR habitat within each of the study areas. Although incidental observations of SAR and/or potential SAR habitat will be noted during field surveys, it is important to note that this work plan does not include any work that may be required under the ESA (i.e., additional surveys, permitting, etc.).

Should species-specific surveys or permitting be required by the MNRF, Dillon has qualified staff (e.g., qualified Butternut Health Assessors, etc.) that can provide the City with these services, as required (Note: SAR mapping will not be on any publicly available mapping).

- Stream Classification: For each of the four Mobility Hub study areas, stream classification of existing watercourses will be established to determine either the required and/or appropriate setbacks for protection from proposed development. Required setbacks are established by CH through a number of policies differentiating between major and minor valley systems. Appropriate setbacks are established by using all available information including sensitivity of features, background reports (i.e., Sustainable Halton reports, etc.), experience in similar situations and potential impacts of proposed adjacent land uses in order to protect the form and function of the watercourse features (Note: the greater of the required or appropriated setback will be identified as a development constraint). Potential restoration and enhancement opportunities will also be considered wherever possible. Stream classification will rely on existing information (e.g., fish community sampling etc.) where available to determine stream type (permanent, intermittent, ephemeral), thermal regime, and whether streams provide suitable fish habitat. Other parameters to consider when determining suitability for fish habitat include riparian and in-stream cover, stream morphology, nutrient inputs etc. Where no information is available site visits may be required to collect information on stream characteristics, fish community sampling, thermal regime, etc. TAC to be included on site walks involving consideration of classification of watercourses.

- Water Quality/Benthic Invertebrates: In two (2) recent/ongoing Secondary Plans (Halton Hills/Mississauga), Amec Foster Wheeler consultatively worked with CH and the area municipality to defer the water quality (chemistry) and benthic invertebrates investigations. The rationale, which was ultimately supported by CH, was based on the perspective that the information collected rarely, if ever, influences land use decisions. Stormwater Management practices need to (most often) meet the highest standards, therefore water chemistry/benthic invertebrates also does not drive the level of protection for the receiving systems (watercourses or Lake). On this basis, the main utility of these data comes forward during the monitoring phase following development. In order to determine the efficacy of the various management practices in mitigating the impacts of development, baseline monitoring (water chemistry/benthic invertebrates) is considered useful and important. Notwithstanding these data are most appropriately collected closer towards the period of planned land use change. Therefore, based on the foregoing, as part of this task, it is proposed to develop the scope of an appropriate water

quality and benthics sampling program for each Mobility Hub to be executed as part of a future investigation.

Based on consultation with CH Planning Ecologists, the following aquatic field studies will be required for each of the Mobility Hubs. The table below should be read concurrently with ***Attachment A***, Figures 1 through 4 which illustrate the portions within each of the Mobility Hub study areas where aquatic studies will occur.

Aquatic Field Studies	**Aldershot**	**Burlington**	**Downtown**	**Appleby**
Stream Classification	✓	✓*	✓*	✓*

**Daylighted portions of the Lower Rambo Creek, north of the Centennial Pathway and isolated portions in the Burlington and Appleby Hubs to be included in assessment. Locations of daylighted portions to be confirmed by CH.*

- <u>Stream/Drainage Corridor and Storm Sewer Outfall Assessment:</u> The various open watercourse corridors in the respective study areas provide important functions for the natural environment, as "natural" conveyance infrastructure (drainage system), riparian habitat and socially by preserving and enhancing open space. In order to continue these functions in the long term, it is important to determine current functionality and from this establish means for enhancement/restoration in the context of future development concepts. The primary corridors proposed to be assessed as part of this study include:

Aldershot *	Grindstone Tributary, West Aldershot Creek, LaSalle Creek, Forest Glen Creek, Teal Creek
Burlington	East/ West Rambo Creek and Roseland Creek
Appleby	Appleby Creek, West Sheldon Creeks, and Shoreacres Creek
Downtown	Lower Hager and Rambo Creeks

* *Additional assessments <u>may</u> be required for Falcon Creek and Glenwood Creek if it is determined* that these receivers *will experience hydrologic change due to the proposed Mobility Hubs development. This additional work would be determined pending discussions through the Technical Advisory Committee and review of the sewershed mapping.*

The scope of this review will include field reconnaissance by a Drainage Engineer, Aquatic Ecologist and a Fluvial Geomorphologist. Based on the visual review, the following will be identified and mapped:

- Bank treatment/areas for stabilization
- Aquatic/riparian habitat
- Stream stability

- Vegetation
- Storm outfalls and neighbouring land uses.

The foregoing approximate mapping exercise will then be used as a base for developing a framework for a restoration/rehabilitation plan for each system. Each watercourse will also be investigated for mitigation or rehabilitation opportunities, with the objective of maximizing the remaining natural potential of the watercourse's form and function (where feasible). This will include a rapid investigation of reach-wide channel stability and identification of causes of instability, where present. For areas where opportunities for mitigation or improvement exist, high level recommendations will be proposed to address key imbalances between the conveyance of flow and sediment. In development of these recommendations the Study Team Fluvial Geomorphologists will work closely with the Study Team Water Resources Engineers to ensure conceptual plans are feasible and sustainable in the long term.

In addition, one of the considerations cited in the TOR relates to potential "day lighting" of enclosed watercourses. These opportunities and their implications on area infrastructure will be reviewed at a high-level as part of this task.

6.0 STORM WATER MANAGEMENT AND RIVERENE HAZARDS

The following sections are intended to provide an overview of select components that are to be assessed as part of the Environmental Impact Studies. It is also to identify the minimum requirements for the study. The project consultant will be required to prepare a final work plan to further detail and refine the information set out in the Request for Proposal and associated appendices. The background and characterization, analysis and reporting work must be completed to the satisfaction of the advisory committee.

It should be noted that although each study component has been discussed separately, all components are to be looked at comprehensively and in an integrated manner. This will also help to ensure that the objectives that have been established for the study area have been met. All of the work described below is to be completed by a licensed professional (Engineer and/or Geoscientist as appropriate. All final reports and maps are to be signed and sealed.

6.1 Existing Hydrology

The project consultant will be required to:

a) Undertake a review of previous subwatershed and stormwater management studies, aerial photos, topographic base maps, flow records, high water marks, precipitation records, and existing "Permits To Take Water" within and upstream of the study areas;

b) Develop and verify physical feature mapping of the subwatersheds, including subwatershed boundaries, upstream catchment areas, watercourses, drainage swales, wetland features, undrained depressions, other drainage improvements, land use, levels of directly and indirectly connected imperviousness, existing stormwater management features, etc. and ensure these are represented in the models;

c) Refine or develop (where required) hydrologic models to be used for each subwatershed area. Refer to Table 1.1 provided below, which summarizes the status of available modelling. The models should be deterministic hydrologic models, capable of continuous simulation (if required, see (i).) with strong physical representation of surface runoff and infiltration, channel storage, base flows, and for the Aldershot mobility hub, a more detailed understanding of the surface/groundwater interaction;

    i) Continuous simulation has not been included in the proposed Work Plan. See Section 6.2 e) (2) for implications to the erosion assessment.

d) Document and justify hydrologic modeling parameters;

e) Determine sub-basins to establish nodes at points of interest;

f) Model selection, parameterization, and extent are to be approved by the advisory committee;

i) The Work Plan assumes the existing models identified in Table B are approved. Model parameterization will be reviewed to ensure previous assumptions are supportable. Adjustments to model discretization/parameterization are expected within Mobility Hub study areas, however watershed wide re-parametrization of existing models has not been included, nor is it expected to be required.

g) Calculate unitary discharge rates at each key node, complete comparisons to the previously calculated flows (where available) to validate modelled flow values;

h) Present the findings to the TAC and based on mutual discussions and agreements proceed to the next stage.

Table B Hydrologic Modeling Requirements

Mobility Hub	Hydrologic Modeling Required	Available Information
Aldershot Mobility Hub*	Grindstone Creek (refinement of 1995 GAWSER model, with expansion of 2007 Waterdown Road interchange SWMHYMO model)	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995) Indian Creek Grade Separation Design (AMEC 2013) Falcon Creek Hydrology and Hydraulics Study (Valdor, 2012)
	Creek West of LaSalle Park Road (Create new model)	Unavailable. New PCSWMM model proposed
	Teal Creek, Forest Glen Creek, LaSalle Creek, (refinement of PCSWMM model)	Class EA for Aldershot Community Stormwater Master Plan (AMEC, 2013)

Burlington Mobility Hub	West Rambo Creek and Diversion (OTTHYMO refinement)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	East Rambo Creek (OTTHYMO refinement)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	Roseland Creek (refinement of SWMHYMO)	TRoseland Creek Flood Control Class EA (Philips Engineering Ltd, 2009)
Downtown Mobility Hub	Lower Rambo Creek (create model)	Unavailable. New PCSWMM model proposed
	Lower Hager Creek (create model)	Unavailable. New PCSWMM model proposed
Appleby Mobility Hub	Appleby Creek (GAWSER refinement)	Appleby Creek Floodline Mapping Update (EWRG 1997)
	Shoreacres Creek (refinement of GAWSER)	Shoreacres Creek Floodplain Mapping Update (EWRG 1997)
	Sheldon Creek (refinement of HSPF model)	Sheldon Creek Hydrologic and Hydraulic Study (DRAFT, AMEC Foster Wheeler, 2016)

* *Additional hydrologic modelling <u>may</u> be required for Falcon Creek and Glenwood Creek if it is determined* that these receivers *will experience hydrologic change due to the proposed Mobility Hubs development. This additional work would be determined pending discussions through the Technical Advisory Committee and review of the sewershed mapping. An existing PCSWMM model is available for Glenwood Creek (Aldershot Community Stormwater Master Plan, AMEC 2013), while an existing GAWSER model is available for Falcon Creek (Falcon Creek Hydrology and Hydraulic Study, Valdor 2012).*

6.2 Proposed Hydrology / Stormwater Management

a) Develop model parameterization for the proposed condition hydrologic model based on the three land use scenarios. Obtain approval for model parameterization by the TAC.

b) Model future uncontrolled conditions for each of the three land use scenarios.

c) Identify downstream constrictions within the major and minor system drainage routes and assess the impact of the proposed development. See also Section 6.3 below.

d) Develop watercourse specific stormwater management strategies that achieve the following goals and objectives:

(1) To ensure new development does not increase the frequency and intensity of flooding, the rate of natural stream erosion or increase slope instability;

(i) See Section 6.2 e) (2) for considerations related to erosion control

(2) To ensure natural heritage features and areas, including their ecological and hydrologic functions, are protected from potential adverse impacts of development;

(3) To prevent accelerated enrichment and contamination of surface and groundwater resources from development activities;

(4) To maintain linkages and related hydrologic and hydrogeologic functions among groundwater features, and surface water features, where required as determined through the scoped hydrologic and hydrogeologic study; and

(5) To ensure that riparian rights of downstream landowners, specific to the use and enjoyment of water across their property is respected.

e) The effectiveness of stormwater management mitigation plans must be confirmed through model simulation results for peak flow control and erosion mitigation performance. The preferred plan must be tested relative to the municipal design storms and Hurricane Hazel Regional Storm Event, and two climate change hydrologic scenarios (as established in the Draft City-Wode Flood Vulnerability, Prioritization and Mitigation Study, Amec Foster Wheeler, November 2016), and the August 4th, 2014 flood event. The following tasks shall be included:

(1) Utilize the results of the pre-development modeling to set targets and unitary discharge rates (paired storage and discharge values presented per impervious ha) at key locations. Provide preliminary sizing for stormwater management facilities;

(2) Determine whether erosion controls are required and provide technical justification for the selected level of control, in consultation with the TAC;

a) The Work Plan includes a preliminary assessment to identify the impacts on erosion potential related to the proposed land-use changes within the Mobility Hubs. 'Risk' will be established by:

(i) Completing a runoff volume impact assessment for the future land use scenarios based on the 25 mm Chicago 3 hour design event. Existing and future condition peak flows and channel velocities will also be considered.

(ii) Input from the fluvial geomorphologic assessment which will provide preliminary insight into the sensitivity of watercourse reaches within and

downstream of the Mobility Hubs. (e.g. highly armoured reaches represent a 'low' risk receiver)

b) Where erosion risk is considered 'low' by the TAC, no additional study will be required. Erosion control requirements for these areas will be approved by the TAC and may include: no erosion control, LID BMPs, extended detention based on current requirements outlined in the Stormwater Management Planning and Design Manual, MOE, 2003. Any emerging guidance will also be considered in consultation with the TAC.

c) Where erosion risk is not 'low' and the TAC determines a more rigorous assessment will be required to establish erosion controls; the scope for this work will be established by the TAC. Key scope gaps to complete a more detailed erosion assessment are considered to be 1. Establishing critical erosion threshold shear/flow; 2. Continuous simulation. Detailed erosion assessment is not included in the Work Plan.

(3) Determine whether post to pre-quantity control should be required for the Regional storm. The SWS must investigate and evaluate the potential risks and determine what level of control will be required. The analysis shall include the increase in risk to life (see qualifiers below) as well as the potential for flood risk to private, Municipal, Regional, Provincial and Federal property under Regional Storm conditions;

a) Risk to life will not be characterized through a detailed evaluation of depth and velocity. Flood impacts will be characterized by changes in water surface elevations, extents of flooding and hydraulic structure performance (i.e. overtopping frequency and depth). In the instance that the extents of flooding are predicted to meaningfully change, the impact and preliminary required mitigation controls will be identified for consideration by TAC as part of this study. Detailed measures or assessments are beyond the scope of the current study.

(4) Hydrologic model parameterization for impervious coverage to apply maximum potential impervious coverage based on proposed and existing zoning, and as established through the land use planning process. Planning policies will be required to ensure future development does not exceed the assumed maximum zoning imperviousness

(5) Assess the impact of the stormwater management strategies relative to creek peak flows and flow duration based on a design storm methodology. Present the hydrologic impacts of the proposed stormwater management strategies.

(6) Present the recommended stormwater management strategy. The conceptual design for the stormwater management facilities should include storage rating curves, facility locations, and outlets.

f) Identify opportunities to utilize Low Impact Development methods (LIDs), assess/quantify their feasibility and demonstrate compliance with the forthcoming MOECC Guidelines (anticipated to be released in Winter 2016/2017). Storm runoff should be treated via a multi-barrier approach, incorporating onsite, conveyance, end of pipe controls and LIDs to acceptable standards as determined in the MOECC's Stormwater Management Planning and Design Manual (2003) or more recent standard.

i) The Work Plan does not include any specific analysis/assessment to meet the anticipated update to the MOECC SWM Guidelines where the analysis/assessment is beyond that described by other tasks outlined in the Work Plan. The updated MOECC guidelines will be reviewed once available to determine if there is any impact to the Work Plan.

g) Hydrologic analyses shall be conducted for existing and future development conditions to determine pre and post-development flows and investigate the impact of post-development conditions on: flows, volumes, flood levels, channel erosion [see i) below] and base flows [see ii) below]. The subwatershed plans shall recommend an array of runoff control measures to be carried out in Secondary Plan and Subdivision Plan level studies to ensure that downstream peak flows are not increased, downstream channel erosion is not increased and that stormwater runoff is appropriately treated to meet water quality targets. The recommendations must be defined in sufficient detail to support completion of the subsequent secondary planning level studies.

i) Section 6.2 e) (2) for description of the erosion assessment included in the Work Plan

ii) Continuous simulation is not included in the Work Plan and as such, post-development impacts to baseflow will not be determined.

6.3 Natural Hazards

The study shall identify the extent of flooding and the limits of the erosion hazard lands within the study areas, in accordance with the Ministry of Natural Resources and Forestry (MNRF)'s Provincial Technical Guidelines and Conservation Authority direction.

To determine the hazard limit associated with valleys (confined and unconfined), both the flooding and erosion hazards are to be considered. The hazard limit is set by the greater of the flood or erosion hazard, plus the applicable development setback based on policy and regulatory requirements. Additional buffers and/or corridor widths maybe needed for

ecological and hydrologic purposes. The minimum setback is 15 metres from major valley systems such as Grindstone Creek, and 7.5 meters from minor valley systems.

a) Flood Hazards

Floodplain mapping refinements and/or generation (where watershed scale mapping and modeling is not available – as per the table below) are to be completed in accordance with MNRF recommendations based on the applicable Provincial Technical Guidelines (i.e., "Technical Guide – River & Stream Systems: Flooding Hazard Limit", Ministry of Natural Resources & Watershed Science Centre, 2002, "Technical Guide – Great Lakes, St. Lawrence River Shorelines, Flooding, Erosion and Dynamic Beaches", or updated current standard). Flood plain mapping must be refined/generated for the Mobility Hub study areas and for riverine flooding, a sufficient distance up and downstream to clearly characterize all hydraulic interactions and identify any future hydraulic impacts associated with development. The models should be detailed and flexible enough to evaluate modifications to the existing floodplains including realignment or changes to the corridor widths and profiles. The U.S. Army Corps of Engineers HEC RAS model is an acceptable tool for the hydraulic analyses.

Note: Provincial Technical Guidelines (i.e., "Technical Guide – River & Stream Systems: Flooding Hazard Limit", Ministry of Natural Resources & Watershed Science Centre, 2002 requirements/recommendations will be met with the following exceptions:

- Model calibration (Section F8 of the Technical Guide) will not be completed
- Testing and sensitivity analysis (Section F9 of the Technical Guide) will only be undertaken on the basis of peak flows where the Regulatory floodplain is not confined to a valley feature, or where the Regulatory floodplain is close to breaching a valley feature under future land use conditions

To establish/refine the existing riverine floodplain constraints to support a planning level study, the following steps must be completed:

i) Survey major watercourse crossing structures within the Mobility Hub study areas and a hydraulically relevant distance up and downstream, where existing data are not available or are not considered to be of a satisfactory level of accuracy, as approved by the TAC. A complete detailed survey of the low flow and bankfull channels (sufficient for floodplain mapping purposes) within municipal creek blocks along Appleby Creek is included in the Work Plan; opportunities to re-allocated the effort associated with this task will be considered by TAC on a priority basis. DEM data (0.5 m resolution) will be provided and may be applied to the floodplain throughout the remainder of the study areas where public access is unavailable. The project consultant is to ensure that the DEM and field survey data are properly integrated.

ii) As part of the refinement of the models, verify the hydrologic information, cross section locations and hydraulic parameters included in the hydraulic analyses and update as appropriate. Document the sources of information utilized within the hydraulic models. Alternatively, create and document a new hydraulic model where required. Hydraulic parameters utilized within the model are to be determined in consultation with the TAC.

iii) Establish reach boundary conditions based on the best available information, but ensure sufficient cross sections between the boundary conditions and study areas of interest to achieve model stability. Where Lake Ontario represents the starting water level, the mean monthly water level associated with Lake Ontario should be used as the boundary condition,

iv) The Lake Ontario's flood hazard limit (100 year high water level) must also be considered as it may govern in the establishment of the hazard within the Downtown Hub.

v) As part of the hydraulic modeling for the Aldershot mobility hub, the Floodplain delineation for Grindstone Creek must consider spill from the adjacent Falcon Creek. The spill values will be provided by the TAC.

vi) Validate the refined existing conditions models through comparison with original models (where available).

vii) Where the regulatory storm is defined by a 1:100 year design storm as opposed to Hurricane Hazel Regional storm event, climate change implications are to be assessed (three projected scenarios will be provided by the TAC) through modeling efforts and presented in a tabular form to inform the potential level of risk associated with anticipated climate change scenarios.

viii) Evaluate the extent of the future floodplains based on proposed hydrologic and hydraulic conditions as envisioned through the secondary planning process.

ix) Prepare full size copies of floodplain mapping (existing and proposed conditions) for the regulatory storm (greater of the 1:100 year or Regional Storm Event). The mapping shall be presented on a topographic contour base, overlain with property boundaries, structures, watercourse locations, and labeled hydraulic cross sections. Cross sections are to be labelled with cross section ID, the associated Regional and 1:100 year water levels, and the 'start' and 'end' of the modeled segments of the cross sections. Submit digital and hard copies of the mapping.

x) Hager-Rambo Diversion Channel & Flood Control System –

(1) The diversion channel is estimated to have capacity for the 50 year design storm based on the original design criteria and subsequent analyses. For larger design events (100 year and Regional Storm), the channel is expected to spill at several locations. A preliminary understanding of existing hydraulic conditions is available from Conservation Halton's draft HEC-RAS model for the channel. Spill paths are not known at this time, however spills are expected to impact the south end of the Burlington Mobility Hub and the Downtown Mobility Hub and may impact the location/nature of future development in these hubs. The magnitude of spill flow is also not known for any design event at this time.

(2) The Hager-Rambo flood control system consists of three (3) facilities including the Freeman Pond (QEW-Highway 403 interchange), West Hager Pond (North Service Road, west of Brant Street) and the East Rambo Pond (North Service Road, west of Guelph Line). The facilities were required to provide flood control (peak flow attenuation) for stormwater diversions related to the Highway 407 corridor (East/West Rambo Creek & East Hager Creek), and also accommodate a diversion from Roseland Creek. The flood control system was design and approved by the City of Burlington, Conservation Halton and the Province of Ontario to provide peak flow control for all events up to and including the Regional Storm.

    Current Provincial policy (ref. MNR, 2002) does not allow modification of Regulatory peak flows through stormwater management in establishing the downstream Regulatory flood hazard. Current policy also does not allow implementation of flood control measures for the purpose of facilitating development downstream. These policies are key considerations for the Mobility Hub Study as development proposed within the Burlington and Downtown Mobility hubs is expected to be affected by a flood flows in excess of the capacity of the Hager-Rambo Diversion Channel including spills. The associated flood risk will significantly increase if the Hager-Rambo flood control system is not credited for reducing Regulatory peak flows. It has not been determined how current policy affects previous Provincial approvals granted to the Hager-Rambo flood control system. However, it has been identified that a Hager-Rambo flood risk assessment is required and must consider peak flows with and without the flood control system in-place. The spill assessment will involve use of simplified techniques and will not involve 2D modelling.

(3) The Freeman Pond and the West Hager Pond detain runoff using an engineered barrier above ground (i.e. berms and/or weirs) which may classify them as dams under the Lakes and Rivers Improvement Act. Current Provincial criteria requires that dam breach assessments be undertaken to inform the design process and

establish flood risk downstream related to a flood wave. A dam breach assessment has not been undertaken to date. Given that the influence the two flood control facilities is integral to the Hager-Rambo system, a preliminary review of dam breach, including spill paths is considered required to understand the potential for an increase to Regulatory peak flows in the system (between the ponds and the diversion channel), and potential increase in flood hazard risk downstream.

(4) Based on the foregoing, the following assessments can be accommodated within the existing Work Plan:

(a) Hydraulic modelling to estimate the order of magnitude of the spills from for the Hager-Rambo Diversion channel, as well as upstream connecting channels, under attenuated and unattenuated Regulatory peak flow based on a steady-state flow methodology. Other simplified estimation techniques will be considered. The preceding assumes that hydraulic models of the channels between the ponds and the diversion channel are readily available from Conservation Halton in a usable state.

(b) Review of potential Freeman Pond, West Hager Pond, and East Rambo Pond breach spill paths to the extent that a preliminary understanding of the potential for the breach to affect the Burlington or Downtown Mobility Hubs. Given that the facilities are generally west of the Hubs (with the exception of the East Rambo Pond which is a depressed feature and thus considered to be lower risk), direct impacts are expected to be limited. Calculation of breach (i.e. Dam Break) peak flows cannot be accommodated in the current Work Plan.

(c) Review of topographic mapping to identify potential Diversion channel spill paths through the Burlington and Downtown Mobility Hubs. The spill path, local topography and the estimated spill magnitude will be considered together to coarsely estimate the potential extents of flood impact within the Burlington and Downtown Mobility Hubs.

(d) DISCLAIMER. To generate a level of accuracy that can be reasonably relied upon to guide development and establish related policies, including garnering the necessary approvals from Conservation Halton and the Province would require detailed hydraulic modelling including unsteady state flow analysis and 2 dimensional flow routing and potential dam breach assessment. Amec Foster Wheeler's Work Plan identified the concern related to the spill, however no effort was included in the Work Plan to conduct the above noted

assessments. Clearly the detailed analysis that would be required cannot be accommodated by the current Work Plan. That said, it is expected that above noted preliminary analyses can be accommodated within the existing scope. The assessments will necessarily be highly conservative and qualifiers regarding the accuracy will be applied. At best, the outcomes are generally expected to improve the understanding of the potential spatial impact of the spill, and inform the scope of additional future study. Given that there is very limited existing understanding of the hydraulics related to the spills, the level of effort required to establish meaningful parameters around the extent of flood risk in the Mobility Hubs is unknown. Therefore, Amec Foster Wheeler will make best efforts within the existing Work Plan to provide meaningful information around flood hazards related to the spill, however it cannot be guaranteed that outcomes of the spill assessment will meet the specific needs of the Mobility Hub Study. Amec Foster Wheeler will work with the engineering and planning teams such that potential gaps in the flood hazard assessment, as they relate to planning needs, can be identified as early as possible and options to re-assign or add additional scope can be considered by the City and TAC.

Table C Hydraulic Modeling Requirements

Mobility Hub	**Hydraulic Modeling Required**	**Available Information**
Aldershot Mobility Hub	Grindstone Creek (refinement of HEC-2 and conversion to HEC RAS)	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995)

Burlington Mobility Hub	West Rambo Creek and Diversion (review and refinement of Conservation Halton Hager-Rambo Diversion Channel Model, 2014)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	East Rambo Creek (existing Amec Foster Wheeler model)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
Downtown Mobility Hub	Lower Rambo Creek (create model)	Unavailable
	Lower Hager Creek (create model)	Unavailable
Appleby Mobility Hub	Appleby Creek (HEC-RAS refinement)	Appleby Creek Floodline Mapping Update (EWRG 1997)
	Sheldon Creek (refinement of Hec Ras)	Sheldon Creek Hydrologic and Hydraulic Study (DRAFT, AMEC Foster Wheeler, 2016)

b) Erosion Hazards

The erosion hazard assessment must be completed in accordance with the most current version of MNRF's "Technical Guide – River & Stream Systems: Erosion Hazard Limit," (currently 2002), which is deemed to be inclusive of Parish Geomorphic's Belt Width Delineation Procedures" (currently Revised 2004). Conservation Halton staff in conjunction with the proponent's geomorphologist and/or geotechnical engineer will determine the status of the valley systems as either confined or unconfined. For confined systems, the erosion hazard is defined as the greater of the physical top of bank or long term stable top of bank. For unconfined systems, the erosion hazard limit is defined as

the meander belt allowance. The 15m and 7.5m regulated setbacks are to be applied to governing erosion hazard (i.e. the meander belt, physical top of bank or stable top of bank).

The erosion hazard assessment must be completed by a licensed qualified professional Fluvial Geomorphologist, Geotechnical Engineer and/or Water Resources Engineer. Justification as to whether climate change impacts need to be considered as part of corridor sizing is required.

Recognizing that some of the Mobility Hub study areas are partially developed, it may be appropriate to analyze meander belt widths on the basis of empirical equations. Where the meander-belt width is determined on the basis of empirical equations, the results of multiple applicable equations are to be presented and justification is to be provided for the equation that is ultimately selected as most appropriate in this area.

At a minimum, the erosion hazard limit must be supported by documentation detailing: collected field data (if applicable), the methodologies applied, analysis and supporting calculations and text justifying the ultimate methodology selected to define the erosion hazard limit. Additionally, digital and hard copy figures must be submitted and shall include a signed and sealed, full size, scaled, plan view drawing showing:

i) Detailed topographic information (contour intervals of less than or equal to 0.5m) with a referenced source for all topographic information;

ii) The current locations of the watercourse centerlines and limits of bankfull channels;

iii) The erosion hazard limits ;

iv) The regulated allowance (15 metres for major valley systems and 7.5 metres for minor systems).

To support the assessments of the erosion hazards, the following must also be assessed:

<u>For unconfined systems:</u>

i) Reach break locations, overlain on an orthophoto complete with topographic mapping,

ii) Any noted areas of erosion concerns and any locations where the 100 year migration rate may have been determined;

iii) The watercourses' current central tendency (meander belt axis);

iv) Available historic watercourse centrelines (where available);

v) The calculated meander belts (preliminary meander belts);

vi) The analyzed 1:100 year erosion setbacks (100 year migration rate) or alternate setbacks using safety factors as required;

For confined systems:

i) Given that this study is intended to support secondary planning and not zoning or lotting, the project consultant is to apply conservative assumptions for stable slope inclinations (i.e. slope inclinations of 3:1 in soil) and toe erosion allowances (maximum tabulated values applicable to site soils) and forego the completion of a detailed geotechnical study at this time. The erosion hazards will need to be further refined through detailed studies at a later date, prior to site development. At that time, the physical top of bank must also be staked by Conservation Halton.

The following must be shown on a scaled sealed figure:

i) Slope cross section locations and I.D.'s

ii) Limit of the Toe Erosion Allowance; and

iii) Limit of the Stable Slope Allowance

6.4 Digital Data Requirements

The project consultant will be required to provide the following information to the City of Burlington, Halton Region, and/or Conservation Halton:

a) For modeling related data products, digital and executable copies of model input and output files, as well as licensed copies of any proprietary modeling software and PDF copies of key summary information (such as the model schematics, drainage area plans, hydraulic cross section locations, etc.) are to be provided to the City Region and Conservation Halton.

b) Digital copies of the written reports are to be provided in both MS Word 2010 and PDF format.

c) All mapping products produced for the study shall be geo-referenced to real world coordinates and have a standard UTM NAD 83, Zone 17 projection with NAD83 vertical datum.

d) New features captured by the project consultant using GPS or heads-up digitizing from air photography will have a capture accuracy rating for the feature included as an attribute (+/- 0.5 m accuracy).

e) A mapping layer index will be provided listing the layer name and providing a description/abstract of the layer's content. Also, FGDC compliant metadata shall be created for each layer produced by the project consultant.

f) Digital data will be delivered in one of the following formats: ESRI file geodatabase v10.2 feature classes or ESRI shape file format ensuring attribute names are not truncated in the shape files. Layers created by the project consultant shall be topologically correct (i.e. adjacent polygon features will be without gaps/overlaps and shall share vertices/nodes where appropriate).

g) If the project consultant utilizes ESRI ArcGIS to produce maps, the matching .mxd will be provided that corresponds to the mapping.

h) If software limitations prevent the project consultant from meeting these requirements, alternate formats may be considered (e.g., DGN) with the written agreement of the City. City GIS staff should be consulted if additional technical details are required to these requirements.

7.0 SUPPLEMENTORY INFORMATION

Table D Terrestrial & Aquatic Studies

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
☒	Ecological Land Classification (ELC)	• May to early June, July to September	• ELC System for Southern Ontario First Approximation (Lee et al., 1999) or as updated from time to time	• Classification to the Vegetation Type. • Should the community not be available within the Guide, please use the community series level and provide notation as to why this approach is used. • Include all data sheets (e.g., soils, disturbance, etc.). • Mapping should clearly differentiate between the polygons.
☐	Wetland Evaluation and Delineation	• Evaluation: variety of seasons to ensure the full evaluation occurs as per OWES • Delineation: Late spring to early fall, before the first hard frost with CH and potentially MNRF staff	• Ontario Wetland Evaluation System (OWES) for Southern Ontario (3rd Edition, 2014 or as updated from time to time)	• Detailed inventory and assessment including vegetation, mammals, birds, reptiles, amphibians, fish, insects, benthos etc., using specific protocol noted in this table. • Ensure sufficient time for MNRF to process. *Note: presence of wetlands to be confirmed through ELC surveys the next planning stage will require OWES delineation.*
☒	Vegetation Inventory	• Single-season: mid-June to August, to be completed concurrently with ELC	• Comprehensive vegetation species list to be provided, will be combined with ELC • Details on species including level of invasiveness, CoC, CoW, species rarity etc., should be recorded	Species rarity to be based on: • Species at Risk in Ontario list (MNRF) • S-Rank using the Natural Heritage Information Centre species lists • Local rarity using Halton Natural Areas Inventory (2006) and Hamilton Natural Areas Inventory (2014)
☒	Breeding Birds	• Breeding birds: May 24 to July 10	Habitat Dependent: • Ontario Breeding Bird Atlas protocols	• Point counts required for monitoring. • Generally consists of two survey visits spaced approximately 10 days apart,

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
			• Area searches and wandering transects	spread evenly over the season.
☐	Amphibians	• Early spring – summer (species dependent) • Active Visual Encounter Surveys (VES) on rainy late March – early April nights	• Bird Studies Canada Great Lakes Marsh Monitoring Program (including 3 separate spring/early summer seasonal survey timing windows). • Active Visual Encounter Searches (VES) for salamanders	• Trapping may be required for JESA, if known or suspected and as required and permitted by the MNRF. • If sampling in urban areas, point counts longer than three minutes may be recommended *Note: presence of potential amphibian breeding habitat to be confirmed through ELC surveys. Where necessary, recommendations to undertake amphibian breeding surveys will be made as part of the development application process.*
☐	Reptiles	• April – June • Late Summer/Fall: Late August to October for migration or congregating species • Weather dependent	• Species and habitat dependent • May include cover board surveys, spring emergence surveys etc. • Consultation recommended ahead of work	*Note: presence of potential reptile hibernacula or nesting areas to be confirmed through ELC surveys. Where necessary, recommendations to undertake additional surveys will be made as part of the development application process.*
☐	Butterflies	• June – August • July (peak) • Weather dependent	• Species and habitat dependent • Consultation recommended ahead of work	*Note: potential significant wildlife habitat for migratory butterflies to be confirmed through ELC surveys.*
☐	Dragonflies and damselflies	• June – August • July (peak) • Weather dependent	• Species and habitat dependent • Consultation recommended ahead of work	*Note: potential significant wildlife habitat for dragonflies and damselflies to be identified through incidental observations and other field studies (ELC, etc.).*

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
☐	Mammals	• Species dependent	• Sightings and tracking • Small mammal trapping depending on the site	*Note: potential significant wildlife habitat for mammals to be identified through incidental observations and other field studies (ELC, etc.). Where necessary, recommendations to undertake species specific surveys will be made as part of the development application process.*
☐	Bats	• During leaf off season for cavity tree surveys	• Species and habitat dependent • SAR Bats require different surveys than SWH bats. • MNRF Guidelines, where applicable • Consultation recommended ahead of work	*Note: potential for bat habitat to be identified through ELC. Where necessary, recommendations to undertake bat surveys will be made as part of the development process.*
☒	Stream Classification	• Summer (June- July)	• Ontario Stream Assessment Protocol (OSAP)	• Collect information on riparian and in-stream cover, stream morphology, nutrient input, etc.
☐	Benthic Invertebrate Sampling	• Spring (May)	• OSAP Section2, Module 3 • Travelling kick and sweep methods completed three times over the study period (May)	• Data to be collected includes % abundance, Family Richness, and % Taxa Richness Index *Note: to be completed during future investigations closer to construction, to set a baseline for monitoring purposes.*

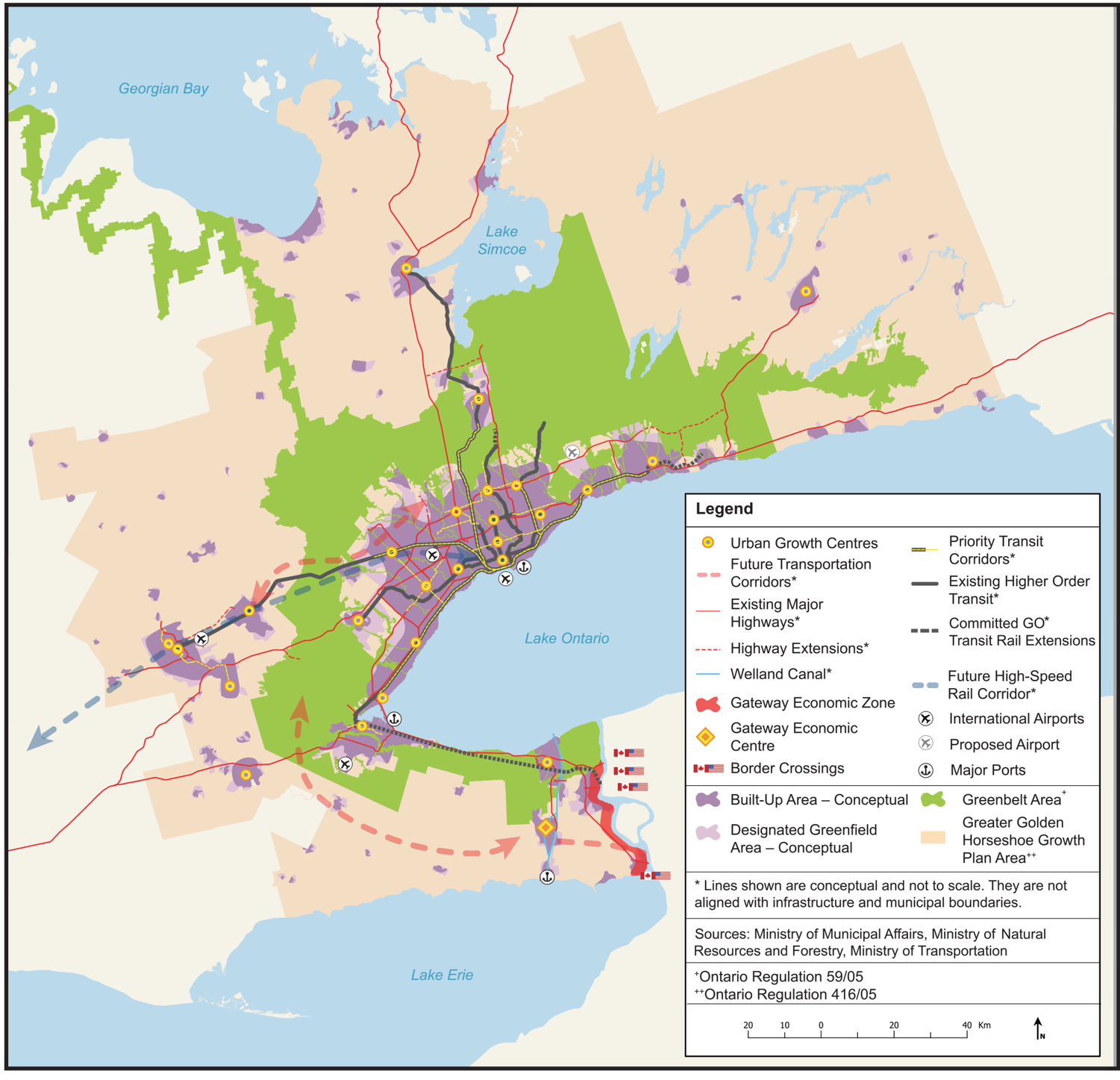
Note: The surveys listed above were agreed to at the meeting with CH on February 14, 2017. Additional surveys may be required as identified through the preliminary field program, to be addressed through the development application and approvals process.

ATTACHMENT A:

Terrestrial and Aquatic Field Study Locations

Appendix B

Background Mapping& Schedules



Ontario

PLACES TO GROW

GROWTH PLAN FOR THE GREATER GOLDEN HORSESHOE, 2017

SCHEDULE 2
Places to Grow Concept

Legend

- Urban Growth Centres
- Future Transportation Corridors*
- Existing Major Highways*
- Highway Extensions*
- Welland Canal*
- Gateway Economic Zone
- Gateway Economic Centre
- Border Crossings
- Priority Transit Corridors*
- Existing Higher Order Transit*
- Committed GO* Transit Rail Extensions
- Future High-Speed Rail Corridor*
- International Airports
- Proposed Airport
- Major Ports
- Built-Up Area – Conceptual
- Designated Greenfield Area – Conceptual
- Greenbelt Area+
- Greater Golden Horseshoe Growth Plan Area++

* Lines shown are conceptual and not to scale. They are not aligned with infrastructure and municipal boundaries.

Sources: Ministry of Municipal Affairs, Ministry of Natural Resources and Forestry, Ministry of Transportation

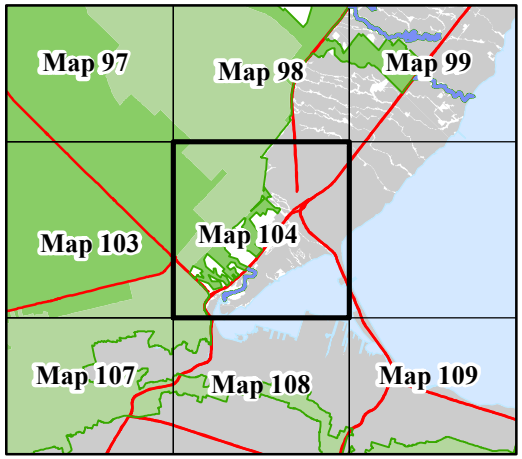
+Ontario Regulation 59/05
++Ontario Regulation 416/05

20 10 0 20 40 Km

N

Note: The information displayed on this map is not to scale, does not accurately reflect approved land-use and planning boundaries, and may be out of date. For more information on precise boundaries, the appropriate municipality should be consulted. For more information on Greenbelt Area boundaries, the Greenbelt Plan should be consulted. The Province of Ontario assumes no responsibility or liability for any consequences of any use made of this map.

greenbelt



LEGEND

Ontario

- Greenbelt Area*
  - Protected Countryside
  - Natural Heritage System
  - Towns / Villages
  - Urban River Valleys
  - Niagara Escarpment Plan Area
  - Oak Ridges Moraine Area
- External Connections
- Settlement Areas Outside the Greenbelt
- Upper Tier Municipal Boundaries
- Lower & Single Tier Municipal Boundaries
- Lots and Concessions
- Major Road or Highway
- Minor Road
- F.N. First Nations

The information displayed on this map has been compiled from various sources. While every effort has been made to accurately depict the information, this map should not be relied on as being a precise indicator of locations of features or roads nor as a guide to navigation.

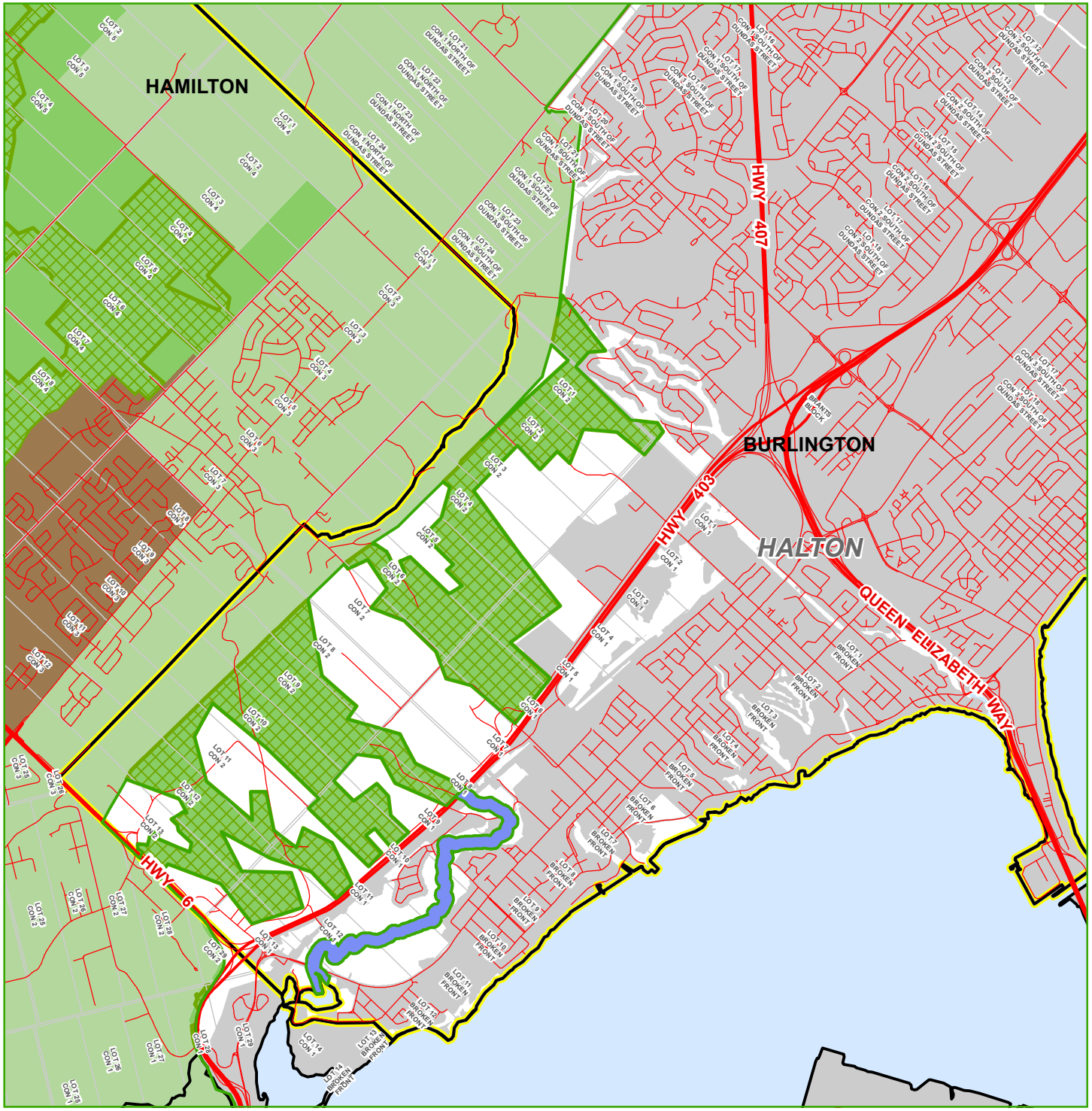
Settlement boundaries generally reflect information provided by the relevant municipality. For precise boundaries and locations of Settlement Areas (Greenbelt Towns/Villages and Hamlets) the appropriate municipalities should be consulted.

Source of Information:
Produced by and using data sources from the Ministry of Municipal Affairs, Ministry of Natural Resources and Forestry and the Ministry of Agriculture, Food and Rural Affairs.

Projection: UTM Zone17 NAD83

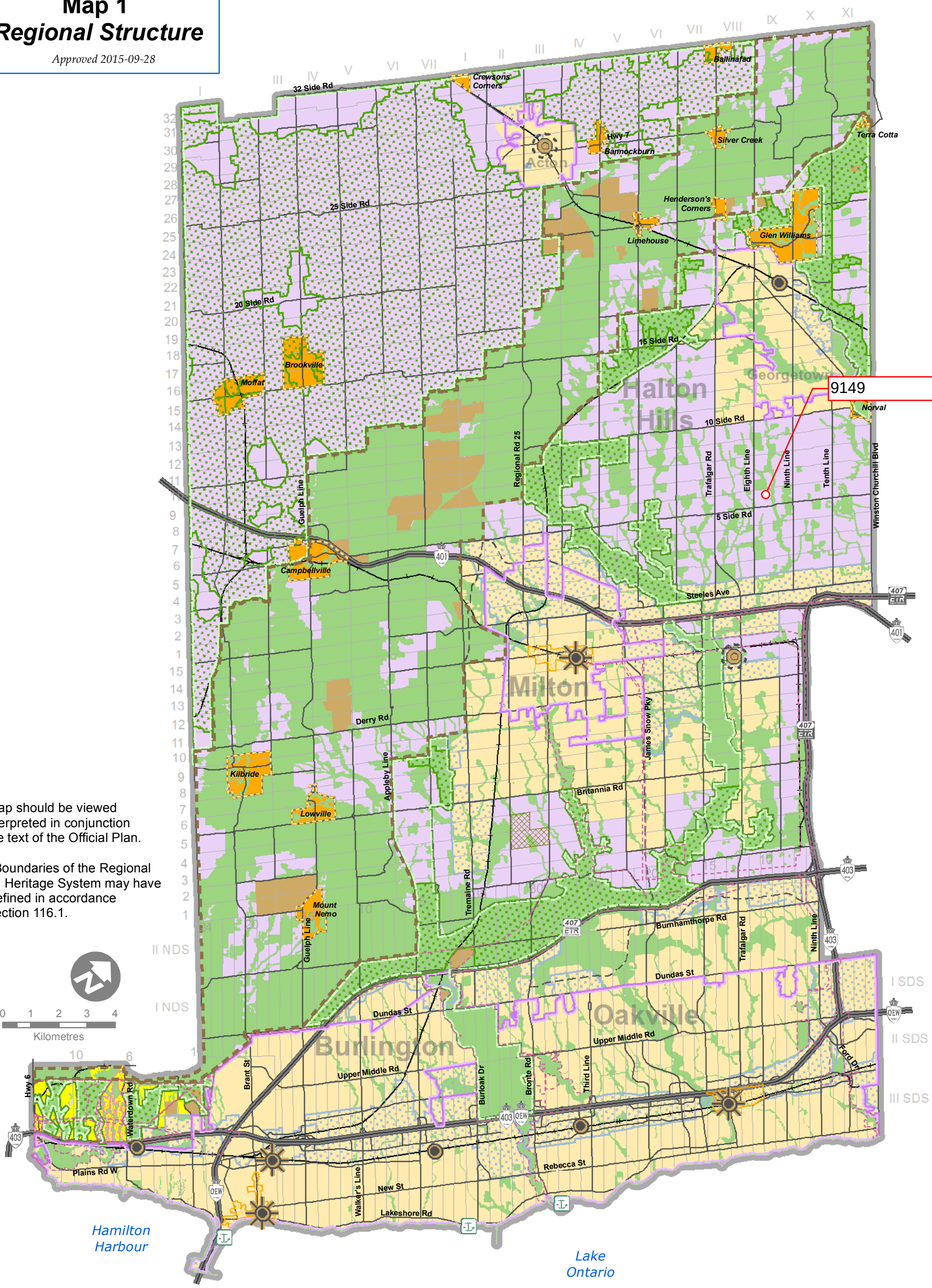
* Ontario Regulation 59/05, as amended.

0 0.25 0.5 1 1.5 2
Kilometres



Map 1
Regional Structure

Approved 2015-09-28



This map should be viewed and interpreted in conjunction with the text of the Official Plan.

* The Boundaries of the Regional Natural Heritage System may have been refined in accordance with Section 116.1.

- Waterfront Park (See Map 2)
- Major Transit Station
- Proposed Major Transit Station
- Mobility Hub
- Rail Line
- Proposed Major Arterial
- Major Road
- Provincial Freeway
- Lot and Concession Line
- Municipal Boundary

- Urban Area *Approved 2013-10-21*
- Hamlet
- Agricultural Area
- Regional Natural Heritage System *
- Mineral Resource Extraction Area
- North Aldershot Policy Area
- Greenbelt Natural Heritage System (Overlay)

- Greenbelt Plan Protected Countryside Boundary
- Niagara Escarpment Plan Boundary
- Parkway Belt West Plan Boundary
- Built Boundary
- Employment Area *Approved 2013-10-21*
- Urban Growth Centre
- Area Eligible for Urban Servicing
- Halton Waste Management Site

September 2, 2015

Schedule B

COMPREHENSIVE LAND USE PLAN- URBAN PLANNING AREA

Legend

- Residential - Low Density
- Residential - Medium Density
- Residential - High Density
- General Employment
- Business Corridor
- Regional Commercial
- Community Commercial
- Employment Commercial
- Neighbourhood Commercial
- Mixed Use Centre
- Mixed Use Corridor - General
- Mixed Use Corridor - Commercial Corridor
- Mixed Use Corridor - Employment
- Greenlands
- Major Parks and Open Space
- Environmentally Sensitive Area (Note: Boundaries based on Map 1 of the Region of Halton Official Plan (2006)
- Parkway Belt Plan Area (Note: All lands within Parkway Belt West Plan Area Subject to Deferral *9)
- Land Use Designation to be Determined
- Urban Planning Area Boundary
- Watercourses - Conceptual only, refer to Part III, Section 6.4.2 d
- Former Waste Disposal Site
- Downtown Urban Growth Centre Boundary

RURAL PLANNING AREA

NORTH ALDERSHOT PLANNING AREA

HAMILTON

OAKVILLE

BURLINGTON BAY

LAKE ONTARIO

*D31/*D32

*D42

*D47

*R16

*D28

HWY 407

HWY 403

HWY 6

Q.E.W.

C.N.R.

C.P.R.

DUNDAS ST.

UPPER MIDDLE ROAD

UPPER MIDDLE RD.

LEIGHLAND RD.

PLAINS RD. W.

PLAINS RD. E

FAIRVIEW ST.

LAKESHORE RD.

NORTH SERVICE RD.

SOUTH SERVICE RD.

HARVESTER RD.

MAINWAY

NEW ST.

SPRUCE AVE

REBECCA ST.

MOUNTAINSIDE DR.

NORTH SHORE BLVD. E

EASTPORT DR.

OLD YORK RD.

WATERDOWN RD.

TOWNSEND AVE.

CEDAR SPRINGS RD.

GUELPH LINE

APPLEBY LINE

TREMAINE RD.

PALLADIUM WAY

THOMAS ALTON BLVD.

DRYDEN AVE

CAVENDISH DR.

HEADON RD.

HEADON FOREST DR.

WALKER'S LINE

BERWICK DR.

MILLCROFT PARK DR.

SUTTON RD.

BURLOAK DR.

CORPORATE DR.

BRANT ST.

KERNS RD.

FISHER AVE.

KING RD.

MAPLE AVE.

HAGER AVE

DRURY LANE

SENECA AVE.

CUMBERLAND AVE

PINECOVE RD.

BELVENIA ROAD

HEATH RD.

HAMPTON

1:50 000 +/-

NOTE: For information on Deferrals and Referrals (*D or *R), please see the Explanatory Notes of the Official Plan.

JUNE 2015

Appendix C

Site Photos

Photo 1 June 28, 2017 Fresh–Moist Black Walnut Lowland Deciduous Forest Type (FODM7-4)	
Photo 2 June 28, 2017 Fresh - Moist Mixed Meadow Ecosite/Dry - Fresh Deciduous Shrub Thicket Ecosite (MEMM4/THDM2)	

Photo 3 June 28, 2017 Fresh – Moist Sugar Maple – Hardwood Deciduous Forest Type (FODM6-5)	
Photo 4 June 28, 2017 Dry-Fresh Sugar Maple Deciduous Forest (FODM5)	

Photo 5 June 22, 2017 Tributary to Appleby Creek Looking downstream within the tributary to Appleby Creek.	
Photo 6 June 22, 2017 Tributary to Appleby Creek Looking downstream along a portion of historically stabilized banks. The gabion baskets were observed here to be were leaning significantly.	

Photo 7 June 22, 2017 Appleby Creek Looking downstream at the linear nature of the Creek. Stone filled gabions line the banks in this area.	
Photo 8 June 22, 2017 Appleby Creek Looking upstream at two of several barriers to fish migration present within the Study Area.	

Photo 9 June 22, 2017 Sheldon Creek Looking downstream from the South Service Road crossing. Recent restoration efforts completed include riparian plantings and bank stabilization.	
Photo 10 June 22, 2017 Sheldon Creek Looking upstream within the Sherwood Forest Park at failed bank stabilization efforts.	

Photo 11 June 22, 2017 Sheldon Creek Looking down from the Harvester Road crossing at the barrier to fish migration.	

Appendix D

Botanical List

Scientific Name	Common Names	SRank[15]	SARA[16]	ESA[17]	Coefficient Conservation	Coefficient Wetness
Acer negundo	Manitoba Maple	S5	---	---	0	-2
Acer platanoides	Norway Maple	SNA	---	---	---	5
Acer saccharinum	Silver Maple	S5	---	---	5	-3
Acer saccharum	Sugar Maple	S5	---	---	4	3
Alliaria petiolata	Garlic Mustard	SNA	---	---	---	0
Allium vineale	Wild Garlic	SNA	---	---	---	3
Anthriscus sylvestris	Wild Chervil	SNA	---	---	---	5
Arctium minus	Common Burdock	SNA	---	---	---	5
Arisaema triphyllum	Jack-in-the-pulpit	S5	---	---	5	-2
Asparagus officinalis	Garden Asparagus	SNA	---	---	---	3
Aster sp.	Aster species	---	---	---		
Briza sp.	Quakegrass species	---	---	---		
Bromus sp.	Brome species	---	---	---		
Carex blanda	Woodland Sedge	S5	---	---	3	0
Carex rosea	Rosy Sedge	S5	---	---	5	5
Carya ovata	Shagbark Hickory	S5	---	---	6	3
Circaea canadensis	Broad-leaved Enchanter's Nightshade	S5	---	---	3	3
Cirsium arvense	Canada Thistle	SNA	---	---	---	3
Cirsium vulgare	Bull Thistle	SNA	---	---	---	4
Cornus sericea ssp sericea	Red-osier Dogwood	S5	---	---	2	-3
Crataegus monogyna	English Hawthorn	SNA	---	---	---	5
Cynanchum rossicum	European Swallow-wort	SNA	---	---	---	5
Dactylis glomerata	Orchard Grass	SNA	---	---	---	3
Dipsacus fullonum	Fuller's Teasel	SE5	---	---	---	5
Erigeron philadelphicus	Philadelphia Fleabane	S5	---	---	1	-3
Euonymus sp.	Euonymus species	---	---	---		
Fagus grandifolia	American Beech	S4	---	---	6	3
Fraxinus pennsylvanica	Green Ash	S4	---	---	3	-3
Galium obtusum	Blunt-leaved Bedstraw	S4S5	---	---	6	-5
Geranium robertianum	Herb-Robert	S5	---	---	---	5
Geum canadense	White Avens	S5	---	---	3	0

[15] Federal Species at Risk Act (SAR)
[16] Provincial Endangered Species Act (ESA)
[17] S-Rank is an indicator of commonness in the Province of Ontario. A scale between 1 and 5, with 5 being very common and 1 being the least common

Scientific Name	Common Names	SRank[15]	SARA[16]	ESA[17]	Coefficient Conservation	Coefficient Wetness
Glyceria canadensis var. *canadensis*	Canada Mannagrass	S4S5	---	---	7	-5
Glyceria striata	Fowl Mannagrass	S5	---	---	3	-5
Hesperis matronalis	Dame's Rocket	SNA	---	---	---	5
Hypericum perforatum	Common St. John's-wort	SNA	---	---	---	5
Impatiens capensis	Spotted Jewelweed	S5	---	---	4	-3
Juglans nigra	Black Walnut	S4	---	---	5	3
Leonurus cardiaca	Common Motherwort	SNA	---	---	---	5
Lonicera tatarica	Tartarian Honeysuckle	SNA	---	---	---	3
Lotus corniculatus	Garden Bird's-foot Trefoil	SNA	---	---	---	1
Maianthemum racemosum	False Solomon's-seal	S5	---	---	4	3
Matricaria chamomilla	German Mayweed or Wild Chamomile	SNA	---	---	---	5
Ostrya virginiana	Eastern Hop-hornbeam	S5	---	---	4	4
Parthenocissus inserta	Thicket Creeper	S5	---	---	3	3
Parthenocissus quinquefolia	Virginia Creeper	S4?	---	---	6	1
Pastinaca sativa	Wild Parsnip	SNA	---	---	---	5
Phalaris arundinacea	Reed Canary Grass	S5	---	---	0	-4
Pinus sylvestris	Scotch Pine	SNA	---	---	---	5
Poa compressa	Canada Bluegrass	SNA	---	---	0	2
Poa pratensis ssp. *angustifolia*	Narrow-leaved Kentucky Bluegrass	SNA	---	---	---	---
Podophyllum peltatum	May-apple	S5	---	---	5	3
Populus nigra cv. Italica	Lombardy poplar (cultivar)	SNA	---	---	---	---
Potentilla recta	Sulphur Cinquefoil	SNA	---	---	---	5
Prunus avium	Sweet Cherry	SNA	---	---	---	5
Prunus serotina	Wild Black Cherry	S5	---	---	3	3
Prunus virginiana	Choke Cherry	S5	---	---	2	1
Quercus rubra	Northern Red Oak	S5	---	---	6	3
Ranunculus acris	Tall Buttercup	SNA	---	---	---	-2
Rhamnus cathartica	Common Buckthorn	SNA	---	---	---	3
Rhus hirta	Staghorn Sumac	S5	---	---	1	5

Scientific Name	Common Names	SRank[15]	SARA[16]	ESA[17]	Coefficient Conservation	Coefficient Wetness
Robinia pseudoacacia	Black Locust	SNA	---	---	---	4
Rosa multiflora	Multiflora Rose	SNA	---	---	---	3
Rosa sp.	Rose species	---	---	---		
Rubus idaeus ssp. *idaeus*	Common Red Raspberry	SNA	---	---	---	5
Rubus occidentalis	Black Raspberry	S5	---	---	2	5
Rumex crispus	Curly Dock	SNA	---	---	---	-1
Salix fragilis	Crack Willow	S4?	---	---	---	-1
Sambucus racemosa ssp. *Pubens*	Red-berried Elderberry	S5	---	---	5	2
Solidago altissima ssp. *altissima*	Eastern Late Goldenrod	S5	---	---	1	3
Solidago canadensis var. *canadensis*	Canada Goldenrod	S5	---	---	1	3
Solidago sp.	Goldenrod species	---	---	---		
Tilia americana	American Basswood	S5	---	---	4	3
Toxicodendron rydbergii	Rydberg's Poison Ivy	S5	---	---	0	0
Tsuga canadensis	Eastern Hemlock	S5	---	---	7	3
Utricularia purpurea	Purple Bladderwort	S4	---	---	10	-5
Vitis riparia	Riverbank Grape	S5	---	---	0	-2

Appendix E

Fluvial Geomorphology Assessment

GeoProcess
RESEARCH ASSOCIATES
Knowledge
Research
Consulting

February 28, 2018

Mr. Daniel Bourassa
Dillon Consulting Limited
1155 North Service Road West
Oakville, ON, L6M 3E3

Re: **Burlington Mobility Hub**

Preliminary Fluvial Geomorphology Assessment Results – Appleby GO Hub

1 Introduction

GeoProcess Research Associates Inc. was retained by Dillon Consulting Limited to conduct a preliminary fluvial geomorphology assessment for several watercourses in the City of Burlington, in support of the Scoped Environmental Impact Study (EIS) for the City's Mobility Hub Planning. The terms of this study were per the revised scoping document provided by AMEC Foster Wheeler in March of 2017.

The objective of this assessment was to provide a preliminary assessment and screening pertaining to the geomorphic resiliency of watercourses located within the Mobility Hub study areas, and to identify reaches that are lacking resiliency, and therefore are potentially sensitive to watershed changes (e.g. changes in land-use and rainfall runoff, etc.). Any reaches deemed highly sensitive to change may warrant additional study (e.g. erosion threshold analyses), per the terms of the scoped EIS.

2 Geomorphic Context

Geomorphic resiliency, or stability, refers to a watercourse's ability to absorb changes to inputting watershed conditions that influence geomorphic processes, such as changes to hydrology or sediment supply, while remaining functional. Rivers are inherently dynamic systems and a stable river may not have zero erosion. Rather, it will achieve a balance between erosion and sedimentation while conveying the water and sediment inputted to the system. This is referred to as a state of quasi-equilibrium. Many factors can influence a river's resiliency including, but not limited to; slope, surficial geology, bed and bank material composition, interaction with floodplain, valley form (confined vs. unconfined), watershed land-use characteristics and proximal or on-line infrastructure (e.g. dams, bridge piers, weirs). The river's existing stability may also influence its continuing ability to absorb change. For example, if a river is already adjusting to a past disturbance, it may be more susceptible to future disturbances (changes). A river in quasi-equilibrium may also have a low resiliency depending on natural factors such as geology. For example, a stable river having sand bed and banks will be less resilient than a bedrock

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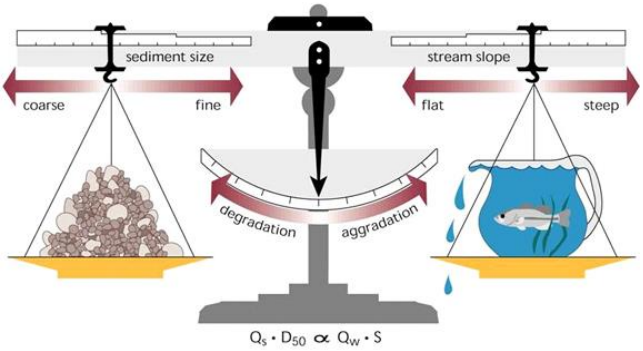
DUNDAS, ON, L9H 6Y6
905.466.6721
www.geoprocessresearch.com

dominated channel. The balance between formative river processes and channel stability is classically illustrated in Lane's diagram, shown in the schematic below.



Lane's (1955) balance scale schematic (from Rosgen, 1996)

3 Study Area

The Study Area consists of areas around the four Burlington Mobility Hubs: Aldershot GO Station, Appleby GO Station, Burlington GO Station and Downtown (Figure 1). The reaches within each mobility hub are indicated in Figures 2-5. These include reaches of:

- Grindstone Creek Tributary;
- Sheldon Creek;
- Appleby Creek;
- Hager Creek;
- Rambo Creek, and;
- Hager-Rambo Channel.

All Mobility Hubs are within the Iroquois Plain physiological region. Here, watercourses transition from the Niagara Escarpment to the relatively flat plains that were the historic location of the Lake Iroquois shoreline. As such, surficial geology ranges from interbedded shale and dolomite bedrock to glaciolacustrine deposits (sandy-clay till) (OGS, 2010). In the northern most areas, closer to the Escarpment transition, rivers have steeper gradients and gradually flatten as they approach Lake Ontario. Descriptions of each watercourse are provided in the Results section.

4 Methods

Reach Delineation

A single river may transition between different morphologies along its course due to changes in geology, slope, valley type, sediment sources, anthropogenic influences or discharge. As such, it is common to separate rivers into segments, or reaches. A reach can range in length, depending on the size and characteristics of the river. However, it should be sufficiently long such that average hydraulic and morphologic characteristics can be confidently estimated. Often, in urban settings, reaches are delineated based on interactions with infrastructure such as bridge crossings or channel erosion protection (e.g. segments entirely lined with gabion baskets). In this assessment, reaches were first delineated based on desktop analyses of planform conditions and further refined after the field investigation, taking into consideration the previously mentioned factors as well as field observations.

Field Assessments

Field assessments were conducted throughout May and June of 2017. Assessments included reconnaissance-level investigations where indicators of channel stability and instability were observed and documented (including GPS locations). Additionally, erosion prone areas were documented, including the extent of channel and valley confinement. Stream and river erosion hazard criteria are governed by Section 3.0 of the Provincial Policy Statement of the *Planning Act*, and are managed locally by Conservation Halton. Erosion hazard (from fluvial processes) identification assists in developing long-term erosion rates and toe erosion setbacks, which differ for different valley types and depend on the river's proximity to the toe of slope. Results from these high-level assessments can be used to identify critical erosion prone reaches that may require more detailed field investigation, and also assist in future land-use planning exercises such as meander beltwidth delineations and erosion hazard setbacks. Detailed, site level erosion hazard delineations were beyond the scope of this study.

A Rapid Geomorphic Assessment (RGA) was conducted for each reach, following the Ministry of Environment (2003) standards. The RGA assesses channel stability in four geomorphic regimes; aggradation, degradation, channel widening and planimetric form adjustment. Each component has several indicators of instability that are itemized on a standardized field form. These indicators were observed (or were omitted from the evaluation if not present) during the field reconnaissance and were noted on the field form. A Stability Index (SI) for each of the four components is obtained by the following formula:

$$SI_i = \frac{IN_{OBS}}{IN_{OBS} + IN_{NOT}}$$

where IN_{OBS} is the number of observed indicators and IN_{NOT} is the number of indicators that were not observed. It should be noted that $IN_{OBS} + IN_{NOT}$ may not always correspond with the total number of indicators for that specific component as there may be some indicators which do not apply to a specific reach. For example, if a reach does not have any storm sewers, then the degradation indicator "Elevated storm sewer outfall(s)" would not be included in either IN_{OBS} or IN_{NOT}. The overall reach Stability Index is obtained by taking the average of the four component's Stability Index.

An SI index between 0 and 0.2 corresponds to a channel in quasi-equilibrium, or "In Regime". This implies that observed instabilities are nominal and associated with normal fluvial processes, being local instances of erosion or deposition and not representative of systemic instability. Values between 0.2 and 0.4 correspond with a channel that is "Transitional or Stressed", implying that evidence of instability is more common. An SI greater than 0.4 corresponds to a channel that is "In Adjustment", meaning that instability is likely systemic (at least reach-wide) and that the channel is shifting to a new state of quasi-equilibrium, likely in response to the adjusting watershed conditions (e.g. likely due to urbanization or past instances of channel alterations).

As mentioned, the current degree of stability relates to a channel's resiliency and ability to absorb additional change (i.e. new stormwater runoff from mobility hub areas). A channel that is currently in adjustment may be more sensitive to additional change, and thus is less resilient. When combined with other field observations such as degree of confinement, ready access to a floodplain and proximity of the channel to the toe of slope, an overall estimate of channel resiliency and sensitivity to change can be established.

Mapping

Results from the field assessments were incorporated into a Geographic Information System (GIS) database to effectively visualise different parameters characterized throughout the assessments.

5 Results

Reach Descriptions

Sheldon Creek

Sheldon Creek within the Study Area (Figure 2) begins downstream of the South Service Road / Highway 403 culvert. Immediately downstream of the culvert, a natural channel design project had previously been undertaken, with the channel consisting of a series of cobble/boulder grade control structures with cobble-lined banks (SHC01). Here, the river is stable and has good access to a floodplain. Downstream, the river cuts through the shale-dolomite bedrock and which maintaining some floodplain access, with indicators of channel widening becoming more prevalent (SHC02). Further downstream, the river becomes more channelized (SHC03) with some instances of structural bank protection in the form of riprap and gabion baskets. At the Harvester Road crossing a weir spans the entire river. Between Harvester Road and the Rail tracks (SHC04), the morphology is similar to SHC03. Downstream of the rail tracks (SHC05), the river again cuts into the shale-dolomite bedrock in a partially confined valley that has intermittent floodplain access. Here, significant indicators of channel widening were present.

Appleby Creek

Downstream of South Service Road / Highway 403, Appleby Creek has two branches (Figure 2). The East branch (APC01B) flows through a confined valley until the confluence with the West branch (APC01A). Both reaches show indicators of active channel adjustment, intermixed with sporadic erosion protection works throughout (riprap, gabion baskets and concrete liners). Downstream of the confluence (APC02) the river cuts through bedrock. There is significant erosion throughout this reach and several historic erosion protection measures have been compromised by bank and bed erosion. Gabion baskets have been undermined and flanked and have fallen in the streambed. Downstream of Harvester Road (APC03), the channel is lined with concrete and gabion baskets, much of which has been rendered ineffective by channel adjustments which remain as debris in the channel. Downstream of the rail tracks (APC04), the channel resumes a more natural planform in a confined valley, cutting through bedrock. Here, channel widening and downcutting processes have resulted in the failure and undermining of much of the erosion protection (gabion baskets) present in this reach.

Rapid Assessment Summary

Figure 3 illustrates the reach characterizations stemming from the RGA results. In addition, valley confinement was mapped and is illustrated in Figure 4. The results for each component of the RGA are summarized in Table 1. A detailed matrix for each field assessment is also presented in Appendix A.

Table 1 Rapid Geomorphic Assessment Results

Reach	Form/Process Factor Value				Stability Index	Classification
	Aggradation	Degradation	Widening	Planimetric Adjustment		
SHC01	0.14	0	0	0	0.04	In Regime
SHC02	0.14	0.25	0.86	0.29	0.38	Transitional or Stressed
SHC03	0	0.14	0.75	0	0.22	Transitional or Stressed
SHC04	0.14	0.44	0.63	0	0.3	Transitional or Stressed
SHC05	0.14	0.6	0.63	0.14	0.38	Transitional or Stressed
APC01A	0.43	0.38	0.88	0.71	0.6	In Adjustment
APC01B	0.43	0.33	0.88	0.71	0.59	In Adjustment
APC02	0.4	0.43	0.33	0.57	0.43	In Adjustment
APC03	0.67	0.33	0.86	0.71	0.64	In Adjustment
APC04	0.14	0.5	0.67	0.71	0.51	In Adjustment

Culvert Inventory

Figure 5 illustrates the locations of outfalls and other similar streambank infrastructure within each reach. A corresponding photo and description of each can be found in Appendix B.

Photographic Record

The photograph locations are shown on the RGA mapping, with locations and images compiled in Google Earth format and available from the following download link:

https://drive.google.com/open?id=1NJbMim4uQuN8OMY40Ke2LjYos_dkQuil

6 Conclusions and Discussion

The restored portion of Sheldon Creek provides good energy dissipation by creating floodplain access. The regraded banks, grade-control structures and cobble/bounder bed/bank material make this reach more resilient insofar as its ability to absorb future change. Downstream, however, the valley becomes more confined and floodplain access is limited. Here, the river is less resilient and previous attempts (many unsuccessful) have been made to mitigate erosion using engineered, structural measures. The bedrock-dominated reaches are more resistant to erosion than are the glaciolacustrine reaches, thus the most downstream (bedrock) reach, although currently exhibiting signs of instability, is expected to adjust at a much slower rate than non-bedrock reaches.

In general, Appleby Creek is in a more degraded state than Sheldon Creek. Much of the previous attempts at erosion mitigation have been compromised by river adjustments, resulting in debris formations within the channel that may be further amplifying erosion and sedimentation processes. The majority of the reach lacks a floodplain connection, instead flowing through channelized, confined corridors.

It should be noted that the Rapid Geomorphic Assessment is intended for channels that still have a natural planimetric shape (i.e. not realigned) and only have minimal channel alterations. Given the heavily modified condition of most of these reaches some of the assessment indicators are not relevant, specifically those in the planimetric adjustment section. However, the assessments were still completed to the typical standards and in such a way to best account for this divergence from the standard procedure. The results of the assessments remain effective indicators of the state of channel equilibrium; however, should be interpreted with the noted limitations in mind.

The reach mapping accompanying this technical memo should be considered within the context of the overall impact assessment and combined with the results of other studies, with the least resilient reaches (those indicated as in-adjustment) shown on the mapping being the focus of future site-level studies related to SWM sizing, outlets and the detailed erosion hazard mapping. It should be noted that the surficial geology mapping in Figure 2 is provided for reference only and may not correspond to the dominant bed and bank material in each reach due to the coarse scale of the mapping. Refer to Appendix A for a summary of reach conditions.

Regards,

GEOPROCESS RESEARCH ASSOCIATES INC.

Jeffrey Hirvonen, MASc.
Principal, Fluvial Geomorphologist

Legend

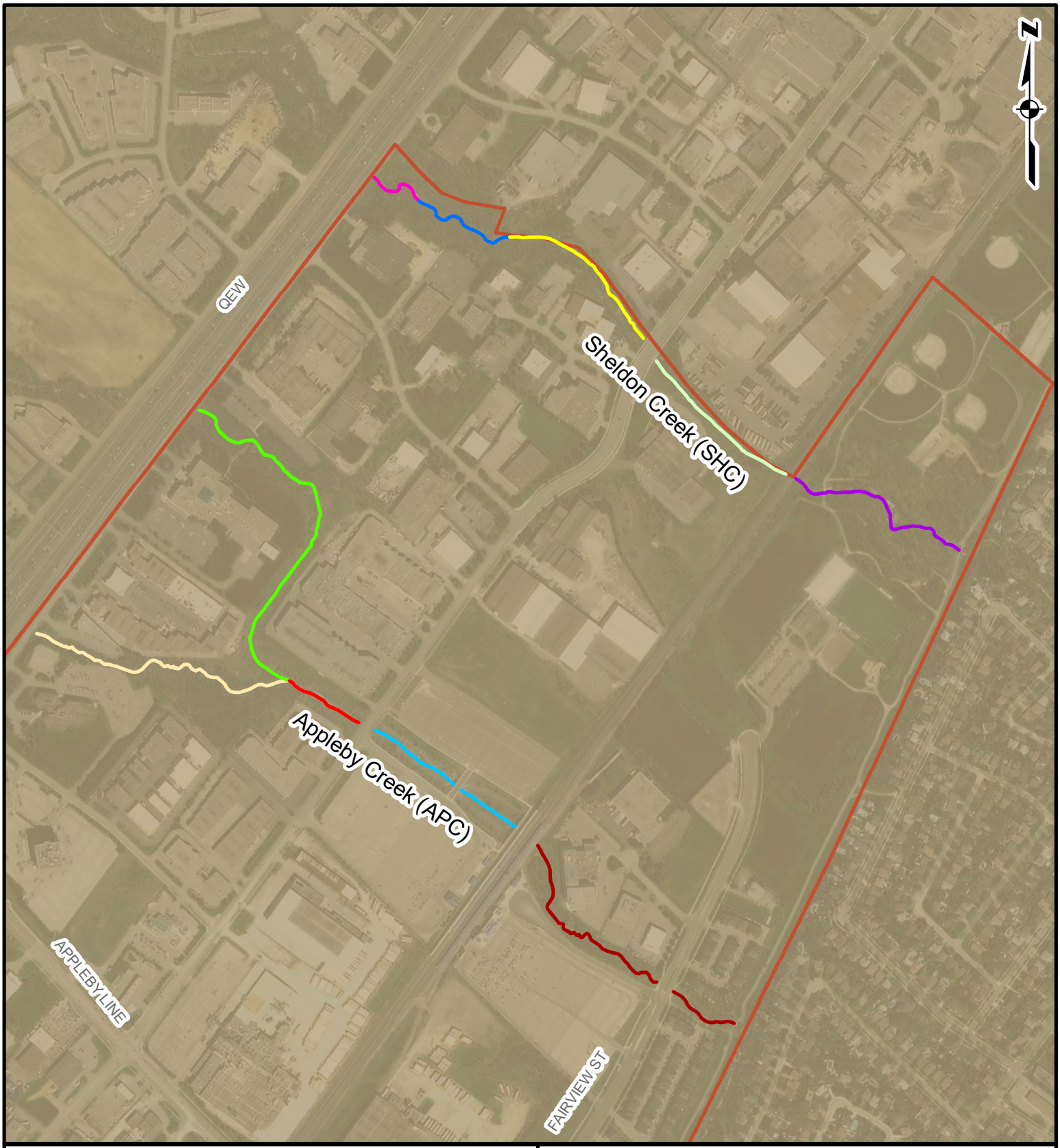
- Aldershot GO Hub Study Area
- Appleby GO Hub Study Area
- Burlington GO Hub Study Area
- Downtown Hub Study Area
- Watercourse
- Ponds

GeoProcess RESEARCH ASSOCIATES

Scale: 0 625 1,250 2,500 Meters

Title: **P2017-237 Mobility Hub Study Site Overview**

Created By:	MI	Checked By:	BP
Date:	2018-01-17	Figure:	1



Legend

- APC01A
- APC01B
- APC02
- APC03
- APC04
- SHC01
- SHC02
- SHC03
- SHC04
- SHC05
- Study Area
- Bedrock

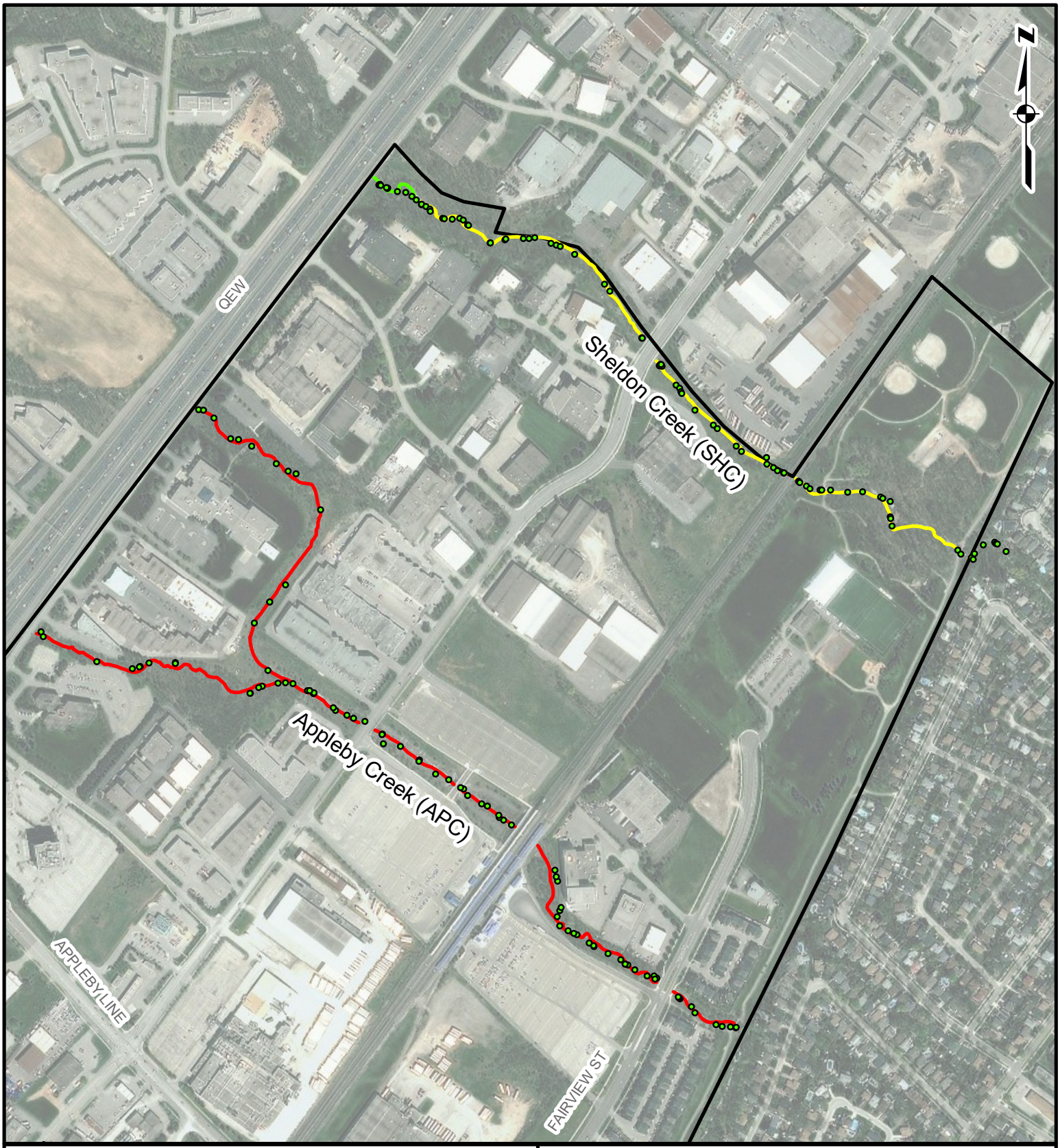
Ontario Geological Survey 2010. Surficial geology of southern Ontario; Ontario Geological Survey, Miscellaneous Release - Data 128 - Revised.

GeoProcess RESEARCH ASSOCIATES

Scale: 0 100 200 400 Meters

Title: **P2017-237 Appleby GO Hub Reach Delineation**

Created By:	**MI**	Checked By:	**BP**
Date:	**2018-01-17**	Figure:	**2**



Legend

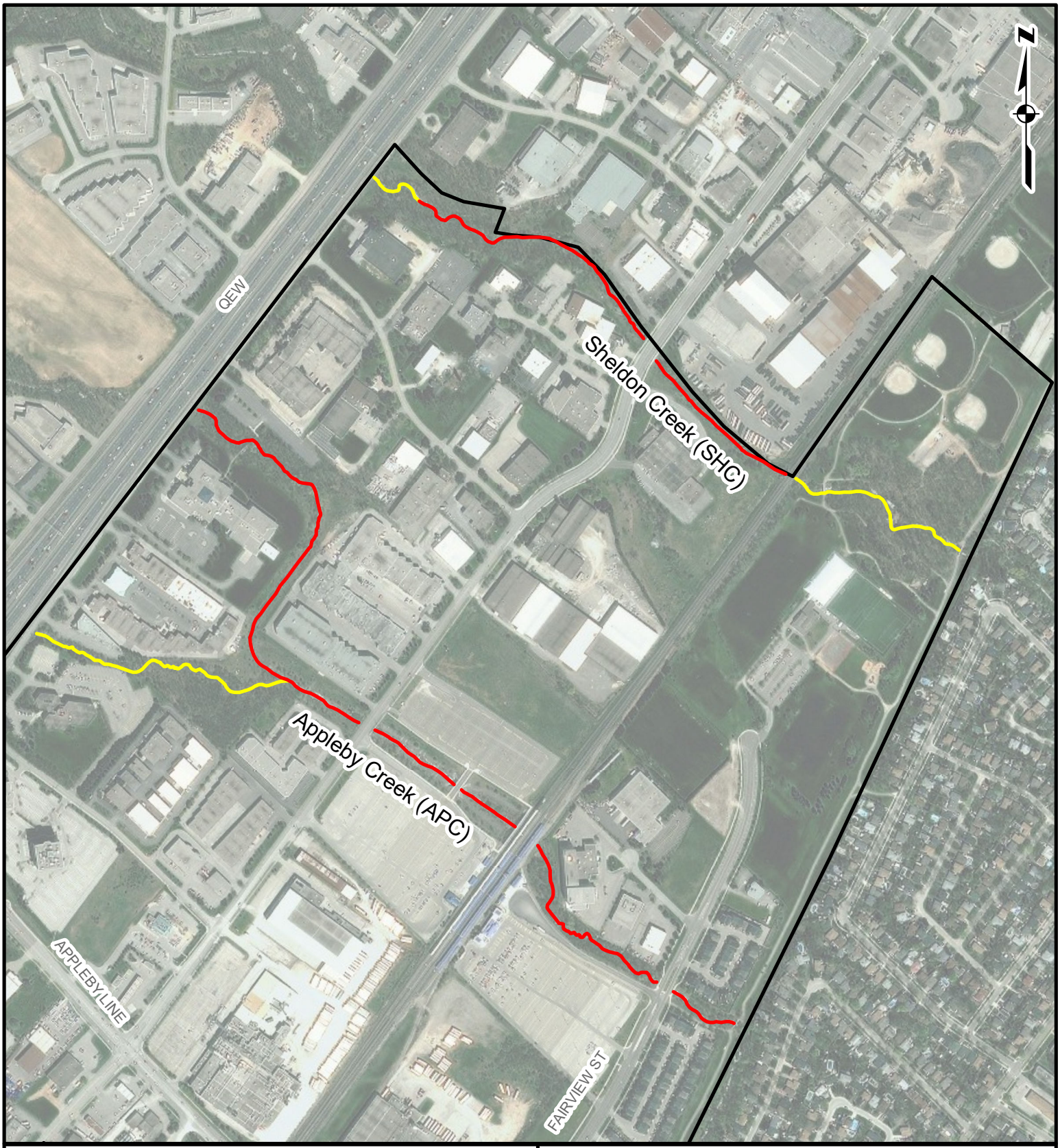
- In Regime
- Transitional or Stressed
- In Adjustment
- GRA Photo
- Study Area

GeoProcess RESEARCH ASSOCIATES

Scale: 0 100 200 400 Meters

Title: **P2017-237 Appleby GO Hub Rapid Assessment Summary**

Created By:	MI	Checked By:	BP
Date:	2018-01-17	Figure:	3



Legend

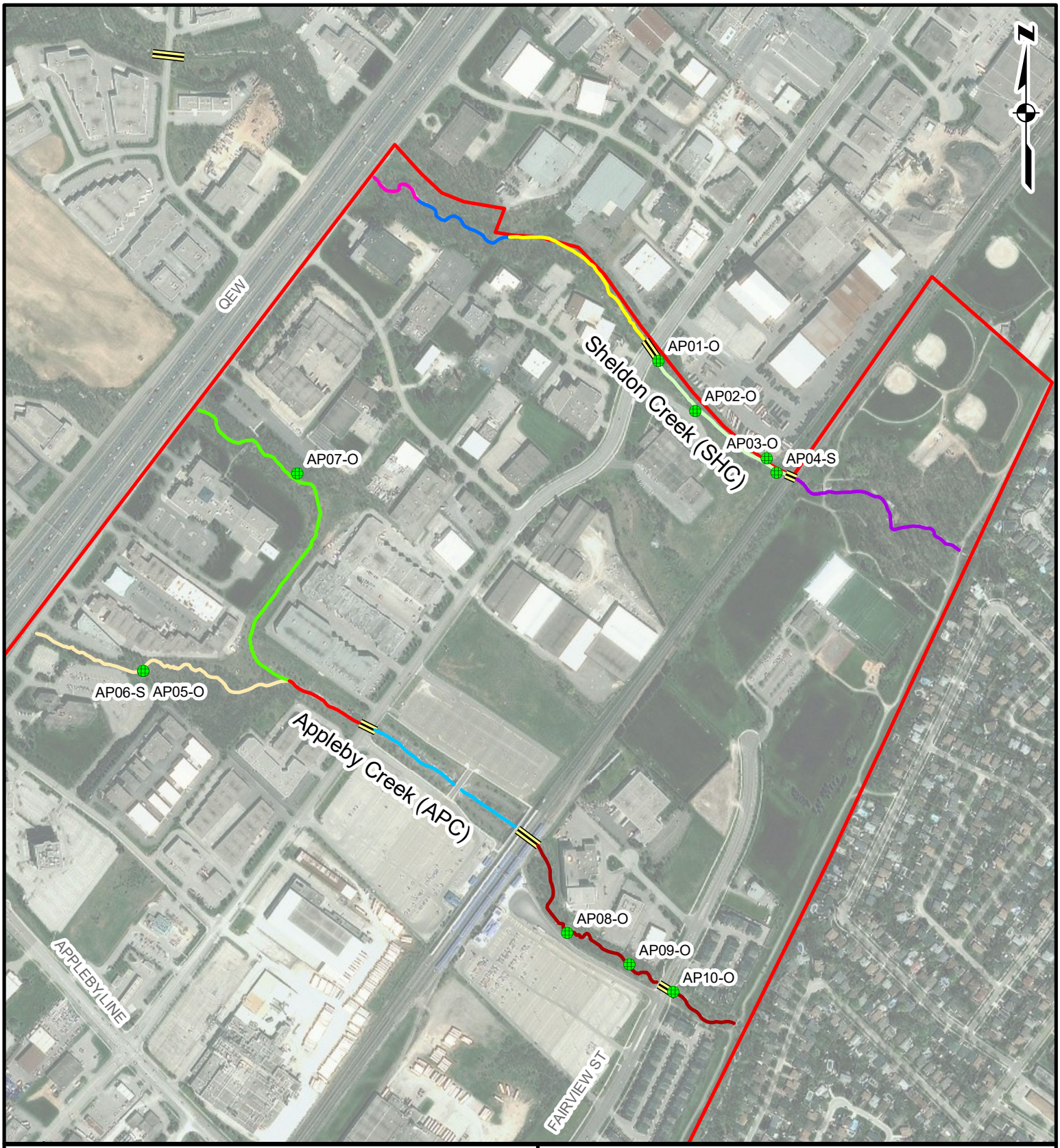
- Confined
- Semi-Confined
- Study Area

GeoProcess RESEARCH ASSOCIATES

Scale: 0 100 200 400 Meters

Title: **P2017-237 Appleby GO Hub Valley Confinement**

Created By:	MI	Checked By:	BP
Date:	2018-01-17	Figure:	4



Legend

- APC01A
- APC01B
- APC02
- APC03
- APC04
- SHC01
- SHC02
- SHC03
- SHC04
- SHC05
- Outfall Structure
- Culvert Structures
- Study Area

GeoProcess RESEARCH ASSOCIATES

Scale: 0 100 200 400 Meters

Title: **P2017-237 Appleby GO Hub Outfall Locations**

Created By:	MI	Checked By:	BP
Date:	2018-01-24	Figure:	5

Appendix A

Detailed Assessment Summary Table

Table 2 Burlington Mobility Hub - Detailed Assessment Summary Table – Appleby GO Hub

Reach	Dominant Morphology	Dominant Bank Material	Dominant Bed Material	Floodplain Access?	Erosion Protection Present?	Valley Confinement	Valley Toe Contact?	RGA Score	RGA Description	Dominant Instability
SHC01	Step-pool	Cobble/Boulder	Cobble / boulder	Yes	Natural channel design	Semi-Confined	No	0.04	In Regime	N/A*
SHC02	Riffle-pool	Shale/Dolomite	Sand / gravel	Partial	No	Confined	Yes	0.38	Transitional or Stressed	Widening
SHC03	Channelized - Step-pool	Sandy-clay till	Gravel / cobble	No	Gabion / riprap (partial)	Confined	Yes	0.22	Transitional or Stressed	Widening
SHC04	Channelized - Riffle-pool	Sandy-clay till	Sand / gravel	No	Gabion / riprap (partial)	Confined	Yes	0.3	Transitional or Stressed	Widening, Degradation
SHC05	Bedrock	Shale with till overburden	Shale / Dolomite	Partial	Gabion / riprap (partial)	Semi-Confined	Yes	0.38	Transitional or Stressed	Widening, Degradation
APC01A	Channelized - Riffle-pool	Sandy-clay till	Sand / gravel with bedrock outcrop	Partial	Gabion / riprap (partial)	Semi-Confined	Yes	0.6	In Adjustment	Widening
APC01B	Channelized - Riffle-pool	Sandy-clay till	Sand / gravel with bedrock outcrop	No	Gabion / riprap / concrete (partial)	Confined	Yes	0.59	In Adjustment	Widening
APC02	Channelized - Bedrock	Shale with till overburden	Gravel / cobble with bedrock outcrop	No	Gabion / riprap / concrete (partial)	Confined	Yes	0.43	In Adjustment	All
APC03	Channelized	Riprap	Concrete	No	Gabion / riprap / concrete	Confined	Yes	0.64	In Adjustment	All
APC04	Riffle-pool	Gabion, Shale	Gravel / cobble	No	Gabion / riprap (partial)	Confined	Yes	0.51	In Adjustment	Widening

*due to recent channel erosion revetments

Appendix B

Infrastructure Inventory

Name:	AP01-O
Area:	Appleby
Watercourse:	Sheldon Creek
Reach:	SHC04
Coordinates:	E600611.396, N4804471.828
Reach Assessment Result:	Transitional or Stressed
Description:	Bridge headwall with dual gated outfalls

Name:	AP02-O
Area:	Appleby
Watercourse:	Sheldon Creek
Reach:	SHC04
Coordinates:	E600664.736, N4804399.649
Reach Assessment Result:	Transitional or Stressed
Description:	Concrete headwall

Name:	AP03-O
Area:	Appleby
Watercourse:	Sheldon Creek
Reach:	SHC04
Coordinates:	E600768.876, N4804330.434
Reach Assessment Result:	Transitional or Stressed
Description:	Concrete wall with gated outfall

Name:	AP04-S
Area:	Appleby
Watercourse:	Sheldon Creek
Reach:	SHC04
Coordinates:	E600782.423, N4804309.902
Reach Assessment Result:	Transitional or Stressed
Description:	Concrete culvert

Name:	AP05-O
Area:	Appleby
Watercourse:	Appleby Creek
Reach:	APC01A
Coordinates:	E599866.398, N4804023.152
Reach Assessment Result:	In Adjustment
Description:	Concrete headwall with gated outfall

Name:	AP06-S
Area:	Appleby
Watercourse:	Appleby Creek
Reach:	APC01A
Coordinates:	E599866.398, N4804023.152
Reach Assessment Result:	In Adjustment
Description:	Utility pole

Name:	AP07-O
Area:	Appleby
Watercourse:	Appleby Creek
Reach:	APC01B
Coordinates:	E600089.231, N4804308.797
Reach Assessment Result:	In Adjustment
Description:	Concrete headwall with PVC pipe

Name:	AP08-O
Area:	Appleby
Watercourse:	Appleby Creek
Reach:	APC04
Coordinates:	E600479.725, N4803643.257
Reach Assessment Result:	In Adjustment
Description:	Concrete headwall, apron with baffle blocks, and gated outfall

Name:	AP09-O
Area:	Appleby
Watercourse:	Appleby Creek
Reach:	APC04
Coordinates:	E600570.011, N4803598.093
Reach Assessment Result:	In Adjustment
Description:	Concrete headwall

Name:	AP10-O	
Area:	Appleby	
Watercourse:	Appleby Creek	
Reach:	SHC04	
Coordinates:	E600632.956, N4803558.485	
Reach Assessment Result:	Transitional or Stressed	
Description:	Concrete bridge headwall with dual gated outfalls	

Appendix F

Flood Hazard and Scoped Stormwater Management Assessment

Flood Hazard and Scoped Stormwater Management Assessment

Appleby GO Mobility Hub
Burlington, Ontario
Project TPB178008

Prepared for:

City of Burlington
426 Brant Street, Burlington, ON L7R 3Z6

1/16/2019

Flood Hazard and Scoped Stormwater Management Assessment

Appleby GO Mobility Hub
Burlington, Ontario
Project TPB178008

Prepared for:

City of Burlington
426 Brant Street, Burlington, ON L7R 3Z6

Prepared by:

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

1/16/2019

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1.0 Introduction

The City of Burlington is undertaking a land use planning study for four (4) Mobility Hub areas. These are areas as located around major transit hubs within the City (Appleby GO, Burlington GO, Aldershot GO, and the Downtown) where re-development and intensification are expected. In support of this planning effort (lead by Brook McIlory Inc), the consulting team's ecologist, Dillon Consulting Limited (Dillon), is preparing a series of Scoped Environmental Impact Studies (EIS) for each of the four (4) hubs. The purpose of the Scoped EIS is to document existing environmental conditions, and assess potential environmental impacts and mitigation strategies related to the expected development and re-development in these areas.

In support of this effort, Wood Environment & Infrastructure Solutions (Wood) is preparing a series of flood hazard and scoped stormwater management assessments for each of the four (4) hubs. These documents are intended to define existing flood hazards for areas of anticipated development, and to also develop preliminary stormwater management strategies, including reviewing drainage infrastructure service capacity, where feasible and required.

The current report is focused on one (1) of the four (4) Mobility Hub areas, specifically the Appleby GO Mobility Hub. Drawing 1 presents the boundaries of the Appleby GO Mobility Hub study area along with the area watercourses and existing stormwater management (flood control) facilities.

Ultimately, the analyses documented within the current report are intended to provide context with respect to the overall flood risk to the Appleby GO Mobility Hub, and the potential implications to the proposed intensification development in these areas.

This report is intended to serve as a primary component of the overall Scoped Environmental Impact Study (EIS) reporting. In addition, the current reporting also includes the Scoped Stormwater Management (SWM) criteria assessment

2.0 Hydrology

2.1 Available Modelling

The Appleby Mobility Hub Area (Drawing 1) intersects a number of different watersheds (ref. Drawing 3). These watersheds and available sources of hydrologic modelling are summarized in Table 2.1 (as per Table B, Scoped EIS Work Plan (updated April 25, 2017).

Table 2.1 Available Hydrologic Modelling – Appleby GO Mobility Hub

Watershed	Study Date and Reference	Modelling Platform
Shoreacres Creek	Shoreacres Creek Floodplain Mapping Updates (EWRG, 1997)	GAWSER
Appleby Creek	Appleby Creek Floodline Mapping Updates (EWRG, 1997)	GAWSER
Sheldon Creek	Sheldon Creek Hydrologic and Hydraulic Study – DRAFT (Amec Foster Wheeler, 2016)	HSP-F

As evident from Table 2.1, the available hydrologic modelling is a mixture of GAWSER (Shoreacres and Appleby Creeks) and HSP-F (Sheldon Creek). It is also noted that the most current hydrologic modelling for Sheldon Creek remains in "Draft" form (as of the time of writing), as it is has not been formally approved by Conservation Halton. Nevertheless, as the most current available hydrologic modelling (and the one proposed as part of the Work Plan Terms of Reference), this modelling has been employed for the current assessment.

2.2 Hydrologic Modelling Updates

2.2.1 Existing Land Use Parameterization

In order to develop a consistent approach to the estimation of flows under existing land use conditions, a consistent land use layer has been employed for all hydrologic models.

The City of Burlington has provided two different sources of land use mapping (Official Plan Mapping and Zoning Bylaw mapping). These mapping data have been reviewed, and ultimately the Zoning Bylaw mapping has been considered to be most representative of current conditions, and more readily useable for hydrologic modelling purposes. This mapping has been updated as required, including merging certain land use classifications, and adding separate distinctions as required (in particular, differentiating between more recent and intense detached residential areas, as opposed to older, less intense residential areas). The resulting land use mapping is presented in Drawing 2.

Imperviousness for these land use areas has been estimated using current aerial photography, with spot checks for three (3) different sub-areas for each land use classification, in order to estimate an average value. For detached residential areas, directly and indirectly connected areas have been estimated based on rooftop downspout connectivity (as evident from Google Earth™ and field review). Table 2.2 presents the resulting land use classifications and associated estimated imperviousness values.

Table 2.2 Estimated Land Use Characterization and Parameterization for Appleby GO Mobility Hub		
Land Use Classification	**Total Imperviousness (%)**	**Directly Connected Imperviousness (%)**
Apartment Buildings	60%	60%
High Density Detached	60%	30%
Low Density Detached	40%	20%
Downtown High Density	60%	60%
Downtown Low Density Residential	35%	15%
High Impervious	90%	90%
Institutional	60%	60%
Park/Corridor	10%	10%
Semi Detached and Town Homes	60%	60%
Roadways	90%	90%

Based on the foregoing parameterization, an average overall impervious coverage of 69% +\- results for the existing drainage areas within the Appleby Mobility Hub Limit. The modelling updates have resulted in an increase of the impervious coverage from the original modelling (which had an average impervious coverage of approximately 35% +/-). This likely reflects less conservative imperviousness assumptions associated with older vintage hydrologic modelling.

Drawings 3 and 4 present the drainage area boundaries for the Appleby Mobility Hub area, and also depict key hydrologic nodes (locations) of interest based on the flows generated from the updated hydrologic modelling.

In addition to the preceding, it is noted that the older previously completed hydrologic assessments (Shoreacres and Appleby Creek – 1997) used the available IDF data of that time (to generate 3-Hour Chicago Design storms), which has generally since been superseded by more current/extensive datasets (GAWSER is capable of continuous hydrologic simulation, but this is beyond the current scope of work). As part of this assessment, the more current City of Burlington IDF data (2004 update) has been applied, along with an analysis of a number of different design storm distributions to determine the most critical. Based on this analysis, the 24-Hour SCS Type II distribution has been selected based on the generally highest simulated flows within the receiving watercourse systems, and for consistency with the previously completed work for the Burlington and Downtown Mobility Hubs (ref. November 30, 2017 memorandum). Note that a sensitivity analysis was completed as part of the assessment of those areas, and ultimately determined that the 24-Hour SCS Type II distribution was the most conservative rainfall distribution.

The Sheldon Creek watershed was previously modelled using a continuous simulation methodology. The Sheldon Creek HSP-F model has hence been updated to simulate the 24-Hour SCS Type II design storm distribution as per the Scoped EIS Work Plan, and for consistency with the other completed watershed analyses.

2.2.2 GAWSER Modelling (Shoreacres and Appleby Creeks)

2.2.2.1 Overview

The Guelph All-Weather Sequential-Events Runoff (GAWSER) modelling program has been applied historically in the Shoreacres Creek and Appleby Creek watersheds. The GAWSER model has multiple methods for calculating subcatchment runoff, which apply variations of main channel and off channel routing of runoff through the subcatchment. The main channel section represents the overall hydraulic routing through the subcatchment, while the off channel represents the smaller drainage paths which lead

to the main channel. The subcatchment length and width parameters are based on the length of the main channel and off channels, respectively.

A review of the lengths and width parameters applied in the 1997 EWRG models determined that for Appleby Creek the subcatchments have a length to width ratio of 7:1 or 3:1. Subcatchment Length (L), Width (W), and Main Channel Travel Time (TMC) have been revised for the discretized subcatchments using the methodology described in the GAWSER User Manual. The GAWSER User Manual Appendix A describes TMC as a linear function of length and flow velocity. The TMC has been estimated based on length weighting assuming the flow velocities within the discretized subcatchments remain the same from the parent catchments.

The Environmental Water Resources Group (EWRG) models have applied 'Model 4' which was been built for urban subcatchment modelling using two off channels to represent the pervious component and the impervious components of the subcatchment. The 'Model 4' parameter requires time of concentration for the main channel (TMCI) and both of the off channels (TOCi and TOCp). A review of the EWRG model parameterization determined that, other than imperviousness and soil composition, the remaining subcatchment parameters can be defined as follows:

- Time of Concentration Impervious Off Channel (TOCi) is set to 0.067 hours
- Time of Concentration Pervious Off Channel (TOCp) is set to:
  - 0.25 hours for urban subcatchments
  - 0.42 for rural subcatchments
  - And 0.48 for subcatchments A7, A7.1 and A7.2 in Appleby Creek
- Base Time (FTB) and Base Time Impervious (FTBi) are set to:
  - 1.2 for urban subcatchments
  - 2.0 for rural subcatchments

The subcatchment area discretization for Appleby Creek and Shoreacres Creek was updated in 2007 by the City of Burlington and utilized in the Urban-Area Flood Vulnerability, Prioritization and Mitigation Study completed by Amec Foster Wheeler (now Wood) in July 2017 (Burlington City-Wide Flood Study). The subcatchment areas were compared with the reported and modelled values from the 1997 EWRG Studies using GIS tools. The review determined that several areas no longer matched the local topography and adjustments to the subcatchment delineation were made to conform to the current topographic contour mapping. For example, West Appleby Creek has been realigned through subcatchment A18 (refer to Drawings 3 and 4). Furthermore, the updated 2007 subcatchment delineation showed area differences when compared to the 1997 reported values. The modelled subcatchments within the Appleby GO Mobility Hub boundary have been updated to match the GIS areas, as well as subcatchments where area differences are greater than 5% (+/-). In order to maintain flows which are comparable to the approved hydrologic models, subcatchments with area changes of less than 5% have retained the original 1997 drainage areas.

The runoff procedures in GAWSER utilize a subcatchment discretization method which considers impervious area as an alternative soil type. The EWRG model divided the soils into hydrologic soil groups A, B, C, and D which is typical of the SCS methodology, however the soil groups have been further discretized into 'high vegetative cover' and 'low vegetative cover'. A review of the available soils mapping (Soil Survey Complex, MNRF 2012) determined that the soils throughout the Appleby Mobility Hub are similar in composition to the soils used for the 1997 Study. Therefore, in order to maintain consistency with the approved model, the relative soil compositions from the pervious component of the parent subcatchments have been retained for the updated modelling.

For example, if the parent catchment was fifty percent (50 %) impervious thirty percent (30 %) Soil Group A and twenty percent (20 %) Soil Group B; then the updated subcatchment with sixty percent (60 %) impervious coverage would have a soil composition of twenty four percent (24 %) for Soil Group A and sixteen percent (16 %) for Soil Group B, i.e.:

Parent Subcatchment:	50 % Impervious	30 % Soil Group A	20 % Soil Group B
Pervious Component:		60 % Soil Group A	40 % Soil Group B
Updated Subcatchment:	60 % Impervious	24 % Soil Group A	16 % Soil Group B

The impervious coverages for the study area subcatchments have been calculated by applying the land use classifications discussed in Section 2.2.1. The subcatchment main channel time of concentration parameter was determined through 'length' weighting of the parent subcatchments to provide a reasonable comparison of flows to the approved modelling.

2.2.2.2 Shoreacres Creek

As noted previously, drainage areas have been updated based on more currently available data. A comparison of the modelled drainage areas for Shoreacres Creek is presented in Table 2.3.

Table 2.3 Shoreacres Creek – Subcatchment Drainage Area Comparison

Subcatchment[1]	Previously Reported Drainage Area (EWRG, 1997) (ha)	Previously Modelled Drainage Area (EWRG, 1997) (ha)	Updated Drainage Area (Wood, 2018) (ha)	Difference versus Model (ha)	Difference versus Model (%)
S22	26.0	26.0	26.0	0.0	0.0
S21	43.0	43.0	-	-	-
S22.1	8.1	8.1	8.1	0.0	0.0
S20	57.0	57.0	-	-	-
S19	138.0	138.0	138.0	0.0	0.0
S18	86.0	86.0	86.0	0.0	0.0
S17	31.0	31.0	31.0	0.0	0.0
S15	56.0	56.0	56.0	0.0	0.0
S14	9.6	9.6	9.6	0.0	0.0
S13	88.0	88.0	88.0	0.0	0.0
S12	-	-	29.6	-	-
S12.1	-	-	24.7	-	-
S12	**48.0**	**56.0**	**54.3**	**-1.7**	**-3.0**
S11	27.0	27.0	27.0	0.0	0.0
S10	16.0	16.0	16.0	0.0	0.0
S9	21.0	21.0	21.0	0.0	0.0
S8	37.0	37.0	37.0	0.0	0.0
S7	91.0	91.0	91.0	0.0	0.0
EX5	23.0	23.0	23.0	0.0	0.0
EX4	19.0	19.0	15.0	-4.0	-21
EX3	8.6	8.6	8.6	0.0	0.0
S6	20.0	20.0	35.8	+15.8	+79
S5.3	18.0	18.0	24.0	6.0	33
S5.2	5.4	5.4	5.4	0.0	0.0
S5.1	28.0	28.0	28.0	0.0	0.0

Table 2.3	Shoreacres Creek – Subcatchment Drainage Area Comparison				
Subcatchment[1]	**Previously Reported Drainage Area (EWRG, 1997) (ha)**	**Previously Modelled Drainage Area (EWRG, 1997) (ha)**	**Updated Drainage Area (Wood, 2018) (ha)**	**Difference versus Model (ha)**	**Difference versus Model (%)**
S5	12.0	12.0	12.0	0.0	0.0
S4	33.0	33.0	33.0	0.0	0.0
S4.4	-	-	22.1	-	-
S4.5	-	-	10.4	-	-
S4.6	-	-	9.7	-	-
S4.7	-	-	26.8	-	-
S4.4	**69.0**	**69.0**	**69.0**	**0.0**	**0.0**
S4.3	10.0	10.0	13.7	+3.7	+37
S3.2	26.0	26.0	26.0	0.0	0.0
S3.1	2.3	2.3	2.3	0.0	0.0
S3	86.0	86.0	86.0	0.0	0.0
S2	15.0	15.0	15.0	0.0	0.0
S1.3	14.0	14.0	14.0	0.0	0.0
S1.1	5.7	5.7	5.7	0.0	0.0
S1.	53.0	53.0	53.0	0.0	0.0
A6.1	-	-	20.0	-	-
A6.2	-	-	10.3	-	-
A6	**42.0**	**42.0**	**45.3**	**+3.3**	**+7.9**
TOTAL	**1,230.7**	**1,238.7**	**1,258.4**	**+19.8**	**+1.6**

1. Subcatchments denoted using underlines have been split in the updated modelling and area comparisons are noted in the following row of bolded values

In addition to the preceding, a review completed by Wood noted that updates were also required to reflect an area currently under construction in Shoreacres Creek (subcatchment S12). Subcatchments S12 and S12.1 within Shoreacres Creek were updated based on "Alton West Subdivision Pond Stormwater Management Report Draft Plan of Subdivision 24T-03003/B Sundial Homes" (Counterpoint Engineering Inc, October 5, 2016). The model has been updated using a lumped catchment approach with subcatchment S12.1 modelled as 29.6 ha at 73 % impervious coverage and S12 modelled as 24.7 ha at 30% impervious coverage. The residential areas (S12.1) were routed through the Alton West Pond which has a storage-discharge relationship as presented in Table 2.4.

Updated subcatchment parameterization, using the methodology described in Section 2.2.2.1, is presented in Table 2.5.

Table 2.4 Alton West Pond Storage Discharge Relationship	
Storage (m^3)	**Discharge (m^3/s)**
0	0
8,042	0.10
10,922	0.13
12,167	0.23
13,272	0.45
14,144	0.63
15,045	0.83
15,276[1]	0.88
16,804[2]	11.18

1. Storage and flow values from appendix C of Counterpoint Engineering 2016 Report
2. Flow value is referenced in Appendix C of Counterpoint Engineering 2016 Report, storage volume has been assumed as 10% greater than 100-year storage.

Table 2.5 Shoreacres Creek Updated Subcatchment Parameters				
Updated Subcatchment (Wood, 2018)			**Parent Subcatchment (EWRG, 1997)**	
Subcatchment	**TMCi**	**Imperviousness (%)**	**Subcatchment**	**Imperviousness (%)**
S4.3	0.053	65.5	S4.3	53.0
S4.4	0.029	58.1	S4.4	42.0
S4.5	0.013	30.6		
S4.6	0.012	50.7		
S4.7	0.031	62.0		
S12	0.090	73.0	S12.1	2.0
S12.1	0.076	30.2		

2.2.2.3 Appleby Creek

As noted previously, drainage areas have been updated based on more currently available data. A comparison of the modelled drainage areas for Appleby Creek is presented in Table 2.6.

Table 2.6 Appleby Creek – Subcatchment Drainage Area Comparison					
Subcatchment[1]	**Previously Reported Drainage Area (EWRG, 1997) (ha)**	**Previously Modelled Drainage Area (EWRG, 1997) (ha)**	**Updated Drainage Area (Wood, 2018) (ha)**	**Difference versus Model (ha)**	**Difference versus Model (%)**
A24	1.60	1.60	1.60	0.00	0.0
A23	55.00	55.00	62.03	+7.03	+12.8
A22	47.00	47.00	47.00	0.00	0.0
A21	14.00	14.00	14.00	0.00	0.0
A20	18.00	18.00	22.79	+4.79	+26.6
A18	44.00	44.00	50.67	+6.67	+15.1
A17.1	25.00	25.00	23.21	-1.79	-7.2
A17	-	-	25.9	-	-
A17.2	-	-	5.87	-	-
A17	**36.00**	**36.00**	**31.77**	**-4.23**	**-11.8**
A16	197.00	197.00	197.00	0.00	0.0

Table 2.6 Appleby Creek – Subcatchment Drainage Area Comparison					
Subcatchment[1]	**Previously Reported Drainage Area (EWRG, 1997) (ha)**	**Previously Modelled Drainage Area (EWRG, 1997) (ha)**	**Updated Drainage Area (Wood, 2018) (ha)**	**Difference versus Model (ha)**	**Difference versus Model (%)**
A15	68.00	68.00	68.00	0.00	0.0
A13.0	4.20	4.20	43.00	-	-
A13.1	58.00	58.00	16.69	-	-
A13.5	-	-	0.61	-	-
A13	**62.20**	**62.20**	**60.30**	**-1.90**	**-3.1**
A12	49.00	49.00	49.00	0.00	0.0
A11	55.00	55.00	66.17	+11.17	+20.3
A10	37.00	37.00	37.00	0.00	0.0
A9	38.00	38.00	39.00	+1.00	+2.6
A8	13.00	13.00	13.00	0.00	0.0
A7	29.00	29.00	15.54	-	-
A7.1	31.00	31.00	51.66	-	-
A7.2	36.00	36.00	36.69	-	-
A7	**96.00**	**96.00**	**103.9**	**+7.90**	**+8.2**
A6	-	-	20.85	-	-
A6.3	-	-	0.90	-	-
A6.4	-	-	10.36	-	-
A6.5	-	-	13.21	-	-
A6	**42.00**	**42.00**	**45.32**	**+3.32**	**+7.9**
A6.1	-	-	19.99	-	-
A6.2	-	-	10.28	-	-
A6.1	**34.00**	**34.00**	**30.27**	**-3.73**	**-11.0**
A4.1	27.00	27.00	26.99	-0.01	0.0
A5	-	-	6.34	-	-
A5.1	-	-	30.34	-	-
A5.2	-	-	22.50	-	-
A5	**55.00**	**55.00**	**59.18**	**+4.18**	**+7.6**
A3	47.00	36.00	36.00	0.00	0.0
A2.1	35.00	35.00	35.00	0.00	0.0
A2	38.00	38.00	38.00	0.00	0.0
A1.2	18.00	18.00	18.00	0.00	0.0
EX1	2.50	2.50	2.50	0.00	0.0
A1.3	5.10	5.10	5.10	0.00	0.0
A1.0	31.00	31.00	31.00	0.00	0.0
TOTAL	**1190.4**	**1179.4**	**1212.7**	**+33.3**	**+2.8**

1. Subcatchments denoted using underlines have been split in the updated modelling and area comparisons are noted in the following row of bolded values

In addition to the preceding, a review completed by Wood noted that subcatchments representing Alton Village required updating to match the as-built conditions in Appleby Creek (subcatchment A13). The Appleby Creek subcatchment A13 in the EWRG model (1997) has been updated to include the Alton Village development from the "Rotary Pond Stormwater Management Pond Detailed Design Brief" (Counterpoint Engineering Inc. March, 2005). The stormwater management applied in the SWMHYMO modelling completed by Counterpoint included lot level controls for the employment lands which control the 100-

year post development flows to the 5-year pre-development peak flow. The residential drainage areas are controlled by a stormwater management facility (Rotary Pond) located upstream of Dundas Street. The Appleby Creek model has been updated with a 43 ha subcatchment (A13) at 61% impervious coverage to represent the residential developments, which is then routed through the Rotary Pond. The storage-discharge relationship for the Rotary Pond is presented in Table 2.7. The portions of subcatchment A13 which do not contribute to the Rotary Pond have been lumped by their outlets at Dundas Street into subcatchments A13.1 and A13.5 (ref. Drawing 3).

Table 2.7 Rotary Pond Storage Discharge Relationship

Storage (m^3)	Discharge (m^3/s)
0	0
3,656	0.115
18,202	0.264
20,402	0.278
24,000[1]	5.5

1. Overflow storage and flow values were contained in the SWMHYMO model inputs in Appendix A of Counterpoint Engineering Design Brief.

Updated subcatchment parameterization, using the methodology described in Section 2.2.2.1, is presented in Table 2.8.

Table 2.8 Appleby Creek Updated Subcatchment Parameters

Updated Subcatchment (Wood, 2018)			Parent Subcatchment (EWRG, 1997)	
Subcatchment	**TMCi**	**Imperviousness (%)**	**Subcatchment**	**Imperviousness (%)**
A24	0.054	78.0	A24	0.0
A17	0.151	66.6	A17	56.0
A17.2	0.071	56.3		
A13.0	0.089	61.0	A13	0.0
A13.1	0.097	25.0		
A13.5	0.022	78.0		
A7	0.122	56.5	A7	30.0
A7.1	0.565	48.1		4.0
A7.2	0.407	59.2		4.0
A6	0.032	60.6	A6	51.0
A6.3	0.018	34.7		
A6.4	0.045	54.6		
A6.5	0.058	47.5		
A6.1	0.063	66.1	A6.1	54.0
A6.2	0.048	79.5		
A5	0.009	45.8	A5	54.0
A5.1	0.042	45.8		
A5.2	0.027	49.4		

2.2.3 HSP-F Modelling (Sheldon Creek)

As noted in Table 2.1, a hydrologic modelling update for Sheldon Creek was conducted recently (2016) by Amec Foster Wheeler (Wood), using the HSP-F modelling platform. The study, and associated modelling remain in "draft" form (as of the time of writing), pending approval by Conservation Halton. Notwithstanding, as the most current available hydrologic modelling (and the one proposed as part of the Work Plan Terms of Reference), this modelling has been employed for the current assessment.

Reference is made to "Sheldon Creek Hydrologic and Hydraulic Study – DRAFT" (Amec Foster Wheeler, 2016) for further details on model development. Given the recent updates to the modelling, additional updates have been limited to adjustments to the existing land use imperviousness for the study area in order to ensure consistency with other areas.

The drainage boundaries for Sheldon Creek were updated as part of the Sheldon Creek Hydrologic and Hydraulic Study and where applicable were matched with the watershed boundary as defined by Conservation Halton. It is understood that although the overall Sheldon Creek Study remains in "draft" form, the subcatchment and watershed boundaries have been accepted by Conservation Halton and have therefore been used to match the watershed boundary of the eastern Appleby Creek subcatchments.

The uncalibrated subcatchment parameters have been applied for the Regional Storm Event as per the direction of Conservation Halton [ref. December 21, 2017 meeting with Amec Foster Wheeler (Wood) and the City and Burlington for the Sheldon Creek Hydrologic and Hydraulic Study (ref. Meeting Summary by Wood, January 30, 2018)]. The model revisions do not incorporate any drainage boundary changes discussed with Conservation Halton as part of the Sheldon Creek Hydrologic and Hydraulic Study. In order to maintain consistency in the analyses the design storm event has been simulated using the uncalibrated subcatchment parameters.

The subcatchment boundaries for the Sheldon Creek watershed were retained from the June 2016 Study and the impervious coverage values were updated for subcatchments 104 and 105 which are within the Appleby Mobility Hub boundary. Subcatchment 105 increased from 80.0 % impervious coverage to 82.9 % impervious coverage. Subcatchment 104 increased from 31.3 % impervious coverage to 42.4 % impervious coverage. The increases in impervious percentage are attributed to the separation of roads from the surrounding land use types as well as the 10 % impervious coverage assumed for park lands in the Mobility Hub study. The Appleby Mobility Hub is located within approximately 42.3 ha of the Sheldon Creek watershed with a total impervious coverage of 49.0 %.

2.3 Hydrologic Modelling Results

2.3.1 GAWSER Modelling (Shoreacres and Appleby Creek)

2.3.1.1 Shoreacres Creek

Updated simulated flows for key watercourse nodes in Shoreacres Creek are presented in Tables 2.9 and 2.10 for the 100-year storm event and for the Regional Storm, respectively; refer to Drawings 3 and 4 for node locations.

Table 2.9 Shoreacres Creek – 100-Year 24-Hour SCS Type-II Storm Event Flows					
Node	Current Drainage Area[1] (ha)	Location	100-Year Storm Peak Flow (m^3/s)		
			Original (EWRG, 1997)	Updated[2] (AFW, 2018)	Difference
619	255	Headon Road -West Tributary	17.2	17.2	0.0
615	311	Walker's Line - West Tributary	21.0	21.0	0.0
611	169	Walker's Line - East Tributary	10.1	11.0	+0.9
609	561	Upper Middle Rd - East Tributary	35.0	35.3	+0.3
608	598	CNR - East Tributary	35.9	36.3	+0.4
607	689	QEW	38.0	38.4	+0.4
651	824	Harvester Rd.	44.1	44.1	0.0
6101	31.7	Fairview Street	-	7.6	-
641	1,011	Centennial Bikeway	52.3	51.7	-0.6
601	1,246	Lake Ontario	71.6	71.8	+0.2

1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling.
2. Includes all current modelling updates noted.

Table 2.10 Shoreacres Creek – Regional Storm Event Flows					
Node	Current Drainage Area[1] (ha)	Location	Regional Storm Peak Flow (m^3/s)		
			Original (EWRG, 1997)	Updated[2] (AFW, 2018)	Difference
619	255	Headon Road -West Tributary	24.5	24.5	0.0
615	311	Walker's Line - West Tributary	30.4	30.4	0.0
611	169	Walker's Line - East Tributary	16.2	16.8	+0.6
609	561	Upper Middle Rd - East Tributary	54.7	55.7	+1.0
608	598	CNR - East Tributary	57.8	59.1	+1.3
607	689	QEW	66.2	68.2	+2.0
651	824	Harvester Rd.	79.5	81.7	+2.2
6101	31.7	Fairview Street	-	4.44	-
641	1,011	Centennial Bikeway	96.1	98.7	+2.6
601	1,246	Lake Ontario	118.0	120.0	+2.0

1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling.
2. Includes all current modelling updates noted.

The results for the 100-year storm event (Table 2.9) include SWM facilities in place; results for the Regional Storm Event (Table 2.10) also include SWM facilities, as the SWM facilities are not required to be removed (as per comments from CH, April 20, 2018) as updated floodplain mapping for Shoreacres Creek is not required.

A sensitivity test was performed for the Regional Storm Event to determine whether the 12-hour event (using zero depression storage) or the 48-hour event (allowing depression storage) produced the greater flow at the outlet. The results of the sensitivity test indicated that the 48 hour storm event produced the higher outflow and therefore the results from this scenario have been presented for Shoreacres Creek.

Both the 100-year storm event results presented in Table 2.9 and the Regional Storm Event results presented in Table 2.10 indicate generally consistency with earlier modelling with relatively minor increases in simulated peak flows for the locations presented under the updated (2018) modelling. This primarily reflects the increased imperviousness for the Mobility Hub study area associated with the updated land use

(Drawing 2). In addition, as noted previously, both watersheds also indicate a small increase in overall drainage area based on the hydrologic modelling updates. Overall, the updated peak flow results are generally comparable to those from the previous studies.

2.3.1.2 Appleby Creek

Updated simulated flows for key watercourse nodes in Appleby Creek are presented in Tables 2.11 and 2.12 for the 100-year storm event and for the Regional Storm, respectively; refer to Drawings 3 and 4 for node locations.

Table 2.11 Appleby Creek – 100-Year 24-Hour SCS Type-II Storm Event Flows

Node	Current Drainage Area[1] (ha)	Location	100-Year Storm Peak Flow (m^3/s)		
			Original (EWRG, 1997)	Updated[2] (AFW, 2018)	Difference
West Branch					
820	139.6	CN (Halton) - West Branch	17.5	18	+0.5
818	190.3	Appleby Line - West Branch	19.8	20.7	+0.9
857	239.4	U/S QEW -West Branch	21.4	24.1	+2.7
817	245.3	West Branch U/S Confluence with East Branch	22.8	24.5	+1.7
East Branch					
813	325.2	Dundas - East Branch	19.6	19.1	-0.5
810	483.3	CN (Halton) - East Branch	25.2	24.8	-0.4
808	534.3	Appleby Line North of Mainway- East Branch	26.9	28.3	+1.4
507	51.4	U/S QEW - East Branch	2.7	4.31	+1.6
807	637.9	East Branch Appleby Ck u/s confluence with West Branch	31.9	34.4	+2.5
Main Branch					
8101	904.1	Harvester Rd.	-	59.7	-
8102	905.0	Between Harvester Rd and Appleby Rd	-	59.7	-
826	928.6	CN (Oakville)	57	61.1	+4.1
8105	965.2	U/S Fairview Street	-	62.4	-
8106	995.5	D/S Fairview Street	-	64.1	-
8107	1018.0	Centennial Bikeway	-	65.1	-
828	1018.0	U/S Pinedale Avenue	61.5	65.0	+3.5
805	1045.0	D/S Pinedale Avenue	63.0	66.8	+3.8
801	1219.4	Lake Ontario	71.3	74.5	+3.2

1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling.
2. Includes all current modelling updates noted.

Table 2.12 Appleby Creek – Regional Storm Event Flows					
Node	Current Drainage Area[1] (ha)	Location	Regional Storm Peak Flow (m^3/s)		
			Original (EWRG, 1997)	Updated[2] (AFW, 2018)	Difference
WEST BRANCH					
820	139.6	CN (Halton) - West Branch	17.2	17.8	+0.6
818	190.3	Appleby Line - West Branch	22.1	23.4	+1.3
857	239.4	U/S QEW -West Branch	24.9	29.2	+4.3
817	245.3	West Branch U/S Confluence with East Branch	28.8	29.9	+1.1
EAST BRANCH					
813	325.2	Dundas - East Branch	30.5	50.5	+20.0
810	483.3	CN (Halton) - East Branch	43.6	63.7	+20.1
808	534.3	Appleby Line North of Mainway-East Branch	48.5	68.3	+19.8
507	51.4	U/S QEW - East Branch	3.2	5.7	+2.5
807	637.9	East Branch Appleby Ck u/s confluence with West Branch	57.4	73.3	+15.9
MAIN BRANCH					
8101	904.1	Harvester Rd.	-	97.9	-
8102	905.0	Between Harvester Rd and Appleby Rd	-	98.0	-
826	928.6	CN (Oakville)	86.4	100.0	+13.6
8105	965.2	U/S Fairview Street	-	103.0	-
8106	995.5	D/S Fairview Street	-	106.0	-
8107	1018.0	Centennial Bikeway	-	109.0	-
828	1018.0	U/S Pinedale Avenue	95.5	109.0	+13.5
805	1045.0	D/S Pinedale Avenue	97.3	111.0	+13.7
801	1219.4	Lake Ontario	112.0	125.0	+13.0

1. Based on updated (2018) subcatchment boundaries; this may differ slightly from previous modelling.
2. Includes all current modelling updates noted.

The results for the 100-year storm event (Table 2.11) include SWM facilities in place; the results for the Regional Storm Event (Table 2.12) have SWM facilities removed, as per Provincial Policy for floodplain mapping (Section 3.3.1).

A sensitivity test was performed for the Regional Storm Event to determine whether the 12-hour event (using zero depression storage) or the 48-hour event (allowing depression storage) produced the greater flow at the outlet. The results of the sensitivity test indicated that the 48 hour storm event produced the higher outflow and therefore the results from this scenario have been presented for Shoreacres Creek.

The 100-year storm event results presented in Table 2.11 indicate generally consistency with previous modelling with relatively minor increases in simulated peak flows for the locations presented under the updated (2018) modelling. This primarily reflects the increased imperviousness for the Mobility Hub study area associated with the updated land use (Drawing 2). The Regional Storm Event results presented in Table 2.12 indicate larger increases (>10%) in the simulated flow which is considered attributable to the removal of stormwater management facilities from the model. In addition, as noted previously both watersheds also indicate a small increase in overall drainage area based on the hydrologic modelling updates. Overall, the updated peak flow results are generally comparable to those from the previous studies.

2.3.2 HSP-F Modelling (Sheldon Creek)

Updated simulated flows for key watercourse nodes in Sheldon Creek are presented in Tables 2.13 and 2.14 for the 100-year storm event and for the Regional Storm, respectively; refer to Drawings 3 and 4 for node locations.

The SCS Curve number methodology does not apply to HSP-F modelling and therefore the soil conditions were maintained for the Regional Storm Event. Furthermore, the HSP-F modelling platform does not use a depression storage parameter which can be altered for simulating the 12 hour Regional Storm Event. Therefore, the 48 hour event has been simulated for the Sheldon Creek watershed. SWM facilities have also been removed from the Regional Storm Event simulation (both the original and updated modelling).

Table 2.13 Sheldon Creek – 100-Year Continuous Simulation and 24-Hour SCS Type-II Design Storm Event Flows

Node	Current Drainage Area[1] (ha)	Location	100-Year Storm Peak Flow (m^3/s)		
			Calibrated Continuous	Uncalibrated Design Storm[2]	Difference
106.1	879	QEW / Highway #403	28.0	30.9	+2.9
105.1	953	CN Railway	34.5	43.3	+8.8
104.1	1,073	New Street	35.3	45.5	+10.2
103.1	1,140	Burloak Drive	37.7	47.9	+10.2
102.1	1,166	Upstream of Confluence with East Branch	33.8	47.2	+13.4
101.1	1,771	Lake Ontario	54.0	70.5	+16.5

1. Based on updated (2018) subcatchment parameterization; this may differ slightly from previous modelling. Does not include drainage boundary changes discussed with Conservation halton as part of the Sheldon Creek Hydrology and Hydraulics Study.
2. Includes all current modelling updates noted.

Table 2.14 Sheldon Creek – Regional Storm Event Flows

Node	Current Drainage Area[1] (ha)	Location	Regional Storm Peak Flow (m^3/s)		
			Original	Updated[2]	Difference
106.1	879	QEW / Highway #403	87.5	87.5	0
105.1	953	CN Railway	95.7	95.7	0
104.1	1,073	New Street	105.3	105.5	+0.2
103.1	1,140	Burloak Drive	108.9	109.1	+0.2
102.1	1,166	Upstream of Confluence with East Branch	109.0	109.2	+0.2
101.1	1,771	Lake Ontario	166.3	166.6	+0.3

1. Based on updated (2018) subcatchment parameterization; this may differ slightly from previous modelling. Does not include drainage boundary changes discussed with Conservation halton as part of the Sheldon Creek Hydrology and Hydraulics Study.
2. Includes all current modelling updates noted.

As discussed in Section 2.2.3, the Regional Storm Event and 100-year design storm event have been simulated using the uncalibrated subcatchment parameterization. Given that the previous simulation of the 100-year event (continuous simulation) employed calibrated modelling, an increase in peak flows is to be expected, as presented in Table 2.13. The use of a design storm (as opposed to continuous simulation) may also yield some flow increases, although further assessment would be required to confirm this finding.

The results of the Regional Storm simulation by contrast yield very little difference, given the use of the uncalibrated modelling in both cases. The results indicate that the hydrologic modelling updates for the Appleby GO Mobility Hub (existing conditions) have minimal impact on the flows through the Sheldon Creek watershed.

3.0 Hydraulics

3.1 Available Hydraulic Modelling

As noted previously, the Appleby Mobility Hub Area (Drawing 1) intersects three (3) watersheds (Drawing 3). Notwithstanding, while a portion of the Shoreacres Creek watershed lies within the study area, the creek itself does not. As such, hydraulic modelling (HEC-RAS) is required only for the remaining two (2) watercourses, as summarized in Table 3.1. This is also consistent with the Scoped EIS Work Plan (updated April 25, 2017 – ref. Table C).

Table 3.1 Available Hydraulic Modelling – Appleby GO Mobility Hub

Watershed	Study Date and Reference	Modelling Platform
Appleby Creek	Floodline Mapping Update (EWRG, 1997)	HEC-2
	Appleby Creek Flood Study EA (Aquafor Beech, 2018)	HEC-RAS
Sheldon Creek	Hydrologic and Hydraulic Study – DRAFT (Amec Foster Wheeler, 2016)	HEC-RAS

3.2 Hydraulic Modelling Updates

3.2.1 Appleby Creek

As part of the Appleby Creek Floodplain Mapping Update Study (EWRG, 1997) a HEC-2 hydraulic model was developed. The Appleby Creek HEC-RAS model was subsequently updated as part of "Urban-Area Flood Vulnerability, Prioritization and Mitigation Study" (Amec Foster Wheeler, July 2017). This modelling has been applied for the current study, and includes recent updates to the modelling beyond the Appleby GO Mobility Hub study limit along Bridle Wood (ref. Flood Vulnerable Area 7). Furthermore, the modelling along Bridle Wood has been superceded by the HEC-RAS modelling completed recently as part of the City of Burlington's Flood Study EA for Appleby Creek (Aquafor Beech, 2018).

As part of this study, the Appleby Creek hydraulic model has been further refined through the Appleby GO Mobility Hub study area to reflect the existing topography and hydraulic structures. The cross sections in the Appleby Creek HEC-RAS model have been compared to the City of Burlington's 2015 DEM for consistency. The comparison determined that the cross sections upstream of Harvester Road adequately matched the current topography and therefore updates have been limited to adding additional cross sections for hydraulic structures and adjusting Manning's roughness coefficients where applicable. The cross sections downstream of the railway tracks have been determined to no longer match the current topography and therefore cross sections 3100, 3010, 2960, 2860, 2842, 2839, 2810, and 2780 have been updated to match the City of Burlington's 2015 DEM (refer to Drawing 5).

The original Appleby Creek model did not incorporate the two northern most railway tracks as part of the hydraulic structure. As such, additional sections have been incorporated at the upstream face of the CN Railway tracks and the twin box culverts have been extended in the model. It has been noted that there is also a pedestrian foot bridge parallel with the railway tracks connecting the overflow parking lot for the Appleby GO Station. The footbridge has not been modelled, as the twin box culverts represent the more constraining structure through this reach.

A new hydraulic structure between cross sections 3298 and 3296 on (Drawing 5) has been incorporated into the model which reflects the roadway crossing which connects the Appleby GO Station parking lot to the overflow parking lot. A field investigation determined that the hydraulic structure is an 11.0 m x 3.4 m concrete arch. In addition, cross sections have been added to the HEC-RAS model to support the HEC-RAS methodology of defining hydraulic structures with four (4) cross sections (two (2) upstream and two (2)

downstream). Flow change locations have been placed outside of the four cross sections which define the hydraulic structures.

As noted, the of City of Burlington has recently undertaken a Flood Study EA for Appleby Creek (Aquafor Beech, 2018) to further investigate potential flooding in the area of Bridle Wood identified in the 2017 Burlington City-Wide Flood Study. The existing conditions HEC-RAS model has been provided by the City of Burlington to incorporate into the hydraulic modelling for the current study (ref. Appendix D). The HEC-RAS model has been updated by inserting the EA model downstream of Fairview Street (i.e. downstream of cross section 2809). The first cross section representing the EA model is cross section 2787.644. All cross sections downstream of this location have been maintained from the EA modelling. The flow change locations have been updated to incorporate the flows from the GAWSER modelling as described in Section 2. Updated flow change locations and values are presented in Table 3.2. Regional Storm Peak Flows have SWM facilities removed, as per Provincial Policy.

The cross sections through the Appleby GO Mobility Hub study area were required to be reversed to match the orientation of the EA cross sections (due to HEC-2 methodology being maintained in the previous version). The cross sections upstream of the QEW have been maintained as per the original HEC-2 orientation as they are beyond the limits of the current study. The cross sections upstream of the QEW should however be revised in future studies to match standard HEC-RAS cross-section orientation, which has been employed within the study limits.

Drawing 5 presents the hydraulic modelling cross-sections for the study area, which extend from north of the North Service Road to Bridle Wood at the south, and covers the extents of Appleby Creek within the Appleby GO Mobility Hub boundary.

Table 3.2 Appleby Creek – Flow Change Locations

Node	HEC-RAS Station	Reach	100 Year Storm Peak Flow (m^3/s)	Regional Storm Peak Flow (m^3/s)
		East Branch		
817	4589	East Tributary at Appleby Line	24.5	29.9
		West Branch		
807	15710	West Tributary at Appleby Line	34.4	73.3
		Main Branch		
8101	3590	Confluence of East and West Tributary	59.7	97.9
8102	3370	Main Branch D/S of Harvester Rd	59.7	98
826	3290	Main Branch U/S of CNR Track	61.1	100
8105	3100	Main Branch D/S of CNR Track	62.4	103
8107	2787.644	Main Branch D/S of Fairview St	65.1	109
803	1979.323	Main Branch D/S of Pinedale Ave	68.5	115
802	1533.912	Main Branch D/S of New St	72.4	121
801	759.6343	Main Branch D/S of Spruce Ave	74.5	125

3.2.2 Sheldon Creek

An updated hydraulic model (HEC-RAS) for Sheldon Creek was most recently developed as part of "Sheldon Creek Hydrologic and Hydraulic Study – DRAFT" (Amec Foster Wheeler, 2016). This report remains in draft as of the time of writing; the hydraulic modelling developed for this study has not been formally approved or endorsed by Conservation Halton. Notwithstanding, as per the Scoped EIS Work Plan, this modelling is the most currently available and is to be applied for the development of estimated floodplains for the current study. Given the recent vintage of the modelling, no modifications have been required to support the current study.

Drawing 6 presents the hydraulic modelling cross-sections for the study area, which extend from the North Service Road to Riverside Drive, and covers the extents of Sheldon Creek within the Appleby GO Mobility Hub boundary.

The flow change locations (Table 3.3) have been updated, and uncalibrated flows have been simulated from Lake Ontario to upstream of the QEW for both the Main Branch and East Branch to establish a hydraulic profile through the study area. As noted previously, the 100-year (design storm) results include SWM facilities, while the Regional Storm Event results exclude them, as per Provincial Policy. The next upstream flow change locations (beyond the study limits) have been set as a duplicate of the most upstream values presented in Table 3.3, in order to provide a conservative upstream hydraulic profile. Beyond these limits all other flow change locations have been set to a value of 1 m3/s to indicate the values have not been updated. Based on Wood's review, these locations are sufficiently distant from the study area so as not to impact results.

Table 3.3 Sheldon Creek – Flow Change Locations

Node	HEC-RAS Station	Reach	100 Year Storm Peak Flow (m^3/s)	Regional Storm Peak Flow (m^3/s)
East Branch				
203.1	4100	QEW to CN Railway	18.4	34.3
202.1	2699.999	CN Railway to New Street	46.8	48.0
201.1	1000	New Street to Confluence	35.5	53.9
Main Branch				
106.1	6342.364	Mainway to QEW	30.9	87.5
105.1	4929.197	QEW to CN Railway	43.3	95.7
104.1	4100	CN Railway to New Street	45.5	105.5
103.1	2681.999	New Street to Burloak Drive	47.9	109.1
102.1	1764.328	Burloak Drive to Confluence	47.2	109.2
101.1	1010.096	Confluence to Lake Ontario	70.5	166.6

3.3 Hydraulic Modelling Results

3.3.1 Appleby Creek

As noted in Section 2.3.1.1 (Table 2.9), in general the 100-Year Storm flows have increased slightly compared to the original modelling for the Appleby Creek watershed through the study area, whereas the Regional Storm Event flows (Table 2.10) have increased by approximately 10% through the study area. The simulated flooding extents for the 100-year storm event and the Regional Storm Event are depicted on Drawing 5.

The Appleby Creek HEC-RAS model indicates overtopping of the hydraulic structures at Harvester Road and Fairview Street for the Regional Storm Event, and spill to the east and west of the CNR crossing (but not overtopping) for the Regional Storm Event. The extents of the CN Railway spill have increased from those predicted in the original modelling due to the increased flows, and the topographic updates incorporated into the current model. A review of the City's 2015 DEM determined that a higher elevation exists for the top of rail elevation than was employed in the previous hydraulic modelling. Based on the updated modelling, two areas of spill are indicated upstream of the railway crossing, both east and west of the Appleby GO station. Further assessment, potentially including 2-dimensional (2D) modelling would be required to more definitively confirm the spill extents in this area.

The developed floodplain mapping of Appleby Creek has identified several parcels as being within the limits of the riverine floodplain. These areas are indicated on Drawing 5, and include:

- 5050 South Service Road on the Appleby Creek West Branch
- 952 Century Drive on the Appleby Creek East Branch
- 5155 Harvester Road on the Appleby Creek Main Branch
- 5195 Harvester Road on the Appleby Creek Main Branch
- 5150 and 5180 Harvester Road (North Appleby GO Station Parking Lots)
- 740 Oval Court on the Appleby Creek Main Branch
- 720 Oval Court on the Appleby Creek Main Branch
- 5135 Fairview Street on the Appleby Creek Main Branch
- 5111 Fairview Street (South Appleby GO Station Parking Lot)

In general, only a portion of the above-noted properties appear to be impacted by the identified riverine floodplain extents. Notwithstanding, as per Provincial and Conservation Halton policies, no re-development would be permitted within identified riverine floodplain limits.

In addition to the preceding, spill upstream of the CNR has the potential to impact parcels adjacent to the Appleby GO parking areas; these parcels would potentially include the following (although as noted, further assessment would be required to definitively confirm the limits of spill):

- 821 Appleby Line
- 5100 Harvester Road
- 5110 Harvester Road
- 5200 Harvester Road
- 5230 Harvester Road

The most vulnerable area appears to be the Appleby GO Station north parking lots, where the majority of the southern portion of the site is encompassed by the estimated floodplain. The lots are impacted by both the Regional Storm Event and the 100-year storm event. Spill from this area under both events (but primarily the Regional Storm Event), does have the potential to impact adjacent properties as noted above. Further hydraulic assessment (likely 2D modelling) would be required to confirm the flood risk limits from spills more definitively.

Although beyond the limits of the Appleby GO Mobility Hub, it is noted that there is a flood risk to the houses along Bridle Wood, which was identified in the "Urban-Area Flood Vulnerability, Prioritization and Mitigation Study" (Amec Foster Wheeler, July 2017). Although this area is outside of the study area, it is understood that it is a known flood risk to the City of Burlington and has been included in the floodplain mapping on Drawing 5 to reinforce the downstream constraints. It is the understanding of Wood that the hydraulic modelling completed as part of the Appleby Creek Flood Study EA (Aquafor Beech, 2018) has determined the extents of the spill at Bridle Wood. Notwithstanding, the updated GAWSER generated Regional Storm Flows in the current study are approximately 10% higher than those used in the EA modelling. Furthermore, the EA modelling was generated using Conservation Halton's 2002 DEM, and therefore the cross section topography in the model is inconsistent with the Region of Halton's 2015 DEM, which has been applied for the floodline mapping in this study.

3.3.2 Sheldon Creek

As noted in Section 2.3.2 (Tables 2.13 and 2.14), in general the Regional Storm Event flows have increased slightly compared to the original modelling for the Sheldon Creek watershed through the study area.

The 100-year return period flows from the updated design storm modelling have been utilized for floodplain mapping to be consistent with the remainder of the study. The 100-year floodlines depicted on Drawing 6 will differ from those presented in the "Sheldon Creek Hydrologic and Hydraulic Study – DRAFT" (Amec Foster Wheeler, 2016) which was prepared using continuous simulation frequency flows for the 100-year storm event.

The simulated flooding extents for the 100-year frequency flows and the Regional Storm Event are depicted on Drawing 6. The Sheldon Creek HEC-RAS model indicates that the Regional Storm Floodplain is generally confined to the channel block area. Notwithstanding, some existing parcels are indicated as being within the limits of the estimated riverine floodplain (refer to Drawing 6):

- 5355 Harvester Road
- 5300 Harvester Road

Only a portion of the above-noted properties appear to be impacted by the identified riverine floodplain extents. Notwithstanding, as per Provincial and Conservation Halton policies, no re-development would be permitted within identified riverine floodplain limits.

Harvester Road is also indicated as being overtopped for the Regional Storm Event based on the updated hydraulic modelling. The cross sections upstream and downstream of the structure however indicate confinement to the channel, however current topographic data for the roadway suggest that the road elevation is somewhat lower and would be overtopped and that flow over the road would re-enter the channel to the south and west of the crossing at Harvester Road.

Notwithstanding, a review of the topographic contours at Harvester Road suggests that any spill at this location would likely be directed back towards the channel. It is possible that the overtopping of Harvester Road could impact the property of 5300 Harvester Road; however a further assessment (and likely through 2D modelling) would be required to confirm this definitively, which is beyond the scope of the current study.

4.0 Stormwater Management

4.1 Planned Development

The currently proposed land use plans for the Appleby Mobility Hub are included in Appendix A. A precinct plan has been developed (May 2018), which separates the overall Appleby Mobility Hub into several sub-areas with common features. The Appleby Mobility Hub precincts are largely Urban Employment or General Employment lands with an area denoted as Appleby GO Central and Fairview Frequent Transit Corridor located south of the CNR Tracks. The area south of Fairview Street will remain Mid-Rise Residential and Sherwood Forest Park is to be maintained as open space.

The preceding is unlikely to result in significant revised land use types for the Appleby Mobility Hub. The northern portion of the study area currently consists of employment lands, while the southern limits include existing residential development. The ultimate land uses expected under "Fairview Frequent Transit Corridor" and "Appleby GO Corridor" may potentially result in revised land usage, however from a hydrologic perspective, significant changes to impervious coverage would not be expected. Figure 4.1 presents the identified remaining greenspace/undeveloped areas (>0.5 ha +\-) within the Appleby GO Mobility Hub (not including creek corridors and Sherwood Forest Park, which would not be expected to change based on the precinct plan).

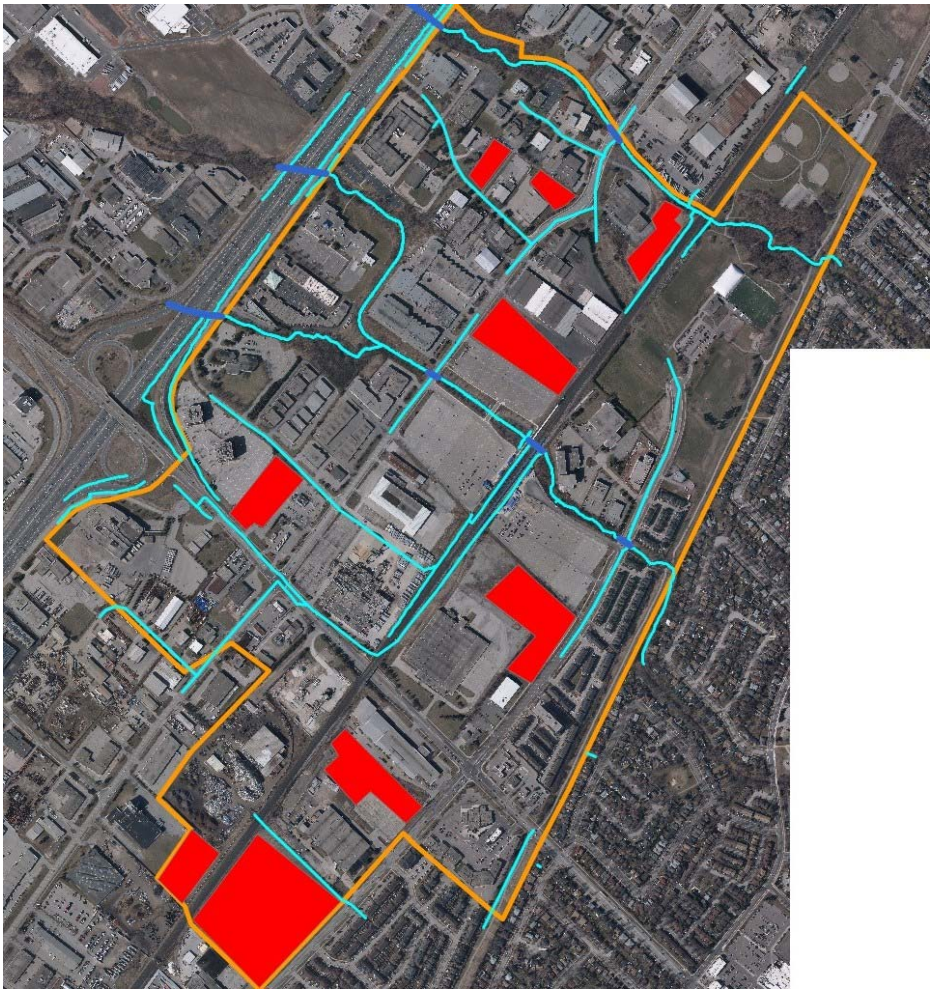


Figure 4.1: Appleby GO Mobility Hub and Existing Pervious Areas

A total of 16.62 ha of such pervious/undeveloped areas has been identified (out of the total Appleby GO Mobility Hub area of 207.4 ha).

- Shoreacres Creek (8.82 ha)
  - 834 Appleby Line (1.11 ha)
  - 4415 Fairview Street (5.85 Ha)
  - 4445 Fairview Street (1.86 ha)
- Appleby Creek (5.92 ha)
  - 5051 Fairview Street (1.32 ha)
  - 747 Appleby Line and 5091 Fairview Street (2.38 ha)
  - 5200 Harvester Road (2.22 ha)
- Sheldon Creek (1.88 ha)
  - 955 Century Drive (0.49 ha)
  - 905 Century Drive (0.45 ha)
  - 5300 Harvester Road (0.94 ha)

In general, the preceding areas reflect undeveloped portions of existing employment land sites. There are two parcels (4415 Fairview Street and 5200 Harvester Road) which are entirely currently open space/undeveloped. The property at 4415 Fairview Street is generally noted as "Fairview Frequent Transit Corridor", however the precinct plan also indicates a Proposed Park (> 1 ha). The property at 5200 Harvester Road is noted as "Urban Employment", however has a similar notation regarding a Proposed Park (> 1 ha). It is therefore uncertain how much of these sites would potentially urbanize, and what portion would remain greenspace/parkland. These two (2) sites represent approximately half of the identified remaining greenspace/pervious area within the Appleby GO Mobility Hub, as such opportunities to maintain greenspace and pervious areas, potentially in conjunction with an overall SWM strategy, should be further explored at the next stages of planning and design.

From a hydrologic/impervious coverage perspective, the changes, if these parcels were to become fully impervious, are relatively minor. As per Drawing 2, the majority of the existing area where re-development is anticipated, have been assessed as high impervious (90%) or institutional-industrial (60%). The exception is the two previously noted undeveloped sites, which have been assessed as park-natural corridor; however as noted larger proposed parks are currently proposed for these areas. The remaining identified pervious areas represent a minority (4% +\-) of the overall Mobility Hub area. Given existing impervious coverages, it is further considered unlikely that estimated values would be notably altered by re-development. Notwithstanding, expected changes in land coverage should be considered as part of the proposed stormwater management (SWM) strategy, as discussed further in Section 4.4.

4.2 Floodplain and Spill Impacts

Riverine Floodplain Limits for Appleby Creek and Sheldon Creek are presented in Drawings 5 and 6 respectively. A number of properties have been identified which are expected to be subject to re-development, but would have existing floodplain impacts (Section 3.3). Potential spill impacts have also been identified for Appleby Creek immediately upstream of the CNR.

A distinction must be made between flood risk due to a riverine floodplain (i.e. floodplain directly along/adjacent to the watercourse) and due to spills (i.e. excess flow draining in an uncontrolled manner,

potentially no longer following the path of the watercourse). The former (riverine floodplains) are regulated by Conservation Authorities, and prevent any development within the floodplain limits (plus a 15 m buffer), unless a Special Policy Area or other exception applies. This would therefore apply to those parcels noted as being impacted by riverine floodplain limits along both Appleby and Sheldon Creeks. Floodplain limits in these cases could potentially be reduced through infrastructure improvements (i.e. channel widening, re-grading, or more likely hydraulic structure (culvert) improvements where appropriate) to reduce floodplain extents, as discussed in Section 4.3. Beyond such measures, development would be restricted to the extents noted.

Spills are also not considered to be regulated (refer to Section 4.2.5 of Policies and Guidelines for the Administration of Ontario Regulation 162/06, Conservation Halton, Amended November 26, 2015). As evident from the results of the hydraulic analyses, there is a significant spill flow area within the Appleby GO Station north parking lot area, which is considered attributable to the capacity of the CNR crossing. This spill flow area could likely be mitigated through upsizing of the culverts crossing the CNR tracks; this is considered further in Section 4.3. There is a lesser spill flow area identified on Sheldon Creek at Harvester Road due to the Regional Storm event overtopping the road, however a review of the topographic contours at Harvester Road suggests that any spill would be directed back towards the channel.

For locations subject to spill impacts (where other mitigation measures are not feasible), it is recommended that appropriate flood mitigation and management strategies be employed. This would primarily include floodproofing of buildings. Passive floodproofing (i.e. floodproofing that does not require human intervention) is preferred, which would be expected to focus on grading of both the site and building, to ensure that openings are greater than spill elevations (typically a 0.30 m freeboard is applied). Active floodproofing (measures that require human intervention) may be warranted in locations where passive floodproofing cannot reasonably be achieved. In conjunction with the preceding, site grading should allow for the safe conveyance and routing of flood spill flows, and consider the safe ingress and egress of vehicles from the site. Site grading in these locations should also work towards achieving a cut/fill balance, in order to avoid the potential for off-site impacts. This should be more strongly enforced for riverine floodplain areas, where a cut/fill can more easily be achieved. For re-developments in spill areas where filling is unavoidable, other compensatory measures may be warranted. Further hydraulic modelling (beyond the scope of the current study) is considered required to better assess and map spill flow impacts. Such hydraulic modelling could also be applied to better determine the potential impacts of any future developments and the most appropriate floodproofing/flood mitigation strategies.

It should again be noted that the hydrologic modelling applied for Shoreacres and Appleby Creeks, while technically sound and appropriate, has not been calibrated (i.e. adjusted to reflect actual observed responses to storm events). Typically, uncalibrated hydrologic models are considered conservative (i.e. over-predict flows and volumes as compared to existing conditions). Thus, further study could potentially result in a reduction in flood risk. In the absence of such information, the results generated by the current study are considered the best available data. The hydrologic modelling for Sheldon Creek has been calibrated to observed flows as part of the "Sheldon Creek Hydrologic and Hydraulic Study – DRAFT" (Amec Foster Wheeler, 2016), however it is noted that the uncalibrated modelling has conservatively been applied for the generation of Regional Storm Flows at the direction of Conservation Halton as part of the 2016 Study. Furthermore, in order to maintain consistency in the reported results presented herein, the 100-year return period design storm flows have been simulated based upon the uncalibrated model, consistent with the Regional Storm Flows.

In addition to the preceding, it should be noted that the riverine hydraulic modelling (open channel – HEC-GeoRAS) has been developed using a digital elevation model (DEM) from the Region of Halton (2015). Hydraulic structures have been included based on elevations from this source, along with corrections from

record drawings, and data from field observations/measurements. Notwithstanding, a further validation should be considered in the future using topographic survey data, to better confirm precise floodplain limits. It is expected that this may occur as specific sites (particularly those identified as being within the floodplain) re-develop and proponents design appropriate mitigation measures. The results generated by the current study are however still considered appropriate for the estimation of floodplain risk.

4.3 Potential Infrastructure Improvements

As noted in Section 4.2, one potential strategy for areas with riverine floodplain impacts is to review the feasibility of infrastructure improvements, which would most likely take the form of hydraulic structure (culvert) improvements. Based on the results presented in Drawings 5 and 6, the primary locations where this could be beneficial include:

- Appleby Creek
    a. Harvester Road (5.5 m W x 2.1 m H concrete box)
    b. CNR (twin 4.2 m W x 3.7 m H concrete boxes)
    c. Fairview Street (twin 3.3 m W x 2.0 m and 2.3 m H concrete boxes)
- Sheldon Creek
    a. Harvester Road (twin 3.4 m W x 2.4 m H concrete boxes)

The greatest benefit in flood reduction would occur through an upgrade to the CNR crossing of Appleby Creek, since as noted previously, this structure results in an extensive backwater effect and spills both to the east and west of the Appleby GO station parking area. Based on a preliminary review, a substantial structure upgrade (approximately doubling of the existing width to 20 m +\-) would be required in this location to prevent upstream spills, which given the span involved, would likely necessitate a bridge (column and girder) type structure which would be more costly and difficult to construct, along with associated channel transition modifications.

More localized benefits could potentially be realized by upgrades to the other noted hydraulic structures, including Harvester Road and Fairview Street along Appleby Creek, which indicate overtopping for the Regional Storm Event, and floodplain impacts to immediately upstream properties. Based on a hydraulic modelling assessment, an upgrade to the hydraulic structure at Fairview Street would need to be a similar width to that of the CNR, approximately 20 m +\-. This would again likely necessitate a bridge (column and girder) type structure which would be more costly and difficult to construct, along with associated channel transition modifications. Based on a further hydraulic modelling assessment, the hydraulic structure at Fairview Street was found to be relatively insensitive to increased spans; thus a hydraulic upgrade of this structure is not currently recommended.

Sheldon Creek is also noted as overtopping at Harvester Road, however a more minimal impact to upstream floodplains is noted, thus this structure would likely be of a lesser benefit overall; no specific hydraulic structure size is currently recommended.

The currently available/developed hydraulic modelling is focused on overland and channel flows only; currently there is no hydraulic modelling available for trunk or local storm sewer systems. As such, an assessment or confirmation of storm sewer capacity for the Appleby GO Mobility Hub is beyond the scope of the current study.

4.4 Stormwater Management Strategy

As discussed in Section 4.1, the proposed re-development within the study area is not expected to result in large overall changes in impervious coverage, given the existing urbanized/developed nature of the study area. Notwithstanding, some potential re-development sites do include larger sections of existing pervious land, and a general strategy for quantity control is still required.

The largest, currently undeveloped parcels of land (pervious areas) are also indicated as possibly including larger (> 1 ha) parklands, which may preserve the overall, primarily pervious land use characteristics. These areas could also potentially be used to provide stormwater management (SWM) controls for adjacent developments, through the implementation of properly landscaped and designed features, including LID BMPs. Notwithstanding, given the complexities of shared-use agreements, on site controls for these areas may be preferred. Similarly, Sherwood Forest Park is indicated as being preserved as parklands; however it may offer an opportunity for the provision of communal SWM features, either an above-ground SWM facility or sub-surface measures. However, given the park's location, grading, the preceding complexities of shared-used agreements, and the potential loss of useable park land, it is considered unlikely that this opportunity would be advanced further or supported by the City.

Potential re-development sites within the Appleby GO Mobility Hub are a mixture of those which likely outlet directly to area watercourses (Appleby and Sheldon Creeks), and are drained by municipal services within the roadways (i.e. storm sewers). As noted in Section 4.3, the capacity of the existing storm sewer network in the Appleby GO Mobility Hub is unknown, as there are no available hydraulic models for these systems. Consistent with current City practices for quantity control, it is recommended that requirements distinguish between these two types of outlets.

Where sites have an existing approved outfall directly to a watercourse system, post-development to pre-development peak flow for the 2 through 100 year storm events are generally considered sufficient. Given the relatively minor change in land use in the area, and the location (towards the downstream limits of the watershed) it is considered unlikely that further overcontrol to reduce any downstream riverine impacts would be of any benefit, and may in fact result in an adverse synchronizing of peak flows.

Given the lack of information on storm sewer capacity (and overland flow routes), it is recommended that the City of Burlington's current informal policy of over-control (100-year post-development peak flow controlled to the 5-year pre-development peak flow) is appropriate for those sites connecting to the City's storm sewer system. This policy ensures that discharges are adequately controlled to the conveyance capacity of the interim drainage system receiver (i.e. the storm sewer) and no overland flow impacts would result from the conversion of area land uses. Should the City develop more detailed hydraulic modelling of the minor (storm sewer) and major (overland flow/roadway) urban drainage systems in this area, such modelling could potentially be used to confirm whether a lesser degree of quantity control would be acceptable. In the absence of such information, the informal policy of over-control is considered warranted for those sites connecting to the City's storm sewer network.

Given the fragmented nature of the pervious areas within the study area, and the study areas location towards the downstream limits of watercourse systems, erosion control requirements are not considered as critical as in more undeveloped, greenfield areas. Notwithstanding, where feasible, erosion control should be considered for implementation; such as the provision of 24-hour extended detention of the 4-hour 25 mm storm event. This could potentially also be achieved through the provision of LID BMPs, as part of the overall site SWM strategy (including quality control).

As re-developments proceed within the study, area there is also an opportunity to holistically improve stormwater quality of discharges to the receiving system. The City of Burlington's current informal policy is to require "Enhanced" Water Quality treatment (80% average annual removal of Total Suspended Solids).

This requirement accounts for the entire proposed impervious coverage, not only the "new" impervious coverage. It is recommended that this policy continue to be applied for re-developments within the study area, given the retroactive stormwater quality improvement to receivers.

It should be noted that the City of Burlington is currently in the process of reviewing and updating its Stormwater Management Design Policies and Guidelines, thus additional stormwater management requirements, particularly with respect to climate change, erosion control, and water balance/infiltration may also result for future developments, beyond the basic quantity and quality requirements noted previously.

In addition to the preceding, the currently proposed land use plan for the Appleby GO Mobility Hub (Draft Precinct Plan – May 2018) indicates the use of "Green Streets" for area roadways. Green Streets provide the opportunity to incorporate Low Impact Development Best Management Practices (LID BMPs) as part of the overall streetscaping design, including surface features (bioswales and bioretention areas, soil retention cells/tree planters) and sub-surface features (exfiltration pipes and storage chambers). These measures would benefit both water quantity, quality, and water budget/infiltration/erosion.

5.0 Conclusions and Recommendations

The land use plans prepared for the Appleby GO Mobility Hubs indicate that re-development and intensification are expected in this area. This report has been prepared in support of this planning effort, in order to summarize the expected flood hazard limits for the Mobility Hub. Existing hydrologic and hydraulic models have been refined in order to reasonably assess expected flood hazards, due to riverine floodplain extents, and potential spill areas.

Conventional 1-dimensional (1D) hydraulic modelling has been prepared for the area watercourses to confirm the riverine floodplain limits, and those locations where floodplain extents would limit any potential re-development. Spills from Appleby Creek at the CNR tracks have the potential to impact a number of re-development areas in the subject Mobility Hub due to its uncontained nature.

A general floodplain management strategy has been proposed, which necessarily distinguishes between riverine floodplain extents (regulated by Conservation Halton) and spills (not regulated). A general strategy has been proposed, as well as potential hydraulic structure upgrades in areas which may assist in reducing currently estimated floodplain extents. An overall stormwater management (SWM) strategy has also been proposed, including quantity and quality control measures to mitigate the impacts of future development. A summary of the proposed measures for the Appleby GO Mobility Hub is outlined in Table 5.1.

The current study provides a basis for the estimation of existing flood hazards and a proposed SWM strategy for the Appleby GO Mobility Hub. As noted, further study may be warranted as future refined land use planning and development studies. The following additional recommendations are noted in this regard:

- The City of Burlington may wish to consider undertaking further field monitoring and data collection efforts to support hydrologic model calibration, which will allow for a more informed estimate of flood risk.
- Further field verification and topographic survey is also recommended in certain locations, including potential spill locations such as the vicinity of the CNR tracks (to verify spill elevations and vulnerable locations).
- More refined hydrologic and hydraulic modelling tools should potentially be considered for future development for the study area, including:
  - Dual drainage hydraulic modelling to confirm the capacity of area storm sewer and overland flow routes
  - Scoped 2D hydraulic modelling to confirm impacts of identified spill flows from Appleby Creek (potentially combined with an update to the 1D hydraulic modelling using available topographic survey).

Table 5.1	Summary of Flood Hazard and SWM Strategies for Appleby GO Mobility Hub	
Management Area	**Consideration**	**Recommendation**
Development Area Flood Management	Riverine floodplain encroachment onto development sites	• No development can occur within 15 m buffer of identified floodplain extents • Consider opportunities to reduce floodplain extents through hydraulic structure upgrades or channel improvements where feasible (limited opportunity within the study area)
	Flood spills onto development sites	• Development can proceed subject to suitable flood management strategy on affected development sites. • Focus on passive floodproofing (re-grading of land and buildings to 0.30 m above identified flood level); consider active floodproofing (measures that require human intervention) where passive floodproofing not feasible. Confirm safe ingress/egress from site. • Attempt to achieve a cut/fill balance for flood storage volume to avoid off-site impacts. • Assess proposed site management strategies through application of developed modelling tools to confirm no off-site impacts and safe conveyance of spill flows.
Area Infrastructure Improvements	Hydraulic Structures (Culverts)	• Consider benefit of hydraulic structure upgrades to reduce floodplain extents for development lands • For Appleby Creek, consider upsizing to: a) Harvester Road (more limited benefit than CNR; would need a larger bridge structure of similar span – 20 m +\- with associated channel modifications) b) CNR (identified as the most deficient hydraulic structure; would require creation of a bridge structure with a width of 20 m +\- and associated channel modifications)
	Storm Sewers	• Insufficient information to recommend specific upgrades. Consider further as part of future study (dual drainage modelling).
	Overland Flow Pathways	• Insufficient information to recommend specific upgrades. Consider further as part of future study, including spill pathways (dual drainage modelling).
	SWM Facilities	• Consider implementation of SWM facilities (for local or external lands) within proposed future park areas (4415 Fairview Street and 5200 Harvester Road) and Sherwood Park as part of future re-development plans, however these may not ultimately be feasible
Stormwater Management Criteria	Quantity Control	• Post to pre peak flow control (2-year through 100-year) for areas discharging directly to creek systems • Over-control (100-year post to 5-year pre) of peak flows for areas connecting to storm sewers or where major system is constrained. • Consider erosion control measures where feasible, potentially in combination with LID BMPs for the overall SWM strategy
	Quality Control	• Enhanced (80% average annual TSS for all impervious areas • Review opportunities for synergies with other studies and road reconstruction projects in particular (“Green Streets”)

The current study should also be considered in conjunction with other ongoing City of Burlington initiatives within the study area (i.e. Appleby Creek Flood Study EA). For the Mobility Hub assessed herein, updated direction from the City's revised Stormwater Management Policies and Design Guidelines should be taken into account in the development of future SWM strategies for re-developments.

Respectfully submitted,

Wood Environment & Infrastructure Solutions,
a division of Wood Canada Limited

DRAFT

Per: Ron Scheckenberger, M.Eng., P.Eng.
Principal, Water Resources

DRAFT

Per: Michael Penney, E.I.T.
Water Resources Analyst

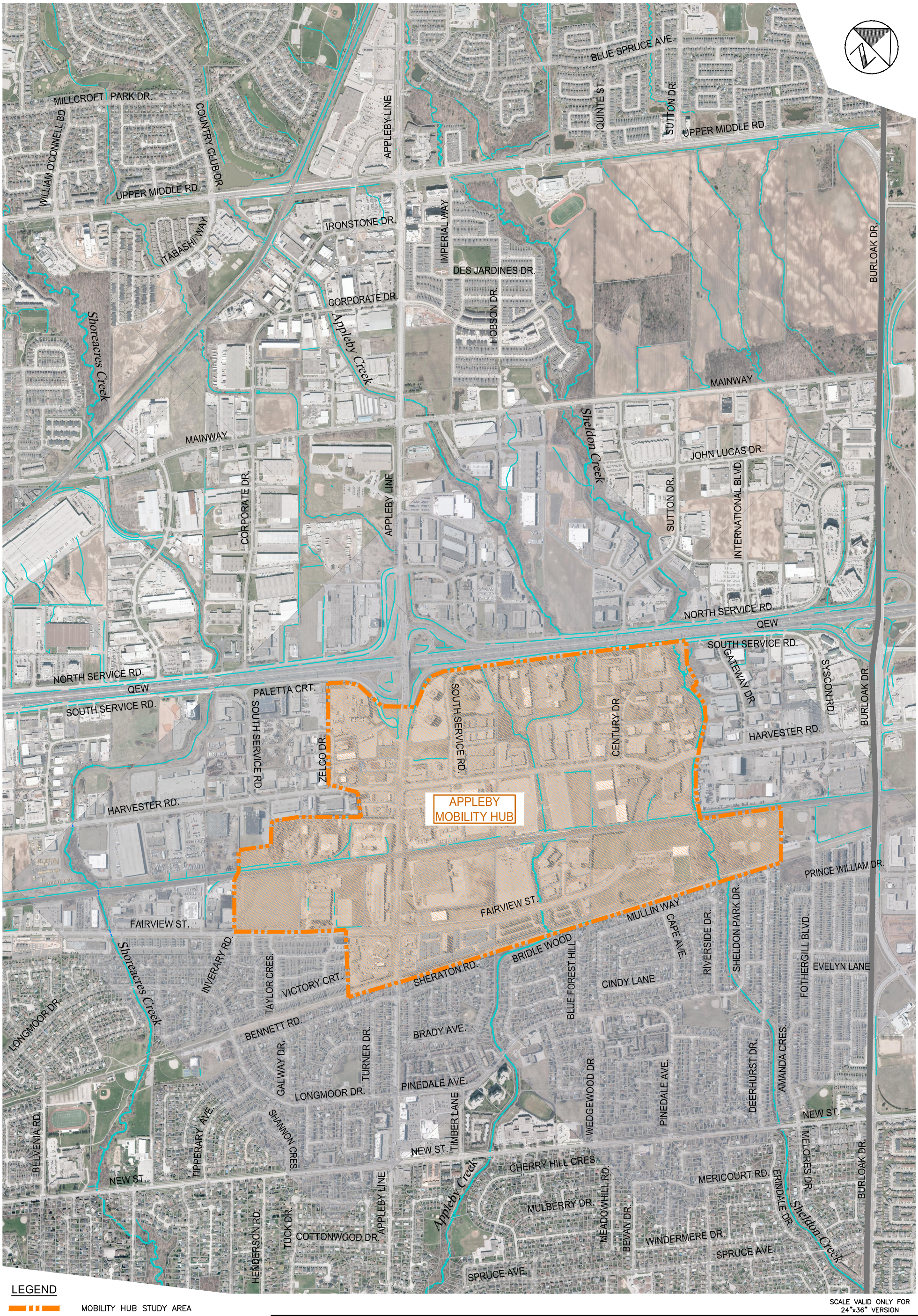
DRAFT

Per: Matthew Senior, M.A.Sc., P. Eng.
Senior Water Resources Engineer

DRAFT

Per: Allison Zhang, Ph.D., E.I.T.
Water Resources Analyst

MP\MJS



LEGEND

- MOBILITY HUB STUDY AREA
- MUNICIPAL BOUNDARY
- WATERCOURSE
- PARCEL FABRIC
- CULVERT LOCATION

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

STUDY AREA PLAN (APPLEBY AREA)

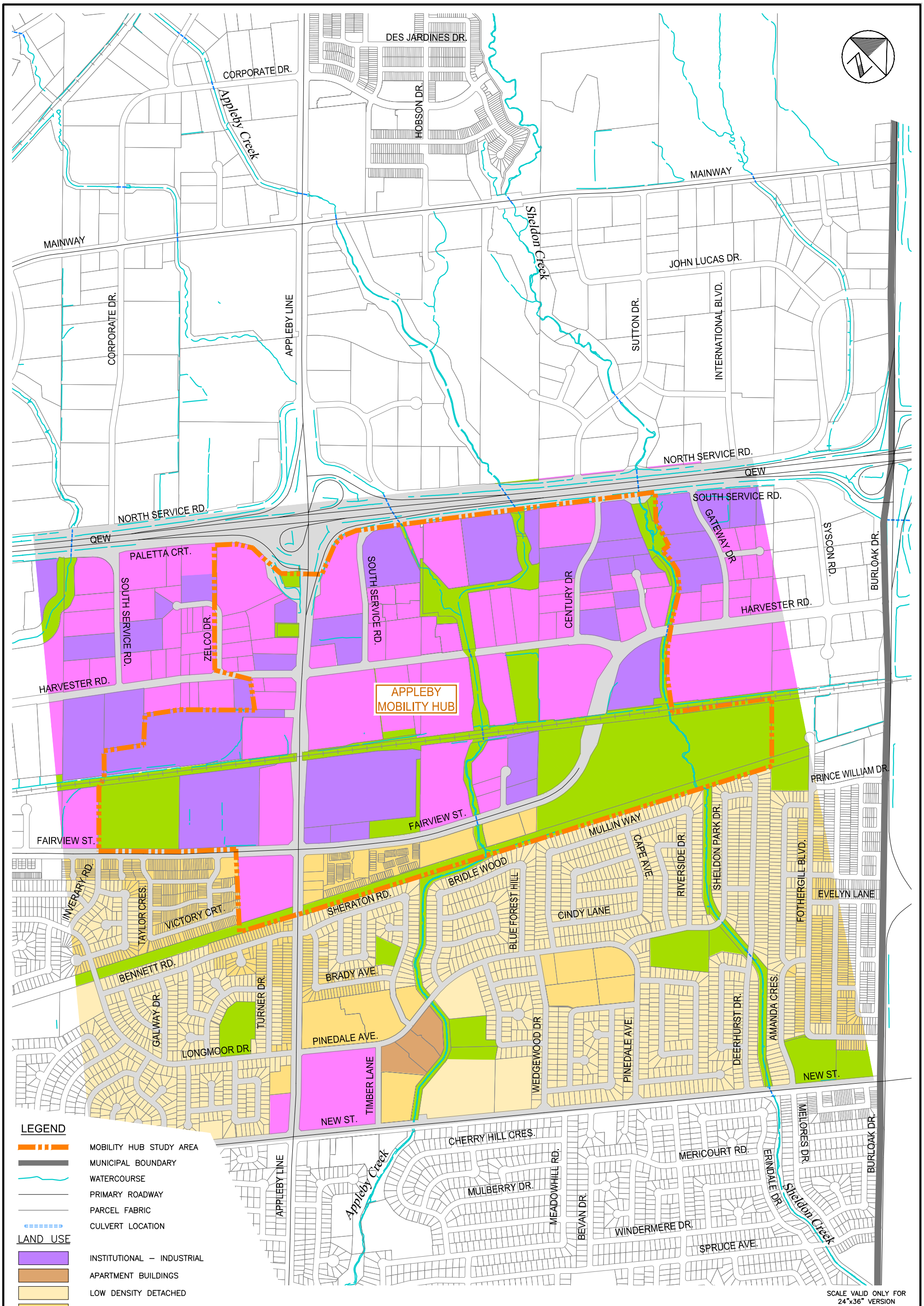
wood.

Scale 1:7500 (0, 75, 150, 300)

Consultant File No. TP178008S

Drawing No. 1

Last Saved: 2018-12-12 Last Saved By: richard.bartolo Plotted: 2019-01-07 Plotted By: richard.bartolo Path: P:\2017\Projects\TPB178008S – Mobility Hub Planning Consulting Services\06_DES-ENG\01_CAD\02_DWGS\05_WR\01_PROJ\2018-12(App)\Dwg1 StudyArea(AP).dwg



LEGEND

- MOBILITY HUB STUDY AREA
- MUNICIPAL BOUNDARY
- WATERCOURSE
- PRIMARY ROADWAY
- PARCEL FABRIC
- CULVERT LOCATION

LAND USE

- INSTITUTIONAL – INDUSTRIAL
- APARTMENT BUILDINGS
- LOW DENSITY DETACHED
- SEMI–DETACHED AND TOWNHOMES
- HIGH IMPERVIOUS
- ROAD
- PARK – NATURAL CORRIDOR

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

EXISTING LAND USE PLAN FOR HYDROLOGIC MODELLING

(APPLEBY AREA)

wood.

Scale 1:6000

0 75 150 300

Consultant File No. TP178008S

Drawing No. 2

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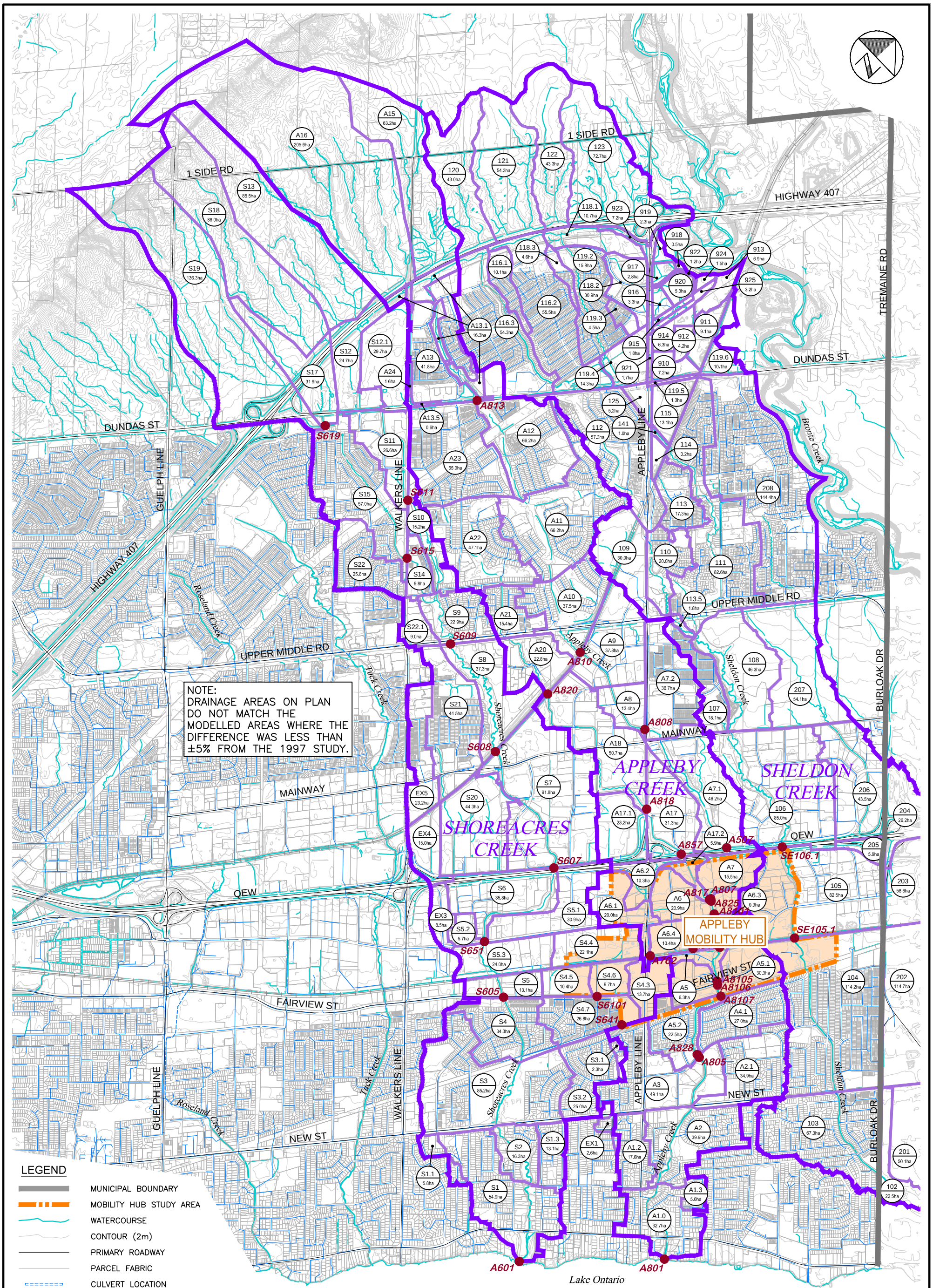

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

SUBCATCHMENT BOUNDARY PLAN (EXTERNAL DRAINAGE AREAS)

wood.

Scale 1:15000
0 75 150 300

Consultant File No.
TP178008S

Drawing No.
3

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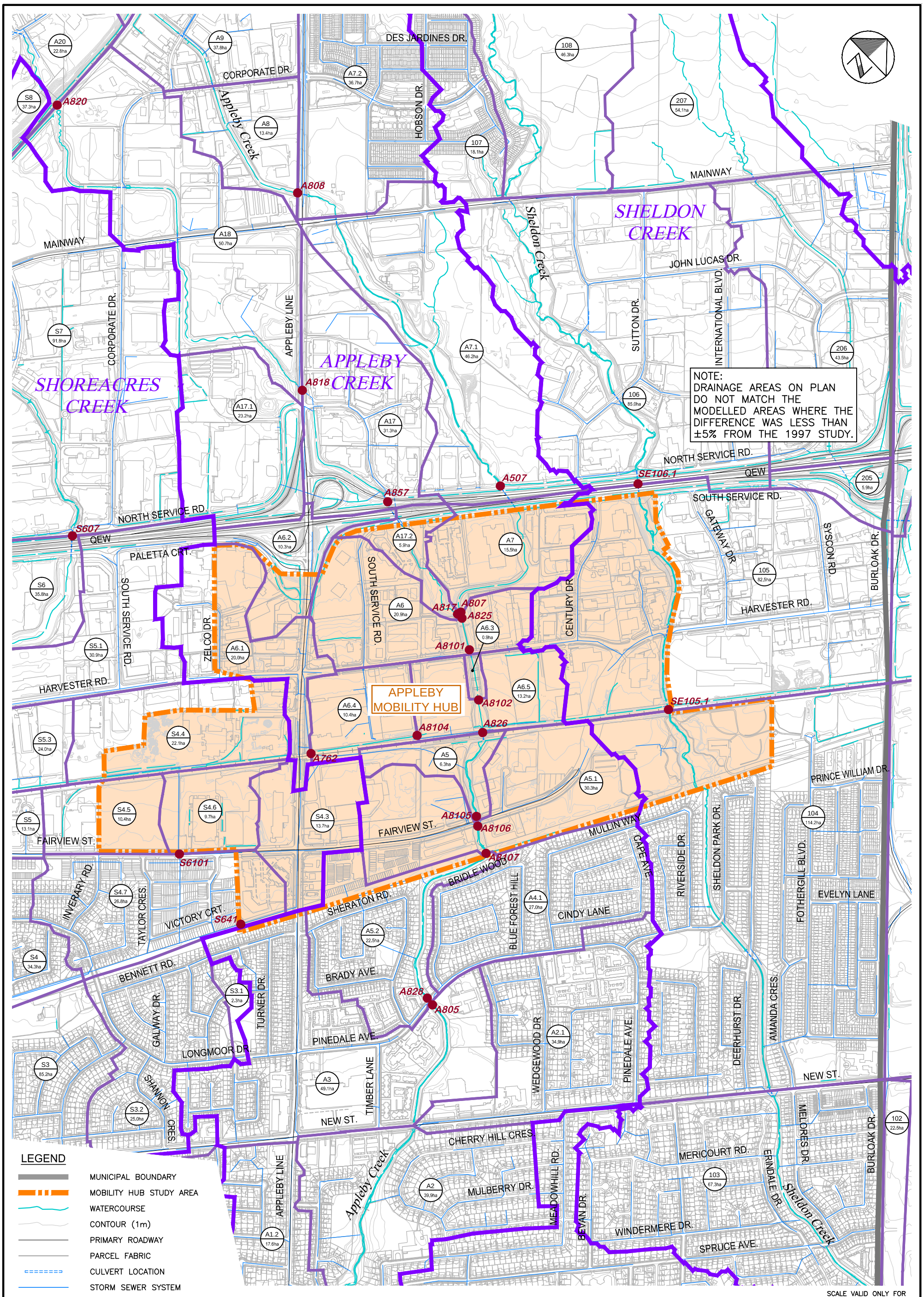

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

SUBCATCHMENT BOUNDARY PLAN (APPLEBY AREA)

wood.

Scale 1:6000
0 75 150 300

Consultant File No. TP178008S

Drawing No. 4

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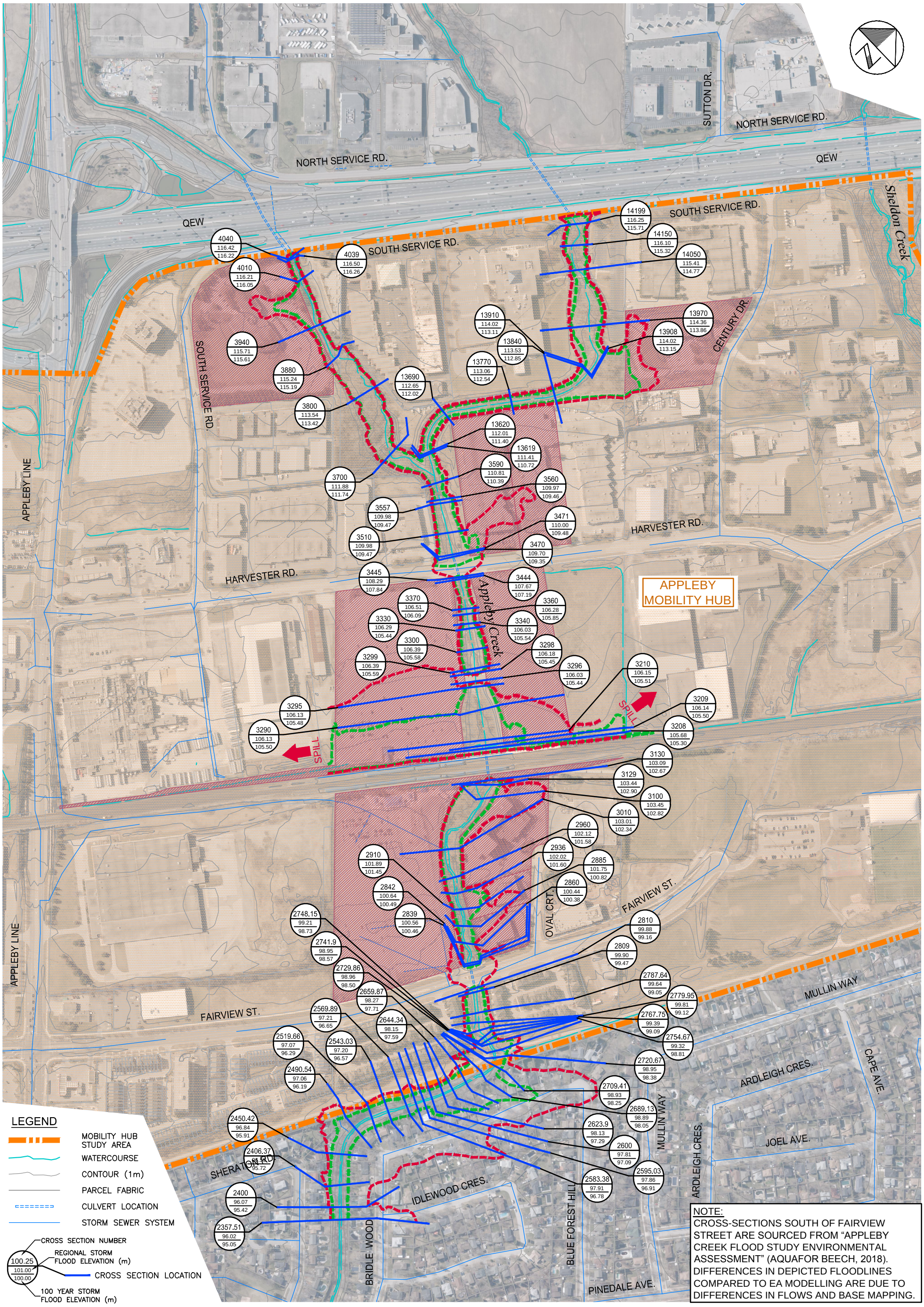


LEGEND

- MOBILITY HUB STUDY AREA
- WATERCOURSE
- CONTOUR (1m)
- PARCEL FABRIC
- CULVERT LOCATION
- STORM SEWER SYSTEM
- CROSS SECTION NUMBER (100.25 / 101.00 / 100.00)
- REGIONAL STORM FLOOD ELEVATION (m)
- CROSS SECTION LOCATION
- 100 YEAR STORM FLOOD ELEVATION (m)
- REGIONAL STORM FLOODPLAIN
- 100 YEAR STORM FLOODPLAIN
- SPILL LOCATION
- PLANNED RE-DEVELOPMENT PARCELS WITH POSSIBLE RIVERINE FLOODING IMPACT

NOTE:
CROSS-SECTIONS SOUTH OF FAIRVIEW STREET ARE SOURCED FROM "APPLEBY CREEK FLOOD STUDY ENVIRONMENTAL ASSESSMENT" (AQUAFOR BEECH, 2018). DIFFERENCES IN DEPICTED FLOODLINES COMPARED TO EA MODELLING ARE DUE TO DIFFERENCES IN FLOWS AND BASE MAPPING.

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

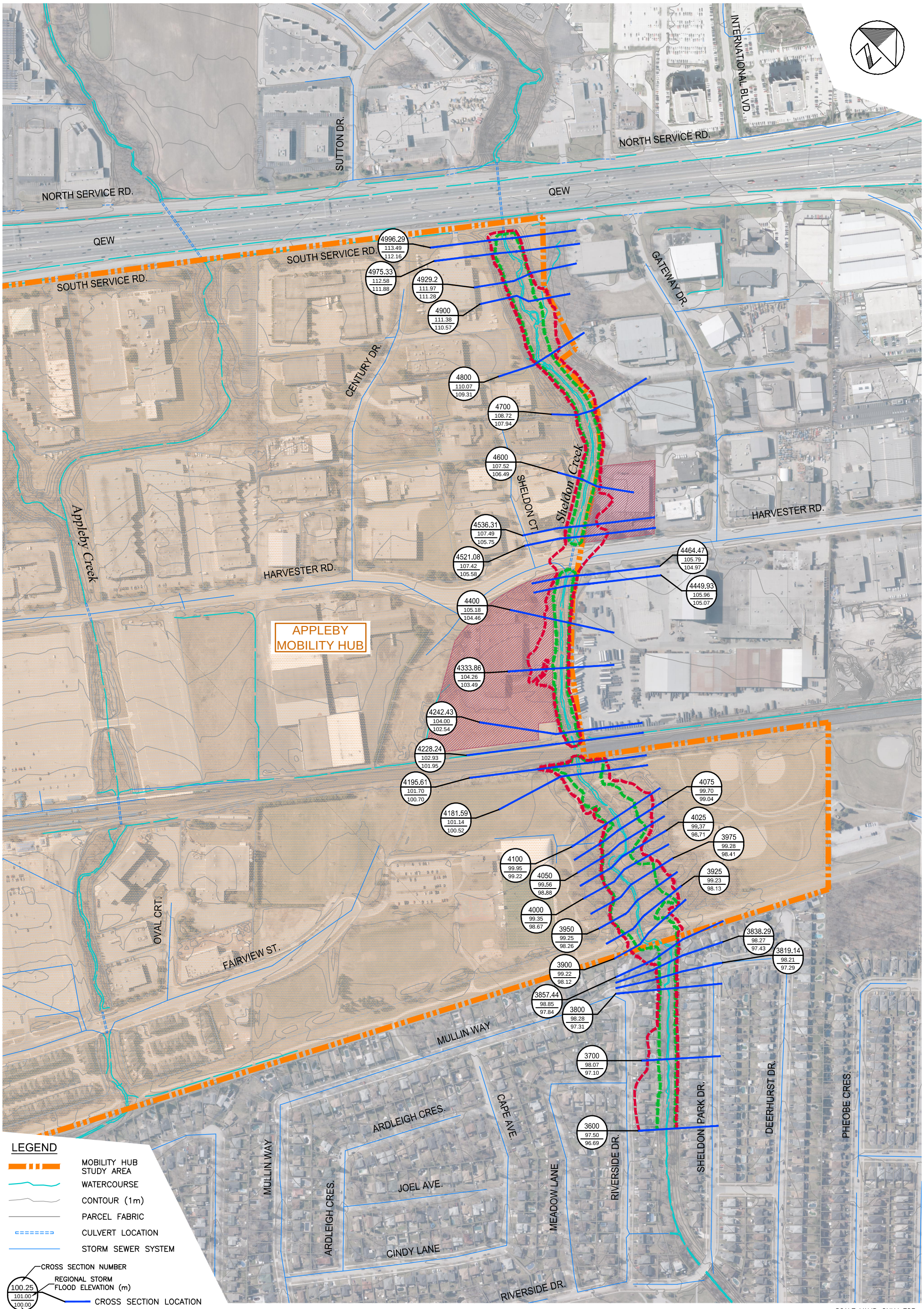
FLOODPLAIN MAPPING
(APPLEBY CREEK)

wood.

Scale 1:2500 (0 25 50 100)

Consultant File No. TP178008S

Drawing No. 5



LEGEND

- MOBILITY HUB STUDY AREA
- WATERCOURSE
- CONTOUR (1m)
- PARCEL FABRIC
- CULVERT LOCATION
- STORM SEWER SYSTEM
- CROSS SECTION NUMBER
- REGIONAL STORM FLOOD ELEVATION (m)
- CROSS SECTION LOCATION
- 100 YEAR STORM FLOOD ELEVATION (m)

(Example: 100.25 / 101.00 / 100.00)

- REGIONAL STORM FLOODPLAIN
- 100 YEAR STORM FLOODPLAIN
- PLANNED RE-DEVELOPMENT PARCELS WITH POSSIBLE RIVERINE FLOODING IMPACT

SCALE VALID ONLY FOR 24"x36" VERSION

MOBILITY HUB PLANNING STUDY

CITY OF BURLINGTON

FLOODPLAIN MAPPING (SHELDON CREEK)

wood.

Scale 1:2500 (0 25 50 100)

Consultant File No. TP178008S

Drawing No. 6

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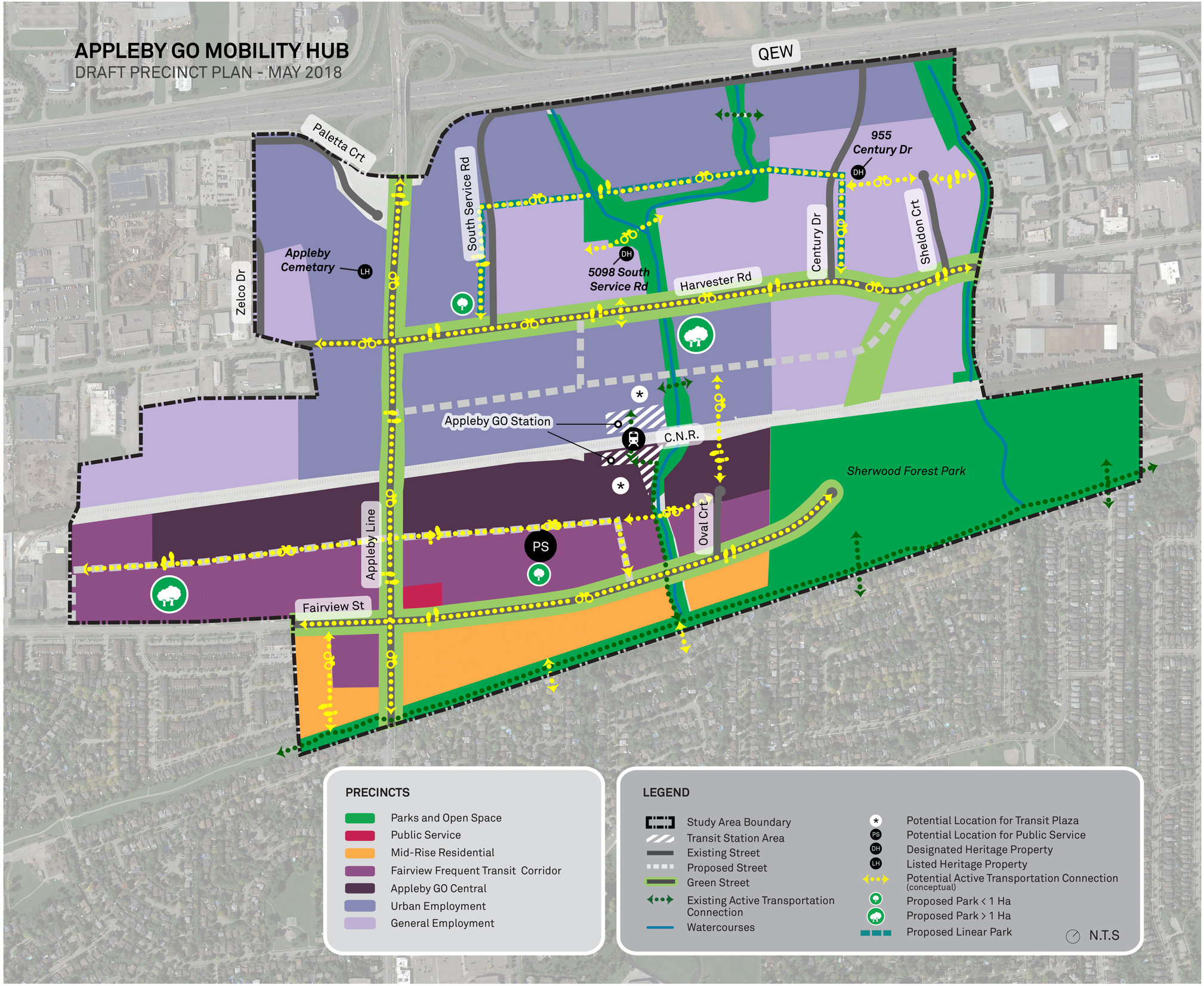
Appendix A

Mobility Hub Land Use Plans

APPLEBY GO MOBILITY HUB

DRAFT PRECINCT PLAN - MAY 2018



GROW BOLD

CITY OF Burlington

Please note that the draft precinct plan, precinct boundaries, associated intention statements and key directions are preliminary and subject to change as a result of on-going technical studies and community and stakeholder feedback.

Appendix B

Background Information and Correspondence (Conservation Halton)

March 6, 2017 (Updated April 25, 2017)
Our File: TPB178008-04

City of Burlington
426 Brant Street
Burlington, ON L7R 3Z6

Attention: Phillip Caldwell, MCIP RPP, Senior Planner

Dear Sir:

Re: Scoped Environmental Impact Studies Work Plan, Mobility Hubs Planning

Brook McIlroy Inc.'s (BMI) proposal for Consulting Services for the City of Burlington Mobility Hub Planning (December 12, 2016) outlined a Work Plan that included departures from the Terms of Reference (TOR) agreed to between the City and Conservation Halton and Region of Halton and outlined in RFP-239-16 (November 17, 2016). The changes to the TOR were proposed by Amec Foster Wheeler and Dillon Consulting in order to provide cost efficiencies to accommodate the City's project budget, and related specifically to the *Scoped Environmental Impact Studies* as defined in Appendix G *Environmental Impact Study Preliminary Guidance For Study Components and Technical Requirements* in the RFP. The intent of this letter is to more clearly communicate the changes to the TOR for the Environmental Impact Study presented in BMI's December 12, 2016 proposal. It is intended that this letter and attachments are read in conjunction with BMI's December 12, 2016 proposal.

On February 14, 2017 staff from the City of Burlington, Conservation Halton, Amec Foster Wheeler and Dillon Consulting met to discuss the Work Plan for the Scoped Environmental Impact Study. The discussion focused on identifying the changes proposed to the TOR and the objective was to obtain agreement between the City, Conservation Halton and the BMI Team on the proposed Work Plan such that there was a consensus moving forward. In an effort to clearly and concisely summarize the proposed changes to the TOR, the original TOR have been modified and changes have been tracked. The changes proposed by Amec Foster Wheeler to *Section 6.0 Stormwater Management and Riverine Hazards* and by Dillon Consulting to *Section 5.0 Environmental Studies and Analysis* and *Section 7.0 Supplementary Information* have been integrated in Attachment A. As noted above, it is intended that this letter and Attachment A are read in conjunction with BMI's December 12, 2016 proposal. Further, Attachment A is intended to clarify our original proposal, not replace it – if the City perceives an inconsistency between the December 12, 2016 proposal and Attachment A, please bring it to the attention of the BMI Team.

Five (5) key study gaps related to *Stormwater Management and Riverine Hazards* have been identified and are summarized below. The proposed gap-filling approaches and study-risks related to potential out-of-scope work are discussed in Attachment A to this letter.

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Burlington, Ontario L7N 3G2
Tel +1 905 335 2353
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amecfw.com

Amec Foster Wheeler Environment & Infrastructure
Registered office: 2020 Winston Park Drive, Suite 700, Oakville, Ontario L6H 6X7
Registered in Canada No. 773289-9; GST: 899879050 RT0008; DUNS: 25-362-6642

1. Uncertainties remain on policy perspectives related to Regulatory flood control and specifically the Hager-Rambo Flood Control System. Conservation Halton agreed to review this matter further and advise on how the Authority will seek to apply policy. Background related to this issue is discussed in Section 6.3 a) x).

2. Flood risk in the Burlington and Downtown Mobility Hubs related to a potential breach of the Freeman Pond and/or West Hager Pond, two of the three flood control facilities that are part of the Hager-Rambo Flood Control System, is a potential gap. Amec Foster Wheeler has outlined preliminary assessments that are proposed and is expected to determine if additional study is required as part of the Mobility Hub Planning.

3. Flood spills have been identified in several locations along the Hager-Rambo Diversion Channel however the associated spill path(s) through the Burlington and Downtown Mobility Hubs and the potential impact on future development is a gap. Amec Foster Wheeler has outlined preliminary assessments that are proposed to be completed and are expected to provide 'high-level' guidance on the flood hazard associated with the spill(s). The level of flood risk prescription that can be obtained within the existing Work Plan scope is uncertain and additional study will be required. The limitations of the assessment are discussed in Section 6.3 a) x).

4. The Work Plan proposes a high-level risk assessment for erosion potential related to future development in the Mobility Hubs. Where erosion potential is determined to be 'low' and the Technical Advisory Committee (TAC) agrees that no further study is required, the proposed Work Plan will meet study objectives. If erosion potential cannot be satisfactorily screened by proposed Work Plan, study gaps may exist. Gaps relate to the potential need to establish erosion thresholds downstream of the Mobility Hubs, and the potential need to undertake continuous hydrologic simulations to complete an erosion duration analysis in support of establishing the criteria for future erosion control requirements. Section 6.2 e) (2) provides additional detail on the proposed approach.

5. Conservation Halton staff have noted they will consider regulating Lower Hager and Lower Rambo Creeks; staff to advise. No implications to the Work Plan are expected.

Additional comments from Conservation Halton (received via e-mail March 23, 2017, secondary comments received via e-mail April 20, 2017) have also been updated into the current revised work plan. To summarize the changes resulting from this additional round of comments:

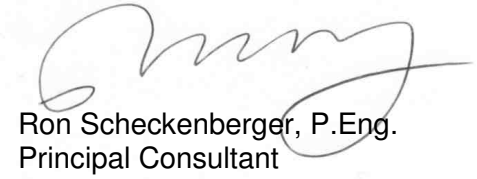
1. Page 6 of PDF (5.0 - Table A) – Aldershot has been revised to a "Yes*", based on the qualifiers and conditions outlined under the "*".
2. Page 10 of PDF (5.0 – Water Quality/Benthic Invertebrates) – Asteriks added for Burlington and Appleby Line.
3. Page 11 of PDF (5.0 – Stream/Drainage Corridor and Storm Sewer Outfall Assessment) Falcon Creek and Glen Wood Creek have not been included in the Table. Falcon Creek is not located within the Aldershot Mobility hub area, and Glenwood Creek has only a minor amount within the area. Qualifying wording has been added to the text that an assessment may be required if it is determined that there is any expected hydrologic impact to these features; if necessary this work would be beyond the current scope. Table B within Section 6.0 (Hydrologic Modelling Requirements) has been similarly updated.

4. Page 17 of PDF (6.2 e) 3) – Proposed Hydrology/Stormwater Management) – Revised wording to include assessment of *preliminary potential* flood mitigation controls in the event of spill. Any detailed measures or assessments would be beyond the scope of the current study and are therefore not included.
5. Page 22 of PDF (6.3 a) x) – Hager-Rambo Diversion Channel & Flood Control System) – wording has been revised to clarify that the system to be assessed will include the channels between the ponds and the diversion channel (although spills will only be assessed at a high level, as noted in the revised terms of reference). This also assumes that the hydraulic models are readily available for these reaches in a usable state. Reference has also been included to the East Rambo Pond (it has been assumed that this is what was being referred to, rather than the East Hager Pond, as no such feature is known to exist beyond the QEW/North Service Road drop structure, which has no storage or attenuation function).

We trust the foregoing is consistent with our discussion on February 14, 2017 and provides an adequate basis upon which to advance the Work Plan for the Scoped Environmental Impact Studies.

Sincerely,

Amec Foster Wheeler Environment & Infrastructure
a Division of Amec Foster Wheeler Americas Limited



Per: Ron Scheckenberger, P.Eng.
Principal Consultant

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

AB/ls/MJS/RBS

c.c. David Sajecki, Brook McIlroy Inc.
Daniel Bourassa, Dillon Consulting
Allen Benson, Dillon Consulting
Justine Giancola, Dillon Consulting
Jeff Hirvonen, GeoProcess

APPENDIX G

ENVIRONMENTAL IMPACT STUDY
PRELIMINARY GUIDANCE FOR STUDY COMPONENTS AND TECHNICAL REQUIREMENTS

DISCLAIMER

Please note that information contained in this Appendix has been provided by partner agencies to the City of Burlington. Given the urban context of the Mobility Hub study areas, additional scoping/elimination of study requirements identified within this Appendix will be explored with the chosen project consultant to ensure study's focus is less on characterization of existing features and more on restoration and enhancement opportunities.

The chosen project consultant will be required to submit a work plan for the Environmental Impact Studies upon awarding of the project contract which will identify an environmental scope of work reflective of the existing urban context of the Mobility Hub study areas and based on the consultant's own past experience as well as other best practices for similar studies. The project consultant's proposed work plan will be evaluated by the City of Burlington and partner agencies through a technical advisory committee (TAC)

1.0 STUDY PURPOSE

The purpose of Environmental Impact Studies in each Mobility Hub area is generally to:

- Inventory, characterize, and assess existing environmental conditions including natural hazards, natural heritage and water resource features and areas;
- Provide recommendations for the protection, restoration, and enhancement, where feasible, of natural heritage, and water resource features and areas;
- Provide recommendations for management and mitigation of natural hazard and other constraints, where feasible;
- Provide sufficient detail to support the designation of the Natural Heritage System (NHS), through refinement of the Regional Natural Heritage System (RNHS), as well as identifying areas for future development;
- Refinement of the Regional Natural Heritage System for the Study Area and development of a Natural Heritage System Restoration and Enhancement Plan to be implemented through redevelopment and private and public land stewardship as part of an innovative Environmental Management Strategy for each study area;
- Conformity with applicable Provincial, Regional, and City land use planning policies, including Section 145(9) of the Regional Official Plan, and applicable Conservation Halton Policies;

- Establish procedures for monitoring water quality and quantity before, during and after development; and
- Other objectives and goals as proposed by the project consultant in their final work plan.

2.0 STUDY PROCESS/PHASING

The Environmental Impact Studies should be broken into the following phases to allow for feedback from relevant technical reviewers/agencies:

- Phase 1 – Background Review and Characterization
- Phase 2 – Analysis
- Phase 3 – Management Strategy Development
- Phase 4 – Implementation and Monitoring

The Environmental Impact Studies will both inform and be informed by the land use scenarios developed as part of the Area Specific Planning process. As a result, study phases should be prioritized based on the information required to inform the delivery of stage 1 and stage 2 project deliverables as established in the Terms of Reference and may include the undertaking certain phases concurrently.

The final Environmental Impact Studies should be completed prior to the approval of Area Specific Plans.

3.0 ADVISORY COMMITTEES/MEETINGS

Work undertaken as part of the Environmental Impact Studies will be reviewed by a technical advisory committee (tac) with representation from the project consultant, the City of Burlington, Region of Halton and Conservation Halton.

4.0 STUDY CONSIDERATIONS

Urban Context – Environmental Impact Studies/Sub-Watershed Studies such as those required within each Mobility Hub area are typically conducted in undeveloped greenfield settings. The existing urban nature of all four Mobility Hub study areas should be considered when undertaking the Environmental Impact Studies.

Innovative Implementation Strategy – Given the urban nature of the Mobility Hub study areas, the Environmental Management Strategy prepared at the conclusion of the Environmental Impact Studies should consider innovative implementation tools not typically considered in relation to Area Specific/Secondary Plans in greenfield areas. As greenfield development will not be the primary mechanism relied on for implementation, policies targeted primarily at guiding future development will not be the best way to fulfill the majority of the recommendations. Redevelopment, public land stewardship, public works relating to natural hazard mitigation and stormwater infrastructure "greening", targeted ecological restoration projects and community education and stewardship may be

more relevant tools in these studies. As a result, the studies should explore utilizing a broadened set of implementation tools to reflect the urban context of these areas.

5.0 ENVIRONMENTAL STUDIES AND ANALYSIS

Table A Environmental Studies and Analysis

Required Environmental Studies/Analysis	Aldershot	Burlington	Downtown	Appleby
Hydrogeologic Assessment following CH Requirements for Completion of hydrogeological studies to facilitate Conservation Halton's reviews http://www.conservationhalton.ca/policies-and-guidelines	Yes*	No*	No*	No*
Identification of the extent of Hazard lands within the hub study area in accordance with MNRF guidelines and Conservation Halton policy and guidelines http://www.conservationhalton.ca/policies-and-guidelines.	Yes*	Yes*	Yes*	Yes*
Flooding Hazard Assessment	Yes	Yes	Yes	Yes
Erosion Hazard Assessment	Yes	Yes	Yes	Yes
Coastal hazard assessment			Yes	
Natural Heritage Studies/ System (see Table D in 7.0)	Yes*	Yes*	Yes*	Yes*
Species at Risk Consultation with the Ministry of Natural Resources and Forestry (MNRF)	Yes	Yes	Yes	Yes
Hydrologic/hydrogeologic evaluation and water balance for the wetlands	Yes*			
Stream classification, fish community inventory and fish habitat assessment	Yes	Yes	Yes	Yes
Water quality evaluation (including water chemistry and benthic invertebrates)	Yes	Yes	Yes	Yes
Stormwater management mitigation plans	Yes	Yes	Yes	Yes

Please note that where **Yes*** is indicated please refer to the proceeding Notes section below.

Table A Notes:

- Hydrogeologic Assessment: For the Burlington Mobility Hub, Downtown Mobility Hub and Appleby Mobility Hub the hydrogeologic assessment will rely on available borehole information to screen for the feasibility and provide future design guideance (where

proposed) for subsurface green infrastructure (LID's). The basic information collected from existing available borehole data would include groundwater levels, soils types, infiltration rates, etc. For the Aldershot Mobility Hub, the following is included in the Work Plan:

- Review CH information including regulations mapping
- Review 1200 King Road data (spring and summer)
- Conduct a field reconnaissance to observe any changes and possible points of water discharge (either surface and / or groundwater)
- Establish micro-topography to define surface water catchment zone
- Develop details of a future monitoring assessment program

With regard to the foregoing, it is expected that following the execution of this scoped investigation there would be a better understanding of the composition and function of the wetland including its possible zone of influence on surface water contribution. This understanding will then inform the potential extent of the constraint, while providing direction on water management strategies and also the form of future studies.

- Identification of Natural Hazard lands: To determine the hazard limit associated with valleys (defined and undefined), both the flooding and erosion hazards are to be considered. The hazard limit is set by the greater of the flood or erosion hazard, plus the applicable development setback based on the appropriate policy and regulatory requirements. It should be noted that additional buffers and/or corridor widths may be needed in consideration of other factors introduced by the study assessment including, but not limited to, the protection of ecological and hydrologic functions such as critical function zones and impacts to adjacent lands.

- Natural Heritage Studies/ System: Natural heritage studies are completed in order to identify and further delineate the existing Regional Natural Heritage System (RNHS). Natural heritage investigations/studies will be conducted while using the guiding policy framework of the RNHS within the Regional Official Plan Amendment No. 38 (ROPA 38). They will provide an appropriate level of detail for the planning analyses such that the components of the RNHS (Key Features; Enhancement Areas and Linkages) can be identified and associated functions characterized. Once the RNHS and its key features are identified and delineated potential impacts of the proposed Secondary Plan and restoration or enhancement opportunities can be presented. Standard field studies include, but are not limited to, Ecological Land Classification (ELC), wetland delineation (using ELC), vegetation surveys, breeding bird surveys, and amphibian breeding surveys. It is noted that for the next stage of study OWES will be required.

Understanding the urban nature of the Mobility Hub study areas and the importance of interconnecting the core areas and key features of the RNHS, there will be a focus on identifying opportunities to use a combination of ecological restoration, natural hazard mitigation (excluding structural technicques), stormwater infrastructure, parks, etc. to establish both active and passive City of Burlington - Mobility Hub Planning Brook McIlroy/ connections with the natural environment. Where this may not be possible, other options such as community education and stewardship programs will be proposed, to establish this connection between residents and the environment.

A Natural Heritage study for the Aldershot GO Train Station lands as well as those lands immediately adjacent has recently been initated. Therefore, the study requirements for those portions of the study area with the Aldershot Mobility Hub area may already be underway and could inform/suppliment additional environmental work required in the study area. Please note that there are additional natural areas within the study area that will need to be assessed using the same criteria.

Based on consultation with CH Planning Ecologists, the following terrestrial field studies will be required for each of the Mobility Hubs. The table below should be read concurrently with ***Attachment A***, Figures 1 through 4, which illustrate the portions within each of the Mobility Hub study areas where field studies will occur.

Terrestrial Field Studies	Aldershot	Burlington	Downtown	Appleby
Ecological Land Classification	✓	✓	✓	✓
Wetland Delineation	✓*			✓*
Vegetation Inventory	✓	✓	✓	✓
Breeding Bird Surveys	✓	✓	✓	✓

**Presence of wetlands to be confirmed through ELC.*

A more fulsome list of the terrestrial and aquatic natural heritage studies that may be considered has been included in Section 7.0, Table D of this Appendix.

- Species at Risk: Species at Risk (SAR) listed as Endangered or Threatened under *Ontario Regulation 242/08* are afforded both species and habitat protection under the Ontario *Endangered Species Act* (ESA), 2007. The MNRF will be consulted to request relevant SAR occurrence records pertaining to each of the four Mobility Hub study areas. This information will be used to help identify potential SAR and SAR habitat within each of the study areas. Although incidental observations of SAR and/or potential SAR habitat will be noted during field surveys, it is important to note that this work plan does not include any work that may be required under the ESA (i.e., additional surveys, permitting, etc.).

Should species-specific surveys or permitting be required by the MNRF, Dillon has qualified staff (e.g., qualified Butternut Health Assessors, etc.) that can provide the City with these services, as required (Note: SAR mapping will not be on any publicly available mapping).

- Stream Classification: For each of the four Mobility Hub study areas, stream classification of existing watercourses will be established to determine either the required and/or appropriate setbacks for protection from proposed development. Required setbacks are established by CH through a number of policies differentiating between major and minor valley systems. Appropriate setbacks are established by using all available information including sensitivity of features, background reports (i.e., Sustainable Halton reports, etc.), experience in similar situations and potential impacts of proposed adjacent land uses in order to protect the form and function of the watercourse features (Note: the greater of the required or appropriated setback will be identified as a development constraint). Potential restoration and enhancement opportunities will also be considered wherever possible. Stream classification will rely on existing information (e.g., fish community sampling etc.) where available to determine stream type (permanent, intermittent, ephemeral), thermal regime, and whether streams provide suitable fish habitat. Other parameters to consider when determining suitability for fish habitat include riparian and in-stream cover, stream morphology, nutrient inputs etc. Where no information is available site visits may be required to collect information on stream characteristics, fish community sampling, thermal regime, etc. TAC to be included on site walks involving consideration of classification of watercourses.

- Water Quality/Benthic Invertebrates: In two (2) recent/ongoing Secondary Plans (Halton Hills/Mississauga), Amec Foster Wheeler consultatively worked with CH and the area municipality to defer the water quality (chemistry) and benthic invertebrates investigations. The rationale, which was ultimately supported by CH, was based on the perspective that the information collected rarely, if ever, influences land use decisions. Stormwater Management practices need to (most often) meet the highest standards, therefore water chemistry/benthic invertebrates also does not drive the level of protection for the receiving systems (watercourses or Lake). On this basis, the main utility of these data comes forward during the monitoring phase following development. In order to determine the efficacy of the various management practices in mitigating the impacts of development, baseline monitoring (water chemistry/benthic invertebrates) is considered useful and important. Notwithstanding these data are most appropriately collected closer towards the period of planned land use change. Therefore, based on the foregoing, as part of this task, it is proposed to develop the scope of an appropriate water

quality and benthics sampling program for each Mobility Hub to be executed as part of a future investigation.

Based on consultation with CH Planning Ecologists, the following aquatic field studies will be required for each of the Mobility Hubs. The table below should be read concurrently with ***Attachment A***, Figures 1 through 4 which illustrate the portions within each of the Mobility Hub study areas where aquatic studies will occur.

Aquatic Field Studies	**Aldershot**	**Burlington**	**Downtown**	**Appleby**
Stream Classification	✓	✓*	✓*	✓*

**Daylighted portions of the Lower Rambo Creek, north of the Centennial Pathway and isolated portions in the Burlington and Appleby Hubs to be included in assessment. Locations of daylighted portions to be confirmed by CH.*

- <u>Stream/Drainage Corridor and Storm Sewer Outfall Assessment:</u> The various open watercourse corridors in the respective study areas provide important functions for the natural environment, as "natural" conveyance infrastructure (drainage system), riparian habitat and socially by preserving and enhancing open space. In order to continue these functions in the long term, it is important to determine current functionality and from this establish means for enhancement/restoration in the context of future development concepts. The primary corridors proposed to be assessed as part of this study include:

Aldershot *	Grindstone Tributary, West Aldershot Creek, LaSalle Creek, Forest Glen Creek, Teal Creek
Burlington	East/ West Rambo Creek and Roseland Creek
Appleby	Appleby Creek, West Sheldon Creeks, and Shoreacres Creek
Downtown	Lower Hager and Rambo Creeks

* *Additional assessments <u>may</u> be required for Falcon Creek and Glenwood Creek if it is determined* that these receivers *will experience hydrologic change due to the proposed Mobility Hubs development. This additional work would be determined pending discussions through the Technical Advisory Committee and review of the sewershed mapping.*

The scope of this review will include field reconnaissance by a Drainage Engineer, Aquatic Ecologist and a Fluvial Geomorphologist. Based on the visual review, the following will be identified and mapped:

- Bank treatment/areas for stabilization
- Aquatic/riparian habitat
- Stream stability

- Vegetation
- Storm outfalls and neighbouring land uses.

The foregoing approximate mapping exercise will then be used as a base for developing a framework for a restoration/rehabilitation plan for each system. Each watercourse will also be investigated for mitigation or rehabilitation opportunities, with the objective of maximizing the remaining natural potential of the watercourse's form and function (where feasible). This will include a rapid investigation of reach-wide channel stability and identification of causes of instability, where present. For areas where opportunities for mitigation or improvement exist, high level recommendations will be proposed to address key imbalances between the conveyance of flow and sediment. In development of these recommendations the Study Team Fluvial Geomorphologists will work closely with the Study Team Water Resources Engineers to ensure conceptual plans are feasible and sustainable in the long term.

In addition, one of the considerations cited in the TOR relates to potential "day lighting" of enclosed watercourses. These opportunities and their implications on area infrastructure will be reviewed at a high-level as part of this task.

6.0 STORM WATER MANAGEMENT AND RIVERENE HAZARDS

The following sections are intended to provide an overview of select components that are to be assessed as part of the Environmental Impact Studies. It is also to identify the minimum requirements for the study. The project consultant will be required to prepare a final work plan to further detail and refine the information set out in the Request for Proposal and associated appendices. The background and characterization, analysis and reporting work must be completed to the satisfaction of the advisory committee.

It should be noted that although each study component has been discussed separately, all components are to be looked at comprehensively and in an integrated manner. This will also help to ensure that the objectives that have been established for the study area have been met. All of the work described below is to be completed by a licensed professional (Engineer and/or Geoscientist as appropriate. All final reports and maps are to be signed and sealed.

6.1 Existing Hydrology

The project consultant will be required to:

a) Undertake a review of previous subwatershed and stormwater management studies, aerial photos, topographic base maps, flow records, high water marks, precipitation records, and existing "Permits To Take Water" within and upstream of the study areas;

b) Develop and verify physical feature mapping of the subwatersheds, including subwatershed boundaries, upstream catchment areas, watercourses, drainage swales, wetland features, undrained depressions, other drainage improvements, land use, levels of directly and indirectly connected imperviousness, existing stormwater management features, etc. and ensure these are represented in the models;

c) Refine or develop (where required) hydrologic models to be used for each subwatershed area. Refer to Table 1.1 provided below, which summarizes the status of available modelling. The models should be deterministic hydrologic models, capable of continuous simulation (if required, see (i).) with strong physical representation of surface runoff and infiltration, channel storage, base flows, and for the Aldershot mobility hub, a more detailed understanding of the surface/groundwater interaction;

    i) Continuous simulation has not been included in the proposed Work Plan. See Section 6.2 e) (2) for implications to the erosion assessment.

d) Document and justify hydrologic modeling parameters;

e) Determine sub-basins to establish nodes at points of interest;

f) Model selection, parameterization, and extent are to be approved by the advisory committee;

i) The Work Plan assumes the existing models identified in Table B are approved. Model parameterization will be reviewed to ensure previous assumptions are supportable. Adjustments to model discretization/parameterization are expected within Mobility Hub study areas, however watershed wide re-parametrization of existing models has not been included, nor is it expected to be required.

g) Calculate unitary discharge rates at each key node, complete comparisons to the previously calculated flows (where available) to validate modelled flow values;

h) Present the findings to the TAC and based on mutual discussions and agreements proceed to the next stage.

Table B Hydrologic Modeling Requirements

Mobility Hub	Hydrologic Modeling Required	Available Information
Aldershot Mobility Hub*	Grindstone Creek (refinement of 1995 GAWSER model, with expansion of 2007 Waterdown Road interchange SWMHYMO model)	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995) Indian Creek Grade Separation Design (AMEC 2013) Falcon Creek Hydrology and Hydraulics Study (Valdor, 2012)
	Creek West of LaSalle Park Road (Create new model)	Unavailable. New PCSWMM model proposed
	Teal Creek, Forest Glen Creek, LaSalle Creek, (refinement of PCSWMM model)	Class EA for Aldershot Community Stormwater Master Plan (AMEC, 2013)

Burlington Mobility Hub	West Rambo Creek and Diversion (OTTHYMO refinement)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	East Rambo Creek (OTTHYMO refinement)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	Roseland Creek (refinement of SWMHYMO)	TRoseland Creek Flood Control Class EA (Philips Engineering Ltd, 2009)
Downtown Mobility Hub	Lower Rambo Creek (create model)	Unavailable. New PCSWMM model proposed
	Lower Hager Creek (create model)	Unavailable. New PCSWMM model proposed
Appleby Mobility Hub	Appleby Creek (GAWSER refinement)	Appleby Creek Floodline Mapping Update (EWRG 1997)
	Shoreacres Creek (refinement of GAWSER)	Shoreacres Creek Floodplain Mapping Update (EWRG 1997)
	Sheldon Creek (refinement of HSPF model)	Sheldon Creek Hydrologic and Hydraulic Study (DRAFT, AMEC Foster Wheeler, 2016)

* *Additional hydrologic modelling <u>may</u> be required for Falcon Creek and Glenwood Creek if it is determined* that these receivers *will experience hydrologic change due to the proposed Mobility Hubs development. This additional work would be determined pending discussions through the Technical Advisory Committee and review of the sewershed mapping. An existing PCSWMM model is available for Glenwood Creek (Aldershot Community Stormwater Master Plan, AMEC 2013), while an existing GAWSER model is available for Falcon Creek (Falcon Creek Hydrology and Hydraulic Study, Valdor 2012).*

6.2 Proposed Hydrology / Stormwater Management

a) Develop model parameterization for the proposed condition hydrologic model based on the three land use scenarios. Obtain approval for model parameterization by the TAC.

b) Model future uncontrolled conditions for each of the three land use scenarios.

c) Identify downstream constrictions within the major and minor system drainage routes and assess the impact of the proposed development. See also Section 6.3 below.

d) Develop watercourse specific stormwater management strategies that achieve the following goals and objectives:

(1) To ensure new development does not increase the frequency and intensity of flooding, the rate of natural stream erosion or increase slope instability;

(i) See Section 6.2 e) (2) for considerations related to erosion control

(2) To ensure natural heritage features and areas, including their ecological and hydrologic functions, are protected from potential adverse impacts of development;

(3) To prevent accelerated enrichment and contamination of surface and groundwater resources from development activities;

(4) To maintain linkages and related hydrologic and hydrogeologic functions among groundwater features, and surface water features, where required as determined through the scoped hydrologic and hydrogeologic study; and

(5) To ensure that riparian rights of downstream landowners, specific to the use and enjoyment of water across their property is respected.

e) The effectiveness of stormwater management mitigation plans must be confirmed through model simulation results for peak flow control and erosion mitigation performance. The preferred plan must be tested relative to the municipal design storms and Hurricane Hazel Regional Storm Event, and two climate change hydrologic scenarios (as established in the Draft City-Wode Flood Vulnerability, Prioritization and Mitigation Study, Amec Foster Wheeler, November 2016), and the August 4th, 2014 flood event. The following tasks shall be included:

(1) Utilize the results of the pre-development modeling to set targets and unitary discharge rates (paired storage and discharge values presented per impervious ha) at key locations. Provide preliminary sizing for stormwater management facilities;

(2) Determine whether erosion controls are required and provide technical justification for the selected level of control, in consultation with the TAC;

a) The Work Plan includes a preliminary assessment to identify the impacts on erosion potential related to the proposed land-use changes within the Mobility Hubs. 'Risk' will be established by:

(i) Completing a runoff volume impact assessment for the future land use scenarios based on the 25 mm Chicago 3 hour design event. Existing and future condition peak flows and channel velocities will also be considered.

(ii) Input from the fluvial geomorphologic assessment which will provide preliminary insight into the sensitivity of watercourse reaches within and

downstream of the Mobility Hubs. (e.g. highly armoured reaches represent a 'low' risk receiver)

b) Where erosion risk is considered 'low' by the TAC, no additional study will be required. Erosion control requirements for these areas will be approved by the TAC and may include: no erosion control, LID BMPs, extended detention based on current requirements outlined in the Stormwater Management Planning and Design Manual, MOE, 2003. Any emerging guidance will also be considered in consultation with the TAC.

c) Where erosion risk is not 'low' and the TAC determines a more rigorous assessment will be required to establish erosion controls; the scope for this work will be established by the TAC. Key scope gaps to complete a more detailed erosion assessment are considered to be 1. Establishing critical erosion threshold shear/flow; 2. Continuous simulation. Detailed erosion assessment is not included in the Work Plan.

(3) Determine whether post to pre-quantity control should be required for the Regional storm. The SWS must investigate and evaluate the potential risks and determine what level of control will be required. The analysis shall include the increase in risk to life (see qualifiers below) as well as the potential for flood risk to private, Municipal, Regional, Provincial and Federal property under Regional Storm conditions;

a) Risk to life will not be characterized through a detailed evaluation of depth and velocity. Flood impacts will be characterized by changes in water surface elevations, extents of flooding and hydraulic structure performance (i.e. overtopping frequency and depth). In the instance that the extents of flooding are predicted to meaningfully change, the impact and preliminary required mitigation controls will be identified for consideration by TAC as part of this study. Detailed measures or assessments are beyond the scope of the current study.

(4) Hydrologic model parameterization for impervious coverage to apply maximum potential impervious coverage based on proposed and existing zoning, and as established through the land use planning process. Planning policies will be required to ensure future development does not exceed the assumed maximum zoning imperviousness

(5) Assess the impact of the stormwater management strategies relative to creek peak flows and flow duration based on a design storm methodology. Present the hydrologic impacts of the proposed stormwater management strategies.

(6) Present the recommended stormwater management strategy. The conceptual design for the stormwater management facilities should include storage rating curves, facility locations, and outlets.

f) Identify opportunities to utilize Low Impact Development methods (LIDs), assess/quantify their feasibility and demonstrate compliance with the forthcoming MOECC Guidelines (anticipated to be released in Winter 2016/2017). Storm runoff should be treated via a multi-barrier approach, incorporating onsite, conveyance, end of pipe controls and LIDs to acceptable standards as determined in the MOECC's Stormwater Management Planning and Design Manual (2003) or more recent standard.

i) The Work Plan does not include any specific analysis/assessment to meet the anticipated update to the MOECC SWM Guidelines where the analysis/assessment is beyond that described by other tasks outlined in the Work Plan. The updated MOECC guidelines will be reviewed once available to determine if there is any impact to the Work Plan.

g) Hydrologic analyses shall be conducted for existing and future development conditions to determine pre and post-development flows and investigate the impact of post-development conditions on: flows, volumes, flood levels, channel erosion [see i) below] and base flows [see ii) below]. The subwatershed plans shall recommend an array of runoff control measures to be carried out in Secondary Plan and Subdivision Plan level studies to ensure that downstream peak flows are not increased, downstream channel erosion is not increased and that stormwater runoff is appropriately treated to meet water quality targets. The recommendations must be defined in sufficient detail to support completion of the subsequent secondary planning level studies.

i) Section 6.2 e) (2) for description of the erosion assessment included in the Work Plan

ii) Continuous simulation is not included in the Work Plan and as such, post-development impacts to baseflow will not be determined.

6.3 Natural Hazards

The study shall identify the extent of flooding and the limits of the erosion hazard lands within the study areas, in accordance with the Ministry of Natural Resources and Forestry (MNRF)'s Provincial Technical Guidelines and Conservation Authority direction.

To determine the hazard limit associated with valleys (confined and unconfined), both the flooding and erosion hazards are to be considered. The hazard limit is set by the greater of the flood or erosion hazard, plus the applicable development setback based on policy and regulatory requirements. Additional buffers and/or corridor widths maybe needed for

ecological and hydrologic purposes. The minimum setback is 15 metres from major valley systems such as Grindstone Creek, and 7.5 meters from minor valley systems.

a) Flood Hazards

Floodplain mapping refinements and/or generation (where watershed scale mapping and modeling is not available – as per the table below) are to be completed in accordance with MNRF recommendations based on the applicable Provincial Technical Guidelines (i.e., "Technical Guide – River & Stream Systems: Flooding Hazard Limit", Ministry of Natural Resources & Watershed Science Centre, 2002, "Technical Guide – Great Lakes, St. Lawrence River Shorelines, Flooding, Erosion and Dynamic Beaches", or updated current standard). Flood plain mapping must be refined/generated for the Mobility Hub study areas and for riverine flooding, a sufficient distance up and downstream to clearly characterize all hydraulic interactions and identify any future hydraulic impacts associated with development. The models should be detailed and flexible enough to evaluate modifications to the existing floodplains including realignment or changes to the corridor widths and profiles. The U.S. Army Corps of Engineers HEC RAS model is an acceptable tool for the hydraulic analyses.

Note: Provincial Technical Guidelines (i.e., "Technical Guide – River & Stream Systems: Flooding Hazard Limit", Ministry of Natural Resources & Watershed Science Centre, 2002 requirements/recommendations will be met with the following exceptions:

- Model calibration (Section F8 of the Technical Guide) will not be completed
- Testing and sensitivity analysis (Section F9 of the Technical Guide) will only be undertaken on the basis of peak flows where the Regulatory floodplain is not confined to a valley feature, or where the Regulatory floodplain is close to breaching a valley feature under future land use conditions

To establish/refine the existing riverine floodplain constraints to support a planning level study, the following steps must be completed:

i) Survey major watercourse crossing structures within the Mobility Hub study areas and a hydraulically relevant distance up and downstream, where existing data are not available or are not considered to be of a satisfactory level of accuracy, as approved by the TAC. A complete detailed survey of the low flow and bankfull channels (sufficient for floodplain mapping purposes) within municipal creek blocks along Appleby Creek is included in the Work Plan; opportunities to re-allocated the effort associated with this task will be considered by TAC on a priority basis. DEM data (0.5 m resolution) will be provided and may be applied to the floodplain throughout the remainder of the study areas where public access is unavailable. The project consultant is to ensure that the DEM and field survey data are properly integrated.

ii) As part of the refinement of the models, verify the hydrologic information, cross section locations and hydraulic parameters included in the hydraulic analyses and update as appropriate. Document the sources of information utilized within the hydraulic models. Alternatively, create and document a new hydraulic model where required. Hydraulic parameters utilized within the model are to be determined in consultation with the TAC.

iii) Establish reach boundary conditions based on the best available information, but ensure sufficient cross sections between the boundary conditions and study areas of interest to achieve model stability. Where Lake Ontario represents the starting water level, the mean monthly water level associated with Lake Ontario should be used as the boundary condition,

iv) The Lake Ontario's flood hazard limit (100 year high water level) must also be considered as it may govern in the establishment of the hazard within the Downtown Hub.

v) As part of the hydraulic modeling for the Aldershot mobility hub, the Floodplain delineation for Grindstone Creek must consider spill from the adjacent Falcon Creek. The spill values will be provided by the TAC.

vi) Validate the refined existing conditions models through comparison with original models (where available).

vii) Where the regulatory storm is defined by a 1:100 year design storm as opposed to Hurricane Hazel Regional storm event, climate change implications are to be assessed (three projected scenarios will be provided by the TAC) through modeling efforts and presented in a tabular form to inform the potential level of risk associated with anticipated climate change scenarios.

viii) Evaluate the extent of the future floodplains based on proposed hydrologic and hydraulic conditions as envisioned through the secondary planning process.

ix) Prepare full size copies of floodplain mapping (existing and proposed conditions) for the regulatory storm (greater of the 1:100 year or Regional Storm Event). The mapping shall be presented on a topographic contour base, overlain with property boundaries, structures, watercourse locations, and labeled hydraulic cross sections. Cross sections are to be labelled with cross section ID, the associated Regional and 1:100 year water levels, and the 'start' and 'end' of the modeled segments of the cross sections. Submit digital and hard copies of the mapping.

x) Hager-Rambo Diversion Channel & Flood Control System –

(1) The diversion channel is estimated to have capacity for the 50 year design storm based on the original design criteria and subsequent analyses. For larger design events (100 year and Regional Storm), the channel is expected to spill at several locations. A preliminary understanding of existing hydraulic conditions is available from Conservation Halton's draft HEC-RAS model for the channel. Spill paths are not known at this time, however spills are expected to impact the south end of the Burlington Mobility Hub and the Downtown Mobility Hub and may impact the location/nature of future development in these hubs. The magnitude of spill flow is also not known for any design event at this time.

(2) The Hager-Rambo flood control system consists of three (3) facilities including the Freeman Pond (QEW-Highway 403 interchange), West Hager Pond (North Service Road, west of Brant Street) and the East Rambo Pond (North Service Road, west of Guelph Line). The facilities were required to provide flood control (peak flow attenuation) for stormwater diversions related to the Highway 407 corridor (East/West Rambo Creek & East Hager Creek), and also accommodate a diversion from Roseland Creek. The flood control system was design and approved by the City of Burlington, Conservation Halton and the Province of Ontario to provide peak flow control for all events up to and including the Regional Storm.

    Current Provincial policy (ref. MNR, 2002) does not allow modification of Regulatory peak flows through stormwater management in establishing the downstream Regulatory flood hazard. Current policy also does not allow implementation of flood control measures for the purpose of facilitating development downstream. These policies are key considerations for the Mobility Hub Study as development proposed within the Burlington and Downtown Mobility hubs is expected to be affected by a flood flows in excess of the capacity of the Hager-Rambo Diversion Channel including spills. The associated flood risk will significantly increase if the Hager-Rambo flood control system is not credited for reducing Regulatory peak flows. It has not been determined how current policy affects previous Provincial approvals granted to the Hager-Rambo flood control system. However, it has been identified that a Hager-Rambo flood risk assessment is required and must consider peak flows with and without the flood control system in-place. The spill assessment will involve use of simplified techniques and will not involve 2D modelling.

(3) The Freeman Pond and the West Hager Pond detain runoff using an engineered barrier above ground (i.e. berms and/or weirs) which may classify them as dams under the Lakes and Rivers Improvement Act. Current Provincial criteria requires that dam breach assessments be undertaken to inform the design process and

establish flood risk downstream related to a flood wave. A dam breach assessment has not been undertaken to date. Given that the influence the two flood control facilities is integral to the Hager-Rambo system, a preliminary review of dam breach, including spill paths is considered required to understand the potential for an increase to Regulatory peak flows in the system (between the ponds and the diversion channel), and potential increase in flood hazard risk downstream.

(4) Based on the foregoing, the following assessments can be accommodated within the existing Work Plan:

(a) Hydraulic modelling to estimate the order of magnitude of the spills from for the Hager-Rambo Diversion channel, as well as upstream connecting channels, under attenuated and unattenuated Regulatory peak flow based on a steady-state flow methodology. Other simplified estimation techniques will be considered. The preceding assumes that hydraulic models of the channels between the ponds and the diversion channel are readily available from Conservation Halton in a usable state.

(b) Review of potential Freeman Pond, West Hager Pond, and East Rambo Pond breach spill paths to the extent that a preliminary understanding of the potential for the breach to affect the Burlington or Downtown Mobility Hubs. Given that the facilities are generally west of the Hubs (with the exception of the East Rambo Pond which is a depressed feature and thus considered to be lower risk), direct impacts are expected to be limited. Calculation of breach (i.e. Dam Break) peak flows cannot be accommodated in the current Work Plan.

(c) Review of topographic mapping to identify potential Diversion channel spill paths through the Burlington and Downtown Mobility Hubs. The spill path, local topography and the estimated spill magnitude will be considered together to coarsely estimate the potential extents of flood impact within the Burlington and Downtown Mobility Hubs.

(d) DISCLAIMER. To generate a level of accuracy that can be reasonably relied upon to guide development and establish related policies, including garnering the necessary approvals from Conservation Halton and the Province would require detailed hydraulic modelling including unsteady state flow analysis and 2 dimensional flow routing and potential dam breach assessment. Amec Foster Wheeler's Work Plan identified the concern related to the spill, however no effort was included in the Work Plan to conduct the above noted

assessments. Clearly the detailed analysis that would be required cannot be accommodated by the current Work Plan. That said, it is expected that above noted preliminary analyses can be accommodated within the existing scope. The assessments will necessarily be highly conservative and qualifiers regarding the accuracy will be applied. At best, the outcomes are generally expected to improve the understanding of the potential spatial impact of the spill, and inform the scope of additional future study. Given that there is very limited existing understanding of the hydraulics related to the spills, the level of effort required to establish meaningful parameters around the extent of flood risk in the Mobility Hubs is unknown. Therefore, Amec Foster Wheeler will make best efforts within the existing Work Plan to provide meaningful information around flood hazards related to the spill, however it cannot be guaranteed that outcomes of the spill assessment will meet the specific needs of the Mobility Hub Study. Amec Foster Wheeler will work with the engineering and planning teams such that potential gaps in the flood hazard assessment, as they relate to planning needs, can be identified as early as possible and options to re-assign or add additional scope can be considered by the City and TAC.

Table C Hydraulic Modeling Requirements

Mobility Hub	**Hydraulic Modeling Required**	**Available Information**
Aldershot Mobility Hub	Grindstone Creek (refinement of HEC-2 and conversion to HEC RAS)	Grindstone Creek Subwatershed Study (Cosburn Patterson Wardman Ltd, 1995)

Burlington Mobility Hub	West Rambo Creek and Diversion (review and refinement of Conservation Halton Hager-Rambo Diversion Channel Model, 2014)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
	East Rambo Creek (existing Amec Foster Wheeler model)	Technical Summary Updated Hydrology: Indian Creek, Hager-Rambo System, Roseland Creek (Phillips, 1997)
Downtown Mobility Hub	Lower Rambo Creek (create model)	Unavailable
	Lower Hager Creek (create model)	Unavailable
Appleby Mobility Hub	Appleby Creek (HEC-RAS refinement)	Appleby Creek Floodline Mapping Update (EWRG 1997)
	Sheldon Creek (refinement of Hec Ras)	Sheldon Creek Hydrologic and Hydraulic Study (DRAFT, AMEC Foster Wheeler, 2016)

b) Erosion Hazards

The erosion hazard assessment must be completed in accordance with the most current version of MNRF's "Technical Guide – River & Stream Systems: Erosion Hazard Limit," (currently 2002), which is deemed to be inclusive of Parish Geomorphic's Belt Width Delineation Procedures" (currently Revised 2004). Conservation Halton staff in conjunction with the proponent's geomorphologist and/or geotechnical engineer will determine the status of the valley systems as either confined or unconfined. For confined systems, the erosion hazard is defined as the greater of the physical top of bank or long term stable top of bank. For unconfined systems, the erosion hazard limit is defined as

the meander belt allowance. The 15m and 7.5m regulated setbacks are to be applied to governing erosion hazard (i.e. the meander belt, physical top of bank or stable top of bank).

The erosion hazard assessment must be completed by a licensed qualified professional Fluvial Geomorphologist, Geotechnical Engineer and/or Water Resources Engineer. Justification as to whether climate change impacts need to be considered as part of corridor sizing is required.

Recognizing that some of the Mobility Hub study areas are partially developed, it may be appropriate to analyze meander belt widths on the basis of empirical equations. Where the meander-belt width is determined on the basis of empirical equations, the results of multiple applicable equations are to be presented and justification is to be provided for the equation that is ultimately selected as most appropriate in this area.

At a minimum, the erosion hazard limit must be supported by documentation detailing: collected field data (if applicable), the methodologies applied, analysis and supporting calculations and text justifying the ultimate methodology selected to define the erosion hazard limit. Additionally, digital and hard copy figures must be submitted and shall include a signed and sealed, full size, scaled, plan view drawing showing:

i) Detailed topographic information (contour intervals of less than or equal to 0.5m) with a referenced source for all topographic information;

ii) The current locations of the watercourse centerlines and limits of bankfull channels;

iii) The erosion hazard limits ;

iv) The regulated allowance (15 metres for major valley systems and 7.5 metres for minor systems).

To support the assessments of the erosion hazards, the following must also be assessed:

<u>For unconfined systems:</u>

i) Reach break locations, overlain on an orthophoto complete with topographic mapping,

ii) Any noted areas of erosion concerns and any locations where the 100 year migration rate may have been determined;

iii) The watercourses' current central tendency (meander belt axis);

iv) Available historic watercourse centrelines (where available);

v) The calculated meander belts (preliminary meander belts);

vi) The analyzed 1:100 year erosion setbacks (100 year migration rate) or alternate setbacks using safety factors as required;

For confined systems:

i) Given that this study is intended to support secondary planning and not zoning or lotting, the project consultant is to apply conservative assumptions for stable slope inclinations (i.e. slope inclinations of 3:1 in soil) and toe erosion allowances (maximum tabulated values applicable to site soils) and forego the completion of a detailed geotechnical study at this time. The erosion hazards will need to be further refined through detailed studies at a later date, prior to site development. At that time, the physical top of bank must also be staked by Conservation Halton.

The following must be shown on a scaled sealed figure:

i) Slope cross section locations and I.D.'s

ii) Limit of the Toe Erosion Allowance; and

iii) Limit of the Stable Slope Allowance

6.4 Digital Data Requirements

The project consultant will be required to provide the following information to the City of Burlington, Halton Region, and/or Conservation Halton:

a) For modeling related data products, digital and executable copies of model input and output files, as well as licensed copies of any proprietary modeling software and PDF copies of key summary information (such as the model schematics, drainage area plans, hydraulic cross section locations, etc.) are to be provided to the City Region and Conservation Halton.

b) Digital copies of the written reports are to be provided in both MS Word 2010 and PDF format.

c) All mapping products produced for the study shall be geo-referenced to real world coordinates and have a standard UTM NAD 83, Zone 17 projection with NAD83 vertical datum.

d) New features captured by the project consultant using GPS or heads-up digitizing from air photography will have a capture accuracy rating for the feature included as an attribute (+/- 0.5 m accuracy).

e) A mapping layer index will be provided listing the layer name and providing a description/abstract of the layer's content. Also, FGDC compliant metadata shall be created for each layer produced by the project consultant.

f) Digital data will be delivered in one of the following formats: ESRI file geodatabase v10.2 feature classes or ESRI shape file format ensuring attribute names are not truncated in the shape files. Layers created by the project consultant shall be topologically correct (i.e. adjacent polygon features will be without gaps/overlaps and shall share vertices/nodes where appropriate).

g) If the project consultant utilizes ESRI ArcGIS to produce maps, the matching .mxd will be provided that corresponds to the mapping.

h) If software limitations prevent the project consultant from meeting these requirements, alternate formats may be considered (e.g., DGN) with the written agreement of the City. City GIS staff should be consulted if additional technical details are required to these requirements.

7.0 SUPPLEMENTORY INFORMATION

Table D Terrestrial & Aquatic Studies

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
☒	Ecological Land Classification (ELC)	• May to early June, July to September	• ELC System for Southern Ontario First Approximation (Lee et al., 1999) or as updated from time to time	• Classification to the Vegetation Type. • Should the community not be available within the Guide, please use the community series level and provide notation as to why this approach is used. • Include all data sheets (e.g., soils, disturbance, etc.). • Mapping should clearly differentiate between the polygons.
☐	Wetland Evaluation and Delineation	• Evaluation: variety of seasons to ensure the full evaluation occurs as per OWES • Delineation: Late spring to early fall, before the first hard frost with CH and potentially MNRF staff	• Ontario Wetland Evaluation System (OWES) for Southern Ontario (3rd Edition, 2014 or as updated from time to time)	• Detailed inventory and assessment including vegetation, mammals, birds, reptiles, amphibians, fish, insects, benthos etc., using specific protocol noted in this table. • Ensure sufficient time for MNRF to process. *Note: presence of wetlands to be confirmed through ELC surveys the next planning stage will require OWES delineation.*
☒	Vegetation Inventory	• Single-season: mid-June to August, to be completed concurrently with ELC	• Comprehensive vegetation species list to be provided, will be combined with ELC • Details on species including level of invasiveness, CoC, CoW, species rarity etc., should be recorded	Species rarity to be based on: • Species at Risk in Ontario list (MNRF) • S-Rank using the Natural Heritage Information Centre species lists • Local rarity using Halton Natural Areas Inventory (2006) and Hamilton Natural Areas Inventory (2014)
☒	Breeding Birds	• Breeding birds: May 24 to July 10	Habitat Dependent: • Ontario Breeding Bird Atlas protocols	• Point counts required for monitoring. • Generally consists of two survey visits spaced approximately 10 days apart,

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
			• Area searches and wandering transects	spread evenly over the season.
☐	Amphibians	• Early spring – summer (species dependent) • Active Visual Encounter Surveys (VES) on rainy late March – early April nights	• Bird Studies Canada Great Lakes Marsh Monitoring Program (including 3 separate spring/early summer seasonal survey timing windows). • Active Visual Encounter Searches (VES) for salamanders	• Trapping may be required for JESA, if known or suspected and as required and permitted by the MNRF. • If sampling in urban areas, point counts longer than three minutes may be recommended *Note: presence of potential amphibian breeding habitat to be confirmed through ELC surveys. Where necessary, recommendations to undertake amphibian breeding surveys will be made as part of the development application process.*
☐	Reptiles	• April – June • Late Summer/Fall: Late August to October for migration or congregating species • Weather dependent	• Species and habitat dependent • May include cover board surveys, spring emergence surveys etc. • Consultation recommended ahead of work	*Note: presence of potential reptile hibernacula or nesting areas to be confirmed through ELC surveys. Where necessary, recommendations to undertake additional surveys will be made as part of the development application process.*
☐	Butterflies	• June – August • July (peak) • Weather dependent	• Species and habitat dependent • Consultation recommended ahead of work	*Note: potential significant wildlife habitat for migratory butterflies to be confirmed through ELC surveys.*
☐	Dragonflies and damselflies	• June – August • July (peak) • Weather dependent	• Species and habitat dependent • Consultation recommended ahead of work	*Note: potential significant wildlife habitat for dragonflies and damselflies to be identified through incidental observations and other field studies (ELC, etc.).*

Y/N	Survey	Optimal Inventory Period	Methodology and Protocols	Notes
☐	Mammals	• Species dependent	• Sightings and tracking • Small mammal trapping depending on the site	*Note: potential significant wildlife habitat for mammals to be identified through incidental observations and other field studies (ELC, etc.). Where necessary, recommendations to undertake species specific surveys will be made as part of the development application process.*
☐	Bats	• During leaf off season for cavity tree surveys	• Species and habitat dependent • SAR Bats require different surveys than SWH bats. • MNRF Guidelines, where applicable • Consultation recommended ahead of work	*Note: potential for bat habitat to be identified through ELC. Where necessary, recommendations to undertake bat surveys will be made as part of the development process.*
☒	Stream Classification	• Summer (June- July)	• Ontario Stream Assessment Protocol (OSAP)	• Collect information on riparian and in-stream cover, stream morphology, nutrient input, etc.
☐	Benthic Invertebrate Sampling	• Spring (May)	• OSAP Section2, Module 3 • Travelling kick and sweep methods completed three times over the study period (May)	• Data to be collected includes % abundance, Family Richness, and % Taxa Richness Index *Note: to be completed during future investigations closer to construction, to set a baseline for monitoring purposes.*

Note: The surveys listed above were agreed to at the meeting with CH on February 14, 2017. Additional surveys may be required as identified through the preliminary field program, to be addressed through the development application and approvals process.

ATTACHMENT A:

Terrestrial and Aquatic Field Study Locations

Conservation Halton

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Protecting the Natural Environment from Lake to Escarpment

July 7, 2017

BY EMAIL AND MAIL

Phil Caldwell
City of Burlington
Planning and Building Department
426 Brant Street, P.O. Box 5013
Burlington, Ontario L7R 3Z6

Dear Mr. Caldwell:

Re: Mobility Hubs Project – Final Work Plan
City of Burlington
CH File: MPR 653

Conservation Halton (CH) staff has reviewed the City of Burlington's Mobility Hubs Final Work Plan dated updated April 25th 2017 and Agreement dated March 9, 2017 and offer the following comments:

- The level of study provided for the Appleby and Aldershot Hubs will generally identify flooding and erosion hazards and is sufficient to support the Area Specific Plans. Additional technical studies will be required to support redevelopment and intensification at the site-specific level. Some of these studies require holistic evaluation on a subwatershed basis, and should be completed in advance of any Site Specific Application, while others can be included as part of a Site Specific Application (Table 1 summarizes study gaps and recommended timing for these submissions). The Area Specific Plan should specify the types, levels, and timing of studies required and who would be responsible for funding and undertaking these studies.

- The level of study for the Downtown and Burlington Hubs is insufficient to determine the general nature and extent of the flooding and erosion hazards. Identification of areas where redevelopment and intensification is appropriate is not possible. **Conservation Halton recommends that the City undertakes additional required comprehensive studies, outlined below, prior to the completion of the Area Specific Plans to determine the general nature and extent of the flooding hazard and to develop appropriate land use policies to minimize risk to life and property through redevelopment and**

intensification in keeping with Section 3.0 – Protecting Public Health and Safety of the Provincial Policy Statement (PPS) (Conservation Halton has delegated responsibility for commenting on Sections 3.1.1-3.1.7 of the PPS under the one-window approach).

Should the City proceed with finalizing the Area Specific Plan (ASP) for the Burlington and Downtown Hubs without this additional analysis and decision making, the ASP should clearly indicate that comprehensive studies to determine the nature and extent of the hazards are required, in conjunction with additional subwatershed level studies, before site-specific applications for redevelopment and intensification could be accepted. The ASP should specify that a Terms of Reference for these comprehensive studies would have to be completed to the satisfaction of the City and Conservation Halton and indicate who would be responsible for undertaking and funding the studies. The policy framework developed for the ASP should implement measure(s) to restrict advancement of development or re-development proposals within the entire Study Area before completion of all additional comprehensive studies and subsequent site specific studies (Table 1 summarizes study gaps and recommended timing for these submissions).

Conservation Halton prefers that the City complete the required technical studies rather than deferring them to a latter stage of the planning process, as this would provide certainty to residents and developers in the Burlington and Downtown Mobility Hubs. Further discussion regarding the preferred approach is requested by CH prior to signing the Agreement.

The technical studies required and the rationale for requesting these studies are outlined below.

Additional Work Needed to Support Identification of the Flood Hazard at an Area Specific Plan Level for the Downtown and Burlington Mobility Hubs:

As acknowledged in the Disclaimer associated with AMECFW's updated April 25, 2017 Work Plan, *"To generate a level of accuracy that can be reasonably relied upon to guide development and establish related polices ... would require detailed hydraulic modelling... Clearly the detailed analysis that would be required cannot be accommodated by the current Work Plan."* The proposed studies do not fully characterize and define the limits of natural hazards associated with the Downtown and Burlington Hubs. Determining the extent of the flooding hazard impacting these Hubs is reliant upon an understanding of potential spill associated with the upstream Hager Rambo Diversion Channel. This is further complicated for the Downtown Hub by the need to understand how potential spills from the diversion channel impact the flood and erosion risks associated with the remnant lower Hager and lower Rambo channels. While a precise delineation of the flood hazard is not necessary at this time, it would be prudent for the City and Conservation Halton to understand the general extent of the flood hazard to establish a basic understanding of the lands available for intensification.

The extent of spill from the Hager Rambo Diversion channel is dependent upon how flow attenuation associated with the upstream Freeman, West Hager and East Rambo ponds are credited in the calculation of the flood hazard. Since Conservation Halton, the City, and the

Province jointly constructed the above-mentioned flood control reservoirs the hazard management approach for this area has credited these facilities in the past. However, current MNRF Guidelines do not support crediting any attenuation associated with on-line flood control reservoirs. As such, existing Approximate Regulation Limit mapping within the Downtown and Burlington Hubs should not be relied upon to determine constraints for intensification. To finalize the floodplain delineation associated with the Burlington and Downtown Mobility Hubs, a decision must be made on whether, it is appropriate to continue to credit the Freeman Pond, West Hager and East Rambo ponds.

Per discussions with the City of Burlington (June 5th, 2017 involving Allan Magi, Cary Clark, Barb Veale, Janelle Weppler, Janette Brenner), the City committed to reviewing their files for historical documentation on the flood control reservoirs. This information is to be reviewed prior to further consultation on this issue. Key information the City was to look for included:

- written documentation regarding the decision(s) made by the City, Conservation Halton and the Province to credit attenuation within the SWM facilities,
- final design and construction details (embankment height, inclusion of design safety factors incorporated into the design, etc.), and,
- ownership and management information.

As the City, Region and Conservation Halton will be potentially accepting additional risk/liability should there be a decision to continue crediting these ponds, additional attributes that contribute to the level of risk, must also be considered, including:

- potential future changes in flow contributing to these ponds due to climate change or development,
- consistency in floodplain mapping approaches relative to other flood control facilities in Conservation Halton's jurisdiction, i.e., dams, regional control ponds, etc.,
- future management requirements for the structures (i.e., Do the ponds need to be managed as dams in future? How will this impact the required frequency of maintenance and inspection? Are remedial works required to meet safety standards?), and,
- other relevant factors as determined through ongoing discussions.

Once a decision on crediting attenuation within the upstream ponds is made, the hydraulic analysis associated with the diversion channel must:

a) be revised based on any flow change,
b) determine whether spills are significant (and cannot be eliminated), and,
c) how any significant spill is credited in reducing downstream flows within the diversion channel.

Should significant spills from the Diversion Channel be recognized and credited, a corresponding analysis determining how spill from the Diversion Channel impacts the flood hazard associated with any watercourse or drainage system receiving the spill flows will be required. The updated April 25, 2017 Work Plan commits the Mobility Hub Consulting Team and TAC to identifying study gaps as early as possible.

A joint decision on crediting the existing flood control reservoirs must be made before land use concept plans and the technical studies supporting the ASP are finalized for the Burlington and Downtown Hubs, as the limit of the Floodplain Hazard will determine which areas may intensify. While this decision making process is understood to be separate from the Mobility Hub Study, the final decision may rely, to some extent, on the findings of the modelling proposed as part of the Mobility Hub Work Plan.

The updated April 25, 2017 Work Plan addresses modeling related to the on-line flood control reservoirs and associated spill, but only in a preliminary way, including the following items:

- estimation of the order of magnitude of the spill from the diversion channel under attenuated and unattenuated peak flow conditions;
- review of potential pond breach spill paths to provide a preliminary understanding of spill path routes through the Burlington and Downtown Mobility Hubs.

This approach will allow only a coarse estimate of the potential flood impact. Insufficient detail will be available to fully characterize the flood hazard. The level of analysis will be less rigorous than the analysis completed for the Appleby and Aldershot Hubs. To achieve a similar level of analysis, the quantification of the spills, their locations and their flow paths would be required as well as a decision on the use of attenuated or unattenuated flows.

Additional Technical Studies Recommended for all Four ASPs Prior to Site Specific Development Applications:

Should the City proceed with Area Specific Plans, additional holistic subwatershed scale technical studies should be completed to support development. In drafting the original ToR for the Mobility Hub Study, Conservation Halton staff accepted the limitations of the Council-driven timelines and access issues associated with fractured property ownership, and scoped several elements typically required to support an Area Specific Plan out of the agreed ToR. This was based on an understanding that these elements would be further assessed through later studies that would holistically address subwatershed impacts. The original requirements of the ToR were further scoped through the Work Plan presented by the City's consultants. Following development of the consultant's Work Plan, the City identified an expectation that development would advance directly from the Area Specific Plan to individual site specific development applications. Conservation Halton staff are very concerned with the proposal to advance directly to individual site specific development applications.

The following technical deficiencies, while not required for the completion of an Area Specific Plan, are better suited to a higher level study rather than a site specific application:

- *Hydrologic Model Review*: The Work Plan included a review of hydrologic model parameterization, but noted watershed wide re-parameterization (outside of the Mobility Hubs) was not included. There is also no requirement for the models to be calibrated and validated. Watershed conditions associated with the planned development, particularly as

described in the older hydrology studies (dated 1997 for Shoreacres, Appleby and the upper Hager Rambo Diversion System), may not fully correspond with actual development. Each Hydrologic model must be calibrated and validated following a watershed wide review, to ensure proposed stormwater management targets appropriately protect downstream residents from increased runoff generated by intensification. Following refinement of the existing condition model, the impact of the anticipated stormwater management controls should be tested to ensure that the shifted hydrographs associated with flow control will not negatively impact flooding or erosion when evaluated cumulatively.

- *Detailed Spill Assessment and 2-Dimensional Modelling:* The 1- Dimensional steady state modelling being created or refined may not be sufficient to assess the developed urban floodplain and/or the Falcon Creek Spill. 2-Dimensional modelling may be required to fully assess the flooding risks for site specific applications in some areas, such as the Downtown Hub, Aldershot Hub, and potentially the Burlington Hub.

- *Dam Break Analysis:* A dam break analysis is recommended to inform risk and for the purposes of emergency planning, downstream of the on-line ponds associated with the Hager Rambo Diversion Channel. (Note: Current MNRF Technical Guidelines recommends regulatory flows be assessed based on peak flow from a dam break conditions wherever public safety is the issue, but identifies a preferred approach of using unregulated flows to identify the flood hazard downstream of dams.) While it is not anticipated that the Dam Break Scenario would be used in establishing regulation limits, it is recommended that this work be completed to identify the level of risk posed by the upstream facilities. This would impact the Downtown and Burlington Hubs.

The current Work Plan is not sufficient for Conservation Halton to support site specific development applications or development adjacent to natural hazards without completion of the above technical studies. Completion of these studies as part of individual site development applications will not allow for comprehensive mitigation measures and will result in substantially more complex and costly submissions and delays. It is recommended that these studies be prepared by the City in advance of site development applications. Alternatively, a less preferable option could include identification within the policies of the Area Specific Plan that the above studies will need to be completed for the entire subwatershed area, by the first developer to advance redevelopment or intensification within each catchment area.

Work Required to Support Site Specific Development Applications:

Upon completion of the above studies, further site specific technical studies will be required to properly define and characterize natural hazards and features in order to satisfy Conservation Halton's regulatory requirements for future site specific development applications. Table 1 provides a summary of items required for site specific applications.

Summary of Future Works Required

Table 1 summarizes the studies required at different stages in the planning process. Additional comments related to individual study components are outlined in Appendix A. This list is not exhaustive and requirements may vary based on the individual sites.

Conservation Halton staff look forward to continue working with the City of Burlington through the review process for this Mobility Hubs Study. Further discussion regarding the points mentioned in this correspondence is recommended. If you have any questions please contact the undersigned at extension 2266.

Yours truly,

Barbara Veale

for Leah Chishimba, MAES
Environmental Planner

Cc: Jonathan Pounder, Conservation Halton, email
Rosa Bustamante, City of Burlington, email
Richard Clark, Region of Halton, email
Jason Elliot, Region of Halton, email
Mary Lou Tanner, City of Burlington, email
Allan Magi, City of Burlington, email
Cary Clark, City of Burlington, email

Table 1: Summary of Tasks/Analysis Requirements

Required Tasks/Analysis	Downtown	Aldershot	Burlington	Appleby
Tasks/Studies Preferably Completed Prior to Finalizing the ASP*				
Completion of all supporting studies identified in the Work Plan	✓	✓	✓	✓
Identification of future study requirements	✓	✓	✓	✓
Discussion and decision making on crediting attenuation associated with the Freeman, West Hager and East Rambo Ponds	✓		✓	
Quantification of spill flows and spill locations related to the Hager Rambo Diversion Channel	✓		✓	
Quantification of downstream flow paths from the Diversion Channel to the remnant channels (2-Dimensional modeling may be required)	✓		✓	
Studies Preferably Completed Prior to Site Specific Development Applications**				
Watershed-wide review and update to the hydrologic model, including calibration and validation	✓	✓	✓	✓
Watershed wide update to the hydraulic model, based on refined hydrology	✓	✓	✓	✓
Evaluate spill impacts associated with Falcon Creek		✓		
Dam break analysis is recommended to inform emergency planning and risk	✓		✓	
Detailed analysis of erosion potential and mitigation for all high risk watercourses	✓	✓	✓	✓
Re-evaluation of the proposed stormwater management strategy with due consideration for implications of timing of anticipated controls	✓	✓	✓	✓
Establish a monitoring framework	✓	✓	✓	✓
Note: Given the importance of assessing cumulative impacts, the above studies should be completed holistically, considering full future build out of catchment, including all development sites within the Mobility Hub.				
Studies Completed as Part of Site Specific Development Applications				
Flooding Hazard Assessment:				
Update hydraulic model based on detailed, accurate, site specific topographic information and map the regulated flooding hazard	✓	✓	✓	✓
Erosion Hazard Assessment:				
Determine and map the erosion hazard associated with confined valley systems and/or refine the unconfined hazard limit. Map the regulated erosion hazard.	✓	✓	✓	✓
Shoreline Hazard Assessment:				
Refine and map the flooding and erosion hazards associated with Lake Ontario	✓			
Stormwater Management (SWM) Assessment:				
Demonstration that all SWM Criteria (enhanced level of quality control, erosion and quantity control, water balance, etc.) required to mitigate development impacts is achieved in accordance with current guidelines.	✓	✓	✓	✓
Terrestrial and Aquatic:				
Additional field work may be required to address data gaps and uncertainties within the characterization of terrestrial and aquatic environments and hydrologic setting.	✓	✓	✓	✓
Hydrologic/hydrogeologic evaluation and water balance for wetlands (where applicable)	✓	✓	✓	✓
Monitoring	✓	✓	✓	✓

* These studies must be completed before acceptance of Site Specific Development Applications

** If these studies are deferred to a site specific development application, the first development to go forward would need to assess impacts associated with all development in the watershed within and adjacent to the Mobility Hub, similar to an EIR/FSS or SIS/EIR process applied in adjacent municipalities.

Detailed Requirements for Site Specific Development Applications for all the Mobility Hubs

APPENDIX A

1. Erosion Hazard:

The Mobility Hub Study Work Plan proposes to assess the extent of hazard associated with Confined Valley Systems through a desk top exercise considering conservative stable slope inclinations and toe erosion setbacks, based on available information. Future development applications on properties located adjacent to or containing a confined valley system will be required to complete the following:

- Top of bank staking in the field by Conservation Halton with an Ontario Land Surveyor (OLS);
- A Fluvial Geomorphic Assessment that assesses toe erosion (considering both current and anticipated future conditions);
- A slope stability assessment in accordance with current MNRF Guidelines, to the satisfaction of Conservation Halton. It is expected that the Geotechnical Assessment will require completion of site specific boreholes and survey of the slope.

Please note that for unconfined valley systems, the tasks associated with the work plan should be sufficient to assess the existing erosion hazard, however, additional works to clarify the extent of the development constraint associated with the meander belt component of the erosion hazard will be required for systems impacted by mitigation strategies (i.e., systems that may be 'day lighted' or otherwise altered), and for systems undergoing significant changes in hydrologic regime.

2. Shoreline Erosion Hazard:

For properties within the Downtown Hub impacted by the shoreline hazard the following will be required:

- A detailed topographic survey and geotechnical borehole analysis.
- Delineation of the erosion hazard and associated development setbacks.
- Assessment of shoreline protection works to ensure they meet current standards. The repair/ replacement/ reconstruction of shoreline protection works will be required if they do not meet current standards.
- A CH permit for the shoreline protection works.

Please note that Conservation Halton requires that the shoreline protection works meet current standards to ensure the erosion hazard is addressed, and to reduce development setbacks.

It is also recommended that pre-consultation be undertaken, as setbacks associated for Lake

Ontario can be significant and there are properties along this stretch where development would be restricted to replacement of no more than what currently exists.

3. **Floodplain Hazard:**

While the Area Specific Plan will provide some rough delineation of floodplain hazards, further refinement will be required in support of any site specific applications. The following analysis 'gaps' and associated study requirements will apply to each property containing or located adjacent to the floodplain hazard:

- The hydrologic and hydraulic models need to be validated through comparison with the measured and observed precipitation, runoff response, flows, and water levels. The validation process may trigger the need for further model calibration and refinement. Model sensitivity should also be assessed through this process.
- The available topographic data utilized in the hydraulic models is not sufficient for site specific property applications, and as such the model must be refined on the basis of detailed topographic survey or LiDAR data (of appropriate quality) to support individual property developments.
- Given the limited feasibility of eliminating the spill from Falcon Creek to the Grindstone Creek and Indian Creek Systems, detailed evaluation of the spill will be required to confirm appropriate downstream flood flows for each of the above listed watersheds. This will need to be assessed prior to any site specific development within the Grindstone Creek system.
- The 1- Dimensional steady-state modelling being refined and created may not be sufficient to assess the developed urban floodplain. 2-Dimensional modelling may be required to fully assess the flooding risks for site specific applications within the Aldershot, Burlington and Downtown Hubs (not anticipated for the Appleby Hub).
- While a preliminary investigation of potential downstream spill pathways has been considered, a full dam breach assessment has not been considered downstream of the Freeman and Triple Ponds or other on-line controls. Additional assessment may need to be undertaken pending the outcomes of the Mobility Hub Study's initial assessment

The above limitations will need to be addressed individually as each application advances, and will require additional effort to ensure data consistency. Gaps should be considered cumulatively and holistically for the entire development catchment to the extent feasible, by the first development to advance within each hub.

4. **Hydrologic Impacts to a Wetland:**

Specific hydrologic impacts to wetlands will need to be evaluated at a site specific stage as the existing models are not integrated groundwater/surface water models and the stormwater management strategies being advanced will be high level. To support development adjacent to a wetland, the following will be required:

- A hydrologic evaluation that demonstrates at minimum that there will be no negative

impact to the hydrologic functions of the wetland as result of the proposed development.

5. **Stormwater Management Criteria:**

Significant gaps are noted with respect to the establishment of Stormwater Management Criteria for the subject lands:

- The hydrologic modeling work relies on a variety of existing models, resulting in the establishment of stormwater management criteria based on numerous different modelling platforms of various degrees of currency. The models are to be updated relative to each of the hubs, but a watershed wide update is not considered within the Work Plan. Therefore, the stormwater management requirements associated with each watershed may not be as 'equitable' as if they were modeled using a consistent modeling platform. It is possible that watershed conditions associated with the planned development, particularly as described in the older hydrology studies (dated 1997 for Shoreacres, Appleby and the upper Hager Rambo Diversion System), may not fully correspond with actual development.
- The Work Plan does not include a requirement to calibrate or validate models using existing information nor does it include requirements to collect and calibrate or validate the existing models utilizing new calibration data. Conservation Halton staff had previously indicated through our comments on the ToR the need for validation of each hydrologic model as part of a subsequent phase of the study. Where validation results in a significant revision to flows, the stormwater management strategy must be reassessed to confirm that the required extent of mitigation is maintained.
- The hydrologic modeling work does not require continuous modeling or the determination of a critical erosion threshold, resulting in less robust analysis tools to assess channel erosion impacts and effectiveness of the mitigation strategy. Where the potential for 'high' erosion risk is identified, more detailed analysis (that considers cumulative impacts associated with full build out of the Mobility Hub) will be required to support a site specific mitigation strategy at the site plan stage.
- The Stormwater Management Strategy is being defined based on the 2003 MOE Stormwater Management Planning and Design Guide. It is anticipated that the MOECC's forthcoming LID Design Guide may significantly alter stormwater management practices, and may require re-assessment or significant revision to the SWM Strategy, when this Design Guide comes into effect.
- The Stormwater Management Strategy is based on an expectation that planning policies will protect against increases in impervious coverage over and above the maximum allowable under current and proposed zoning. At the site specific development stage, updated hydrologic modelling may be required should intensification increase impervious coverage beyond what was considered at the time of the Mobility Hub Study.
- Fractured ownership within each of the hub areas are anticipated to result in a series of

on-site controls, as opposed to development of communal, municipally controlled infrastructure. Timing impacts associated with the development of numerous site specific controls will not be fully assessed through the Mobility Hub Study. Development of a municipal site control strategy to address intensification concerns regarding ensuring maintenance of on-site stormwater management controls is also recommended.

Given the importance of assessing cumulative impacts, additional study prior to initiation of development is to be completed holistically, and have due consideration for the full future build out of the watercourse catchment, including other sites within the Mobility Hub. This assessment may be submitted as part of an enhanced Stormwater Management Design Brief.

6. **Monitoring:**

Monitoring, such as detailed geomorphic monitoring, has not been included in the work plan. Determination and completion of necessary pre and post-construction monitoring has been deferred to future study, and therefore may result in the delay of future site specific development while the pre-construction monitoring program is confirmed and sufficient baseline monitoring is completed.

7. **Terrestrial and Aquatic:**

Once, initial characterization work is completed, and more is known in terms of proposed land uses and potential impacts, additional field work may be required to address data gaps and uncertainties within the characterization of terrestrial and aquatic environments and hydrologic setting.

Conservation Halton

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Protecting the Natural Environment from Lake to Escarpment

April 20, 2018

BY EMAIL AND MAIL

Phil Caldwell
City of Burlington, Planning and Building Department
426 Brant Street, P.O. Box 5013
Burlington, Ontario L7R 3Z6

Dear Mr. Caldwell:

Re: Aldershot and Appleby Mobility Hubs – Flood Hazard Assessment Scoped Environmental Impact Study and Scoped SWM Assessment
Mobility Hubs - City of Burlington
CH File: MPR 653

Conservation Halton has reviewed the following report submitted to support the Mobility Hub Study in the Aldershot and Appleby Hubs:

- Amec Foster Wheeler's February 21, 2018 Memo Re: Aldershot and Appleby Mobility Hubs – Flood Hazard Assessment – Scoped EIS, City of Burlington.

Inclusion of file documentation including the creation of readme files documenting modelled changes are greatly appreciated, and strengthen the future utility of the models, report and analysis,

General Comments

There are three key comments that require further discussion with Conservation Halton to resolve. More detailed technical comments are provided in Appendix A:

1. **Flood Risk Analysis** – As noted in ***Section 2.2.1 Bi-Lateral Spills (Falcon Creek)***, there is a bi-lateral spill from Falcon Creek towards Indian Creek to the east and Grindstone Creek to the west. This has the potential to impact the extent of development potential within the Aldershot Hub. However, the spill from Falcon Creek has not been incorporated in the Flood Risk analysis for Grindstone Creek. The spill should be considered when evaluating flood risk and determining the extent of the regulatory floodplain in the Aldershot Hub study area, until such time that the spill is mitigated.
2. **Stormwater Management Ponds** – In past discussions regarding the Downtown and Burlington Mobility Hubs, Conservation Halton has requested that the hydrologic and hydraulic models incorporate scenarios with and without upstream infrastructure, in light of the unique circumstances surrounding the diversion system. The extent of the regulatory storm floodplain shown in Drawing 11 (Appleby Creek) is based on the crediting of upstream stormwater management facilities located north of the QEW. For the purposes of the Appleby Mobility Hub, the standard approach, based on Provincial Guidelines, should be used to define the regulatory storm floodplain.

3. **Redevelopment and Intensification within the Regulatory Floodplain** – The concept plan shows some redevelopment and intensification within the regulatory floodplain within the Aldershot and Appleby Mobility Hubs. Consideration for this type of development runs counter to Provincial Policy Statement policies (Section 3.1) and is not supported by Conservation Halton's Board-approved policies. Any redevelopment within regulated areas will require permission from Conservation Halton. We recommend that all concepts to facilitate intensification and redevelopment, including potential floodplain modifications, be aligned with Conservation Halton's planning and regulatory policies to ensure that permits can be supported.

Next Steps

For subsequent submissions, the inclusion of a detailed response matrix would facilitate a quicker review. We appreciate the opportunity to comment on the Mobility Hub Study and would welcome further dialogue to resolve the above issues. If you require additional information or have any questions please contact the undersigned at extension 2231.

Yours truly,

Heather Dearlove, B.Sc.
Environmental Planner

Cc: Ron Scheckenberger, Amec Foster Wheeler, email
Jonathan Pounder, Conservation Halton, email
Barb Veale, Conservation Halton, email
Hassaan Basit, Conservation Halton, email
Rosa Bustamante, City of Burlington, email

Appendix A: Detail Comments

Detailed Comments from the Review of the February 21, 2018 Memo

1. ***2.1.2.2 GAWSER Modelling (Grindstone and Falcon Creeks):***
   a. OMAFRA Soil mapping would appear to indicate great similarity between catchments GR 308 and GR307. The predominate use of a BC soil type for pervious portions of catchment GR308 (as indicated in Table 2.3) should be reviewed and clarified.
   b. The receiving outlet for catchment FL01 should be reviewed in greater detail. Conservation Halton's 2002 DEM confirms that catchment FL01 drains north to the hydrologic connection adjacent to the rail line, but indicates that this catchment drains westerly to Grindstone Creek as opposed to easterly to Falcon Creek. Review of the 2017 aerial photo indicates that the hydrologic connection is piped for approximately 250 m between the southern parking lot and railway until a point along the railway co-incident with the extension of Clearview Avenue. The ultimate receiver for FL01 should be reviewed in greater detail and the report updated accordingly.
   c. The analysis completed by Amec Foster Wheeler indicates that LaSalle Creek and Forest Glen Creek are not expected to receive drainage from the Aldershot Mobility Hub. Please confirm whether this statement is intended to apply to both major and minor system drainage, and provide supporting information (Based on Conservation Halton's topographic information, there appears to be limited gradient defining the watershed divide between Forest Glen and Teal Creeks, increasing potential for major system outflows from the Aldershot Mobility Hub to drain to Forest Glen Creek). Please review this potential, and update the report accordingly.

2. ***2.1.2.3 PCSWMM Modelling (West Aldershot Creek and adjacent Creeks):***
   a. Additional justification for the proposed SCS Soil Classification of BC for all catchments within the West Aldershot Creek is requested to be included within the report. Available OMAFRA mapping indicates the soil to be a Guelph Loam, which has a hydrologic soil classification of B. The Guelph Loam is surrounded by Grimsby Sandy Loam and Springvale Sandy Loam, both having a hydrologic soil classification of A.
   b. Additional justification for the proposed SCS Soil Classification of BC for the Teal Creek is requested to be included within the report. Available OMAFRA mapping indicates the soils within catchments S6, S7, S15, S19, and S74 to be either a Guelph Loam, which has a hydrologic soil classification of B or a Winnona Sandy Loam which has a hydrologic soil classification of AB.
   c. It is recommended that the final EIS contain Subcatchment Parameterization Tables for West Aldershot and Teal Creeks, as was done for Grindstone Creek and Falcon Creek.
   d. Flagging potential issues arising from direct application of the modeling from the 1995 Grindstone Creek Study by Cosburn, Patterson, and Wardman is appreciated. As the on-line ponds included in the Future Conditions Grindstone Creek model service areas that have not yet developed, and as flow rates indicated in Table 3.4 Appendix E of the 1995 Subwatershed Study indicate future condition regulatory flows will continue to exceed existing condition regulatory flows, Conservation Halton is supportive of directly applying the 1995 model to determine external flow contributions.

3. ***2.1.3.1 GAWSER Modelling (Grindstone and Flacon Creeks):***
   a. The tributary numbering convention from Grindstone Creek Subwatershed study (and described in Section 2.1.2.2 of the report) has not been followed in the drainage node location descriptors

included in Tables 2.5 and 2.6. The location descriptors should be revised to ensure consistency with the upper level study.

b. Conservation Halton has substantially different catchment areas associated with influent areas at Nodes G815 and G804 as compared to the values reported in Table 2.5. Conservation Halton's data indicates that Grindstone Creek Tributary 3 (Node G815) has an upstream drainage area of approximately 180 ha (as compared to the modelled drainage area of 96 ha), while node G804 identified in our GIS as having a contributing drainage area of 140 ha, as opposed to the modelled as 220 ha drainage area. Conservation Halton recommends that the drainage area contributions upstream of the two culverts be reviewed and updated in the report.

   Alternately, provided there is no development proposed between the tributary reach in question (between Nodes G815 and G804) and the QEW, and recognizing the current study approach represents the most conservative scenario, the potential discrepancy in drainage areas may be referenced in the report as an item that may require future investigation to support infrastructure or other future works within Grindstone Creek Tributaries 2 and 3 north of the Aldershot Mobility Hub.

4. ***2.2.1 Bi-Lateral Spills (Falcon Creek):***
   a. Given the significance of the high point elevation in the spill assessment, additional documentation confirming the noted high point spill elevation of 102.80 m will need to be included in the report.
   b. In regards to spill flow optimization, Conservation Halton would normally be supportive of advancing the assessment of flow to Grindstone Creek on the basis of full optimization of flows from Falcon Creek (i.e. allowing for concurrent spills to Indian Creek to reduce Falcon Creek flows, impacting spills to Grindstone). As there are discrepancies between the Falcon Creek spill to Indian Creek considered in the detailed design of the adjacent King Road Grade Separation and the optimized and non-optimized flows presented in Table 2.9, Conservation Halton is supportive of Amec Foster Wheeler's analysis approach, which advances consideration of Falcon Creek spills to Grindstone Creek independently of spill to Indian Creek within this higher level study. Conservation Halton would be in a position to support flood risk analysis in Grindstone Creek being based on flow optimization values presented in Table 2.9 following receipt and review of the Amec Foster Wheeler's 2018 hydraulic model assessing the extent of lateral spill.

      The optional future work analyzing spill to Grindstone Creek based on optimization of Falcon Creek flows to both Grindstone and Indian Creeks concurrently should only be undertaken in conjunction with the collection of more detailed topographic information.
   c. Text within Section 2.2.1 appears to indicate confusion over Conservation Halton's expectations related to flow optimization and spills. As a point of clarification, Conservation Halton looks to have non-optimized flows utilized for the 'spilling' watercourse (in this case Falcon Creek) to protect downstream capacity within the system should grades be adjusted to eliminate spills in future, i.e. spill flows out of a system should not be recognized as reducing flows downstream within the same system. Conservation Halton does not require spill assessments within the watersheds receiving spills (in this case Indian Creek and Grindstone Creek) to be based on non-optimized flow conditions, recognizing that under non-optimized flow conditions, spills would be prevented and not occur.

5. ***3.1.2.2 GAWSER Modelling (Shoreacres & Appleby Creeks), page 23:***
   a. Additional discussion and examples are required to clarify Amec Foster Wheeler's approach of maintaining the parent catchment's length and width parameter ratios for the additional

catchments further discretized from the parent catchment. While the goal of maintaining a consistent lumped catchment response is appreciated, the concept of application of an area based weighting to parameterize routing within re-discretized subcatchments is not a standard practice. Additional discussion is required before Conservation Halton will be in a position to support this approach as part of the Mobility Hub Study. A greater understanding of the following is required:

i. Which catchments were altered and how?
ii. How closely do area averaged routing parameters represent the actual routing for the re-discretized catchments?
iii. What limitations does the use of this approach place on future use of this model? How sensitive is the outcome of the Mobility Study and future studies to flows calculated internal to the original subcatchments, i.e. what is the impact of the approach, are there any foreseeable model uses that would rely on accurate model representation at a point internal to the parent catchment?

b. The regional conditions Appleby Creek model maintains route reservoir functions associated with the Rotary Pond, while the regional conditions Shoreacres model maintains route reservoir commands for a number of reservoirs. To ensure the extent of the regulatory floodplain is characterized in accordance with MNRF Technical Guidelines, a regional model run for Appleby Creek should be completed without the Route Reservoir command for the Rotary Pond. Similar adjustments to the updated Shoreacres models are not required, as the regulated floodplain associated with Shoreacres Creek does not intersect the Appleby Mobility Hub. Please update the model and report accordingly.

c. The proposed approach of scaling pervious area characteristics on the basis of extent of pervious cover in the initial subcatchment can be supported where the current impervious coverage is understood to have been representative of the extent of impervious coverage at the time of the initial model. The scaling approach applied is not expected to be reflective of potential changes in the proportion of pervious coverage parameters where new impervious areas have been introduced in catchments with multiple pervious characteristics. While the work completed for the Mobility Hub study is accepted as sufficient for the purposes of Secondary Planning, this approach is not generally supported for future projects. For future studies, pervious coverage parameterization should be modelled based on the best available information. No changes to the analysis is required.

d. Table 3.7 shows a decrease in anticipated impervious coverage for parent catchment A5 (a catchment located south of the QEW within a built up area). Please review the ortho photography for this area and confirm the appropriateness of the proposed modelled impervious coverages. Please review and update the report accordingly.

6. ***3.1.3.1 GAWSER Modelling (Shoreacres & Appleby Creeks):***

a. The 1:100 year flow reported at node 6101 (in Table 3.9) is significantly higher than expected given the reported drainage area. The model and table should be reviewed more closely and updated as required.

b. The 135 ha increase in drainage area between nodes 651 and 607 is not clear based on the information presented in Drawing 9. Please review and update as required.

c. While sufficiently outside of the detailed study area, such that additional model refinements are not anticipated, additional consideration may be warranted as to why Table 3.9 indicates a disproportionate flow increase between nodes 601 and 641. Additional clarification is required.

7. ***3.2.3.1 Appleby Creek, page 36:*** 2-D modelling is indicated as required to more definitively confirm spill extent upstream of the railway crossing and east and west of the Appleby GO station. From a regulatory development constraint perspective, 2-D modelling will not be required. The recommended approach from a regulatory perspective would be to define the spill point (based on the topographic location where flow is no longer directed towards Appleby Creek), and mitigate the spill through a combination of grading outside of the regulated limit and/or infrastructure improvements (larger culverts/twinned culverts, etc.).

8. ***3.1.3.2 HSP-F Modelling (Sheldon Creek), page 34:*** Tables 3.11 and 3.12 refer to the location of Node 105.1 as Mainway. The nodal description should be updated to be reflective of the location indicated in Drawing 10.

9. ***Drawing 1 – Study Area Plan (Aldershot Area):*** Drawing 1 excludes several culvert crossings under the CN tracks which are identified in Conservation Halton's mapping and appear to be supported by the downstream channel formations visible in the Halton Region's orthophoto imagery – including two crossings west of Waterdown Road within the study area and one downstream. It is also noted that there is a culvert connection across the QEW connecting Tributary 4 to the downstream feature. For clarity it is recommended that all culverts or pipes be included within the stream flow network to ensure flow pathways are clarified. Please update the drawing to include all culvert or pipe connections within the study area.

10. ***Drawing 3 – Subcatchment Boundary Plan:***
    a. The inclusion of specific study references for external drainage areas is appreciated. For completeness, please provide a copy of the catchment plans associated with referenced reports within an appendix of the final report as this will increase future report utility.
    b. The boundary plan does not include all nodes identified in Table 2.5 and 2.6. Please update the drawing for completeness.

11. ***Drawing 4b Preliminary Floodplain Mapping (Grindstone Creek – East of Waterdown Road):*** The regulatory floodplain elevation provided hydraulic cross sections 19, 0.800, and 0.750 is slightly greater than what has been modelled. Please update the drawing accordingly.

12. ***Drawing 9 Subcatchment Boundary Plan (External Drainage Areas):*** Please review and revise for clarity the letter assigned to node 601, and the placement of node S641

13. ***Drawing 11 Preliminary Floodplain Mapping (Appleby Creek):*** The provided hydraulic cross section identification labels associated with Reach 2 should be revised for consistency with the hydraulic model.

14. ***Grindstone Creek Hydraulic Model – Upstream of Waterdown Road and Grindstone Creek Hydraulic Model – Downstream of Waterdown Road:*** Neither of the two Grindstone Creek hydraulic models incorporates the calculated spill flows from Falcon Creek. To support the analysis of future development potential, the flood risk from this spill must be considered, and the floodplain limits updated accordingly.

15. ***Grindstone Creek Hydraulic Model – Upstream of Waterdown Road:*** The following minor issues/concerns related to the Grindstone Creek Hydraulic Model – Upstream of Waterdown Road need to be clarified or resolved as part of future studies, but <u>are not</u> anticipated to significantly impact the extent of the floodplain to the point where these issues need to be addressed as part of the City's Secondary Planning Study:
    a. Hydraulic cross sections 20 and 0.15 needed to be extended unless they can be shown to relate to a spill.

b. Standard conventions for modelling expansion and contraction and Manning's n associated with the Parking Lot/403 on-ramp at approximate hydraulic cross section 14 do not appear to have been followed. Please review and revise bounding hydraulic cross sections accordingly.

c. The hydraulic cross section spacing adjacent to the Waterdown Road culvert and CNR crossings may not have properly accounted for the full expansion and contraction zones around the structures, as the distance to up and downstream cross sections was reported to be less than the culvert opening.

d. The ineffective flow station elevations applied to upstream and downstream hydraulic cross sections bounding structure 0.25 are greater than the minimum top of road elevation modelled. Ineffective flow stations should be adjusted as per conventions or justification provided.

e. Bank station widths should be adjusted to be more representative of existing conditions.

f. Flow stations should be updated to ensure consistency with final models. Minor discrepancies were noted related to the flow change at Hydraulic Cross Sections 1, 0.45, and 0.224. Updates for consistency will be required as part of future site specific studies.

16. ***Grindstone Creek Hydraulic Model – Upstream of Waterdown Road:*** The following minor issues/concerns related to the Grindstone Creek Hydraulic Model - Downstream of Waterdown Road need to be clarified or resolved as part of future studies, but <u>are not</u> anticipated to significantly impact the extent of the floodplain to the point where these issues need to be addressed as part of the City's Secondary Planning Study:

    a. Main channel widths must be updated relative to existing site conditions.

    b. Overbank Manning's n values in the lower portion of reach M4 should be updated to reflect naturalized conditions.

    c. Levees or ineffective flow areas should be added to cross sections within the upper reach of M4.

    d. Flow stations should be updated to ensure consistency with final models. Minor discrepancies were noted related to the majority of flow change stations for the Regional model. Updates for consistency will be required as part of future site specific studies.

17. ***Appleby Creek Hydraulic Model:*** The following concerns are expected to have impactful changes to the modelled regulatory water surface elevation and <u>are</u> to be addressed as part of the Mobility Hub Study:

    a. Main channel bankfull stations must be reviewed and updated as necessary to be representative of existing conditions within the Mobility Hub area and the relevant hydraulic distance extending beyond the Mobility Hub boundary.

    b. Justification for selected main channel and overbank Manning's n values in River 1 Reach 2 is required where the values selected differ from the provided Table (see the last page of Appendix A) or the model should be adjusted to apply more standardized overbank and main channel Manning's n values within the limit of hydraulic relevance to the Mobility Hub.

    c. The expansion and contraction zones around crossing structures do not appear to have been modelled in accordance with recommended HEC RAS conventions. Review and refinement of the modelled expansion and contraction zones around the following hydraulic crossings is required: 2710, 2825, and 3460.

    d. Model stability within the majority of the Mobility Hub study area should be reviewed, and refinements made as the hydraulic model repeatedly defaults to critical depth across multiple sequential cross sections. Adjust the model and update accordingly.

18. ***Sheldon Creek Hydraulic Model:*** The following concerns are expected to have impactful changes to the modelled regulatory water surface elevation and are to be addressed as part of the Mobility Hub Study:
    a. Flow change nodes have been applied downstream of crossing structures, despite catchment mapping from previous studies indicating flow contributions would be based on catchments located upstream of crossing structures. Please update the flow change locations or provide justification supporting the proposed flow change location.
    b. Please ensure that non-calibrated flows have been incorporated for the entire portion of the downstream study area and a hydraulically significant upstream distance.
    c. Model stability within the majority of the Mobility Hub study area should be reviewed, and refinements made as the hydraulic model repeatedly defaults to critical depth across multiple sequential cross sections.
    d. Main channel bankfull stations must be reviewed and updated as necessary to be representative of existing conditions within the Mobility Hub area and the relevant hydraulic distance extending beyond the Mobility Hub boundary.
    e. Justification for selected main channel Manning's n value of 0.03 is required. There are also opportunities to adjust overbank Manning's n values, outside of the municipal creek corridor to be more reflective of existing conditions, should the above changes increase the extent of flooding.
19. **Sheldon Creek Hydraulic Model:** Additional concerns with the Sheldon Creek Hydraulic model have been expressed in Conservation Halton's letter of related to the City's Floodplain Modelling Update for Sheldon Creek. Conservation Halton will require further refinement of the Sheldon Creek model (relative to several of the issues flagged in the letter), as part of future study updates in support of specific development applications.
20. It may be beneficial to explore accuracy of available topographic mapping sources, as Aquafor Beech has been retained by the City of Burlington to explore flood risk and mitigation potential within Appleby Creek downstream of the Fairview Road. Preliminary modelling and mapping prepared by Aquafor Beech has indicated higher flood elevations within the Bridelwood neighborhood, but despite the increased modelled water surface elevation determined by the Aquafor Beech model, their floodplain mapping does not show the regulatory floodplain extending beyond or substantially into any of the residences along Bridlewood Crescent.

Recommended Overbank Manning's n Values:

In reviewing potential standards to be applied as part of internal watershed wide floodplain mapping efforts, Conservation Halton staff are considering the following criteria. While Conservation Halton staff do not require modelling to be updated to reflect values in the below table, justification within the report is required should the Engineer choose to select alternate Manning's n values as more representative for a given land use. Please note that for publicly owned channel corridors, it is expected that a Manning's n value of 0.08 be applied for the entire overbank corridor width. Alternate values may be accepted where publicly owned lands extend within the regulated floodplain but are outside of the 'channel corridor', i.e. for sports fields, manicured parks, etc.

Recommended Overbank Manning's n Values		
	Existing Condition	**Manning's 'n'**
Channel	Concrete	0.015
	Armourstone or gabions	0.025

	Vegetated or Natural Rock	0.035
Floodplain	Asphalt/Concrete	0.02
	Manicured Grass/Lawns – rural, within 30 m of watercourse*	0.08
	Manicured Grass/Lawns – urban, within 30 m of watercourse and in public ownership or large estate lots*	0.08
	Manicured Grass/Lawns, Other	0.045
	Pasture – within 30 m of watercourse*	0.08
	Pasture – other	0.045
	Crop – within 30 m of watercourse*	0.08
	Crop – other	0.045
	Field/Meadow – within 30 m of watercourse*	0.08
	Field/Meadow – other	0.055
	Brush and Wooded	0.08

Appendix C

Hydrologic Modelling Files

Appendix D

Hydraulic Modelling Files

wood.

Appendix G

Stream Rehabilitation Opportunities

MEMO

GeoProcess RESEARCH ASSOCIATES
Knowledge Research Consulting

October 20, 2021

Daniel Bourassa
Dillon Consulting Limited
1155 North Service Road West
Oakville, ON, L6M 3E3

Re: Burlington Mobility Hub
Stream Rehabilitation Opportunities – Appleby and Aldershot Mobility Hubs

Dear Mr. Bourassa:

GeoProcess Research Associates Inc. (GRA) was retained by Dillon Consulting Limited (Dillon) in 2017 to complete a preliminary geomorphic assessment of several watercourses to identify potential geomorphic constraints as part of Environmental Impact Studies for the future development of four Mobility Hubs in the City of Burlington. Based on Agency comments, it was requested that additional details be provided on the potential watercourse rehabilitation opportunities for the Appleby and Aldershot Mobility Hubs. This memo outlines watercourse rehabilitation options to be considered during the site-specific development phases. The recommendations are classified by reach, per the 2017 assessment (for consistency and ease of comparison). These opportunities were informed by the 2017 field assessment data and, as such, should be verified in future phases of the project due to the actively adjusting watercourse conditions documented in many of the assessed reaches. Two accompanying maps illustrate the 2017 reach delineations and provide representative photos of the field conditions and rehabilitation opportunities.

1. Appleby Mobility Hub

Reach	Rehabilitation Opportunities
SHC01	SHC01 was previously rehabilitated with cobble bed and bank material for erosion protection. The reach was stable at the time of the 2017 field assessment and no rehabilitation measures,m are recommended based on the 2017 conditions.
SHC02	SHC02 is within a confined valley having approximately 20 m of available floodplain. The 2017 field assessment indicated active widening of the shale banks as the dominant mode of adjustment, with some locations of valley toe contact. Despite the indicators of adjustment, it is expected that the bedrock banks will be more resilient than the sandy till bank material in the downstream reaches. Potential rehabilitation opportunities include assessing locations of valley toe contact and mitigating toe erosion risk, should it

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	be deemed a threat to infrastructure. The benefit of rehabilitation here will need to be weighed against potential impacts associated with access and riparian removal within the confined, well-vegetated valley.
SHC03	SHC03 exhibited some signs of widening during the 2017 assessment. However, coarse cobbles and boulders were present and providing erosion protection in many areas. This reach is more constrained than the upstream reaches with less available floodplain. As such, rehabilitation opportunities are limited to modifications to the bankfull channel (e.g. width-depth improvements and naturalized erosion protection) and the removal of woody debris present throughout the reach. Also, the feasibility of removing the channel spanning weir at the downstream end of the reach should be investigated.
SHC04	SHC04 had a similar level of valley confinement and erosion protection (toe stones) as SHC03. As such, rehabilitation opportunities are limited to improvements within the bankfull channel, similar to SHC03. There was a 0.5 m headcut present at the approximate midpoint of the reach, with the channel downcutting downstream of this feature. This local instability should be stabilized to mitigate further instabilities propagating upstream towards the Harvester Road culvert.
SHC05	SCH05 exhibited indicators of channel instability during the 2017 field assessment. Given the greater floodplain availability and construction access potential (leveraging the public trails) within SHC05, there are opportunities to provide naturalized erosion protection at locations where rapid bank erosion is occurring. Floodplain benches can be added to reconnect the frequent flow regime to the floodplain, providing additional energy dissipation to further reduce erosive forces.
APC01A	APC01A was found to be unstable with remnants of failed, legacy erosion protection measures throughout the reach. Rehabilitation opportunities consist of a reach-scale design incorporating naturalized erosion protection of the bed and banks and removing the existing gabions and riprap. The downstream portion of the reach has opportunities to promote additional energy dissipation employing floodplain benches given the less confined valley.
APC01B	There were instances of woody debris accumulation within APC01B that were causing localized instabilities (e.g. a small headcut at the approximate midpoint of the reach). Rehabilitation opportunities include the strategic removal of woody debris and select locations where existing erosion protection has failed. Concurrent with these removals should be the evaluation of localized naturalized erosion protection measures should they be deemed necessary.
APC02	APC02 was in a state of adjustment with instances of failed erosion protection throughout the reach. Rehabilitation opportunities include rehabilitating the concrete spillway at the upstream end to a series of steps and pools for increased energy dissipation. Additionally, the removal of all failed concrete grade control structures and gabion baskets can be replaced with naturalized erosion protection measures.
APC03	APC03 was a trapezoidal channel having several failed concrete grade control structures. Rehabilitation opportunities consist of revegetation of the corridor in concert with the replacement of the concrete grade control structures with more naturalized erosion protection such as armourstone or boulder steps. The feasibility of maintaining the trapezoidal channel lining while integrating the rehabilitation measures should be further investigated.
APC04	APC04 is in a confined valley with commercial and residential buildings close to the valley wall. The erosion protection was found to be degrading. As such, rehabilitation opportunities include the removal of existing gabion bank protection bring replaced with naturalized bed and bank protection (e.g. vegetated buttresses and riffle-pool morphology bed features).

2. Aldershot Mobility Hub

Reach	Rehabilitation Opportunities
GST01	GST01 was depositional due to vegetation encroachment within the bankfull channel. Despite the deposition, the previously realigned reach is well-vegetated with available floodplain access. As such, rehabilitation efforts should be focused on downstream reaches.
GST02	GST02 was in adjustment, exhibiting signs of downcutting and widening. This reach is in a natural woodlot with more confinement than GST01. Rehabilitation opportunities include bankfull channel modifications (e.g. width-depth improvements and naturalized erosion protection measures). However, any rehabilitation measures within this reach require additional feasibility assessment to balance construction impacts (i.e. the removal of mature trees within the woodlot) with potential improvements gained through the rehabilitation efforts.
GST03	GST03 was a channelized reach lined with concrete matting. The matting was generally stable with limited degradation. This reach should be monitored as future degradation of the existing erosion protection measures may result in reach-scale instabilities given the valley confinement throughout the reach. It should be noted that since the 2017 assessment, a portion of this reach immediately upstream of Waterdown Road has been reconstructed to accommodate the construction of a stormwater management facility.
GST04	GST04 is in a confined valley and the 2017 field assessment revealed frequent valley toe contact and erosion. Rehabilitation opportunities should consider assessing the erosion risk associated with the valley wall contact and associated stability of the valley slopes. If erosion risks are present, integrated bed and bank (valley toe) protection can be implemented.
GST05	GST05 had an abundance of construction debris resulting in localized erosion of the valley toe. Rehabilitation opportunities include removing the debris and replacing with a naturalized grade control and valley toe protection. These efforts can be integrated with potential opportunities discussed for GST04.
GST06	GST06 is in a less confined valley with more floodplain access than the upstream reaches. While indicators of instability were noted in the 2017 field assessment, rehabilitation opportunities should be focused in the more confined, erosion-prone reaches.
GST06i	Despite GST06i being assessed as unstable, the reach is situated in a mature woodlot and thus potential rehabilitation opportunities (removal of debris and failed concrete structures) should be weighed against potential impacts due to the rehabilitation (impacts to the woodlot).
GST07	GST07 was found to have an enlarged cross-section due to both downcutting and widening. However, it was suggested that adjustments have occurred at slower rates owing to the more resilient bed and bank material. Rehabilitation opportunities in this reach should focus on further determining the resiliency and, if warranted, increasing the floodplain connectivity through the implementation of bankfull benches.

Rehabilitation opportunities should be prioritized based on erosion risk to existing infrastructure and potential degradation to the aquatic environment. Some of these opportunities also overlap with existing planned watershed activities and should consider recommendations and phasing outlined in those studies (for example the 2020 Appleby Creek Erosion Control EA). Based on the 2017 field assessment, reaches with the most valley confinement and toe erosion (e.g. APC1-4, GST4-5) should be subject to further study to evaluate existing and future erosion risk. Based on the site-specific erosion risk, rehabilitation solutions can be refined and prioritized. Please do not hesitate to contact the undersigned should you have any questions about the information contained in this memo.

Regards,

GEOPROCESS RESEARCH ASSOCIATES INC

Jeff Hirvonen, MASc
Principal

Ben Plumb, PhD, P.Eng.
River Engineer

600000
600500
601000
4804500
4804000
4803500

SHC01
SHC02
SHC03
SHC04
SHC05
QEW
Harvester Road
APC01B
APC01A
APC02
APC03
APC04
Appleby Line












Legend

- Study Area
- Watercourses
- Reach Breaks
- Contours (1 m)

N

0 100 200 300 metres

GeoProcess RESEARCH ASSOCIATES

CREATED BY:	BDP	PROJECT NO.:	P2017-237
CHECKED BY:	JPH	DATE:	Oct 19, 2021

Coordinate System: NAD83 - UTM Zone 17N

NOTE: Refer to accompanying memo for description of rehabilitation opportunities. Information based on 2017 field assessment and should be verified at future project phases.

APPLEBY MOBILITY HUB

GEOMORPHIC REHABILITATION OPPORTUNITIES

592500
593000
593500
4796000
4795500




GCT01
GCT02
GCT03
GCT04
GCT05
GCT06
GTC06i
GCT07

QEW
Waterdown Road
Plains Road E
Plains Road W

Legend

- Study Area
- Watercourses
- Reach Breaks
- Contours (1 m)

N

0 100 200 300 metres

GeoProcess RESEARCH ASSOCIATES

CREATED BY:	BDP	PROJECT NO.:	P2017-237
CHECKED BY:	JPH	DATE:	Oct 19, 2021

Coordinate System: NAD83 - UTM Zone 17N

NOTE: Refer to accompanying memo for description of rehabilitation opportunities. Information based on 2017 field assessment and should be verified at future project phases.

ALDERSHOT MOBILITY HUB

GEOMORPHIC REHABILITATION OPPORTUNITIES

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