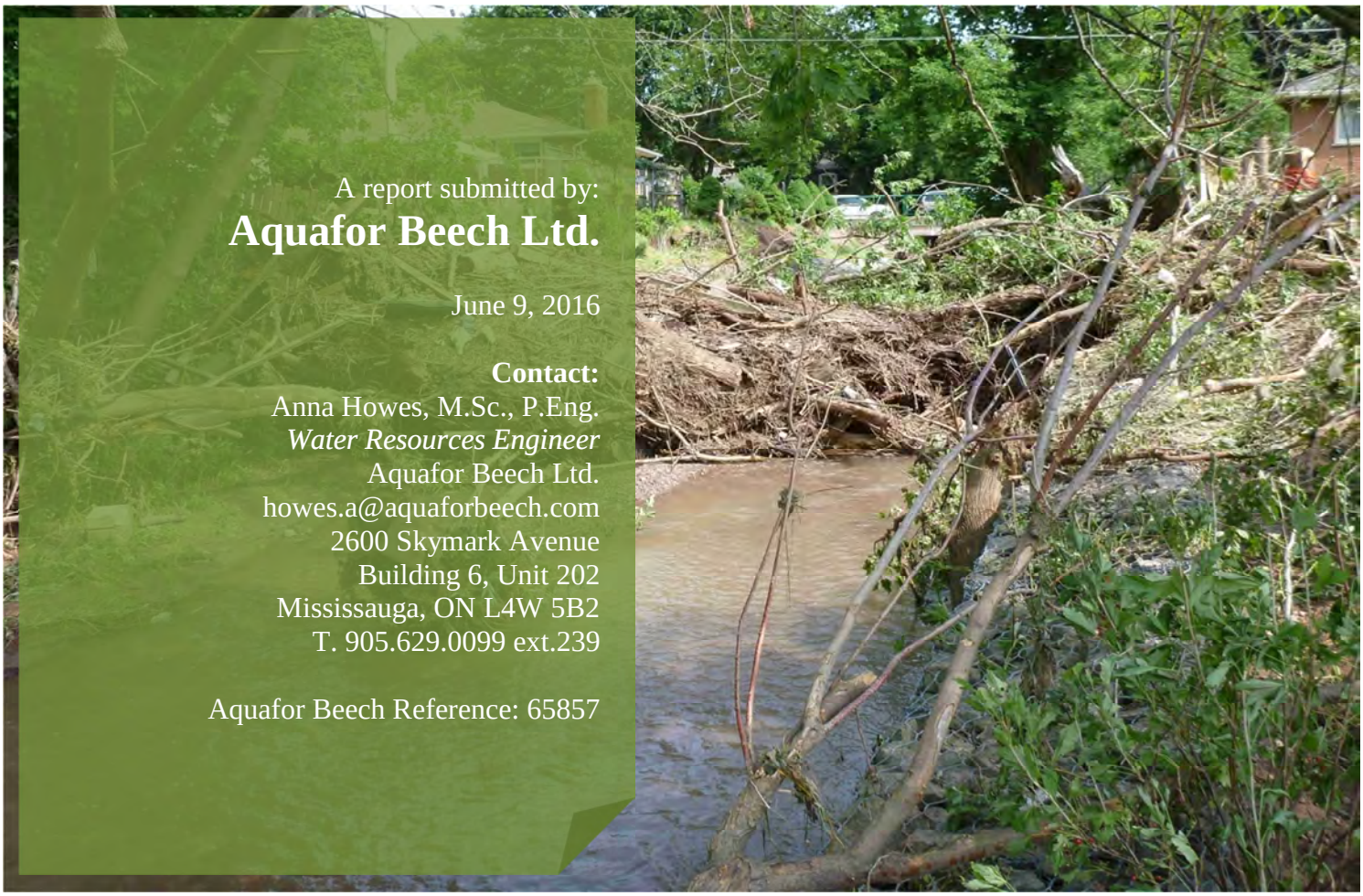
Submitted to:

Corporation of the City of Burlington

Engineering Department
426 Brant Street, P.O. Box 5013
Burlington, ON L7R 3Z6

Tuck Creek Flood Assessment and Crossing Upgrades between New Street and Spruce Avenue Class Environmental Assessment

Final Report



A report submitted by:

Aquafor Beech Ltd.

June 9, 2016

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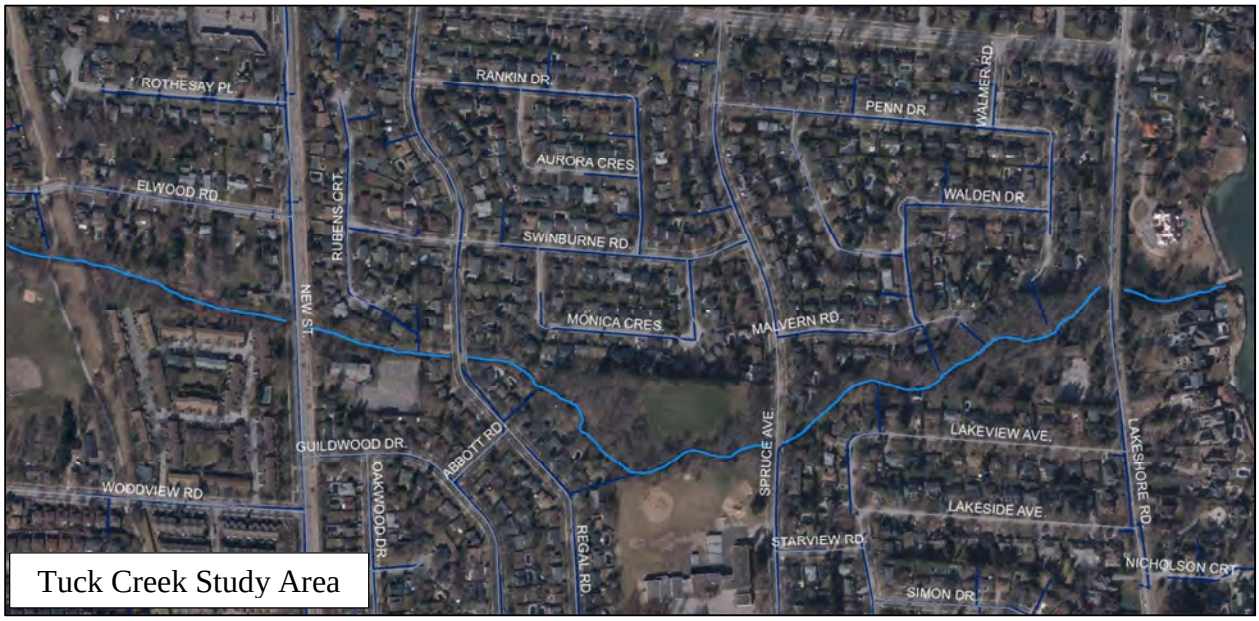
Aquafor Beech Reference: 65857

Executive Summary

Introduction

The headwaters of Tuck Creek are located on the Niagara Escarpment and the watercourse drains to Lake Ontario running to the south-west of Walkers Line. The watershed is long and narrow and is fully developed within the urban boundary where it exhibits erosion and flooding issues. An erosion Municipal Class Environmental Assessment (EA) was undertaken on Tuck Creek for a study area between the Hydro right-of-way (ROW) north of New Street and Spruce Avenue (Aquafor Beech Ltd., 2012). The detailed design subsequently received approval from Conservation Halton in July 2014. However, the August 4, 2014 storm event resulted in major changes to the existing channel requiring a resurvey and adjustments to the detailed design.

Following the storm event, the City retained Amec Foster Wheeler to undertake the *Flood Vulnerability, Prioritization and Mitigation Study* for City watercourses. Top prioritized recommendations from the study included upgrades to the Regal Road, New Street, and Spruce Avenue culverts and a channel capacity increase between the Hydro ROW and Regal Road. Upgrades to the crossings had not been included in the erosion EA since the bridges within the study area had been assessed and were not scheduled for major maintenance or replacement in the 1 to 5 year time frame. Given the August 4, 2014 flooding within the study area, the erosion works for the original EA were put on hold and Aquafor Beech Limited was retained by the City to complete a Municipal Class Environmental Assessment (EA) with respect to flooding in the Tuck Creek watershed between the Hydro ROW and Lake Ontario.



Study Objectives

The focus of the current study is to identify flood mitigation opportunities within the Tuck Creek watershed from the Hydro ROW to Lake Ontario. The study objective is to reduce the number of buildings in this area that are located within the floodplain. Other considerations include the reduction of erosion where infrastructure and private property are at risk and the preservation or enhancement of Aquatic and terrestrial habitat.

PHASE I: IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

The problems of flooding and erosion are present in the Tuck Creek study area. These issues are a result of urbanization within the watershed which causes changes to the hydrology resulting in an increase in runoff volume and a shorter time to peak for flows. In the study area, many houses adjacent to the creek are located in the floodplain of Tuck Creek. As the channel adjusts to the modified hydrology, bank erosion poses an additional risk to adjacent properties.

Urbanization within the watershed also limits the feasible opportunities to address the problems as development has often occurred within the floodplain and the width of the creek corridor is often limited. Although there are constraints on the physical extents of the changes, upgrades to road crossing, channel deepening, and channel widening can be investigated.

PHASE II: EVALUATION OF ALTERNATIVE SOLUTIONS

Five (5) alternatives were developed to reduce flooding within the study area:

- Alternative 1, Do Nothing,
- Alternative 2, Bridge Upgrades,
- Alternative 3, Bridge Upgrades and Channel Deepening,
- Alternative 4, Bridge Upgrades and Channel Widening, and
- Alternative 5, Bridge Upgrades and Channel Deepening and Widening.

Conceptual hydraulic modeling was completed to identify the changes to the floodlines for each of the alternatives. The results with respect to the number of buildings located in the floodplain are summarized in the table below. Numbers followed by a "+" indicate that there is at least 1 spill within the floodplain so the exact number of building affected cannot be determined.

Alternative	Regional Storm		100-Year Storm	
	Buildings within Floodplain	Percent Reduction	Buildings within Floodplain	Percent Reduction
1	102+	-	57+	-
2	95+	7%	48+	16%
3	83+	19%	25+	56%
4	63+	38%	3	95%
5	43+	58%	0	100%

Hydrologic modeling was also completed to determine the effects of implementing Low Impact Development (LID) measures in the study area or the watershed. Reduction to the peak flows was only notable if LID measures were implemented throughout the watershed. As implementation at this scale was not feasible in the short term, the use of LID as a means of flood reduction for the current study was not further investigated.

Evaluation of Alternatives

Each of the alternatives was evaluated based on a set of criteria including natural environment criteria (terrestrial and aquatic habitat), economic criteria (capital and construction costs, operation and maintenance costs, and flood damage costs), social/cultural criteria (effect on flooding, aesthetics, community disruption), and technical criteria (design feasibility, implementation time, permitting). The results of the evaluation identified Alternative 4 (upgrades to bridges and channel widening) as the preliminary preferred alternative.

Public Consultation

A Public Information Centre (PIC) was held on Monday November 30, 2015 at City Hall (426 Brant Street). A series of posters was presented which outlined the study background, problems, opportunities, alternatives, and preliminary alternative evaluation. The PIC was attended by 20+ people. In general, attendees were in support of the preliminary preferred alternative: bridge upgrades and channel widening.

Selection of Preferred Alternatives

Based on the results of the alternatives evaluation and the consultation with the City, CH, and the public, Alternative 4 (upgrades to New Street, Regal Road, and Spruce Avenue crossings and creek width increases) was selected as the preferred alternative. This alternative provides a 95% reduction in the number of building flooded for the 100-year storm and 38% reduction for the Regional storm. While increases to channel width will result in the loss of mature trees along the creek banks, it is the opinion of Aquafor Beech Limited that diverse native tree plantings completed as part of the proposed works will aid in mitigating tree cover losses resulting from Emerald Ash Borer infestations. As well, the widening of the channel provides an opportunity at the detailed design stage for the definition of a low-flow channel and terrace/floodplain. Reconnection of the watercourse to the floodplain will provide both erosion benefits and ecological benefits.

Estimated Costs and Implementation

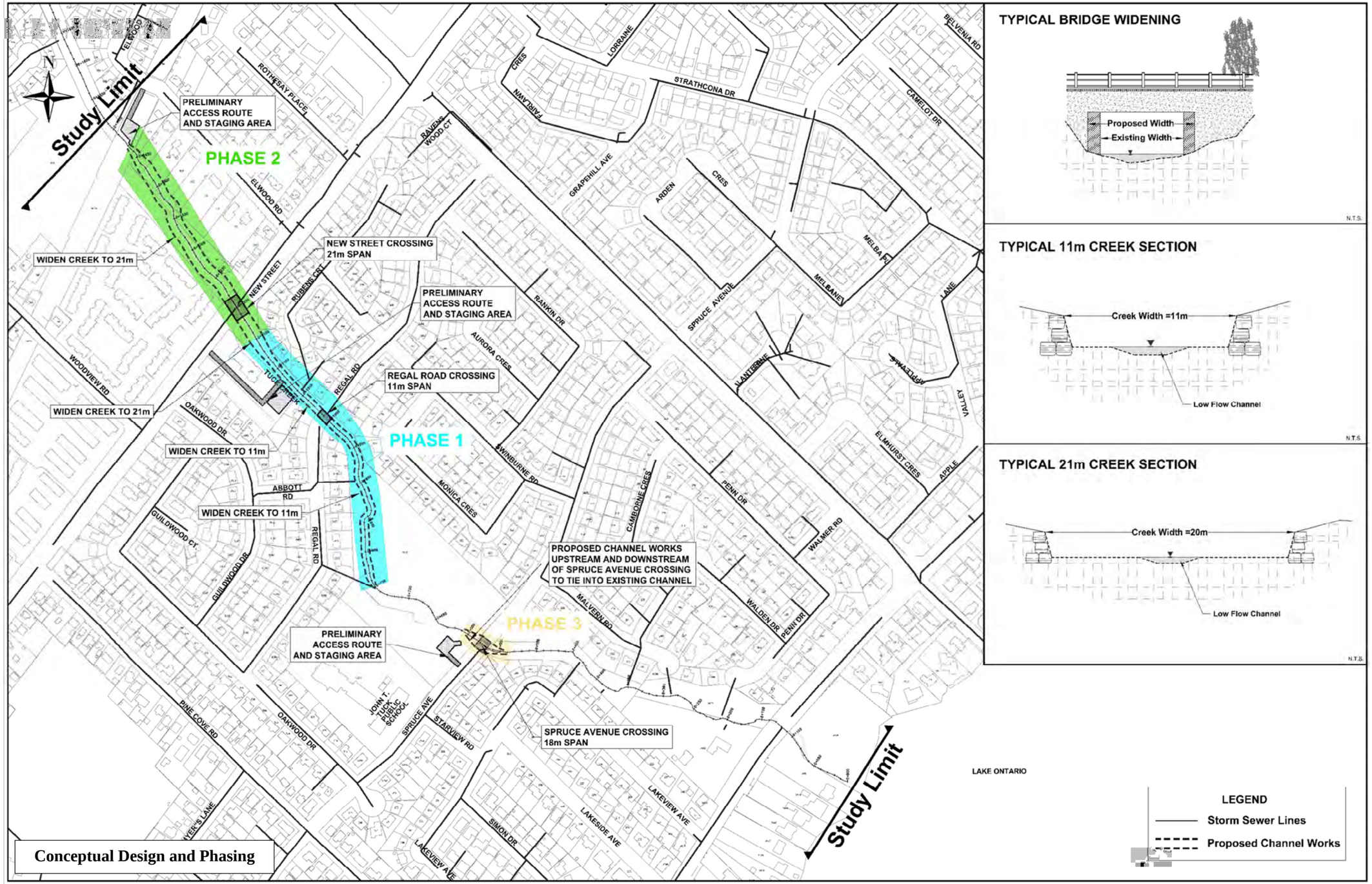
Costs for the bridge replacements and channel restoration works were estimated and are summarized in the table below. It is recommended that the City start with the implementation of the Regal Road bridge and the associated channel works. The New Street bridge and channel works are recommended to be completed next, followed by the Spruce Avenue bridge and associated channel works. A figure showing the conceptual design and phasing is included below.

Component	Bridge Works	Channel Works	Total
Phase 1: Regal Road Bridge Replacement & Associated Channel Upgrades	$1.6M	$1.5M	$3.1M
Phase 2: New Street Bridge Replacement & Associated Channel	$2.8M	$1.2M	$4.0M
Phase 3: Spruce Avenue Bridge Replacement & Associated Channel	$1.8M	$0.3M	$2.1M
Total	**$6.2M**	**$3.0M**	**$9.2M**

Conclusions and Recommendations

Flooding within the study area can be significantly reduced for storms up to the 100-year event. However, flooding within the study area for the Regional storm cannot be eliminated through works in the study area alone. Implementation of the preferred alternative will protect the majority of the study area for the 100-year event and will assist in reducing the impact of the Regional storm.

Although LID measures will only have a notable effect on return period flows if implemented throughout the Tuck Creek watershed, it is recommended that these measures be implemented as the opportunity arises within the watershed.



TYPICAL BRIDGE WIDENING

N.T.S.

TYPICAL 11m CREEK SECTION

N.T.S.

TYPICAL 21m CREEK SECTION

N.T.S.

LEGEND

Storm Sewer Lines

Proposed Channel Works

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1 INTRODUCTION

The Tuck Creek watershed has an area of about 10.6 km^2 and falls approximately 90 metres from Dundas Street to the outlet at Lake Ontario. The location of the watershed is shown on Figure 1.1. The Tuck Creek headwaters originate on the Niagara Escarpment and the watercourse drains to Lake Ontario running to the south-west of Walkers Line. The watershed is long and narrow and is fully developed within the urban boundary extending south of Dundas Street with the exception of infill opportunities. The uppermost reaches of the watershed north of Dundas Street lie within the Parkway Belt and will not be developed.

Tuck Creek consists of a number of headwater tributaries which join to form a single main branch north of Upper Middle Road. The channel exhibits varying conditions throughout its length, ranging from an entirely natural state to portions which have undergone some degree of channelization. The watershed soils are primarily loams and clay loams with relatively low infiltration capacities.

Within the urban boundary, Tuck Creek exhibits erosion and flooding issues. A previous erosion Municipal Class Environmental Assessment (EA) was undertaken on Tuck Creek for a study area between the Hydro right-of-way (ROW) north of New Street and Spruce Avenue (Aquafor Beech Ltd., 2012). This EA addressed 2 areas of erosion in the study area but did not address flooding concerns. Flooding within the study area was linked to bridge capacity. The bridges within the study area had been assessed and were not scheduled for major maintenance or replacement in the 1 to 5 year time frame. Since addressing the flooding required bridge improvements, the EA addressed only erosion concerns. Phases 1 and 2 of the erosion EA were completed in 2012.

The detailed design (Phase 5 of the erosion EA) was undertaken subsequently. The City received approval from Conservation Halton for the erosion control works on July 16, 2014. However, the August 4, 2014 storm event resulted in major changes to the existing channel requiring a resurvey and adjustments to the detailed design.

Following the storm event, the City retained Amec Foster Wheeler to undertake the ***Flood Vulnerability, Prioritization and Mitigation Study*** for City watercourses. Top prioritized recommendations from the study included upgrades to the Regal Road, New Street, and Spruce Avenue culverts and a channel capacity increase between the Hydro ROW and Regal Road.

As such, the erosion works for the original EA were put on hold and Aquafor Beech Limited was retained by the City to complete a Municipal Class Environmental Assessment (EA) with respect to flooding in the Tuck Creek watershed between the Hydro ROW and Lake Ontario. The extent of the study area is shown in Figure 1.2. The following document summarized the EA process outlining the problems and opportunities and presenting the alternative solutions and the recommended preferred alternative.

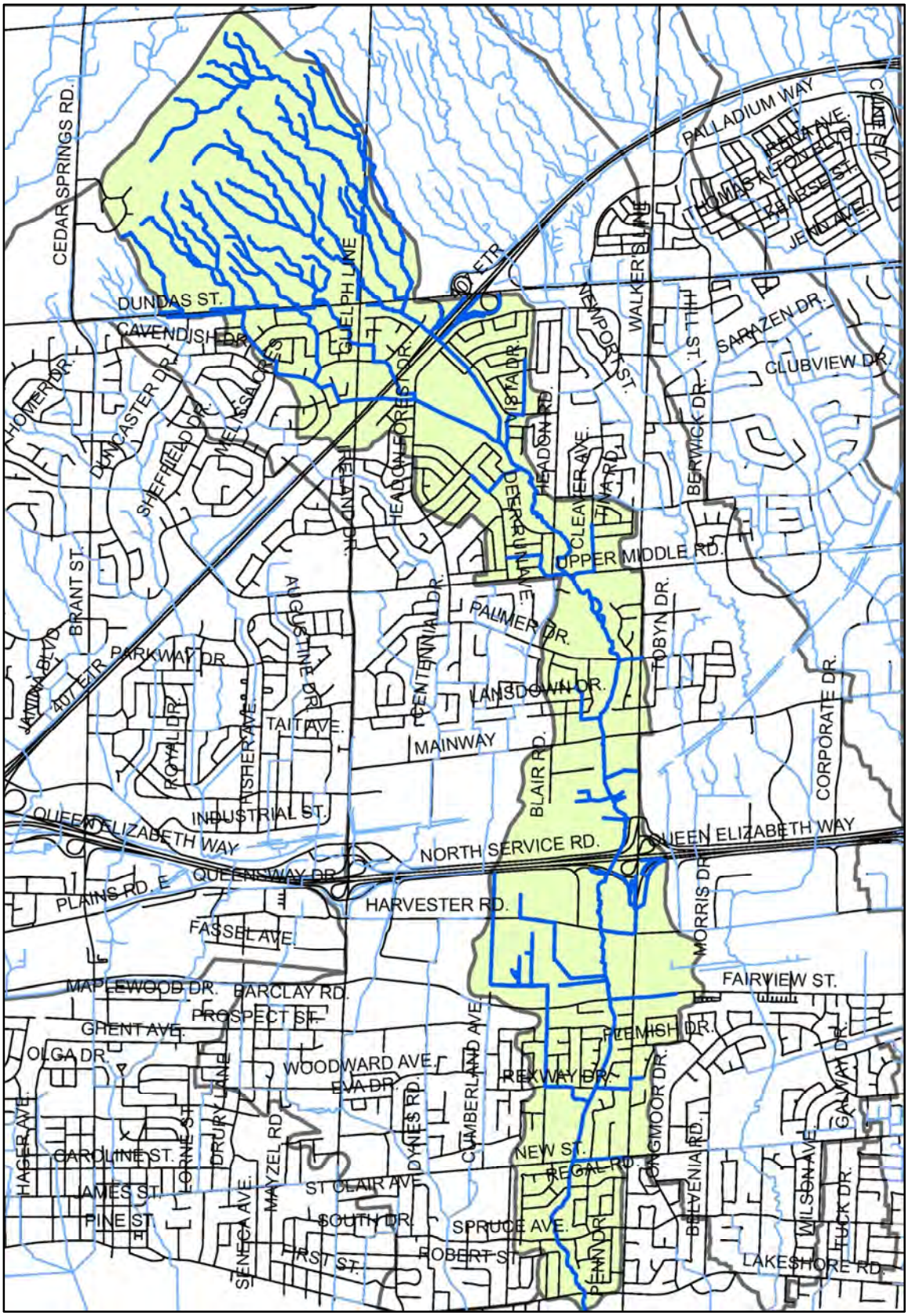


Figure 1.1: Tuck Creek Watershed

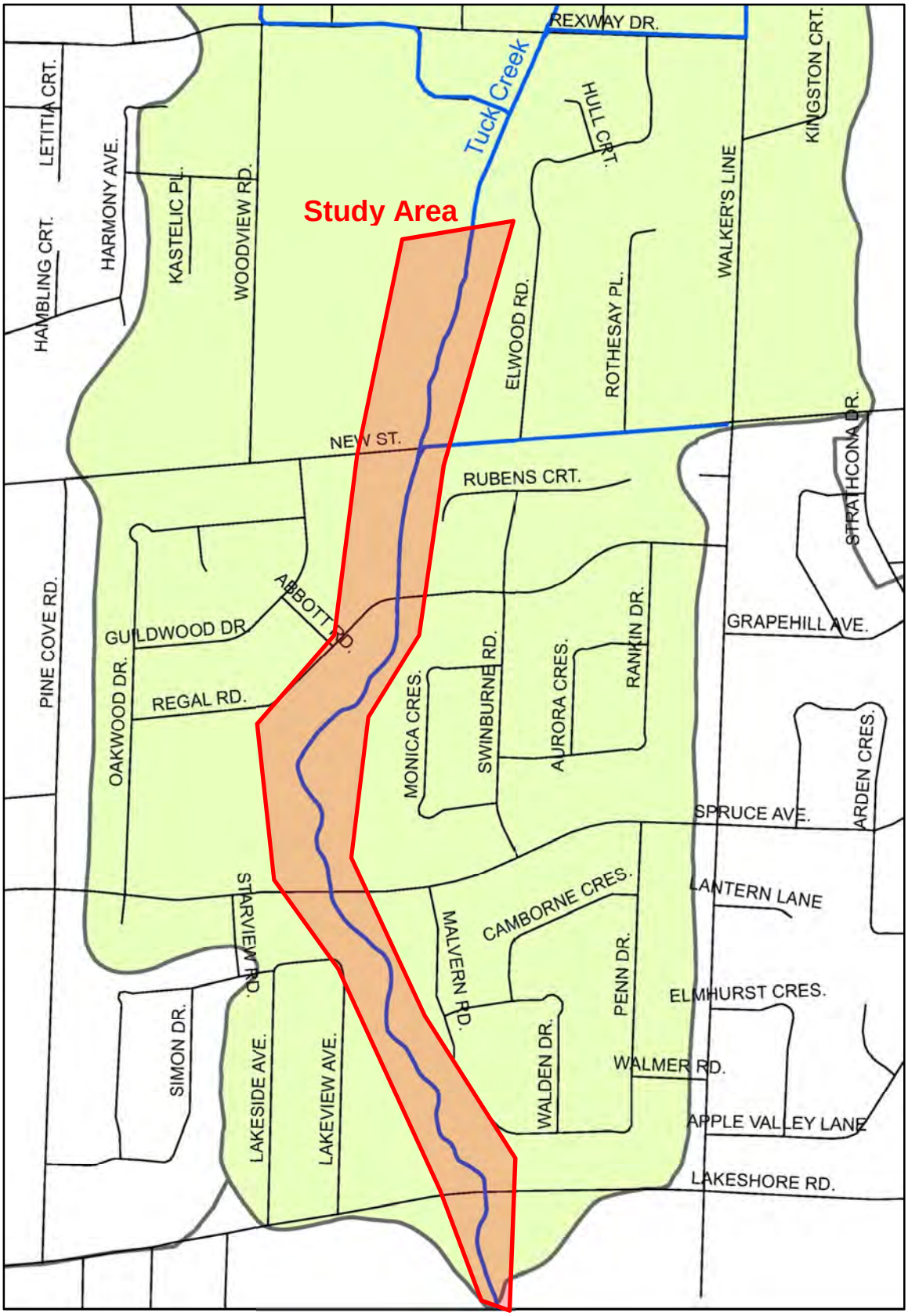


Figure 1.2: Tuck Creek Study Area

1.1 Background

As noted in the introduction, the impetus for this study was heavy rainfall during the afternoon and evening of August 4, 2014 which caused significant flooding in the City of Burlington. A total of 190 mm of rain has been estimated to have fallen over the course of the storm. High flows in City watercourses resulted in road and highway closures and flooding of more than 3,000 residential buildings. Debris build-up in the watercourses exacerbated conditions locally. Lands within the Tuck Creek, Shoreacres Creek, Roseland Creek, and Appleby Creek watersheds were hardest hit. Within the Tuck Creek watershed, approximately 65 building reported flooding and 13 road crossing overtopped including New Street, Regal Road, and Spruce Avenue.

1.2 Study Objectives

The focus of the current study is to identify flood mitigation opportunities within the Tuck Creek watershed from the Hydro ROW to Lake Ontario. The study objective is to reduce the number of buildings in the study area that are located within the floodplain. Other considerations include the reduction of erosion where infrastructure and private property are at risk and the preservation or enhancement of aquatic and terrestrial habitat.

1.3 Environmental Assessment Process

The Environmental Assessment Act was legislated by the Province of Ontario in 1980 to ensure that an Environmental Assessment is conducted prior to the onset of development and development related (servicing) projects. Depending on the individual project or Master Plan to be completed, there are different processes that municipalities must follow to meet Ontario's Environmental Assessment requirements.

Class Environmental Assessments (Class EAs) are prepared for approval by the Minister of the Environment. A Class EA is an approved planning document that defines groups of projects and activities and the Environmental Assessment (EA) process which the proponent commits to for each project undertaking. Provided the process is followed, projects and activities included under the Class EA do not require formal review and approval under the EA Act. In this fashion, the Class EA process expedites the environmental assessment of smaller, recurring projects.

This Class Environmental Assessment document reflects the following five key principles of successful planning under the Environmental Assessment Act.

- Consultation with affected parties early on, such that the planning process is a cooperative venture.
- Consideration of a reasonable range of alternatives.
- Identification and consideration of the effects of each alternative on all aspects of the environment.
- Systematic evaluation of alternatives in terms of their advantages and disadvantages, to determine their net environmental effects.
- Provision of clear and complete documentation of the planning process followed, to allow "traceability" of decision-making with respect to the project.

The accompanying flow chart (Figure 1.3) illustrates the process followed in the planning and design of projects covered by this Class Environmental Assessment. The five phases, as defined in the flow chart, are summarized in the document as follows:

Phase 1: Identify the problem or deficiency.

Phase 2: Identify alternative solutions to the problem, by taking into consideration the existing environment, and establish the preferred solution taking into account public and agency review and input. At this point, identify approval requirements (e.g., Ontario Water Resources Act, Lakes and Rivers Improvement Act, and Environmental Protection Act) and determine the appropriate schedule for the project and proceed through the appropriate phases (Figure 1.3).

Phase 3: Examine alternative methods of implementing the preferred solution, based upon the existing environment, public and government agency input, anticipated environmental effects, and methods of minimizing negative effects and maximizing positive effects.

Phase 4: Document, in an Environmental Study Report, a summary of the rationale and the planning, design, and consultation process of the project as established throughout the above phases, and make such documentation available for scrutiny by review agencies and the public.

Phase 5: Complete contract drawings and documents, and proceed to construction and operation; monitor construction for adherence to environmental provisions and commitments. Where special conditions dictate, also monitor the operation of the completed facilities.

Public and agency consultation is also an important and necessary component of the five phases.

The Municipal Engineers Association's Class EA document classifies projects as Schedule A, B or C depending on their level of environmental impact and public concern.

- **Schedule 'A'** projects are generally routine maintenance and upgrade projects; they do not have big environmental impacts or need public input. Schedule 'A' projects are all so routine that they are generally pre-approved without any further public consultation.

- **Schedule 'B'** projects have more environmental impact and do have public implications. Examples would be stormwater ponds, river crossings, expansion of water or sewage plants beyond up to their rated capacity, new or expanded outfalls and intakes, and the like. Schedule 'B' projects require completion of Phases 1 and 2 of the Class EA process.

- **Schedule 'C'** projects have the most major public and environmental impacts. Examples would be storage tanks and tunnels with disinfection, anything involving chemical treatment, or expansion beyond a water or sewage plant's rated capacity. Schedule 'C' projects require completion of Phases 1 through 4 of the Class EA process, before proceeding to Phase 5 implementation.

The current study on Tuck Creek is classified as a Schedule B project and follows Phases 1 and 2 of the planning and design process with Phase 5 to follow at a subsequent stage. This report outlines Phases 1 and 2 of the EA process.

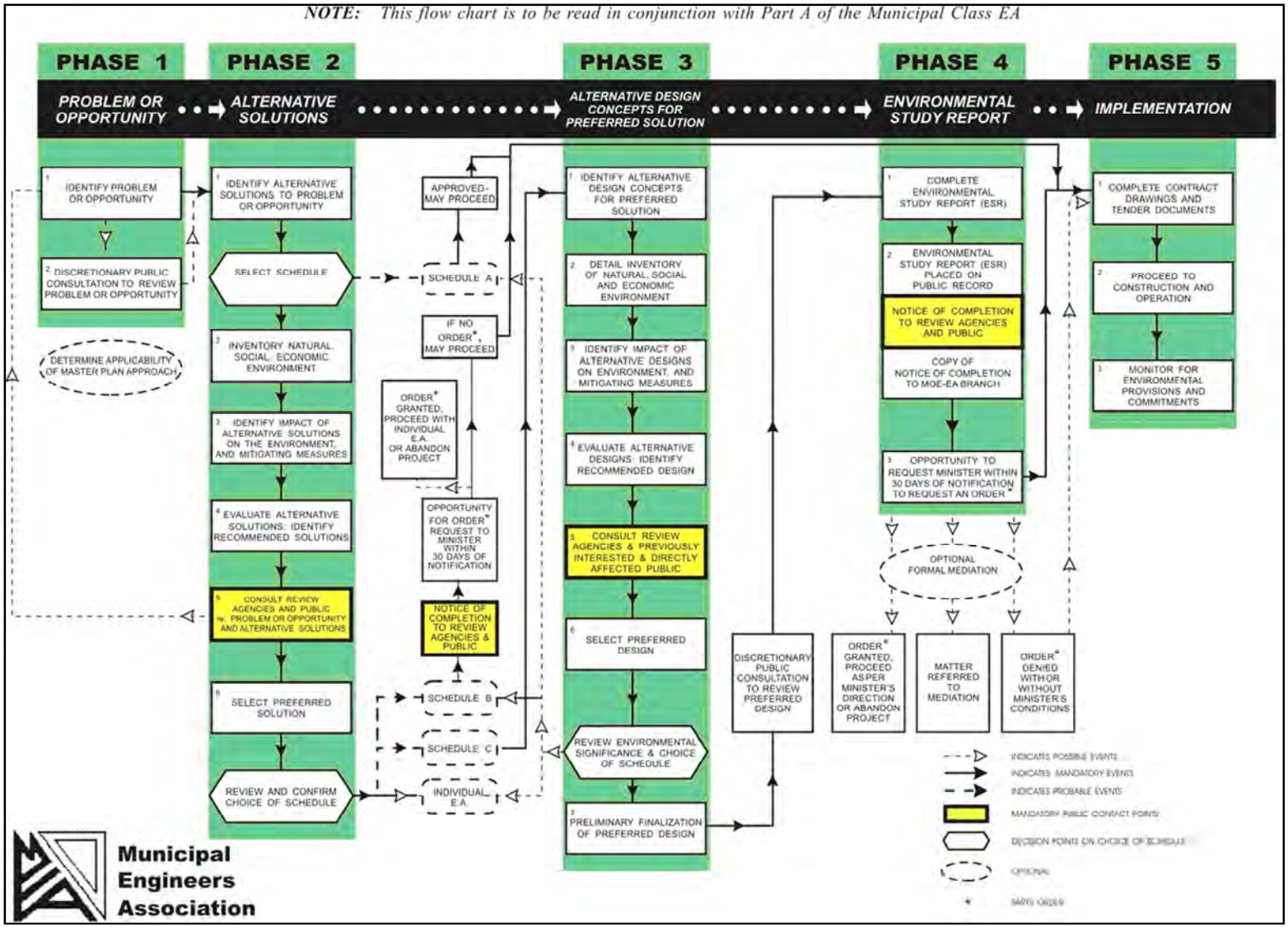


Figure 1.3: Municipal Class Environmental Assessment Planning and Design Process

PHASE I: IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

2 IDENTIFICATION OF PROBLEMS AND OPPORTUNITIES

Identification of problems and opportunities is the first phase of the Environmental Assessment Process. The specific problems and opportunities in the Tuck Creek study area are described in further detail in the sections below.

2.1 Problems

The problems present in the Tuck Creek study area are a result of urbanization within the watershed. This urbanization also limits the feasible opportunities to address the problems due to the development in close proximity to the watercourse.

Urbanization within the watershed has led to a change in the hydrologic regime of Tuck Creek. As surfaces are hardened (i.e. covered by asphalt, concrete, buildings), infiltration of precipitation is reduced so that the volume of runoff reaching receiving waters is increased. As well, watershed surface roughness is decreased and thus, compounded by the use of storm sewers, runoff reaches receiving waters more rapidly. The overall change to the hydrology is an increase in runoff volume and a shorter time to peak for flows. This is typically referred to as urban hydromodification.

Development within the Tuck Creek study area pre-dates the use of stormwater management techniques. As development progressed upstream, flows within the study area would have continued to increase thus resulting in higher waterlevels for return period events over time. As such, many houses adjacent to the creek are currently located within the Tuck Creek floodplain. This was confirmed during the August 4, 2014 event which saw wide-spread riverine flooding in Tuck Creek.

In addition to flooding, erosion is a concern within the study area, as outlined in the previous EA (Aquafor Beech Ltd., 2012). Historical straightening of Tuck Creek and urban hydromodification have led to an altered energy balance in the creek. As is typical in urban creeks, the channel is adjusting to this change through widening and, to a degree, incision. The resulting channel will have a greater capacity to accommodate higher flows. However, adjacent land will be lost in the process through erosion. Where private property abuts the creek corridor, this erosion may put properties at risk.

2.2 Opportunities

There are several opportunities available for addressing flooding concerns in the Tuck Creek watershed within the study area. These opportunities include the following items:

- **Upgrades to road crossings** – Existing culverts at New Street and Regal Road overtop under the 10-year flow while the existing culvert at Spruce Avenue overtops under the 25-year flow. Increasing conveyance through these culverts could reduce backwater thereby lowering upstream water surface elevations and decreasing the extent of flooding. It should be noted that upgrades to the Lakeshore Road culvert were undertaken as a

results of recommendations from the 1985 watershed study by Proctor and Redfern Group. The 1996 hydrology and hydraulics study by Aquafor notes that the culvert was twinned thereby lowering the floodlines such that the road does not overtop for the 100-year event. Although the Regional event continues to overtop the road, the water level for this event was reduced by about 1 m after twinning of the structure. The results from the current updated model also show that the Lakeshore Road crossing overtops only for the Regional event. For the 100-year event, no buildings are impacted by flooding. As such, no upgrades to the Lakeshore Road culvert were assessed during the current study.

- **Channel deepening** – Increasing the channel capacity through lowering the channel bed may provide reduced water surface elevations thereby contributing to a reduction in building flooding.
- **Channel widening** – Increasing the channel capacity through widening may also provide lower water surface elevations thus reducing building flooding.

In completing the above-mentioned channel upgrades, remediation of erosion concerns within the study area can also be addressed through appropriate bank treatments.

3 REVIEW OF BACKGROUND DOCUMENTS

Several previous studies have been completed on Tuck Creek. The documents associated with these studies were reviewed and information pertinent to the current study is summarized below.

Study: Tuck Creek Erosion Control Municipal Class Environmental Assessment
Author: Aquafor Beech Limited
Date: 2012
This study identified and defined the erosion issues on Tuck Creek between the Hydro ROW and Spruce Avenue. It also outlined recommended channel restoration measures extending from the upstream side of the Regal Road crossing to upstream of the recreational trail crossing at the Hydro ROW. Flooding within the study area was not addressed.

Study: Tuck Creek Erosion Control Study: Hydrology and Hydraulics
Author: Aquafor Beech Limited
Date: 1996
This study was undertaken to update and expand the existing hydrologic model for Tuck Creek and to prepare floodline mapping for the watercourse. The hydrologic and hydraulic models developed in this study were the starting point for the hydrologic and hydraulic modeling for the Tuck Creek erosion EA (Aquafor Beech Ltd., 2012).

Study: Tuck Creek Erosion Control Study
Author: Aquafor Beech Limited
Date: 1996
This study addressed erosion concerns on Tuck Creek in 2 locations: 1) between Lakeshore Road and Spruce Avenue, and 2) between Upper Middle Road and Headon Road. The works at the first site are located within the study area of the current EA.

Study: Tuck, Shoreacres, Appleby & Sheldon Creeks Watershed Study
Authors: Proctor and Redfern Group, M.M. Dillon Ltd., and MacLaren Plansearch Inc.
Date: 1985
This study noted that flood storage for Tuck Creek is not feasible due to the large storage volume required. The study recommended the following measures:

1. Deepen the channel by 0.9 m from New Street to Regal Road and enlarge the channel with a rectangular cross-section.
2. Enlarge and deepen the New Street and Regal Road culverts.
3. Deepen the channel upstream of New Street to the Hydro ROW and use a trapezoidal grass-lined channel.
4. Rechannelize the watercourse downstream of Regal Road.

4 EXISTING CONDITIONS

The study team undertook an inventory of existing conditions within Tuck Creek between the Hydro ROW and Lake Ontario. The following sections describe the findings of this inventory, as well as a description of the Regional Natural Heritage System.

4.1 Natural Environment

4.1.1 Geology, Physiology, and Soils
Soils within the Tuck Creek watershed consist of Fox sandy loam, Chinguacousy clay loam, Brady sandy loam, Jeddo clay loam, and Oneida clay loam (Gillespie and Wicklund, 1971). The Fox sandy loam and Brady sandy loam are found at the downstream end of the watershed while the upstream portion consists of Chinguacousy clay loam, Oneida clay loam. The watercourse bed is mainly located on Jeddo clay loam.

The surface geology of the study area is shown in Figure 4.1. As seen in the figure, the study area consists mainly of lacustrine and outwash sand. Paleozoic bedrock, composed of shale and dolomite, is also present in the study area.

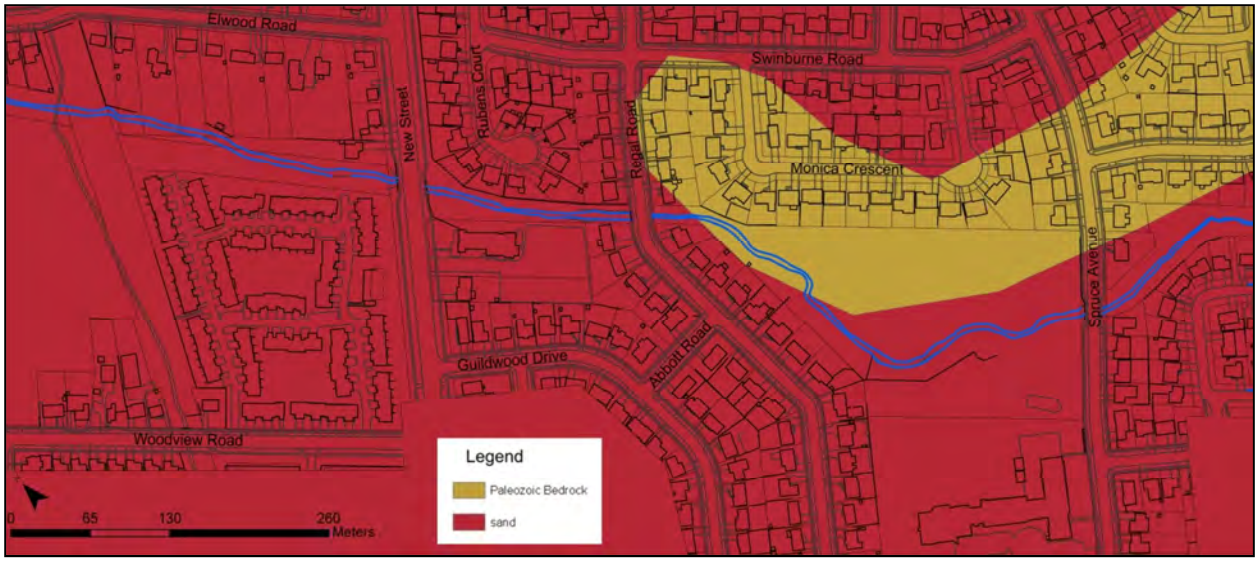


Figure 4.1: Surface Geology of Tuck Creek between the Hydro ROW and Spruce Avenue

4.1.2 Vegetation Communities and Flora

An Aquafor Beech Limited ecologist conducted an assessment of the vegetation communities and flora within public property from Spruce Avenue to Lakeshore Road on September 1st 2015. Aquafor's ecologist previously completed an assessment of vegetation communities and flora from Spruce Avenue to the Hydro ROW. Details of this assessment are included in Section 3 and **Appendix B** of the erosion EA document (Aquafor Beech Ltd., 2012). Subsequent spring botanical surveys were conducted on May 10th 2016; the analysis and results from these surveys will be provided under separate cover along with the butternut health assessments.

For the assessment between Spruce Avenue and Lakeshore Road in September 2015, vegetation communities were assessed according to the methodology of the *Ecological Land Classification for Southern Ontario: First Approximation and Its Application* (Lee et al. 1998). Flora was recorded using an area search methodology. Floristic Quality Analysis (FQA) was completed according to the methods of Oldham et al. (1995).

Global and provincial statuses are not available for the vegetation communities present in the area surveyed (NHIC, 2015). Local flora ranks are assessed according to the Halton Natural Areas Inventory (Dwyer 2006).

Results

The results of spring botanical surveys, conducted on May 10th 2016, will be included under separate cover. One (1) mature butternut not previously recorded in 2010 was located during 2016 spring vegetation surveys. Its location is shown as B2 in Figure 4.5 below. No other species of conservation concern were found during the survey. The highest concentration of spring ephemerals was located in FOD9 (Figure 4.2) and areas of cultural woodland immediately adjacent. Native and exotic spring ephemerals recorded include yellow trout lily (*Erythronium americanum*), false solomon's seal (*Maianthemum racemosum*), Jack-in-the-pulpit (*Arisaema triphyllum*), white trillium (*Trillium grandiflorum*), red trillium (*T. erectum*), Carolina spring beauty (*Claytonia virginica*), squill (*Scilla siberica*), grape hyacinth (*Muscari* sp.), star-of-

Bethlehem (*Ornithogalum umbellatum*), tulip (*Tulipa* sp.), Mayapple (*Podophyllum peltatum*), Virginia waterleaf (*Hydrophyllum virginianum*), and early meadow rue (*Thalictrum dioicum*).



Figure 4.2: Spring ephemerals in FOD9

A total of one (1) vegetation community type having one inclusion is present within the area surveyed on September 2015 (Figure 4.3). In this community, sixty-five (65) species of flora were recorded, one of which is a species-at-risk. An annotated list of flora recorded in 2015 and Ecological Land Classification (ELC) field sheets are presented in **Appendix C**.



Figure 4.3: Representative photograph of cultural woodland community south of Spruce Avenue, approximately mid-way between Spruce Avenue and Lakeshore Road

The vegetation community along Tuck Creek between Spruce Ave. and Lakeshore Rd. consists of a cultural woodland with a raspberry cultural thicket inclusion (see Figure 4.5 for map). Other vegetation communities shown in Figure 4.5, i.e. those upstream of Spruce Ave., represent ELC assessments completed in 2010 as part of a previous erosion EA study (Aquafor Beech Ltd., 2012). The following paragraphs present a characterization of the cultural woodland

communities assessed in 2010 and 2015. Note that spring vegetation surveys, completed in 2016, will be submitted under separate cover.

CUT1 (2015)

The canopy of the cultural woodland community south of Spruce Avenue is dominated by Black Walnut (*J. nigra*), with Green Ash (*Fraxinus pennsylvanica*) and Manitoba Maple (*Acer negundo*) as abundant associates. Sub-canopy and understory layers are dominated by the exotic invasive shrub European Buckthorn (*Rhamnus cathartica*), with Manitoba Maple and Green Ash as associates. The ground layer is dominated by young European Buckthorn and Yellow Avens (*Geum aleppicum*); Manitoba Maple and Garlic Mustard (*Alliaria petiolata*) are abundant associates. Soils consist of moderately moist silty clay.

Flora species assemblage is typical of a disturbed suburban wooded creek system. Aquafor notes that vegetation immediately south of Spruce Avenue consists primarily of planted shrub and tree species. Over 40% of the flora recorded is considered introduced in Ontario. Floristic Quality Analysis (FQI) results (60 eligible species out of 68 recorded) are as follows:

» Conservatism-Based Metrics:

Total Mean C: **1.6**
Native Mean C: **2.9**
Total FQI: **12.4**
Native FQI: **16.7**
Adjusted FQI: **21.5**
% C value 0: **58.3%**
% C value 1-3: **20%**
% C value 4-6: **21.7%**
% C value 7-10: **0%**
Native Tree Mean C: **4.3**
Native Shrub Mean C: **1.7**
Native Herbaceous Mean C: **1.8**

» Species Richness:

Total Species: **60**
Native Species: **33 (55%)**
Non-native Species: **27 (45%)**

» Species Wetness:

Mean Wetness: **1.4**
Native Mean Wetness: **0.4**

» Physiognomy Metrics:

Tree: **22 (36.7%)**
Shrub: **6 (10%)**
Vine: **4 (6.7%)**
Forb: **24 (40%)**
Grass: **3 (5%)**
Sedge: **1 (1.7%)**
Rush: **0 (0%)**
Fern: **0 (0%)**
Bryophyte: **0 (0%)**

The total FQI and native FQI are 12.4 and 16.7, respectively, both of which are considered low. The average coefficient of conservatism and coefficient of wetness for all eligible species are 1.4 and 1.6, respectively, indicating that the majority of all species recorded exhibit a low affinity to specific habitat types and are slightly more likely to be found in upland habitats than wetland habitats.

Butternut (*J. cinerea*), a nationally and provincially endangered species, was found in several locations throughout the study area (Figure 4.5). The diameter at breast height (DBH) for individuals south of Spruce Avenue varied from approximately 3 cm to 20 cm; all trees appeared to be in good health. Further information about this species is detailed below in Section 4.1.5. Health Assessments for trees potentially impacted under the options presented in this EA will be completed in the summer of 2016, the results of which will be submitted under separate cover. MNRF consultation is scheduled to occur.

CUT1 (2010)

Note: The following description has been copied ad verbatim from the Tuck Creek Erosion Control EA (Aquafor Beech Limited, 2012). A representative photograph of the FOD9 community (Figure 4.4) has been included for informational purposes.

The entire riparian habitat in the areas where creek restoration and rehabilitation is proposed is classified as Mineral Cultural Woodland (CUW1). This community consists of a strip of forest having between 35 and 60% tree cover located along an altered stream corridor with man-made structures within a suburban setting. Included is a Fresh – Moist Oak – Maple – Hickory Deciduous Forest (FOD9) located to the east of the creek on the south side of Regal Road parallel to the area where creek restoration and rehabilitation is proposed. This community contains a mix of upland and lowland species including red oak, silver maple, bitternut hickory, white ash, red ash, ironwood, black cherry, white elm and basswood. It exhibits multifaceted topography with both tablelands and bottomlands and contains a small terrestrial-aquatic interface. The FOD9 community represents the area of highest terrestrial ecological quality within the study area. The entire forest is highly impacted by human activity, having a network of unauthorized trails, litter, vandalism, and a small campfire area. Invasive species such as Garlic Mustard (*Alliaria petiolata*) and English Ivy (*Hedera helix*) are prevalent in the understory, and in some cases residents have dumped yard waste over property fences.



Figure 4.4: Representative photo of the FOD9 community upstream of Spruce Avenue.

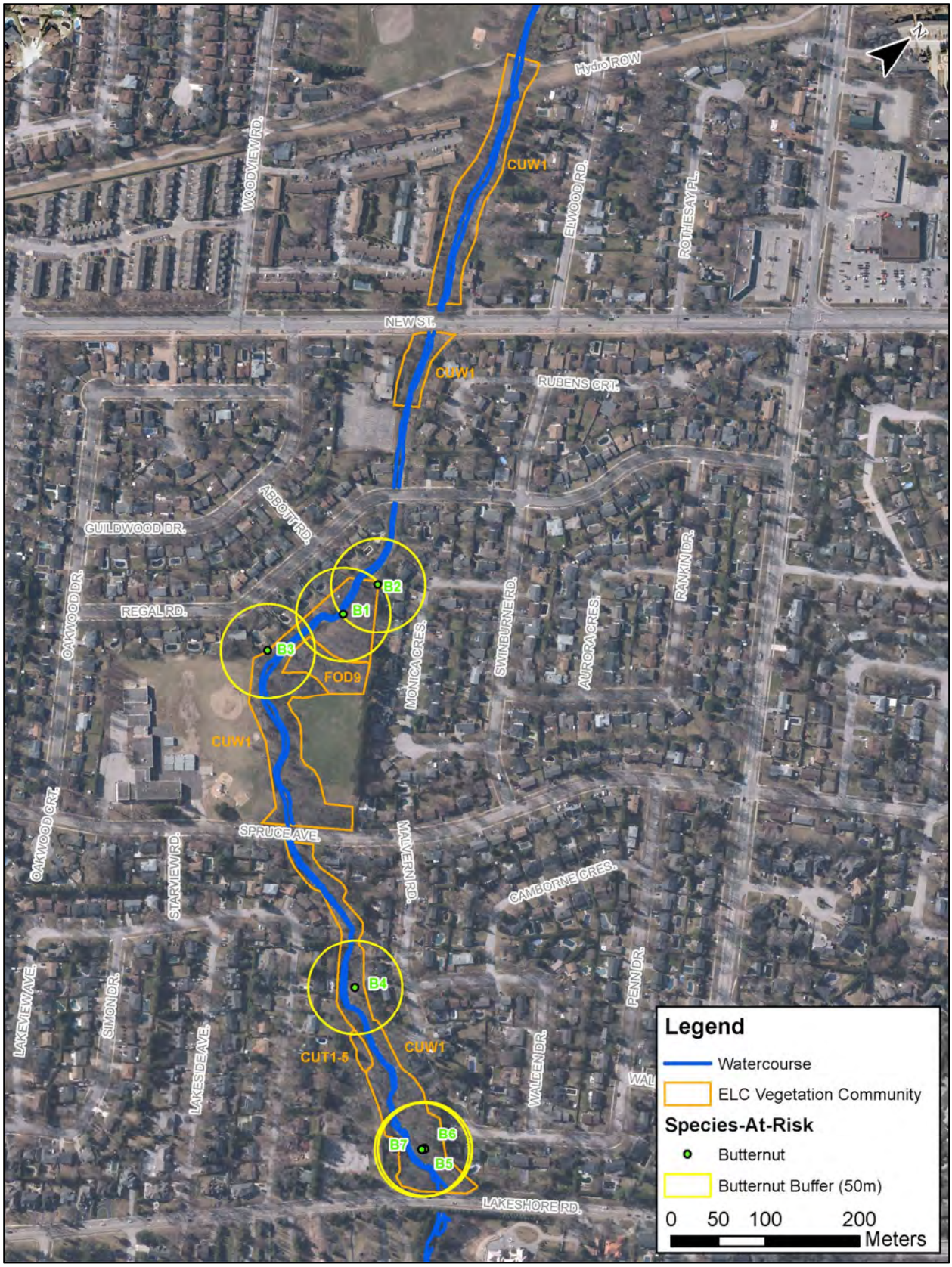


Figure 4.5: Vegetation Communities and Locations of Species-At-Risk

4.1.3 Significant Woodland Assessment

To be considered significant, woodlands in Halton Region must have a minimum size of 0.5 hectares (as determine through a watershed plan, SWS, or EIS) and meet one or more of the following four criteria (Section 277; Region of Halton, 2009):

(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 or larger if it is located outside the Urban Area but below the Escarpment Brow, 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 100 m 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.

The Region of Halton OP definition for a "major creek or certain headwater creek" (section 256.2) is as follows:

> MAJOR CREEK OR CERTAIN HEADWATER CREEK means, as it applies to Section 277(4) of this Plan, all watercourses within a Conservation Authority Regulation Limit as of the date of the adoption of this Plan and those portions of a watercourse that extend beyond the limit of the Conservation Authority Regulation Limit to connect a woodland considered significant based on criteria under Section 277(1), 277(2) or 277(3) and/or wetland feature within the Regional Natural Heritage System. The extent and location of major creeks or certain headwater creeks will be updated from time to time by the appropriate Conservation Authority and as a result may lead to refinements to the boundaries of significant woodlands.

The cultural woodland between Regal Road and New Street was not evaluated for significant woodland status as it is too small (0.2 ha) to meet Halton Region's minimum size requirement of 0.5 ha. For the remaining three woodlands that are over 0.5 ha in size, an assessment of the woodland status using the significant woodland criteria was completed. The results of this assessment are detailed in Table 4.1. The three woodlands – Lakeshore Road to Spruce Avenue, Spruce Avenue to Regal Road, and New Street to the Hydro ROW – have areas larger than Halton Region's 0.5 ha minimum size requirement, and are wholly or partially within 50 m of a major creek (i.e. Tuck Creek). Therefore, each of these three cultural woodlands qualifies as regionally significant woodland.

The locations of significant woodlands are shown in Figure 4.6.

Table 4.1: Assessment of woodland status against significant woodland criteria

Criteria		Woodland		
		Lakeshore Road to Spruce Avenue	**Spruce Avenue to Regal Road**	**New Street to Hydro ROW**
1) The woodland contains forest patches over 99 years old.	Meets criteria?	**No**	**No**	**No**
	Rationale:	No trees over 99 years of age were observed during ELC and botanical inventories.	No trees over 99 years of age were observed during ELC and botanical inventories.	No trees over 99 years of age were observed during ELC and botanical inventories.
2) The patch size of the Woodland is 2 ha or larger if is located in the Urban Area, or 4 ha or larger if it is located outside the Urban Area but below the Escarpment Brow, or 10 ha or larger if it is located outside the Urban Area but above the Escarpment Brow.	Meets criteria?	**No**	**No**	**No**
	Rationale:	The patch is located in the Urban Area and is 1.4 ha in size, less than the required size of 2 ha.	The patch is located in the Urban Area and is 1.8 ha in size, less than the required size of 2 ha.	The patch is located in the Urban Area and is 0.8 ha in size, less than the required size of 2 ha.
3) The Woodland has an interior core area of 4 ha or larger, measured 100 m from the edge.	Meets criteria?	**No**	**No**	**No**
	Rationale:	No point within the Woodland is 100 m from the edge; therefore, the Woodland has no interior core.	No point within the Woodland is 100 m from the edge; therefore, the Woodland has no interior core.	No point within the Woodland is 100 m from the edge; therefore, the Woodland has no interior core.
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.	Meets criteria?	**Yes**	**Yes**	**Yes**
	Rationale:	The Woodland is wholly within 50 m of a major creek as defined by Section 256.2 of the Region of Halton OP.	The Woodland is partially within 50 m of a major creek as defined by Section 256.2 of the Region of Halton OP.	The Woodland is wholly within 50 m of a major creek as defined by Section 256.2 of the Region of Halton OP.



Figure 4.6: Locations of significant woodlands

4.1.4 Wildlife

Wildlife recorded incidentally during other field surveys are listed below in Table 4.2 for the portion of the study area between Spruce Avenue and Lakeshore Road. All observed species are considered to be common, urban tolerant, and are not of conservation concern. Incidental wildlife observations for the portion of the study area from Spruce Avenue to the Hydro ROW are documented in Section 3.2.1 of the erosion EA (Aquafor Beech Ltd., 2012).

NHIC database screening shows the study area is an Important Bird Area (IBA). The West End of Lake Ontario IBA is an important location for feeding opportunities and shelter during the migration period, particularly for waterfowl (IBA Canada, 2016). Field work was conducted outside of peak migration periods, limiting the likelihood of observing the smaller number of waterfowl that venture inland from the lake.

Given the high degree of urbanization, limited riparian area, and lack of niche habitat, most wildlife observed in this area would be species considered as common.

Table 4.2: Incidental wildlife observations

Species		**Status**			
Scientific Name	**Common Name**	**COSEWIC**	**COSSARO**	**G-Rank**	**S-Rank**
Birds					
Poecile atricapillus	Black-capped Chickadee	-	-	G5	S5
Turdus migratorius	American Robin	-	-	G5	S5B
Mammals					
Castor canadensis	North American Beaver	-	-	G5	S5
Procyon lotor	Northern Raccoon	-	-	G5	S5
Sciurus carolinensis	Eastern Gray Squirrel	-	-	G5	S5
Herpetofauna					
N/A					
Odonates and Lepidopterans					
N/A					

4.1.5 Species at Risk and other Species of Conservation Concern

For the purpose of this report, species of conservation concern are defined as species that are considered Endangered, Threatened, or of Special Concern by COSEWIC or COSARRO; species with global ranks between G1 and G3; species with provincial ranks between S1 and S3; and/or species considered rare in the Region of Halton according to the Halton Region Natural Areas Inventory (Dwyer 2006).

In order to assess the presence of species of conservation concern, Aquafor Beech Limited completed the following tasks:

- Biological inventories for flora and fauna;
- NHIC database search (1 km square);
- Species at Risk information request from the MNRF Aurora District Office; and
- Species of Conservation Concern screening exercise.

In order to determine the likelihood of species of conservation concern occurring on or near the subject property, Aquafor Beech Limited conducted a screening exercise using the results of biological inventories on the subject property as well as the results of the background information gathering exercises listed above. Correspondence from the MNRF Species at Risk Biologist is contained in **Appendix D**.

Results

Twelve (12) species of conservation concern which, according to the NHIC database and MNRF records, have previously been recorded within or near the subject property, along with their habitat requirements, are listed below in Table 4.3. Also included in the table is an assessment of the likelihood that the species could occur on the subject property based on the habitat(s) present.

One (1) plant species of conservation concern, butternut, was recorded on the subject property during biological inventories conducted in September 2015 (see Table 4.3). A total of seven (7) individuals were found*. The locations of the butternuts are illustrated in Figure 4.5. Bank erosion threatens one of the trees, butternut B1, which is in danger of falling into the creek. (Figure 4.7, taken in 2015, shows eroding bank adjacent to tree B1. The extent of this erosion has increased since the photo was taken.)

Butternut is considered an Endangered species, and is protected under the Endangered Species Act (ESA). At this time it is not known if the butternuts present on site are pure or hybrid individuals. Aquafor notes that there are English Walnuts (*J. regia*) present in residential backyards; this species regularly hybridizes with butternut and it is possible that the individuals on site may be hybrids. Consultation with the MNRF and the completion of a butternut health assessment are scheduled for summer 2016. As the proposed works near Spruce Avenue are more than 50 m from any of the butternuts observed downstream of Spruce Avenue, the proposed works will likely not harm the species and/or their habitat, assuming that the butternuts on site are not hybrids there are no concerns regarding the contravention of the ESA. However, any channel works between Regal Road and Spruce Avenue may impact the habitat of the 2 butternuts located in this area (Trees B1, B2, & B3). Section 7.4 outlines the steps to be undertaken at the detailed design stage to address this potential impact.

Furthermore, it is worth noting that Aquafor Beech Limited inspected the bridges at Spruce Avenue and Lakeshore Road for Barn Swallow (*Hirundo rustica*, THR) nests. No nests were found at either location in 2015 or 2016.

*As previously discussed with the review agencies, butternut B2, reported in 2010/2011, was not found on site during investigations in 2015. The small tree may have fallen into the creek or was removed by landowners. As such, it was not shown in the mapping included in the previous submission of this EA report. However, a previously unrecorded mature butternut was found during spring botanical surveys completed in May of 2016. This tree is in close proximity to butternut B1. As such, this newly found tree is herein referred to as butternut B2.



Figure 4.7: Butternut B1 and adjacent creek bank

Table 4.3: Species of conservation concern screening summary

Species		Status				Source	Habitat Requirements	Likelihood of Occurrence on Subject Property	
Scientific Name	**Common Name**	**COSEWIC**	**COSARRO**	**G-Rank**	**S-Rank**			**Present?**	**Rationale**
Aureolaria virginica	Downy Yellow False Foxglove	-	-	G5	S1	NHIC Database	Undisturbed forests with oaks, pine, and/or hickory (Michigan Flora Online, 2011).	No	Dry, disturbed woodlands within the study area are unsuitable for this species. No individuals were observed during ELC and botanical inventories.
Crataegus brainerdii	Brainerd's Hawthorn	-	-	G5	S2	NHIC Database	Dry open woodlands, woodland edges, thickets, and hedgerows (Michigan Flora Online, 2011).	No	Potential habitat for this species is present within the study area. However, no individuals were observed during ELC and botanical inventories.
Crataegus pruinosa var. dissona	Northern Hawthorn	-	-	G4G5	S3	NHIC Database	Dry open woodlands, woodland edges, thickets, and hedgerows (Michigan Flora Online, 2011).	No	Potential habitat for this species is present within the study area. However, no individuals were observed during ELC and botanical inventories.
Euonymus atropurpureus	Eastern Burning Bush	-	-	G5	S3	NHIC Database	Rich alluvial soils in riparian thickets, damp sandy and rocky woods (Soper et al., 1994)	No	Potential habitat for this species is not present within the study area. No individuals were observed during ELC and botanical inventories.
Juglans cinerea	Butternut	END	END	G4	S3?	Aquafor Beech Ltd.	Deciduous forests and floodplains in well-drained soils (SARA, 2016).	Yes	This species is present on site. A total of six (6) individuals were identified and surveyed during ELC and botanical inventories completed by Aquafor Beech Limited on September 1, 2015. See Figure 4.5 for locations and Section 4.1.5 for further discussion.
Mertensia virginica	Virginia Bluebells	-	-	G5	S3	NHIC Database	Forests with rich soils and forests in floodplains (Michigan Flora Online, 2011).	No	Potential habitat for this species is present within the study area. However, no individuals were observed during ELC and botanical inventories.
Sphenopholis nitida	Shiny Wedge Grass	-	-	G5	S1	NHIC Database	Dry, generally undisturbed woods. Known record at Royal Botanical Gardens in Hamilton (Dore and McNeill, 1980).	No	Potential habitat for this southern species is not present within the study area and it is likely that the study area is outside of the species' range. No individuals were observed during ELC and botanical inventories.
Uvularia perfoliata	Perfoliate Bellwort	-	-	G5	S1	NHIC Database	Dry open woodlands and clearings (Newcomb, 1977).	No	Potentially suitable habitat for this species within the study area. However, no individuals were observed during ELC and botanical inventories.
Cordulegaster obliqua	Arrowhead Spiketail	-	-	G4	S2	NHIC Database	Small, swift streams and muddy seeps in forests (Paulson, 2015).	No	An urbanized creek with stormwater inputs is unsuitable habitat for this species. No individuals were observed during ELC and botanical inventories.
Coregonus reighardi	Shortnose Cisco	END	END	GH	SH	NHIC Database	Deep, cold waters of the Great Lakes. Usually found in depths of 22 to 110 metres (OMNRF, 2015).	No	NHIC records are historical. Species has not been collected from the area since 1915. Potential habitat for the species is not present in the study area.
Crotalus horridus	Timber Rattlesnake	EXP	EXP	G4	SX	NHIC Database	Often associated with upland forested areas and rocky areas such as outcrops, ledges, and talus (Ontario Nature, 2015).	No	This species has been recorded on the Niagara Escarpment, with the last confirmed sighting made in the 1940's (OMNRF, 2015). This species is extirpated from Ontario.
Nycticorax nycticorax	Black-crowned Night-heron	-	-	G5	S3B, S3N	NHIC Database	Marshes, streams, and lakes with suitable deciduous trees for nesting (Curry, 2006).	Unlikely	Potential marginal habitat for this species is present in the study area. However, it is unlikely that the species would be present near the bridge. Furthermore, this species is at the northern extent if its range and was not observed during field work.
Restricted Species		-	-	-	-	NHIC Database	-	-	-

4.1.6 Tree Inventory

A tree inventory was completed during the erosion EA (Aquafor Beech Ltd., 2012) which covered trees with diameters at breast height (DBH) greater than 15 cm in the vicinity of the creek from Regal Road to the Hydro ROW. An additional tree inventory was completed by a certified arborist in October 2015. This survey included all trees with DBH values greater than 10 cm located within the creek block north of New Street. **Appendix E** provides a figure showing the location of the trees surveyed and the tree species and DBH.

Approximately 30% of the trees included in the tree inventory were ash species (*Fraxinus* spp.). Emerald Ash Borer (*Agrilus planipennis*) infestation was evident on many of the ash within the study area. It is likely that ash tree mortality caused by this insect pest will have a significant negative effect on the amount of tree canopy cover in the riparian corridor. It is the opinion of Aquafor Beech Limited that an opportunity exists for diverse native tree plantings during any creek works associated with the flood reduction study to aid in mitigating tree cover losses resulting from Emerald Ash Borer infestations.

4.1.7 Fisheries

Fisheries records for Tuck Creek were provided by Conservation Halton. Records exist for three (3) locations as described in Table 4.4 below. TUK-2 is approximately 1 km upstream of the study area while TUK-5 and TUK-1 are within about 500 m of the downstream end of the study area. The period of record extends from 2001-2012.

Table 4.4: Fish Sampling Stations
(Data Provided by Conservation Halton)

Station	Location	Easting	Northing
TUK-2[1,2]	Downstream of Harvester road just west of Walkers Line	598434.310	4801655.160
TUK-5[2]	Upstream of Lakeshore Road just east of Lakeview Avenue	600176.280	4799858.600
TUK-1[1]	Downstream of Lakeshore Road between Lakeview Road and Walkers Line	600236.280	4799842.600

1 Sampling conducted by MNRF 2 Sampling conducted by Conservation Halton

Fish species that have been captured at each location are listed in Table 4.5. Sampling dates and numbers of species captured are listed in **Appendix F**. Although the fish community found in Tuck Creek are mainly warm to coolwater, the watercourse has been designated a coldwater fishery by Conservation Halton, due to the presence of rainbow trout (*Oncorhynchus mykiss*). Seven (7) adult rainbow trout were observed incidentally during spring botanical surveys (report to be submitted under separate cover) on May 10th 2016, at UTM 599965, 4799931 (+/- 4 m) (**Figure 4.8**). Conservation Halton has specified that no in-water works may occur between March 15 and June 15, to protect spawning rainbow trout.



Figure 4.8: Rainbow Trout in Tuck Creek between Lakeshore Rd and Spruce Avenue

Fish species known to occur in the study area are listed in **Table 4.5**. With the exception of rainbow trout, the species that exist in Tuck Creek are fairly tolerant to development or other disturbances. All are common in Ontario.

Table 4.5: Fish Species Captured in Tuck Creek

Scientific Name	Common Name	TUK-2	TUK-5	TUK-1
Catostomus commersoni	White Sucker	ü	ü	ü
Culaea inconstans	Brook Stickleback		ü	
Cyprinidae	Carps and Minnows		ü	
Gasterosteus aculeatus	Threespine Stickleback		ü	
Luxilus cornutus	Common Shiner	ü	ü	
Oncorhynchus mykiss	Rainbow Trout		ü	
Pimephales promelas	Fathead Minnow	ü	ü	ü
Rhinichthys atratulus	Blacknose Dace	ü	ü	ü
Rhinichthys cataractae	Longnose Dace		ü	ü
Semotilus atromaculatus	Creek Chub	ü	ü	ü

4.1.8 Regional Natural Heritage System

The Regional Natural Heritage System (RNHS), as defined by ROPA 38 of the Region of Halton's Official Plan (2009), consists of the following:

1. areas so designated on Map 1;
2. the shoreline along Lake Ontario and Burlington Bay;
3. significant habitats of endangered species and threatened species not included in the designation on Map 1; and

4. Key Features, which include:
    a. *significant* habitat of endangered and threatened species,
    b. *significant wetlands*,
    c. *significant* coastal wetlands,
    d. *significant* woodlands,
    e. *significant* valleylands,
    f. *significant* wildlife habitat,
    g. *significant* areas of natural and scientific interest, and
    h. fish habitat.
5. *enhancements to the Key Features* including C*entres for Biodiversity*,
6. *linkages*,
7. *buffers*,
8. *watercourses* that are within a *Conservation Authority* Regulation Limit or that provide a *linkage* to a *wetland* or a *significant woodland*, and
9. *wetlands* other than those considered *significant* under Section 115.3(1)b).

The RNHS within the study area, illustrated on Map G1 of the Official Plan (2013), is illustrated in Figure 4.9. As shown in this map, RNHS features are limited to the riparian corridor and natural areas within Tuck Park. The analysis that follows presents a summary of the relevant elements of the RNHS, which consists of items 3/4a, 4d, 4h, 6, and 7 as listed above. Item 1, as shown in **Figure 4.9**, is subject to minor refinements per the analysis herein. The refined RNHS is illustrated in **Figure 5.12**.



Figure 4.9: RNHS as identified by the Region of Halton, with upstream and downstream study area limits shown (adapted from the Region of Halton OP Map 1G, 2013)

Key Natural Features of the RNHS

As detailed above in Section 4.1.3 illustrated in Figure 4.6, three significant woodlands are present within the study area. The woodlands consist of common vegetation community types (cultural woodland and fresh-moist Oak-Maple-Hickory Deciduous Forest).

These woodlands contribute to the urban tree canopy within the City of Burlington and Region of Halton. The woodlands are designated as regionally significant due to their proximity to Tuck Creek, which serves as habitat for warmwater and coolwater fish species (see Section 4.1.7 for further details regarding fisheries). The woodlands contribute to water quality within the creek (e.g. shading/temperature regulation, erosion control, etc.), and well as fish habitat through the provision of secondary inputs (e.g. leaf litter, insects, woody debris, etc.).

As detailed in Section 4.1.4, incidental mammal observations within the study area consist of common urban adapted wildlife. Anuran surveys were not completed as part of this or previously completed studies. As no permanent or temporary pools are present within the study area, amphibian habitat is limited or likely absent. Breeding bird surveys were also not completed as part of this or previous studies, and publicly available information such as the crowdsourced online database eBird, is lacking. Given the linear woodland habitat present in the study area, it is likely that the area supports common and urban-adapted avifauna breeding and foraging activities. Cavity trees, which could provide habitat for cavity-nesting species, were not observed within the study area. The southern end of the study area, identified by the MNRF as an Important Bird Area (IBA), likely aids avifauna migrating along the shore of Lake Ontario, though the woodland is not large enough to qualify as candidate significant wildlife habitat (i.e. shorebird and landbird stopover areas). As no changes are proposed for wooded areas south of Spruce Ave. (with the exception of localized impacts near the Spruce Ave. bridge), impacts to the IBA are not applicable.

One (1) species-at-risk was identified within the limits of the project study area. As described in Section 4.1.5, a total of seven (7) butternut trees were identified within or immediately adjacent to the study area. Their habitat, consisting of lands within 50 m of the base of the tree, is illustrated in Figure 4.5 and again in Figure 5.12. At the time of writing the trees have not been subject to a butternut health assessment (BHA); thus, it is not known if the butternut within the study area are retainable. The trees' hybrid status is also unknown. As such the assessment contained herein is conservative, assuming that the trees are retainable, pure (i.e. not hybrids) butternuts protected under the Endangered Species Act. The BHA is scheduled to be completed in the summer of 2016 in consultation with the MNRF; the results of the assessment will be available prior to the detailed design phase of this project.

Linkages

Riparian vegetation communities along Tuck Creek serve as a linkage for flora as well as terrestrial and avian fauna. Due to the absence of significant/substantial terrestrial habitat types, the linkage function of the Tuck Creek riparian corridor is likely minor, serving local, urban-adapted wildlife. No significant fish barriers were identified during field walks beyond depositional bars formed as a result of the August 4, 2014 storm event. As such, Tuck Creek, at least the portion contained within the study area, also functions as a linkage for aquatic species. As rainbow trout were observed in the creek as recent as May 2016, it is assumed that fish barriers between Lakeshore Road and Lake Ontario are non-existent and that fish can move freely from the Lake upstream to at least the hydro corridor, although there may be some passage limitations due to deposition of material from the August 4, 2014 storm.

RNHS Summary
(RNHS illustrated in Figure 5.12)

The elements of the Regional Natural Heritage System within the study area include:

- Habitat of Endangered Species (7 Butternut)
- Significant Woodlands (3 in total)
- Fish Habitat (Tuck Creek)
- Linkages (Tuck Creek and adjacent riparian corridor)
- Associated buffers (note: minimum NHS buffers not illustrated in corresponding map)

4.1.9 Hydrology

The existing conditions hydrologic model was developed during the erosion EA study (Aquafor Beech Ltd., 2012). The model is a SWMHYMO model which incorporates existing land use conditions within the watershed. The flows derived from the model are summarized in Table 4.6. These flows were also used in the hydraulic modeling for the study area.

Table 4.6: Tuck Creek Peak Flows

Location	Peak Flow (m^3/s)						
	2-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	Regional
West Branch @ Headon Forest Dr.	5.395	7.8	9.5	12.8	15.4	17.697	26.5
East Branch @ Headon Forest Dr.	3.095	5.3	7.1	9.7	11.7	13.830	28.7
Confluence of East and West Branches	10.675	16.7	21.7	28.6	34.0	39.611	69.0
Upper Middle Rd	13.59	19.5	23.4	28.3	33.5	39.118	79.7
South of Upper Middle Rd	13.932	20.1	23.8	28.9	34.1	39.492	81.3
Palmer Rd	14.515	21.1	25.4	30.9	36.2	41.392	88.7
QEW	16.602	23.8	28.2	34.3	39.5	44.358	96.0
CNR Oakville	20.626	28.0	33.2	40.8	46.1	50.541	108.4
New St.	23.464	32.5	39.0	48.1	54.7	61.299	125.4
Lake Ontario Outfall	24.113	33.6	40.7	50.2	57.1	64.332	132.1

4.1.10 Hydraulics

Hydraulic modeling of the Tuck Creek study area was performed using the U.S. Army Corps of Engineers HEC-RAS model. The model was run under subcritical, steady state conditions.

The model developed for this study was derived from the model used as the base model for the erosion EA (Aquafor Beech Ltd., 2012) and included the portion of Tuck Creek from upstream of Hwy 407 to downstream of Lakeshore Road. The model was originally provided in HEC-2 by Conservation Halton. This model was them imported into HEC-RAS for the erosion EA. The flows in the model were updated to reflect the hydrology from the 2012 EA.

For the current study, the model was updated to be geo-referenced and included the section of Tuck Creek from the Hydro ROW downstream to Lake Ontario. Efforts were made to maintain the hydraulic coefficients used in the 2012 model. Cross section geometry and inflow data were also imported from the 2012 model. The tail water boundary condition for the modelled scenarios was updated using Lake Ontario monthly mean water level records (1918 to 2013) obtained from the Canadian Hydrographic Service (2015) and included in **Appendix B**. The average maximum water level of 75.158 m over the 20 year period was used.

The model geometry was refined using survey data collected after the August 4, 2014 storm. Topographic survey data in the study area was completed during 2 surveys, the first occurring in the in the fall of 2014 for the Hydro ROW to Regal Road and the second in the fall of 2015 for Regal Road to Lake Ontario. The recreational trail bridge at the Hydro ROW that was replaced

between 2011 and 2014 and so its representation in the model was also updated using the new bridge survey data. Results of the updated model are attached in **Appendix B**.

Variations in the water surface elevations between the 2012 and updated models range from an increase of 0.97 m to a decrease of 1.43 m. However, the main cause of these changes is due to the refining of the channel geometry using the survey data collected following the August 4, 2014 storm. Changes in channel inverts between the 2012 and updated models range from an increase of about 0.6 m to a decrease of about 1.2 m. A comparison of the results between the 2012 and updated water surface elevations is included in **Appendix B**.

Despite the changes in water surface elevations between the two models, the Regional and 100-year floodplain mapping for the updated model corresponds well with the estimated floodline from the August 4, 2014 storm. The estimated floodline for the August 4, 2014 storm was provided by Conservation Halton based on their report following the storm event (Conservation Halton and Environmental Water Resources Group Ltd., 2015). Figure 4.10 provides a comparison of these floodlines. The correspondence between the estimated 2014 storm floodline and the updated hydraulic model floodlines suggest that the model provides a reasonable representation of the conditions in the study area.



Figure 4.10: Comparison of Existing Condition Floodplain to Estimated August 4, 2014 Floodplain

4.1.11 Fluvial Geomorphology

Photographs of typical conditions within the Tuck Creek study area are included in **Appendix A**. Within the study area, urban development abuts the Tuck Creek corridor. From the Hydro ROW to Regal Road, the creek appears to have been historically straightened. From downstream of Regal Road to Lake Ontario, the creek appears to follow a more meandering path although limited corridor width and crossings at Spruce Avenue and Lakeshore Road have affected channel planform.

Where there are no channel bed treatments, the substrate consists of shale and the bed morphology is characterized by riffle or run-like sediment accumulations and shallow pools. Composition of the loose channel bed materials is principally composed of fractured shale and limestone, although angular rip rap from upstream treatments is also present. Pools are bedrock lined and typically contain few loose substrate materials.

Effects of the August 4, 2014 storm are evident throughout the study area. Elevated flows led to increased channel bed and bank erosion. As flows from the storm receded, transported bed material was deposited resulting in large depositional bars of fractured shale, limestone, and rip rap. In some areas, these bars appear to have resulted in a change in the channel thalweg location. Additional changes to the channel banks and planform resulted from emergency bank and bed regrading following the storm.

Erosion is present throughout the study area from Lakeshore Road to the Hydro right-of-way north of New Street. Some erosion is expected in a natural watercourse; however, erosion can be exacerbated by urbanization within a watershed and by channelization of a watercourse. Both of these conditions are present in Tuck Creek.

Channel bank treatments are present intermittently through the study area. These include armourstone walls, gabion basket revetments, and rip rap. Most of the gabion basket treatments are reaching their end of life with rip rap emptying as the wire mesh fails. A portion of the armourstone bank protection downstream of Lakeshore Road was recently reconstructed. However, some of the armourstone treatments upstream of Lakeshore Road are starting to become undermined; this condition may have resulted (or been exacerbated by) erosion during the August 4, 2014 event.

Rapid Geomorphic Assessments (RGAs) were completed during the field work for the erosion EA (Aquafor Beech Ltd., 2012). The study area was divided into 6 reaches as shown in Figure 4.11. The results from the RGAs are summarized in Table 4.7. These results show that the dominant processes within the study area are degradation and widening. These processes are typical of watercourses with urbanized land use in the watershed, as is the case with Tuck Creek.

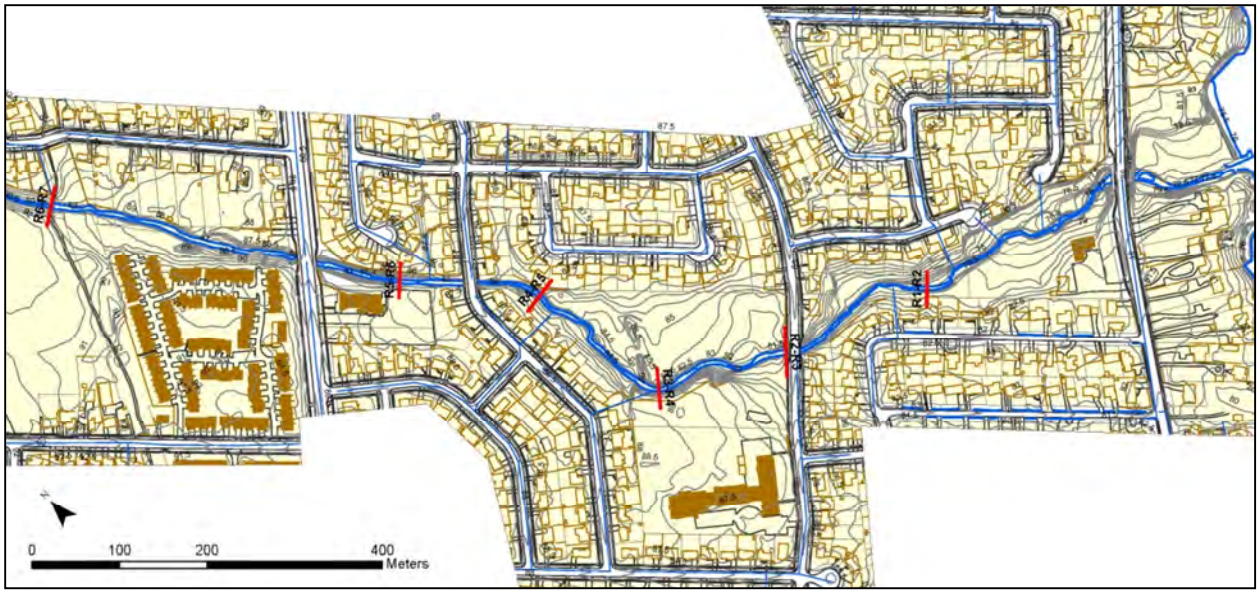


Figure 4.11: Reaches on Tuck Creek

Table 4.7: Results from the Rapid Geomorphic Assessments

Reach	Stability Index	Dominant Process	Classification
1	0.17	Degradation	In regime
2	0.17	Degradation	In regime
3	0.20	Degradation/Widening	In regime
4	0.37	Degradation/Widening	Transitional or stressed
5	0.14	Widening	In regime
6	0.45	Degradation/Widening	In adjustment

4.2 Municipal Infrastructure

Municipal infrastructure within the Tuck Creek corridor in the study area includes City storm sewer outfalls and Region of Halton water mains. The location of the storm sewer outfalls is shown in Figure 4.12. The water, sanitary, and storm sewer infrastructure at watercourse crossings is shown on Figure 4.13 to Figure 4.16 for New Street, Regal Road, and Spruce Avenue. As seen in the figures, Region of Halton water mains cross Tuck Creek at New Street and Spruce Avenue. In addition to the municipal infrastructure, existing crossing structures are summarized in Table 4.8.

Table 4.8: Existing Channel Crossing Structures for Tuck Creek within the Study Area

Crossing	Width of Opening (m)	Invert Elevation (m)	Obvert Elevation (m)
New Street	13.7	84.63	87.83
Regal Road	9.1	93.41	87.01
Spruce Avenue	10.5	83.76	87.01
Lakeshore Road culvert 1	4.27	75.29	77.73
culvert 2	3.67	75.29	77.89

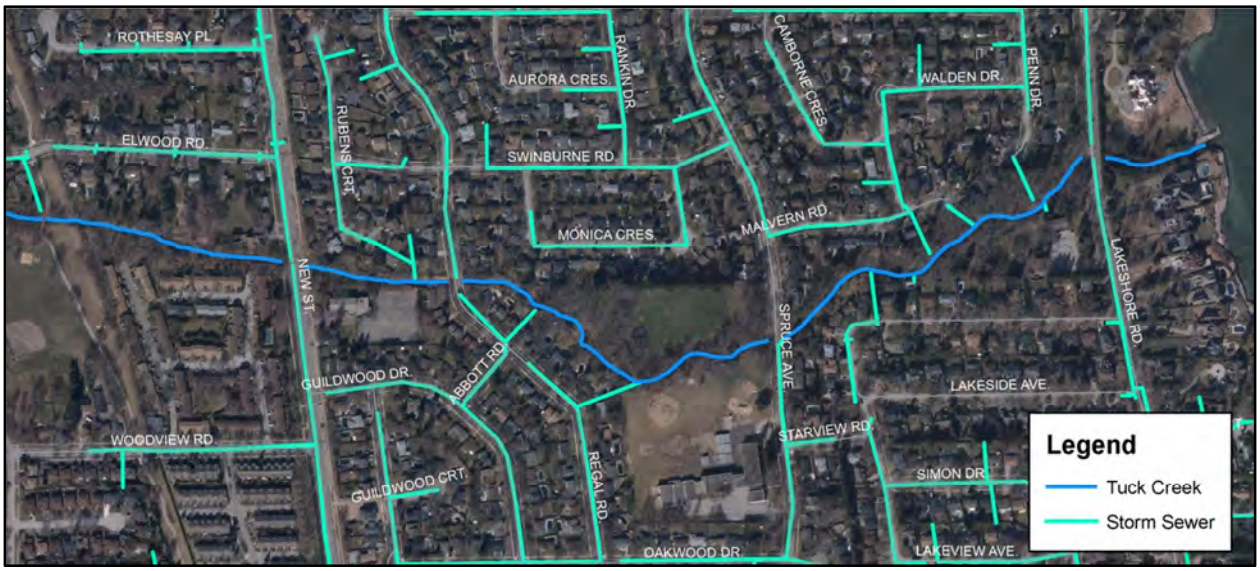


Figure 4.12: Storm Sewer Infrastructure in Study Area

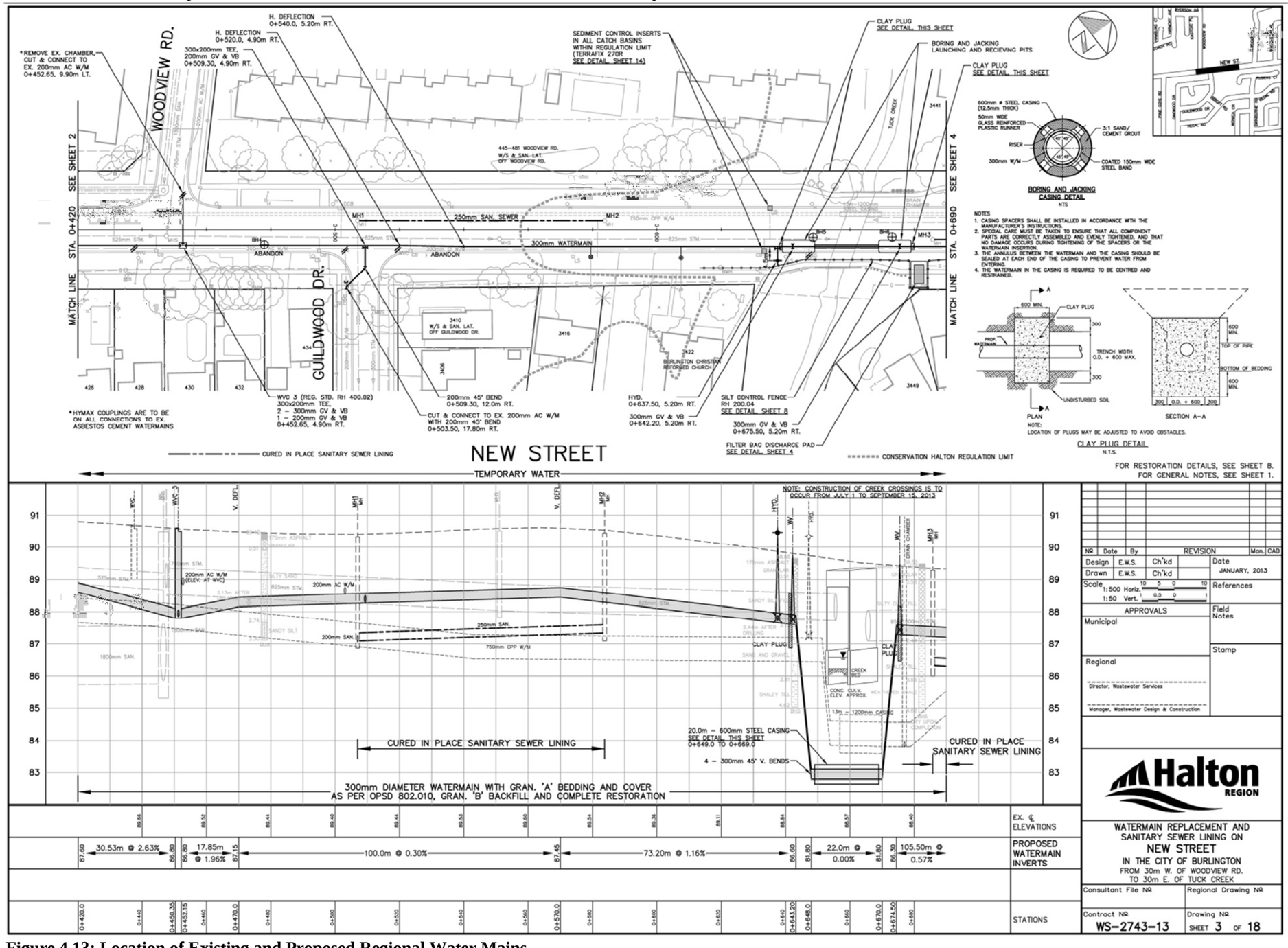


Figure 4.13: Location of Existing and Proposed Regional Water Mains
Source: Region of Halton (2013)

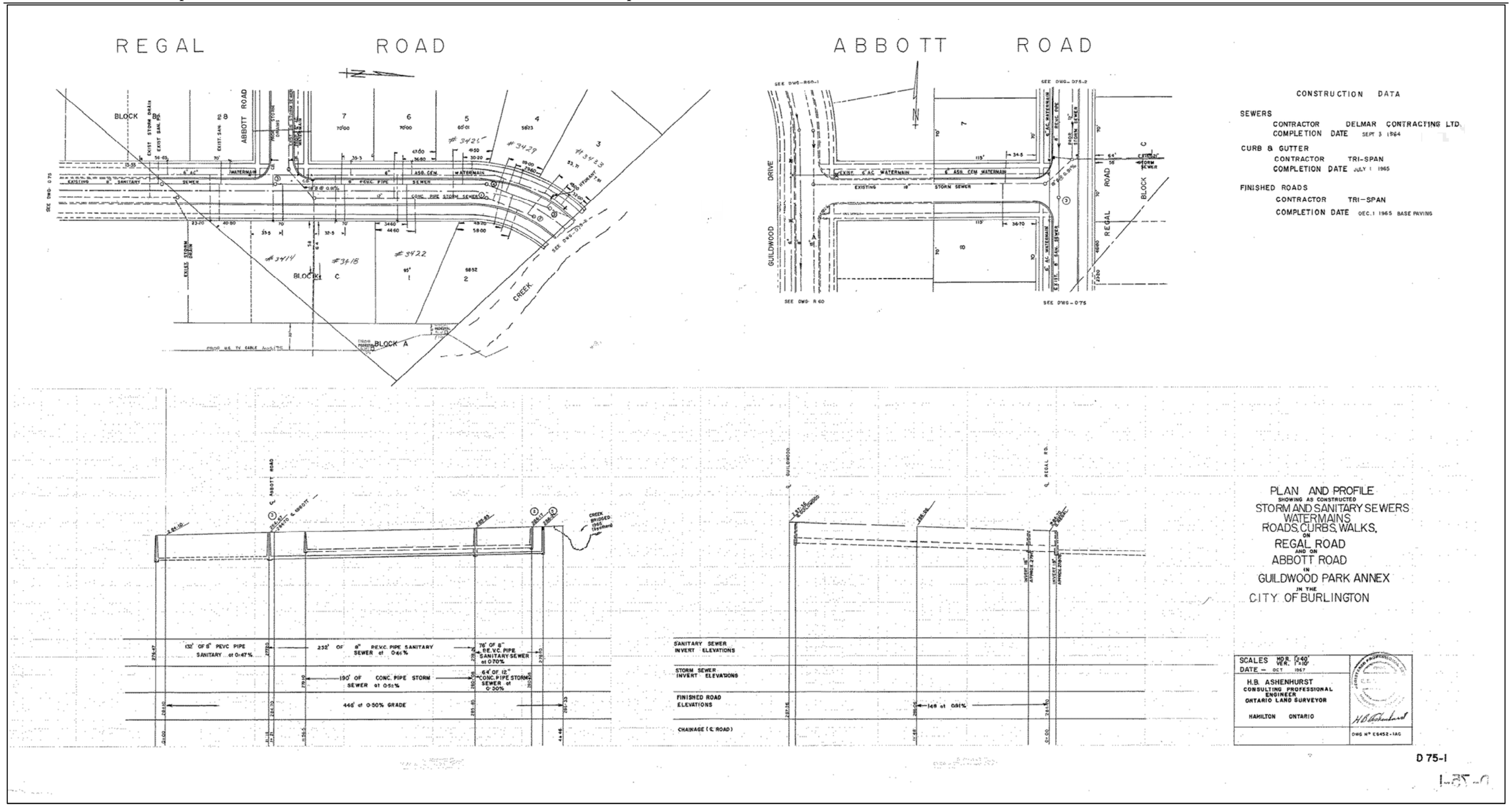


Figure 4.14: Infrastructure at Regal Road Crossing, West Side
Source: H.B. Ashenhurst (1967)

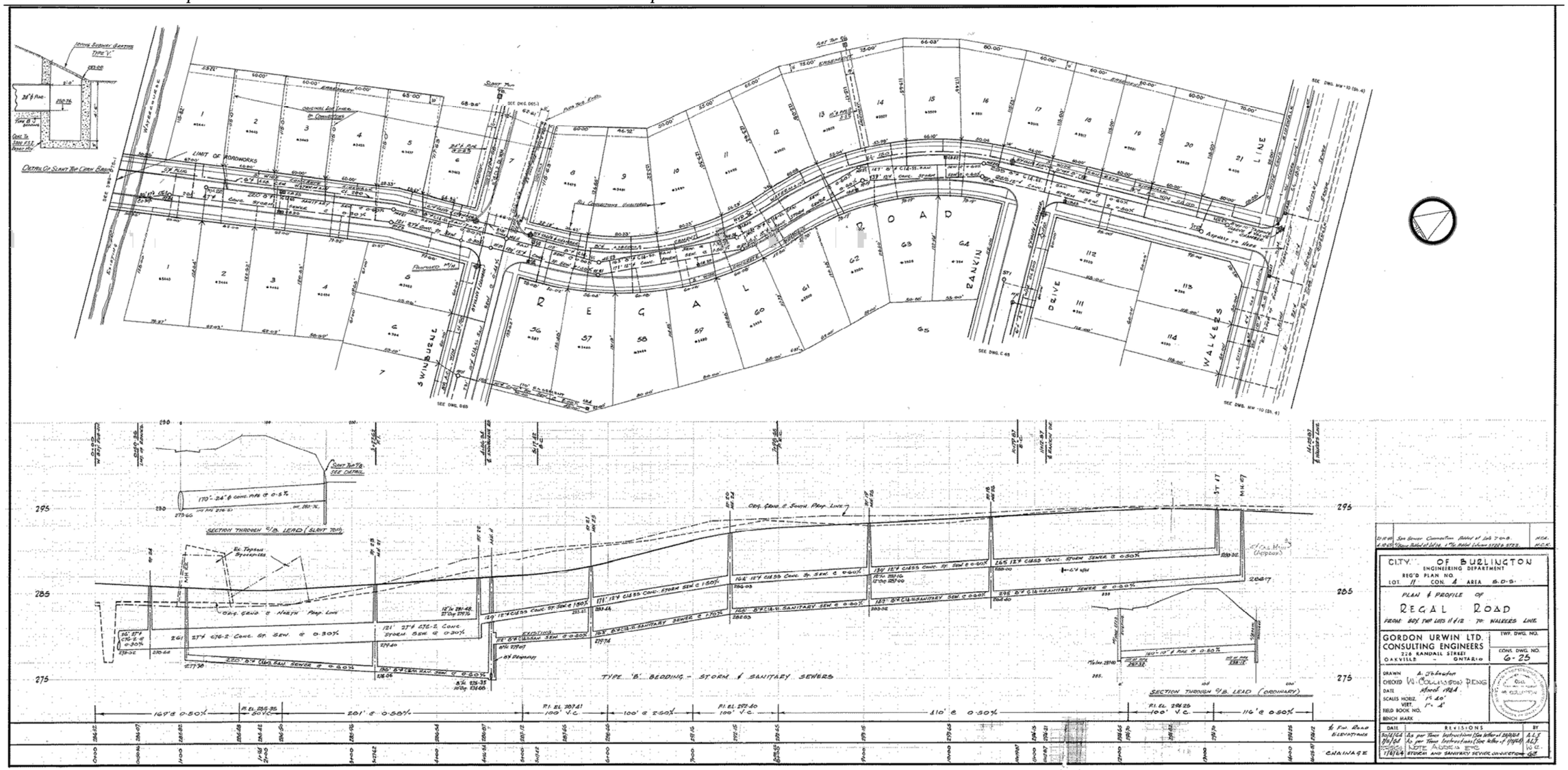


Figure 4.15: Infrastructure at Regal Road Crossing, East Side
Source: Gordon Urwin Ltd. Consulting Engineers (1964)

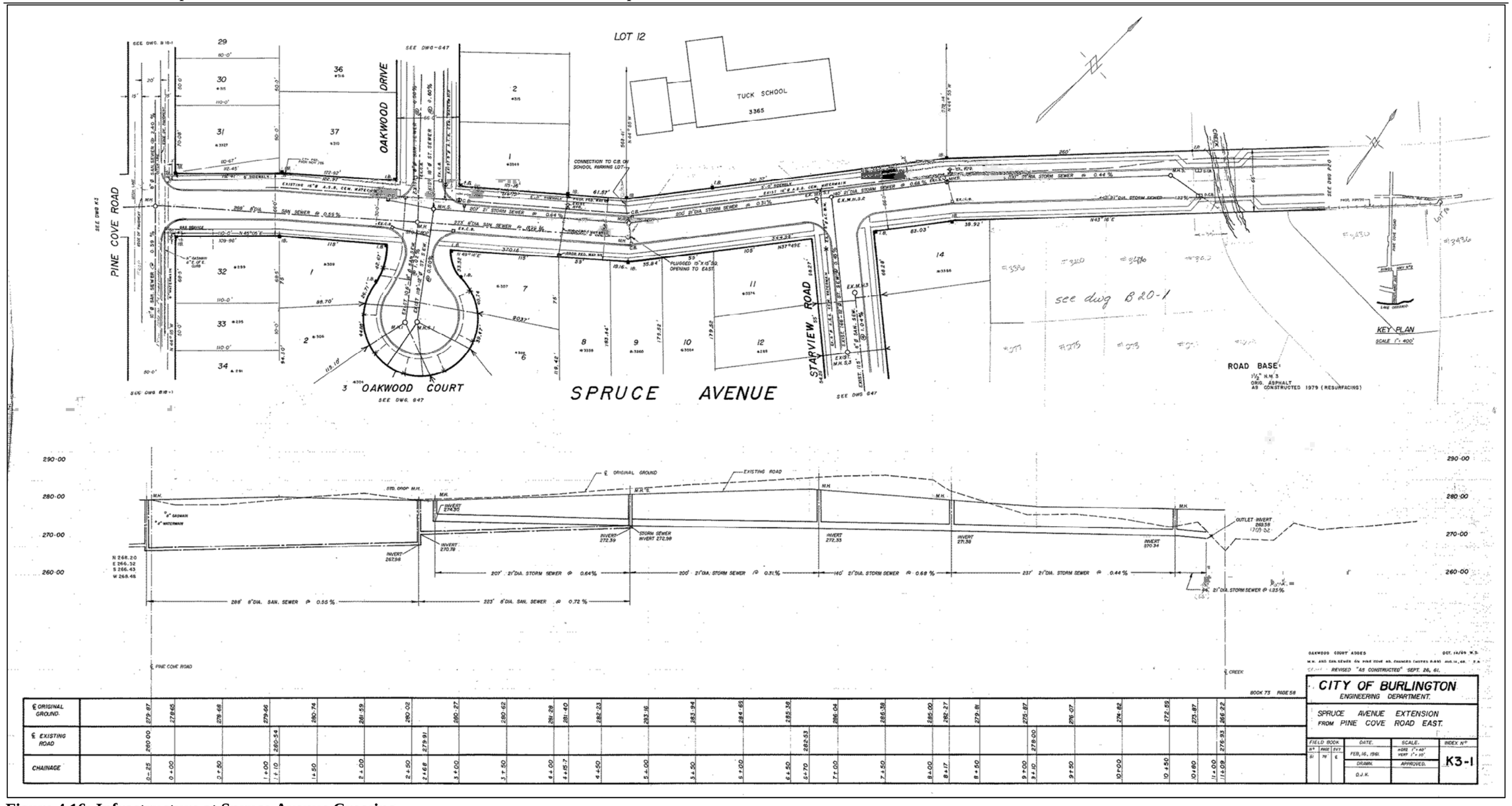


Figure 4.16: Infrastructure at Spruce Avenue Crossing
Source: City of Burlington Engineering Department (1969)

4.3 Socio-Economic Environment

4.3.1 Land Use

As noted in the Burlington Official Plan (City of Burlington, 2010), initial settlement in what is now the City of Burlington occurred along Lake Ontario and proceeded northward. Urban growth and expansion has been continuous in Burlington since the 1950s. At present, development within the Tuck Creek watershed extends to Dundas Street (see **Figure 4.17**).

Within the developed portion of the watershed, land uses include residential, commercial, business, employment, and parks/open space (**Figure 4.17**). The study area is contained within low density residential land use with some medium density residential land use on the south-west side of Tuck Creek upstream of New Street.

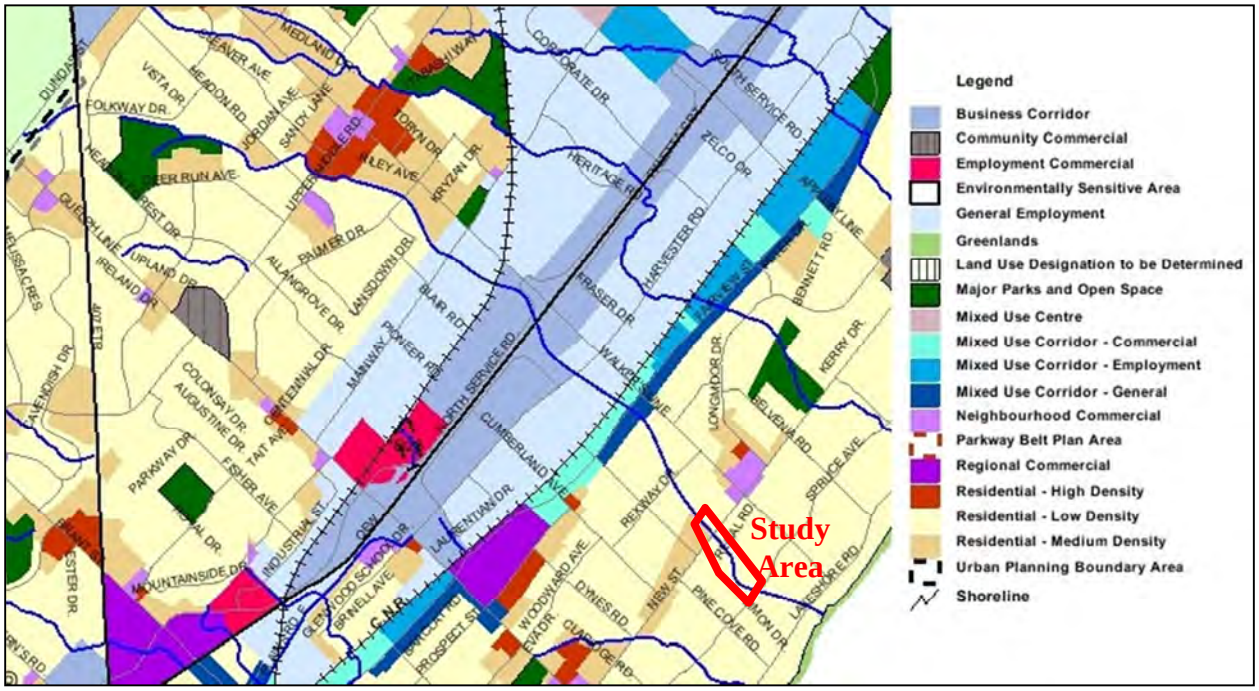


Figure 4.17: Land Use within the Tuck Creek Watershed
Source: http://mapping.burlington.ca/COBmaps/WebPages/Map/MapViewer.aspx

4.3.2 Transportation/Utility Corridors

A Hydro Right-of-Way traverses the upstream end of the study area. The Trans-Northern Pipeline is also located within the hydro corridor. No other major utility corridors pass through the study area.

Within the Tuck Creek watershed, major transportation corridors include the Queen Elizabeth Way, Highway 407, and two Canadian National Railway lines.

4.3.3 Ownership

Within the study area, Tuck Creek is located on both public and private property. At the upstream end of the study area, the watercourse is contained within the Hydro Right-of-Way. Downstream of the Hydro ROW, Tuck Creek traverses 5 privately owned properties over a

distance of approximately 110 m. Following this, the creek returns to a City-owned block for the remaining distance to New Street (approximately 120 m). From New Street downstream to Spruce Avenue, the watercourse is contained within City-owned blocks.

The City has obtained easements over the creek where it is contained within private property. However, the land will still be privately owned. As such, any work done on the watercourse within the privately owned portion of the creek must be done in consultation with the land owners.

PHASE II: EVALUATION OF ALTERNATIVE SOLUTIONS

The evaluation of alternative solutions is the second phase of the EA process. The development and evaluation of alternatives is described in the sections below.

5 DEVELOPMENT OF ALTERNATIVES

In consideration of the study objectives, alternatives were developed for each site. Input was sought from the City, Conservation Halton, and the public with respect to the alternatives. The following subsections provide descriptions of the alternatives for each site, the evaluation and public consultation process, and the selection of the preferred alternative. As well, a discussion of additional measures to reduce flooding in the watershed has been included at the end of the section.

5.1 Description of Alternatives

Five (5) alternatives were developed to reduce flooding within the study area. These alternatives include various combinations of bridge and channel upgrades. Details of each alternative are provided below.

5.1.1 Alternative 1 – Do Nothing

Without intervention, the risk of flooding in the study area will be unchanged. The floodlines were used to identify buildings which were either located within the floodlines or were touched by the floodlines. The number of buildings meeting these criteria was counted to determine the number of buildings impacted by flooding. In areas with spills, the exact number of buildings within the floodplain could not be determined. Currently more than 102 buildings are located in the Regional storm floodplain and more than 57 buildings are located in the 100-year storm floodplain. (Exact numbers of buildings in the floodplain within the study area are not known due to the presence of spills.) During the August 14, 2014 storm event, approximately 65 building in the Tuck Creek watershed reported flooding and 13 road crossing overtopped including New Street, Regal Road, and Spruce Avenue.

Existing conditions floodlines are illustrated in Figure 5.1. The estimated floodline for the August 4, 2014 storm was provided by Conservation Halton based on their report following the storm event (Conservation Halton and Environmental Water Resources Group Ltd., 2015).



Figure 5.1: Existing Regional and 100-Year Storm Floodlines and Estimated August 4, 2014 Floodline

5.1.2 Alternative 2 – Bridge Upgrades

This option involves bridge upgrades at New Street, Regal Road, and Spruce Avenue with open-footing structures. The deck of the New Street crossing will also be widened from the current 25 m to 30 m to accommodate bike lanes. The goal of the bridge upgrades was to reduce overtopping of the roads during infrequent storms; therefore, the sizes of the structures were maximized considering available lands, site conditions as well as recommendations made in previous studies (e.g. 1985 Proctor and Redfern Group et al., 1985). Table 5.1 summarizes the proposed structures. The rises of the structures varies depending on the channel invert as these are open-footing structures.

Table 5.1: Proposed Structures

Location	Span (m)	Width (m)	Height of Soffit Above Channel (m)
New Street	21	30	3
Regal Road	11	18	3
Spruce Avenue	18	15	4

The proposed structures were added to the hydraulic model and Table 5.2 shows the change in water surface elevations upstream of these crossings. Complete model results are included in **Appendix B**.

Model results for Alternative 2 indicate that bridge upgrades alone do not provide much benefit at New Street and Regal Road and only provide moderate benefit at Spruce Avenue for the Regional event. For the 100-year event, structure upgrades provide moderate benefit at New Street and Spruce Avenue but little benefit for Regal Road. Floodlines for the Regional and 100-year events are illustrated in Figure 5.2 and Figure 5.3 respectively.

With the implementation of bridge upgrade, more than 95 buildings still remain in the Regional storm floodplain 7% reduction) and 48+ buildings are located in the 100-year storm floodplain (16% reduction). It should be noted that structure upgrades are localized solutions and therefore do not provide significant flood reduction benefits for the system-wide flooding issues present in the study area. However, this solution can be used in conjunction with other system-wide upgrades to provide enhanced flood reduction potential. This opportunity is further explored in the subsequent alternatives.

Table 5.2: Water Surface Elevation upstream of Proposed Crossings

Location	Event	Existing Condition (m)	Alternative 2 (m)	WSL Change (m)
New Street	Regional	88.98	89.03	0.05
	100 Year	88.78	88.28	-0.5
Regal Road	Regional	88.02	88.02	0.00
	100 Year	87.74	87.66	-0.07
Spruce Avenue	Regional	85.08	84.75	-0.33
	100 Year	84.6	83.42	-1.18



Figure 5.2: Alternative 2, Regional Floodline



Figure 5.3: Alternative 2, 100-Year Floodline

5.1.3 Alternative 3 – Bridge Upgrades and Channel Deepening

This option involved the bridge upgrades (as per Alternative 2) combined with channel deepening for the section of Tuck Creek from approximately 170 m upstream of New Street to 85 m downstream of Regal Road. Channel deepening was represented in the hydraulic model using a rectangular channel cross-section with a lowered channel invert. The level to which the invert was lowered was determined by tying in the existing channel invert at approximately 270 m upstream of New Street and approximately 190 m downstream of Regal Road while maintaining a channel slope of approximately 1% in between. Table 5.3 summarizes the inverts of the deepened sections in the Alternative 3 hydraulic model.

Table 5.3: Channel Deepening Summary

River Station	Existing Channel Invert (m)	Proposed Channel Invert (m)	Vertical Channel Cut (m)
1401	88.22	87.31	-0.91
1241	85.95	84.52	-1.43
1229	85.41	84.46	-0.95
1216	New Street Crossing		
1203	85.21	84.32	-0.89
1196	85.67	84.29	-1.38
1194	85.61	84.27	-1.34
1145	85.02	84.02	-1
1042	84.15	83.49	-0.66
1037	84.2	83.46	-0.74
1028	Regal Road Crossing		
1019	83.7	83.37	-0.33
1015	83.79	83.35	-0.44
996	83.7	83.25	-0.45
974	83.25	83.13	-0.12
954	83.25	83.03	-0.22
934	83.37	82.93	-0.44

Model results for Alternative 3 (bridge upgrades and channel deepening) show a decrease in water surface elevation in the deepened sections of the channel. Table 5.4 and Table 5.5 summarize the changes in water surface elevation for the Regional and 100-year storm events respectively in the deepened channel. Complete model results are included in **Appendix B**.

Table 5.4: Change in Water Surface Elevations for Regional Storm in the Deepened Channel for Alternative 3

River Station	Existing Condition (m)	Alternative 3 (m)	WSL Change (m)
1401	90.58	90.49	-0.09
1327	89.55	89.28	-0.27
1241	88.95	88.76	-0.19
1229	88.98	88.91	-0.07
1203	88.99	88.91	-0.08
1196	88.6	88.62	0.02
1194	88.63	88.65	0.02
1145	88.7	88.68	-0.02
1042	88.23	87.58	-0.65
1037	88.02	88.01	-0.01
1019	87.96	87.99	0.03
1015	87.78	87.76	-0.02
996	87.74	87.73	-0.01
974	87.51	87.51	0
954	87.43	87.41	-0.02
934	86.36	86.32	-0.04

Table 5.5: Change in Water Surface Elevation for 100-Year Event in the Deepened Channel for Alternative 3

River Station	Existing Condition (m)	Alternative 3 (m)	WSL Change (m)
1401	90.13	89.85	-0.28
1327	89	88.25	-0.75
1241	88.73	87.92	-0.81
1229	88.78	88	-0.78
1203	87.93	87.97	0.04
1196	87.94	87.77	-0.17
1194	88.01	87.81	-0.20
1145	87.99	87.78	-0.21
1042	87.62	87.46	-0.16
1037	87.74	87.56	-0.18
1019	87.47	87.46	-0.01
1015	87.46	87.17	-0.29
996	86.5	86.63	0.13
974	86.72	86.66	-0.06
954	86.06	85.99	-0.07
934	85.72	85.7	-0.02

Slight increases in water surface elevation occur for 2 sections (RS 1203 and 996) during the 100-year storm. These sections are immediately downstream of bridge crossings. At RS 1203, this change is less than 10 cm and is within the accuracy of the hydraulic model. At RS 996, although the elevation immediately downstream of the bridge has increased, it is lower than the existing conditions water surface elevation at the next river station downstream, RS 974.

Alternative 3 floodlines for the Regional and 100-year storm are illustrated below in Figure 5.4 and Figure 5.5 respectively. The implementation of Alternative 3 results in 83+ buildings in the Regional floodplain (19% reduction) and 25+ buildings in the 100-year floodplain (56% reduction).



Figure 5.4: Alternative 3, Regional Floodline



Figure 5.5: Alternative 3, 100-Year Floodline

5.1.4 Alternative 4 – Bridge Upgrades and Channel Widening

This alternative involves a combination of the bridge upgrades specified in Alternative 2 and channel widening for the section of Tuck Creek from approximately 170 m upstream of New Street to 100 m downstream of Spruce Avenue. Proposed channel width was determined by the following rules:

- Maintain an offset of approximately 2 m from adjacent property boundaries in areas with constrained creek corridor width,
- Widen channel to match bridge crossing spans, and
- Widen channel through the open space between Regal Road and Spruce Avenue to approximately 11 m.
    - Note that within the area adjacent to butternut B1, channel widening should occur on the east bank of the creek, while 5 m bank reconstruction should occur in areas near the tree. In this way, there will be a net benefit to the butternut.

Minor invert adjustments were also made to create a smooth transition in channel slope. Table 5.6 summarizes the proposed channel widening.

Table 5.6: Proposed Channel Widening

River Station	Existing width (m)	Proposed width (m)	Invert Adjustment (m)
1401	6	21	n/a
1327	5	21	n/a
1241	8	21	n/a
1229	6	21	n/a
1203	4	21	n/a
1196	5	21	n/a
1194	7	21	n/a
1145	7	10	n/a
1042	4	11	n/a
1037	5	11	n/a
1019	5	11	n/a
1015	7	11	n/a
996	5	11	n/a
974	4	11	n/a
954	6	11	n/a
934	10	11	-0.37
854	8	11	n/a
731	9	10	n/a
614	6	18	n/a
607	3	18	n/a
576	6	6	-0.2
511	6	6	-0.33

The hydraulic model results show an overall decrease in water surface elevation upstream of Spruce Avenue in the study area for the Regional and 100-year storms and no change in water surface elevation downstream of Spruce Avenue. The only exception of this is at the cross-section immediately downstream of Spruce Avenue, where rapid channel geometry change in the downstream channel causes an increase in water surface elevation for the 2- to 100-year storm events. However, this increase is considered negligible as the overall flooding condition at this crossing is improved as a result of implementing Alternative 4. Under existing conditions, Spruce Avenue overtops during the 25-year event while under Alternative 4, the crossing is only be overtopped by the Regional storm event. Additionally, immediately downstream of Spruce Avenue, the floodlines are contained within the creek corridor and no buildings are flooded under either existing conditions or alternative 4 conditions. Complete model results for Alternative 4 are included in **Appendix B**.

Floodlines for the Regional and 100-year storms are illustrated below in Figure 5.6 and Figure 5.7 respectively. The implementation of Alternative 4 results in 63+ buildings in the Regional floodplain (38% reduction) and 3 buildings in the 100-year floodplain (95% reduction).



Figure 5.6: Alternative 4, Regional Floodline



Figure 5.7: Alternative 4, 100-Year Floodline

5.1.5 Alternative 5 – Bridge Upgrades and Channel Deepening and Widening

Alternative 5 combined bridge upgrades (Alternative 2) with channel deepening (Alternative 3) and channel widening (Alternative 4). The hydraulic model from Alternative 4 was used as a starting point and channel inverts were lowered to match those from Alternative 3. Complete model results are included in **Appendix B**. Model result indicates the effect of Alternative 5 is similar to that of Alternative 4 in which the overall water surface elevation decreases upstream of Spruce Avenue and no change occurs downstream of Spruce Avenue. Figure 5.8 and Figure 5.9 illustrate the Regional and 100-year floodlines respectively. The implementation of Alternative 5 results in 43 buildings in the Regional floodplain (58% reduction) and no buildings in the 100-year floodplain (100% reduction).



Figure 5.8: Alternative 5, Regional Floodline



Figure 5.9: Alternative 5, 100-Year Floodline

5.1.6 Investigation of Low Impact Development Opportunities

An investigation of the impact of implementing Low Impact Development (LID) measures within the Tuck Creek watershed was undertaken using the SWMHYMO hydrologic model. Existing conditions were compared to four (4) scenarios for LID measures:

1) 5 mm of initial abstractions for LID over the entire Tuck Creek watershed,
2) 10 mm of initial abstractions for LID over the entire Tuck Creek watershed,
3) 5 mm of initial abstractions for LID over the study area, and
4) 10 mm of initial abstractions for LID over the study area.

Based on the catchments in the existing model, the study area for the hydrologic model extended from New Street to Lake Ontario. As this was a high level assessment of the impact of LID on flows within the watershed, the initial abstractions for LID were applied uniformly to the catchments.

Results from the modeling are summarized in Table 5.7 and Table 5.8 below for LID applied to the entire watershed and the study area respectively. A comparison of existing flows to those with LID measures is presented in Figure 5.10 for the flow at New Street and Figure 5.11 for the flow at Lake Ontario.

As seen in the tables and figures, application of LID measures to the entire watershed results in a notable decrease in flows for the 50- and 100-year storms. However, application of LID measures only to the catchment between New Street and Lake Ontario does not result in an appreciable decrease in flows. As such, the immediate benefit of implementing LID measures within the study area would not be appreciable in terms of a reduction in flooding. However, working to implement LID measures throughout the watershed over the long term could provide a sizeable decrease in storm flows for the 50- and 100-year events.

Table 5.7: Summary of Flows for LID Measures Applied to Entire Tuck Creek Watershed

Location	Area	100-Year Storm			50-Year Storm		
		Existing	5mm LID	10mm LID	Existing	5mm LID	10mm LID
West Branch @ Headon Forest Dr.	187.4	17.7	15.6	13.0	15.4	13.1	10.8
East Branch @ Headon Forest Dr.	205.5	13.8	11.4	9.1	11.7	9.4	7.3
Confluence of East and West Branches	494.9	39.6	33.7	27.9	34.0	28.5	22.8
Upper Middle Rd	592.8	39.1	33.7	28.5	33.5	28.6	24.3
South of Upper Middle Rd	604.8	39.5	34.3	29.1	34.1	29.2	24.9
Palmer Rd	670.8	41.4	36.3	31.1	36.2	31.4	26.8
QEW	733.4	44.4	39.2	34.0	39.5	34.9	30.0
CNR Oakville	843.3	50.5	45.7	39.9	46.1	41.6	35.9
New St.	993.4	61.3	55.4	47.9	54.7	49.1	42.1
Lake Ontario	1057.9	64.3	58.1	50.3	57.1	51.1	43.8

Outfall							

Table 5.8: Summary of Flows for LID Measures Applied only to Study Area

Location	Area	100-Year Storm			50-Year Storm		
		Existing	5mm LID	10mm LID	Existing	5mm LID	10mm LID
Lake Ontario Outfall	1057.9	64.3	64.0	63.6	57.1	56.8	56.4

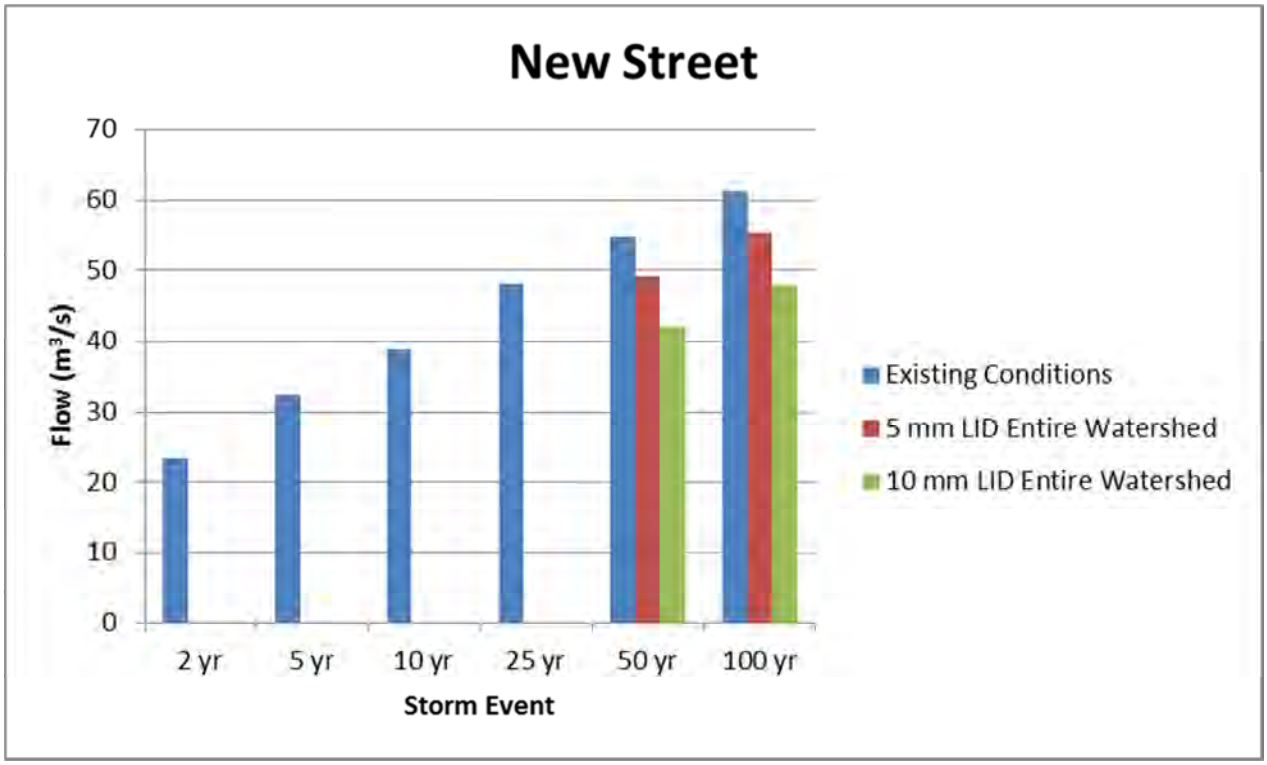


Figure 5.10: Comparison of Modeled Flows for Tuck Creek at New Street

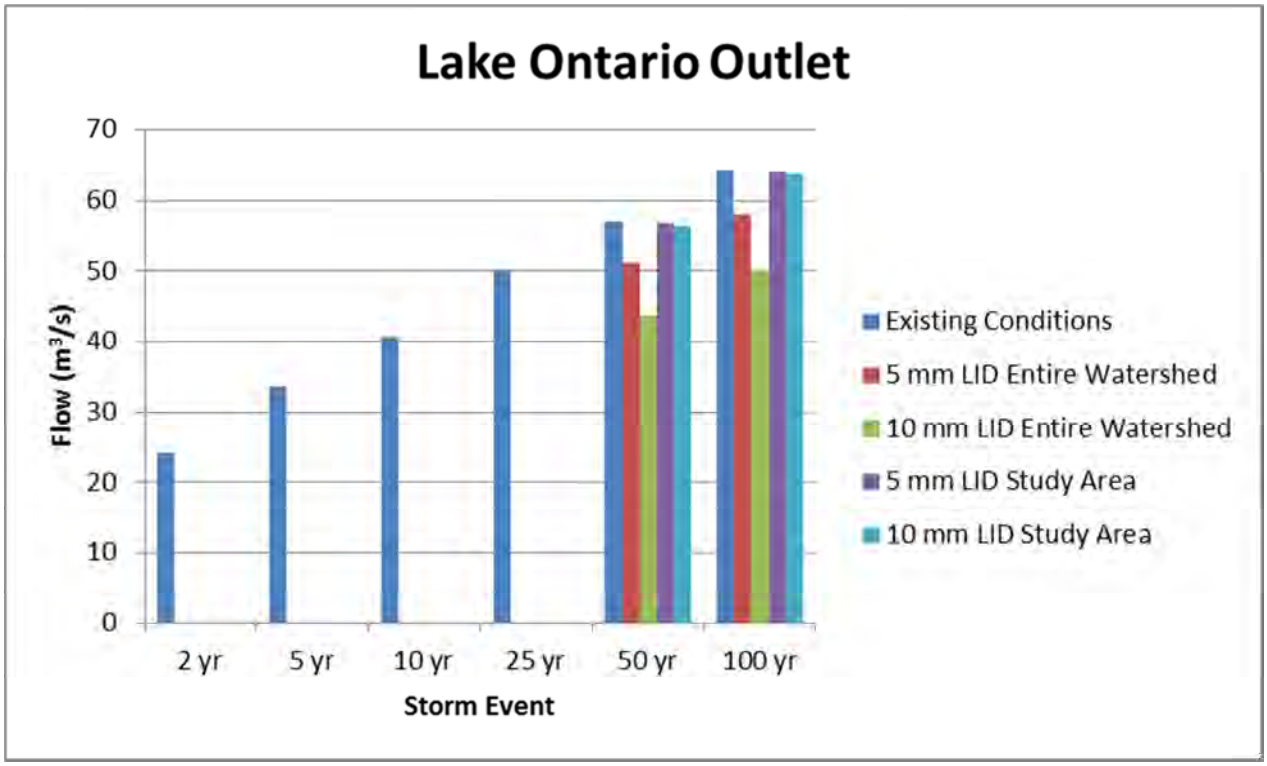


Figure 5.11: Comparison of Modeled Flows for Tuck Creek at Lake Ontario

5.1.7 Summary of Impacts of Alternatives on Flooding

Table 5.9 provides a summary of the number of buildings in the floodplain for the Regional and the 100-year storms for each of the alternatives. Numbers followed by a "+" indicate that there is at least one spill so the exact number of buildings affected cannot be determined.

Table 5.9:Summary of Flood Reduction by Alternative

Alternative	Regional Storm		100-Year Storm	
	Buildings within Floodplain	Percent Reduction	Buildings within Floodplain	Percent Reduction
1	102+	-	57+	-
2	95+	7%	48+	16%
3	83+	19%	25+	56%
4	63+	38%	3	95%
5	43+	58%	0	100%

5.1.8 Summary of Impacts of Alternative on the RNHS

As detailed in Section 4.1.8, the components of the RNHS within the study area include the habitat of Endangered species, significant woodlands, fish habitat, and the Tuck Creek corridor (a minor linkage). The potential impacts to the ecological form and function of these components under each of the five alternatives are summarized in Table 5.10. As flooding reduction is largely confined to residential areas, many of the ongoing potential impacts to the RNHS as a result of flooding (i.e. Alternative 1 – do nothing) apply to the other alternatives.

The RNHS and areas of proposed impact are illustrated in Figure 5.12, below.

Table 5.10: Summary of Potential Impacts to the RNHS by Alternative

Alternative	Regional Natural Heritage System			
	Endangered Species Habitat	**Significant Woodlands**	**Fish Habitat**	**Linkage**
1	• Ongoing bank erosion will reduce area of butternut habitat, and butternut B1 will likely fall into the creek. Butternuts B2-B7 will likely not be directly affected. • Ongoing flooding may impact butternut seedling survival. • Ash tree canopy loss may increase available light penetration, which may improve butternut health. However, this benefit may be negated by an increase in competition with invasive species.	• Ongoing flooding and ash tree loss may impact significant woodlands, including the composition of ground flora. Flooding disturbance and tree canopy loss may result in the reduction of native woodland ground flora and the creation of conditions suitable for the spread of invasive species such as Garlic Mustard and European Buckthorn, which in turn will impact the ecological function of the woodland over the long term. Flooding may also reduce the extent of conditions suitable for native woody plant regeneration. • Flood events in residential areas could increase material available for deposition in woodlands.	• Ongoing erosion could negatively impact fish habitat by reducing water quality. • Extant rip-rap in channel does not contribute to fish habitat.	• Flood events in residential areas could increase material available for the creation of debris jams which may disrupt fish passage.
2	• Impacts as above (Alt. 1). • No direct negative impacts to butternut or their habitat as a result of bridge upgrades.	• Impacts as above (Alt. 1). • Localized short-term impacts to vegetation near Spruce Avenue and New Street bridges. The total area of vegetation removals within significant woodlands is approximately 0.2 ha.	• Impacts as above (Alt. 1). • Localized temporary impacts to the creek and fish passage during bridge construction.	• Impacts as above (Alt. 1). • Temporary disruption of fish passage during bridge construction.
3	• No direct negative impacts to butternut or their habitat as a result of channel deepening or bridge upgrades.	• Impacts as in Alt. 1. • Localized short-term impacts to vegetation near Spruce Avenue and New Street bridges and along channel corridor for channel deepening works. The total area of vegetation removals within significant woodlands is approximately 0.7 ha.	• Widespread disruption of fish passage and 800 m of fish habitat during construction. • Increasing creek entrenchment will degrade fish habitat. • Removal of rip-rap will affect fish habitat positively. • Localized temporary impacts to the creek and fish passage during bridge construction.	• Impacts as above (Alt. 1). • Temporary disruption of fish passage during channel deepening and bridge construction.

Alternative	Regional Natural Heritage System			
	Endangered Species Habitat	**Significant Woodlands**	**Fish Habitat**	**Linkage**
4	• No direct negative impacts to butternut or their habitat as a result of bridge upgrades. • Channel widening could impact butternut B1 if mitigation measures are not employed. If mitigation measures are employed (i.e. widening of bank opposite tree B1 and bank reconstruction near tree B1), then the net impact would be positive. • Channel widening occurs within butternut habitat (trees B1-B3).	• Localized short-term impacts to vegetation near Spruce Avenue and New Street bridges, and trees within areas identified for creek widening. The total area of vegetation removals within significant woodlands is approximately 1.4 ha. • Reduction of flood impacts (see Alt. 1) on significant woodlands. • Opportunity for tree planting within woodlands to offset losses resulting from EAB and channel widening.	• Localized temporary impacts to the creek and fish passage during bridge construction. • Temporary, widespread impacts to fish habitat and potential spawning in areas of channel widening. • Removal of rip-rap will affect fish habitat positively. • Opportunity to create low-flow channel to promote fish passage • Short to medium-term impacts to habitat structure and function (e.g. undercut banks, overhanging vegetation).	• Temporary disruption of fish passage during channel widening and bridge construction. • Temporary disruption of terrestrial wildlife linkage function(s) during construction. • Localized, short-term disruption of terrestrial wildlife use of corridor in areas subject to vegetation removals. • A total of about 1.4 ha of tree removals will impact linkage function of the riparian corridor.
5	• Impacts as above (Alt. 4).	• Impacts as above (Alt. 4).	• Impacts as above (Alt. 4). • Widespread disruption of fish passage and 800 m of fish habitat during construction. • Increasing creek entrenchment will degrade fish habitat in the immediate and long-term.	• Temporary disruption of fish passage during channel deepening, channel widening, and bridge construction. • Localized, short-term disruption of terrestrial wildlife use of corridor in areas subject to vegetation removals. • A total of about 1.4 ha of tree removals will impact linkage function of the riparian corridor.

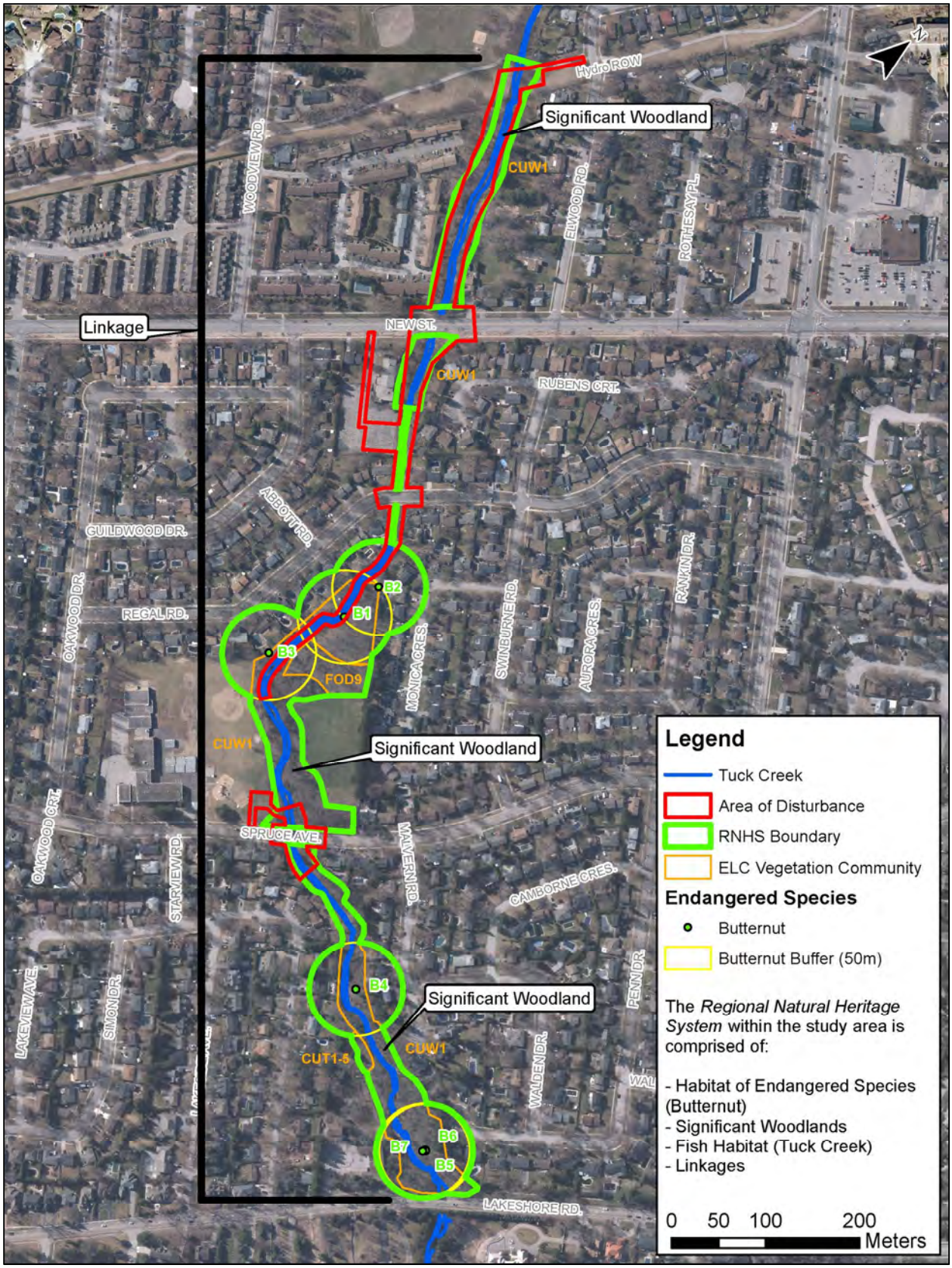


Figure 5.12: Regional Natural Heritage System and Proposed Areas of Disturbance

5.2 Evaluation Criteria

As part of the Municipal Class Environmental Assessment process, each alternative must be evaluated based on a set of Physical/Natural Environment, Social/Cultural, and Economic Criteria. An additional category, Technical/Engineering Considerations, was also included. The set of criteria was developed by Aquafor Beech and reviewed by the City. The list of criteria and the associated scoring is presented in Table 5.11.

Table 5.11: Evaluation Criteria

Category	Criteria	Evaluation
Natural Environment	Terrestrial	1 = worst impact 5 = most benefit
	Aquatic	1 = worst impact 5 = most benefit
Economic	Capital/Construction	1 = most expensive 5 = least expensive
	Operation & Maintenance	1 = most expensive 5 = least expensive
	Flood Damages	1 = most expensive 5 = least expensive
Social/Cultural	Effect on Flooding	1 = least reduction 5 = greatest reduction
	Aesthetics	1 = least visually pleasing 5 = most visually pleasing
	Community Disruption	1 = maximum disruption 5 = minimum disruption
Technical	Feasibility	1 = least technically feasible to implement 5 = most technically feasible to implement
	Implementation Time	1 = greatest time required 5 = least time required
	Permitting	1 = Regulatory agencies would not support the alternative 5 = Regulatory agencies would support the alternative

5.3 Evaluation of Alternatives

For each alternative, the evaluation criteria were considered. A description of the relative ranking of each alternative is provided in Table 5.12. Subsequently, numeric values were assigned to each criterion for each alternative. As outlined in Table 5.11, a score of 1 implies a neutral/negative effect on the outcome. Scores of 2 or 5 relate to varying degrees of positive effect that an alternative, for the defined criterion, would have on the outcome. The sum of the criterion scores was determined for each alternative and the alternative with the highest score was deemed to be preferred. A summary of the alternative scores is presented in Table 5.13. As

seen in the table, Alternative 4 ranked highest and was identified as the preliminary preferred alternative.

Table 5.12: Description of Alternatives Evaluation

Evaluation Criteria	Alternative 1: Do Nothing	Alternative 2: Bridge Upgrades	Alternative 3: Bridge Upgrades and Channel Deepening	Alternative 4: Bridge Upgrades and Channel Widening	Alternative 5: Bridge Upgrades and Channel Deepening and Widening
Natural Environment • Terrestrial Habitat • Aquatic Habitat • (Collectively, the RNHS)	• Ongoing erosion will impact Endangered species (butternut B1), their habitat (butternuts B1-B3), and seedling survival. • Continued loss of trees through bank erosion and Emerald Ash Borer • Possible invasion of invasive species following decline of woodland canopy will impact ecological structure and function of significant woodlands • Canopy losses could impact local wildlife habitat and linkage function of riparian corridor • Ongoing erosion negatively affects fish habitat • Increased potential for debris jams/disruption of fish passage • Rip rap remains in fish habitat • Opportunity to leave mature ash trees as snags for wildlife	• Ongoing erosion will impact Endangered species (butternut B1), their habitat (butternuts B1-B3), and seedling survival. • Continued loss of trees through bank erosion and Emerald Ash Borer • Possible invasion of invasive species following decline of woodland canopy will impact ecological structure and function of significant woodlands • Canopy losses could impact local wildlife habitat and linkage function of riparian corridor • Acute and temporary loss of trees and significant woodlands at bridge work sites (approximately 0.2 ha) • Ongoing erosion negatively affects fish habitat • Increased potential for debris jams/disruption of fish passage • Rip rap remaining in fish habitat • Compensation with native tree plantings • Opportunity to leave mature ash trees as snags for wildlife	• Short-term localized loss of trees and significant woodlands at bridge work sites and along channel for widening works (approximately 0.7 ha) • No likely direct or indirect impacts to butternut or their habitat • Increasing creek entrenchment will degrade fish habitat • Increased potential for debris jams/disruption of fish passage • Likely impacts to creek and fish passage during channel deepening. Localized temporary impacts to fish passage during bridge reconstruction. • Compensation with native tree plantings to offset losses from EAB and proposed construction • Opportunity to leave mature ash trees as snags for wildlife	• Short-term localized loss of trees and significant woodlands at bridge work sites (approximately 0.2 ha) • Removal of significant woodland north of New Street and downstream of Regal Road; localized vegetation removals in significant woodland north of Spruce Ave. (approximately 1.2 ha) • Canopy losses will likely impact wildlife habitat and corridor/linkage function • Possible invasion of invasive species following decline/removal of woodland • Temporary disruption of fish passage during construction • Temporary impacts to fish habitat and potential spawning during channel widening • Short to medium-term impacts to fish habitat structure and function • Channel widening occurs within butternut habitat (trees B1-B3) • Channel widening could impact butternut B1 if mitigation measures are not employed. If mitigation measures are employed, there will be a net benefit for this tree. • Compensation with native tree plantings to mitigate existing and construction-related impacts • Opportunity to replace ash trees succumbing to the Emerald Ash Borer • Opportunity to leave mature ash trees as snags for wildlife • Opportunity for invasive species management activities • Opportunity for low flow channel to promote fish passage	• Greatest impact to natural environment overall • Short-term localized loss of trees and significant woodlands at bridge work sites (approximately 0.2 ha) • Removal of significant woodland north of New Street and downstream of Regal Road; localized vegetation removals in significant woodland north of Spruce Ave. (approximately 1.2 ha) • Canopy losses will likely impact wildlife habitat and corridor/linkage function • Possible invasion of invasive species following decline/removal of woodland canopy • Temporary disruption of fish passage during construction • Temporary impacts to fish habitat and potential spawning during channel widening • Increased creek entrenchment will degrade fish habitat • Long-term impacts to fish habitat structure and function • Channel widening occurs within butternut habitat (trees B1-B3) • Channel widening could impact butternut B1 if mitigation measures are not employed. If mitigation measures are employed, there will be a net benefit for this tree. • Compensation with native tree plantings to mitigate existing and construction-related impacts • Opportunity to replace ash trees succumbing to the Emerald Ash Borer • Opportunity to leave mature ash trees as snags for wildlife • Opportunity for invasive species management activities • Opportunity for low flow channel to promote fish passage

Evaluation Criteria	Alternative 1: Do Nothing	Alternative 2: Bridge Upgrades	Alternative 3: Bridge Upgrades and Channel Deepening	Alternative 4: Bridge Upgrades and Channel Widening	Alternative 5: Bridge Upgrades and Channel Deepening and Widening
Economic • Construction Costs • Operation & Maintenance (O&M) Costs • Flood damage	• No construction cost • Highest O&M costs • Highest potential flood damages costs	• Lowest construction costs • Mid-range O&M costs • Higher-end potential flood damages costs	• Higher-end construction costs • Mid-range O&M costs • Higher-end potential flood damages costs	• Higher-end construction costs • Mid-range O&M costs • Lower-end potential flood damages costs	• Highest construction costs • Highest O&M costs • Lowest potential for flood damages costs
Social/Cultural • Effect on Flooding • Aesthetics • Community Disruption	• No reduction in flooding • Mature trees maintained unless at risk from erosion or Emerald Ash Borer • Disruption during O&M activities	• Least potential reduction in flooding • Mature trees maintained in creek corridor unless at risk from erosion or Emerald Ash Borer • Disruption during bridge replacements and any erosion protection works	• Low potential reduction in flooding • Some loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor	• High potential reduction in flooding • Loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor	• Highest potential reduction in flooding • Loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor
Technical • Feasibility • Implementation Time • Permitting	• Low feasibility as it does not address flooding • No time required to implement • No agency permitting would be required	• High feasibility since works would be within City-owned lands • Bridges can be upgraded one at a time • Regulatory agencies would be supportive of this option	• Low feasibility as further incising channel can lead to erosion issues • Works can be implemented in phases • Regulatory agencies would not be supportive of this option due to the lowering and incising of the channel	• Higher feasibility since works would be within City-owned lands • Works can be implemented in phases • Regulatory agencies would be supportive of this option provided a low-flow channel is created with vegetation above the top of bank	• Low feasibility as further incising channel can lead to erosion issues • Works can be implemented in phases • Regulatory agencies would not be supportive of this option due to the lowering and incising of the channel

Table 5.13: Evaluation of Alternatives

Evaluation Categories	Evaluation Criteria	Alternative 1: Do Nothing	Alternative 2: Bridge Upgrades	Alternative 3: Bridge Upgrades and Channel Deepening	Alternative 4: Bridge Upgrades and Channel Widening	Alternative 5: Bridge Upgrades and Channel Deepening and Widening
Natural Environment	Terrestrial	5	4	3	2	1
	Aquatic	2	2	1	4	1
Economic	Construction	5	4	2	3	1
	O&M	1	3	4	4	4
	Flood Damages	1	2	3	4	5
Social/Cultural	Effect on Flooding	1	2	3	4	5
	Aesthetics	3	3	1	4	1
	Community Disruption	5	4	3	3	3
Technical	Feasibility	1	5	1	4	1
	Implementation Time	5	4	3	3	3
Preliminary Overall Ranking		**29**	**33**	**24**	**35**	**25**

5.4 Public Consultation

A Public Information Centre (PIC) was held on Monday November 30, 2015 at City Hall (426 Brant Street). A series of posters was presented which outlined the following items:

- Background information on the August 4, 2014 storm,
- Problems and opportunities in the study area,
- The existing conditions in the study area,
- Possible remedial alternatives,
- Land acquisition,
- Preliminary alternatives evaluation, and
- Additional, non-traditional alternatives for storm runoff reduction.

The posters from the PIC are included in **Appendix G**.

The PIC was attended by 20+ people. Workbooks were provided to all attendees to solicit public input on the project. Seven (7) completed workbooks were received at the end of the PIC. Copies of these workbooks are included in **Appendix G**.

In general, attendees were in support of the preliminary preferred alternative: bridge upgrades and channel widening. There were some concerns raised about loss of mature trees and reduction of the "natural" character of the creek. However, the majority of attendees were concerned about the possible recurrence of flooding and the preliminary preferred alternative was generally seen to be the most feasible solution for providing flood reduction.

5.5 Selection of Preferred Alternative

Based on the results of the alternatives evaluation and the consultation with the City, CH, and the public, Alternative 4 (bridge upgrades and channel widening) was selected as the preferred alternative. This alternative provides a reduction of building flooding of 95% for the 100-year storm and 38% for the Regional storm. It includes upgrades to widen the road crossings at New Street, Regal Road, and Spruce Avenue along with creek width increases from the Hydro ROW to Spruce Avenue.

While increases to channel width will result in the loss of mature trees along the creek banks, it is the opinion of Aquafor Beech Limited that diverse native tree plantings and possibly an invasive species management plan completed as part of the proposed works will aid in mitigating tree cover losses resulting from Emerald Ash Borer infestations, increase local biodiversity, and provide habitat for wildlife. As well, the widening of the channel provides an opportunity at the detailed design stage for the definition of a low-flow channel connected to a terrace/floodplain. This design can provide erosion and ecological benefits by allowing high flows to spill out of the channel and be conveyed within the floodplain.

5.6 Additional Measures to Address Erosion and Flooding within the Watershed

In addition to implementing the preferred alternative described above, there are LID measures that can be undertaken by residents within the Tuck Creek Watershed or by the City within the municipal road right of way to help reduce the source of erosion and flooding problems in the creek: increased runoff from development within the watershed. Development within a watershed increases the percentage of impervious surface and thus increases the runoff to

receiving waters. The result is higher, flashier flows within the watercourse which can lead to erosion and flooding issues.

Stormwater management practices are used to control the release of runoff by holding back water from urban areas thereby reducing peak flows within watercourses. Source controls are physical measures that encourage infiltration of water into the ground thereby reducing stormwater runoff. Source control measures can be implemented by private landowners on a lot-by-lot basis or by the City in municipally-owned road right of ways. Measures include the following:

- Rainwater harvesting,
- Downspout disconnection,
- Soakaway pits,
- Bioretention,
- Compost amendments,
- Tree clusters,
- Filter strips, and
- Permeable pavement.

As noted in Section 5.1.6, implementation of these LID measures would need to be undertaken on a watershed scale to result in a notable decrease in flows for the 50- and 100-year storms. However, implementation of LID measures as the opportunity arises in the Tuck Creek watershed will help to incrementally reduce flows in Tuck Creek. In combination, source control measures will act together to mitigate downstream erosion and flooding. Ongoing landowner education regarding source control will make residents aware of the measures they can undertake to help reduce stormwater runoff from their property. A description of each source control measure is provided in the following subsections. Examples of source controls are shown in Figure 5.13 while the application of these LID measures is summarized in Table 5.14.

5.6.1 Rainwater Harvesting

Rainwater harvesting is the practice of intercepting, diverting and storing rainfall for future use. The rain that falls upon a catchment surface, such as a rooftop, is collected and conveyed into an above or below-ground storage tank. On a small scale, the storage tank is a rain barrel which holds water for future non-potable use such as plant watering. On a larger scale, the storage tank may be connected to a non-potable water system within the house which supplies water for uses such as toilets or for irrigation applications such as underground sprinkler systems for landscaped elements. This capture and re-use of rainwater can, in turn, significantly reduce stormwater runoff volumes and pollutant loads.

Harvested rainwater that is used for watering landscaping meets the objectives of the water balance requirement, as these flows are infiltrated or evapotranspired after storage. On a larger scale, the reduced demand on the water resources (such as groundwater aquifers and reservoirs) from which municipal water supplies are drawn will add to the water balance benefits of rainwater harvesting

5.6.2 Downspout Disconnection

Simple downspout disconnection involves directing flow from downspouts to a pervious area. This prevents stormwater from directly entering the drainage system or flowing across a "connected" impervious surface such as a parking lot. Downspout disconnections are typically used in combination with other LID source controls, but can be used as stand-alone techniques if appropriate quantities of pervious area are present.

Rooftop disconnection with treatment is possible on lots with any size and configuration; however functional downspout disconnection requires a minimum length of pervious flow path and appropriate soil conditions.

5.6.3 Soakaway Pits

Soakaway pits are typically stone-filled trenches that temporarily store water to be infiltrated. Manufactured underground infiltration galleries (or stone-less trenches) can also be included in the general category of soakaway pits.

Runoff is directed to the trench via a downspout or swale or other conveyance feature. French drains and dry wells are variations on the soakaway pit, with slightly different geometries. A French drain is a shallow underground trench with a perforated pipe running along the bottom whereas a dry well is deeper and shorter.

The degree to which the water balance requirements are met will depend on the quantity of runoff stored and percolated into the native soils. Runoff reduction capability of soakaway pits, is presumed to be high, given that infiltration is the designed intent of the practice; however, some surface overflows do occur when the infiltration storage capacity is exceeded. While soakaway pits are not specifically designed to store the channel protection volume, their ability to reduce runoff volumes should help protect downstream channels from erosion. Because the application is limited by building setbacks, soakaway pits are not a best management practice that can be used in very high density settings.

5.6.4 Bioretention

Bioretention (also known as 'rain gardens') captures, temporarily stores, and treats stormwater runoff by passing it through an engineered filter media. The primary component of a bioretention practice is the filter bed, composed of a mixture of sand, soil, and organic material as filtering media.

During storms, runoff temporarily ponds above the filter bed surface and then filters through the media. Bioretention can be applied in most soils or topography, since underdrains which collect and return filtered water to the surface system may be used when full infiltration into native soils is not feasible. If infiltration rates in native soils permit, filtration practices can be designed without an underdrain for full infiltration and water balance benefits. A combination of these methods can be used to infiltrate a portion of the filtered runoff. Pre-treatment, such as a settling forebay or grass filter strip, precedes the filter bed to remove particles that would otherwise clog the filter bed. Conveyance of excessive flows can be directed out or away from the bioretention facility by using a flow-splitter to capture a limited discharge or an overflow

structure with its invert set at the maximum ponding depth. Snow storage can be provided by bioretention, especially those located adjacent to parking lots and roadways. To function as snow storage, bioretention must include an overflow for snow melt in excess of the designed ponding depth. Additionally, the plant material must be salt-tolerant, perennial, and tolerant of periodic inundation. Bioretention also has the benefit of improving site aesthetics.

Bioretention is best suited to meet water quality objectives but can also be used to meet water balance objectives by reducing runoff volume through evapotranspiration and infiltration of runoff. Bioretention and other filtration and infiltration practices benefit aquatic life by reducing the heat effect from urban runoff. In contrast to ponds, bioretention facilities do not raise water temperature.

5.6.5 Soil Compost Amendments

Compost amendments are tilled into existing soils thereby enhancing or restoring soil properties by reversing the loss of organic matter and compaction. They also are used to make Hydrologic Group C and D soils suitable for on-site stormwater BMPs such as downspout disconnection, filter strips, and grass channels. Soil amendments benefits include increased infiltration, stormwater storage in the soil matrix, survival rate of new plantings, root growth and stabilization against erosion, improved overall plant health, and decreased need for irrigation and fertilization of landscaping. Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process. The area or strip of amended soils should be hydraulically connected to the stormwater conveyance system.

While soil amendments will never be used solely to meet stormwater management objectives, they are effective in reducing the overall runoff volume, will contribute to a lower peak discharge, and can help reduce the size of total runoff storage needed.

5.6.6 Tree Clusters

New trees can be planted in pervious areas of existing residential neighbourhoods. Tree clusters function similarly to forested areas by intercepting rainfall and allowing the processes of evapotranspiration (ET) and infiltration to reduce stormwater runoff. Soils at tree cluster sites may need to be amended to achieve the desired benefits.

Tree clusters provide multiple benefits, including rainfall interception, runoff reductions through increases in evapotranspiration and infiltration, and sustaining of baseflows which cumulatively act to mitigate changes to the pre-development water balance while providing a landscaped aesthetic.

Tree planting enhance the appeal of a neighbourhood, increase land and building values, and can reduce construction costs and energy use. Trees also provide a wide range of environmental, economic and community benefits, such as air quality improvement and wildlife habitat.

5.6.7 Filter Strips

Filter strips (also known as vegetated filter strips and grassed filters) are vegetated areas that treat sheet flow from adjacent impervious areas. Filter strips slow runoff velocities and settle out

sediment and attached pollutants. Small berms provide some storage. In some soils, storage and infiltration occurs in the underlying soils. Originally used as an agricultural treatment practice, filter strips have evolved into an urban SWM practice. Filter strips contribute to a lower peak discharge by maintaining runoff in sheet flow, thereby resulting in a longer time of concentration.

Combining filter strips with other best management practices is highly recommended. They can also provide a convenient area for snow storage and treatment, and are particularly valuable due to their capacity for melt water infiltration. Because filter strip designs include few pipes or other structures, physical changes to the practice are not needed for wintertime operation.

5.6.8 Permeable Pavement

Permeable pavements, an alternative to traditional impervious pavement, can be used for low traffic surfaces such as driveways and paths. Permeable paving techniques include interlocking concrete block pavers (open joint and porous stone pavers), plastic lattice or grid systems (grass pavers), pervious concrete, and porous asphalt. Porous asphalt and pervious concrete are pavement mixes with washed aggregate to eliminate fines. With all permeable pavements, the resulting surface voids allow stormwater to filter through the pavement into an underlying stone reservoir. Water then infiltrates or enters an underdrain system.

Permeable paving allows for filtration, storage, or infiltration of runoff, which can reduce stormwater flows compared to traditional impervious paving surfaces like concrete and asphalt. Other benefits include reduce snow removal costs due to rapid ice melting and drainage, and reductions in urban heat island effect since pavers have less thermal conductivity and thermal capacity than traditional impervious pavement (Ferguson, 2005). These systems provide an aesthetic alternative to traditional paving and are typically applied to smaller drainage areas. In general, permeable pavement systems can be used anywhere a traditionally paved system might have been installed.



Rainwater Harvesting Systems



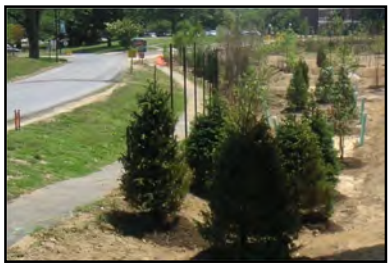
Downspout Disconnection



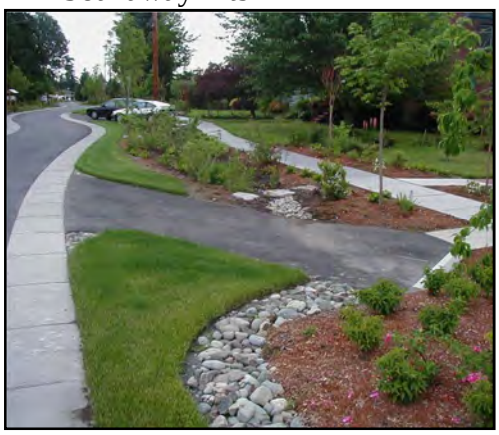
Soakaway Pits



Bioretention Cell



Tree Clusters



Filter Strip



Permeable Pavement

Figure 5.13: Source Control Measures

Table 5.14: Application of Source Control Measures

Source Control	Application
Rainwater harvesting	Private property
Downspout disconnection	Private property
Soakaway pits	Private property or road right of way
Bioretention	Private property or road right of way
Soil compost amendments	Private property or road right of way
Tree clusters	Private property or road right of way
Filter strips	Road right of way
Permeable pavement	Private property

6 CONCEPTUAL DESIGN

The conceptual design represents the identified preferred approach to flood reduction in the study area, including preliminary recommendations for crossing and channel design objectives and parameters. A framework for implementation at the subsequent detailed design stage is outlined in Section 1. The conceptual design is based on existing conditions (as documented in Section 4) and follows the evaluation of the flood reduction alternatives, selection of the preferred alternative, and consideration of design factors.

The preferred alternative (Alternative 4) consists of upgrades to bridges and channel widening. The following list provides a summary of the conceptual design parameters while the conceptual design is illustrated in Figure 6.1.

New Street – A crossing span of 21 m is proposed at this location. The existing creek block upstream of New Street has a width of approximately 25 m. On the downstream side, the creek block width is about 50 m. Thus, the upstream creek block provides the constraint on the crossing span. With a span of 21 m, an allowance of 2 m on either side of the creek upstream of New Street is provided to allow for bank treatments.

Subsequent to the EA process, the City of Burlington decided to explore the option of a narrower bridge span at New Street since the downstream corridor width was limited. As such, the HEC-RAS model for Alternative 4 was re-run with a 13 m span at New Street. Compared to the existing floodlines, the model results showed no increases to the floodlines for the Regional or 100-year events associated with a 13 m span at the New Street crossing.

The advantage of a narrow span at New Street would be a lower construction cost (discussed subsequently in Section 7.1). The disadvantage of a narrower span is that it reduces future flexibility if the opportunity arises to widen the creek corridor between New Street and Regal Road (e.g. through land acquisition).

Regal Road – A crossing span of 11 m is proposed at this location. The existing creek blocks upstream and downstream of Regal Road are approximately 15 m in width. As such, the 11 m span allows for 2 m on either side of the bridge for bank treatments upstream and downstream of the crossing.

Spruce Avenue – A crossing of 18 m is proposed at this location. The existing creek block downstream of Spruce Avenue is approximately 22 m in width while the upstream block is about 155 m in width. As such, the downstream block provides the constraint on the bridge width design. The span of 18 m allows for 2 m on either side of the creek downstream of the crossing for bank treatments.

Channel between 0+1150 and 0+1460 – This portion of the channel extends from downstream of New Street to the Hydro ROW. The proposed channel width through this section is 21 m. A low-flow channel will be required within this section to provide concentrated flows for aquatic habitat. The remainder of the lowered portion of the channel will provide conveyance of overbank flows and it is expected that vegetation will be established in this portion of the channel.

Channel between 0+750 and 0+1150 – This portion of the channel extends from downstream of Regal Road to downstream of New Street. The proposed channel width through this section is 11 m, corresponding with the proposed width of the Regal Road crossing. A low-flow channel will be required within this section to provide concentrated flows for aquatic habitat. The remainder of the lowered portion of the channel will provide conveyance of overbank flows and the opportunity to incorporate vegetation in this portion of the channel should be explored at the detailed design stage.

Channel between 0+520 and 0+600 – This portion of the channel requires minor modifications to provide tie-in for the works associated with the Spruce Avenue crossing replacement. The length of the treatments will be determined at the detailed design stage and will be dependent upon channel shear stresses and velocities and required bank grading.

The selection of specific channel objectives and parameters for the flood reduction works (e.g., bridge design, channel planform, riffle and pool locations, cross-sectional areas and geometries, substrate sizing, and vegetation restoration) are to be specified at the detail design stage. Additionally, Conservation Halton has noted the following permit requirements:

- Signed and sealed paper and digital floodplain mapping for the entire stretch of floodplain impacted by the works.
- The detailed design must be undertaken by a qualified professional with experience in natural channel design.
- The planting plan must be undertaken by a qualified professional with experience in designing planting plans for creek blocks.
- Fish passage over channel bed works must be considered in the detailed design with access provided for a range of flows from low-flow conditions to the 2-year event. The weakest swimmers of the target species must be accommodated. Target species are rainbow trout, brown trout, and white sucker.

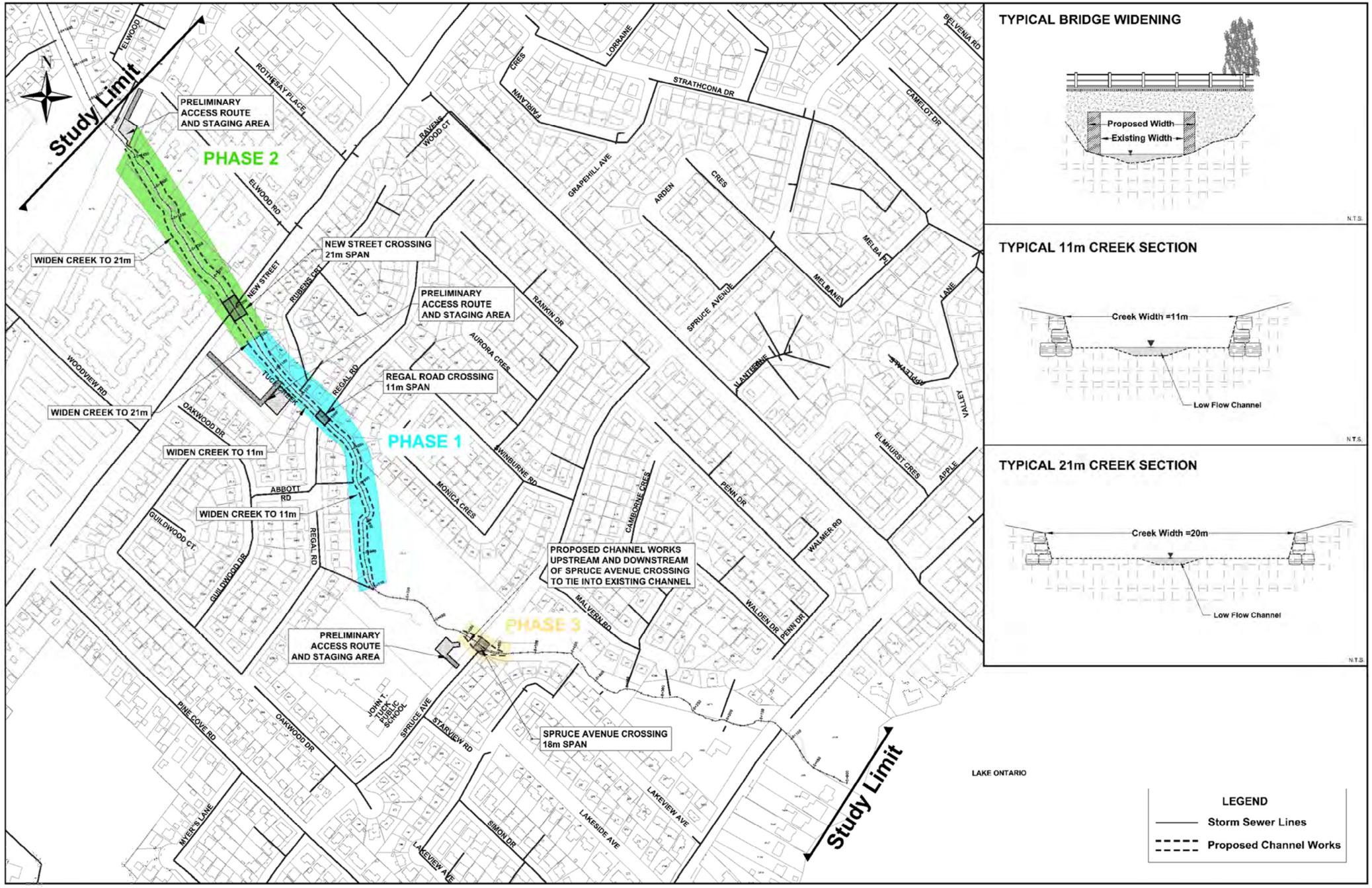


Figure 6.1: Conceptual Design for Preferred Flood Reduction Alternative

7 IMPLEMENTATION STRATEGY

Based on the conceptual design, costs estimates and an implementation plan were developed. These are detailed in the sections below along with requirements for the detailed design and construction phase.

7.1 Cost

Cost estimates were prepared for the conceptual design for the bridge replacements and the channel works. The costs for the bridge replacements were prepared by Planmac Engineering Inc. Table 7.1 summarizes the itemized costs for each structure. Miscellaneous items include water proofing. The estimated cost for both 21 m and 13 m span bridges at New Street is provided while the total costs for the replacement of the structures includes the 21 m span bridge and is about $6.1M.

Table 7.1: Cost Estimates for Bridge Replacements

Item	New Street (21 m span)	New Street (13 m span)	Regal Road	Spruce Avenue	Total
Engineering & Design	$40,000	$40,000	$40,000	$40,000	$120,000
Removal	$980,000	$980,000	$550,000	$570,000	$2,100,000
Concrete	$80,000	$70,000	$50,000	$50,000	$180,000
Rebar	$370,000	$340,000	$240,000	$250,000	$860,000
Steel Girders	$260,000	$130,000	$90,000	$140,000	$490,000
HP Piles	$340,000	$340,000	$240,000	$200,000	$780,000
Asphalt	$30,000	$30,000	$20,000	$20,000	$70,000
Miscellaneous Items	$350,000	$350,000	$200,000	$300,000	$850,000
15% Contingency	$360,000	$340,000	$210,000	$230,000	$800,000
Total Estimated Cost	**$2,810,000**	**$2,620,000**	**$1,640,000**	**$1,800,000**	**$6,250,000**

Estimates for channel works were based on the lengths of the works and the number of storm sewer outfall repairs or replacements. Costs used in the estimates are summarized in Table 7.2 and are based on average values from channel restoration projects previously completed by Aquafor. The channel restoration unit cost was derived from a mean of the total construction cost per metre for various municipal channel restoration projects. The unit cost includes mobilization and demobilization, channel works, and site restoration. A summary of channel restoration costs for each phase of the project is provided in Table 7.3.

Table 7.2: Costs Used for Channel Restoration Estimates

Item	Estimated Unit Cost
Channel Restoration	$3,000/m
Outfall Repair	$10,000/outfall
Outfall Replacement	$30,000/outfall

Table 7.3: Estimated Channel Restoration Costs

Item	Upstream and Downstream of New Street	Upstream and Downstream of Regal Road	Upstream and Downstream of Spruce Avenue
Engineering & Design	$70,000	$80,000	$20,000
Channel Restoration	$930,000	$1,200,000	$240,000
Outfall Repair	-	$20,000	-
Outfall Replacement	$30,000	$30,000	-
15% Contingency	$140,000	$190,000	$40,000
Total Cost	**$1,170,000**	**$1,520,000**	**$300,000**

The cost estimates for the bridge and channel upgrades for each phase of the project are summarized in the table below. The total cost for the works associated with flood reduction in the Tuck Creek study area is about $9.2M. Note that this cost includes a 21 m span bridge at New Street. The cost would be reduced by about $0.2M with a 13 m span bridge at New Street.

Table 7.4: Estimates Costs for each Phase of the Flood Reduction Works

Component	Bridge Works	Channel Works	Total
New Street & Associated Channel	$2.8M	$1.2M	$4.0M
Regal Road & Associated Channel	$1.6M	$1.5M	$3.1M
Spruce Avenue & Associated Channel	$1.8M	$0.3M	$2.1M
Total	**$6.2M**	**$3.0M**	**$9.2M**

7.2 Prioritization of Implementation

It is expected that the bridge and channel upgrades associated with the preferred alternative will be completed in stages as City funding becomes available. It is recommended that each bridge be completed along with the adjacent channel works. The existing Regal Road bridge provides the greatest constriction within the study area. As such, it is recommended that this crossing be completed first. The New Street crossing and upstream channel capacity provide the next greatest constraint within the study area. Thus, it is recommended that this crossing be completed next with the Spruce Avenue crossing upgrade completed last. The proposed implementation plan is outlined below while Figure 7.1 illustrates the extents of each phase.

1. **Phase 1: Chainage 0+750 m to 0+1150 m** – Replace the Regal Road crossing. Complete upstream and downstream channel works associated within widening the channel to 11 m. The downstream works should tie into the existing channel at 0+750 m m. The upstream channel works will require a temporary tie in to existing conditions downstream of the New Street crossing.

2. **Phase 2: Chainage 0+1150 to 0+1460** – Replace the New Street crossing. Complete upstream and downstream channel works associated with widening the channel to 21 m. The downstream works will tie into the channel upgrades completed in Phase 1. This tie-in will include a transition a 21 m cross-section to an 11m cross-section. The upstream

works will tie into the existing channel within the Hydro ROW, with transitions for both the low-flow channel and the floodplain.

3. **Phase 3: Chainage 0+520 m to 0+600 m** – Replace the Spruce Avenue crossing. Complete channel works upstream and downstream of the crossing, as required, to tie into the existing channel.

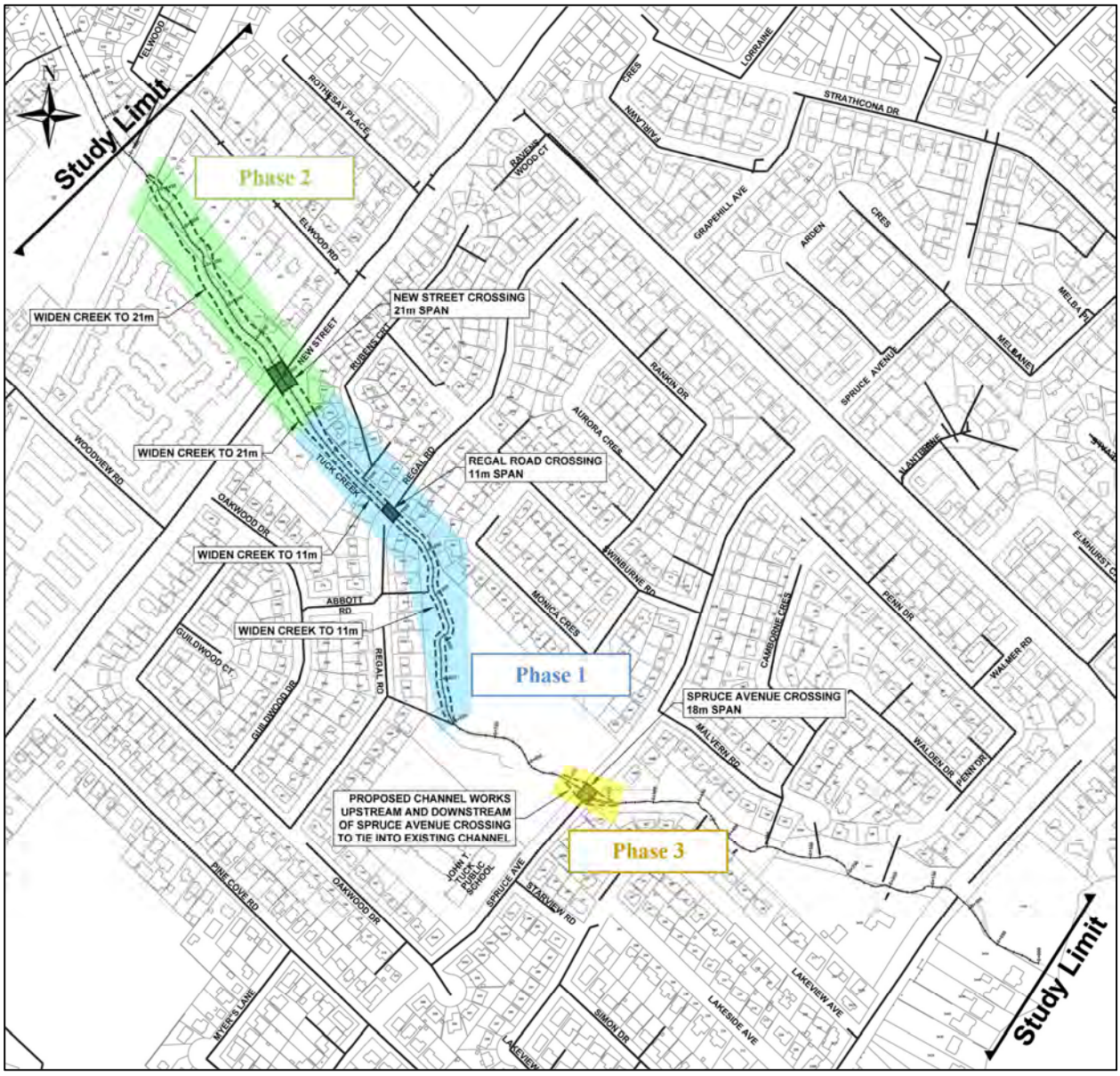


Figure 7.1: Phasing of Flood Reduction Works

7.3 Environmental Assessment Requirements

This study was undertaken as a Schedule B project under the Municipal Class Environmental Assessment process. Phases 1 and 2 of the planning and design process were addressed in this study. Implementation of the preferred alternative can proceed under Phase 5 of the Municipal

Class EA process. Note that the design in Phase 5 will replace previous erosion control design works between Regal Road and the hydro corridor.

7.4 Detailed Design Requirements

The current study provides a conceptual design for the preferred alternative to reduce flooding within the Tuck Creek study area. The next step in the process is to undertake detailed design for the preferred alternative. At the detailed design stage, the following items will need to be addressed.

Butternut Health Assessments – Butternut health assessments should be undertaken for any butternuts whose habitat will be impacted by flood reduction works. As noted in correspondence with MNRF (see copy of email in **Appendix D**), general habitat of the butternut is considered suitable areas within a 50-metre radius of the trunk of stem of the tree. The MNRF should be contacted at the detailed design stage to determine whether or not authorization for the works is required under the Endangered Species Act (ESA). As previously mentioned, butternut health assessments are scheduled for summer 2016. The results of the assessments will be available prior to detailed design.

Spring Flora Surveys – Several rare species of flora potentially present within the study area are best identified in the spring months (i.e. *Crataegus* spp., *Mertensia virginica*, and *Uvularia perfoliata*). As ecological inventories for this project were completed in the late summer, the aforementioned flora could not have been identified. As mentioned in **Section 4.1.2**, spring flora surveys conducted in May 2016 and details will be provided under separate cover.

Restoration Planting Plan – A vegetative restoration plan must be developed specifying native species to be used to restore channel banks, the floodplain, staging areas, and the access route. The plan must include compensation for trees removed for construction in accordance with Section 1.18 of the City of Burlington By-law 68-2013: "Where a Public Tree(s) is to be removed and where its removal is not required due to age, health or other reasons in accordance with sound arboriculture principles, the applicant shall plant Tree(s) with the total combined diameter being equal to or greater than that of the Tree(s) to be removed. Where the total combined diameter of the Tree(s) to be planted is less than the total combined diameter of the Tree(s) removed, Council approval will be required."

Invasive Species Management – Invasive species such as European buckthorn, Manitoba maple, periwinkle (*Vinca minor*), and garlic mustard (Figure 7.2) have been recorded within the Tuck Creek riparian corridor. There is concern that canopy losses due to ash decline and/or tree removals will result in the proliferation of these sun-loving invasive species. It is thus recommended that an invasive species management plan be developed at the detailed design stage. Considerations under the plan could include short, medium, and long-term solutions to invasive species management, including removals; replacement of woody and herbaceous invasive species with native species; opportunities for community involvement; and adaptive monitoring and management.



Figure 7.2 Garlic mustard in the woodland understory of Tuck Creek

Conservation Halton Permit – A permit for works on Tuck Creek will be required from Conservation Halton in accordance with Ontario Regulation 162/06. A design package will need to be submitted to Conservation Halton with updated floodplain mapping, the design drawings, a design brief, and hydraulic model files. Scheduling of the project should allow for review of the submission by CH and revisions to the design and resubmission following receipt of comments from CH.

DFO Request for Review - Once the detailed design has been prepared for the channel works, a request for review under the Fisheries Act should be submitted to DFO. Since channel work below the high water mark will be required, this project cannot be exempted from review based on the DFO's self-assessment process.

7.5 Implementation Measures

The following implementation measures must be considered at the detailed design and implementation stages.

Construction Staging, Erosion and Sediment Control Measures – Appropriate plans are to be included within the detailed design package, based on consultations with the City and Conservation Halton. The construction access route and staging areas are to be determined during the detailed design in consultation with the City and Conservation Halton. A restoration plan will be required to ensure that the access route and staging area are replanted and restored in accordance with Conservation Halton's requirements. Additionally, Conservation Halton has noted that Tuck Creek is a cold water fishery due to the presence of rainbow trout. As such, no in-water works will be permitted between March 15 and June 15.

Due to the presence of shale on the creek bed, consideration should be given to the equipment used in the creek. Rubber-tired equipment may be required or bed protection, such as matting; specifications will be determined during the detailed design stage. Any material placed in the creek as bed protection must be removed prior to the reinstatement of flows. Additional consideration during construction should be given to existing structures in the creek such as the bridges at Regal Road and New Street.

Tree Protection Fencing – Tree protection fencing following the specifications in Conservation Halton's Landscaping and Tree Protection Guidelines should be erected along all construction

access routes and work areas. Fencing should consist of posts or t-bars with filter cloth affixed to paige wire fencing. Tree protection fencing should be located at a minimum distance of 1m from the dripline of potentially affected trees. It is likely that, due to the woodland setting specific to this project, maintaining the minimum 1m distance will not be possible in some areas. In such case, fencing should be located as far as possible from the tree.

Butternut Protection Measures – Special considerations should be taken regarding butternut trees during any works in the vicinity of the trees. As noted in Section 7.4, an ESA permit may be required for works within butternut habitat. Any construction requirements from MNRF must be followed. Additionally, construction supervision by the stream restoration consultant or a qualified terrestrial ecologist is required during work near any butternut.

Channel works downstream of Regal Road are likely to extend into butternut habitat. Butternut B1 is located on the channel bank and has many exposed roots (see Figure 4.5). It is recommended that tree protection fencing within the creek bed be high enough to rise above the exposed butternut roots, and that a wood plank affixed to t-bar staked horizontally be used to ensure that accidental "bumping" by machinery will not move the tree protection fencing. Additionally, it is recommended that neon flagging tape or other highly visible material be affixed to the tree protection fencing to increase visibility and remind construction personnel of the importance of these trees.

Butternut B2 is located within the creek block/significant woodland adjacent to a residential fence. It is recommended that tree protection fencing be erected around this tree. Butternut B3 is located in the private backyard of a home (see Figure 4.5). The yard is surrounded by chain link fence and as such, Aquafor staff does not feel that any special provisions regarding tree protection for tree B3 is necessary.

Provision of Wildlife Habitat – As noted in Section 4.1.6, there are a number of ash trees within the study area that are visibly impacted by Emerald Ash Borer. It is recommended that alternatives to tree removals in areas outside of construction zones be considered. Accordingly, it is recommended that large trees, including but not necessarily limited to ash, that are dead or clearly dying and that will not likely become hazard trees (i.e., those outside of falling distance from private property and trails) be limbed and left standing in order to provide habitat for wildlife. Should large diameter trees (i.e. >50 cm DBH) require removal, it is recommended that large logs be left on the woodland floor for use by wildlife.

Environmental Approvals and Permitting – In addition to approvals by the City's works and parks departments and potential permits under the ESA, applications will be required for permits from Conservation Halton under Ontario Regulation 166/06 (Development, Interference with Wetlands and Alterations to Shorelines and Watercourses), as noted in Section 7.4. Approval from the MNRF is required for a fish collection permit (fish rescue).

As well, works must consider the Provincial Policy Statement regarding water (Policies 2.2.1 and 2.2.2) which states that "planning authorities shall protect, improve or restore the quality and quantity of water" and that "site alteration shall be restricted in or near sensitive surface water features and sensitive ground water features". To comply with the Provincial Policy Statement,

channel works should be completed in the dry to protect water quality, and downstream base flows should be provided during construction to protect water quantity. It should also be noted that no sensitive surface water or groundwater features were identified during the field assessments.

Tendering, Construction Administration, and Supervision – The stream restoration consultant may be retained to provide all of these services. However, as a minimum, the stream restoration consultant should provide input to the tender document, specifically the special provisions, and should provide at least part-time construction supervision. Full-time supervision will be required during construction near any butternuts. The stream restoration consultant may also be asked to provide recommendations for qualified stream construction contractors for consideration within the City's tender process.

Woody Planting Protection – Beaver has been observed in Tuck Creek. To aid in protecting woody plantings from damage by beaver and other rodents, woody plantings should be wrapped in plastic spiral tree guards after planting.

Tree Compensation –Trees cut as part of the preferred alternative should be compensated for per the provisions of the City of Burlington's Bylaw #68-2013. In addition to trees recorded as part of the tree inventory, the recent plantings along the watercourse south of Regal Road, if impacted, should be accounted for as part of replanting efforts.

Suggested areas for replanting include areas within woodlands that have been impacted by unauthorized trails and/or clearing (with a priority placed on areas within and near the FOD9 vegetation community, which represents a portion of significant woodland exhibiting the highest ecological quality in the study area), as well as in open areas east of Tuck Creek adjacent to the significant woodland north of Spruce Avenue.

7.6 Monitoring Requirements

For stream restoration projects, Conservation Halton typically requires a commitment to post-construction monitoring for a period of a minimum of 3 to 5 years following construction as a part of the permitting agreement. Detailed as-built surveys and drawings should also be completed immediately following construction by the contractor and/or stream restoration consultant. The specific details and length of monitoring required for each restoration site may be developed by the stream restoration consultant in consultation with the City, Conservation Halton, and/or DFO during the permitting process. Typical monitoring requirements are described below with detailed restoration planting monitoring requirements are described in Section 7.6.1.

<u>Pre-Construction and During Construction</u>

- Field inspections are to be conducted periodically before and during construction to document and photograph site conditions associated with the bank and channel construction process. The field inspections should be conducted at least once prior to construction and weekly during the construction period. Photographs should be collected from the same vantage point to allow for time series comparison.

Immediately Post-Construction

- A site inspection should be undertaken which includes monitoring channel stability during stabilization period.
- An as-built survey shall be undertaken of the completed channel and bank works (plan, profile, and cross-sections) to verify implementation of design within reasonable tolerances.
- Drawings are to be prepared with as-built survey for inclusion in first monitoring report.

Post-Construction Monitoring (minimum 3 years)

- Monitoring site visits (typically 2 per year in the spring and fall) are to be completed, including monitoring of intended channel functions and restoration works (additional inspections after large storms to be completed by the City).
- Monitoring reports (minimum 3) shall be prepared and submitted to stakeholders and regulatory agencies in December of each year following construction for the duration of the monitoring period. Reports to contain field assessment of channel form and restoration including the following items:
    - Planform (bank stability and treatments);
    - Profile (riffle placement and hydraulics);
    - Cross-section (flow concentration and width adjustments);
    - Planting success (including bank and slope treatments, see Table 7.5 for further details);
    - Photographic inventory and map to document observations; and
    - Recommendations for any required mitigative measures.
- Adaptive management responses related to restoration works to include replacement/repair of failed restoration identified through monitoring (see Table 7.5).

7.6.1 Monitoring of Restoration Plantings

It is recommended that restored areas be subject to a monitoring plan which shall document the success of restoration plantings. The primary goals of the monitoring plan is to ensure that new plant material can reach the free to grow stage, and to identify potential need for adaptive management measures. The free to grow (FTG) stage is defined as the point at which 90% of woody plantings have surpassed the average height of adjacent grasses and forbs, and presumably will not be outcompeted.

Table 7.5 lists the key restoration performance measures recommended for inclusion in the monitoring plan, along with frequency and duration of monitoring activities, and adaptive management actions related to each performance measure. Each monitoring parameter is to be included in a monitoring plan which is recommended to occur in years 1, 3, and 5 post-construction, subject to monitoring results. Additional monitoring at year 10 may be required if monitoring results in years 1-5 do not provide reasonable confidence that the restoration plantings will succeed over the long term. It is recommended that a minimum of five (5) permanent vegetation monitoring plots be established for monitoring, with locations to be confirmed as part of the approvals for the restoration plan (e.g. in consultation with the City of Burlington, Region of Halton, and Conservation Halton). It is also recommended that monitoring reports be submitted to the City of Burlington, Region of Halton, and Conservation Halton for review. Depending on the results of the butternut health assessments and potential requirements under the ESA, monitoring results may also have to be submitted to the MNRF. General

monitoring recommendations relative to each of the monitoring parameters are outlined in the table below.

Table 7.5: Monitoring, Targets, and Adaptive Management Actions for Restoration Plantings

Performance Measures	Location	Targets	Potential Outcomes	Adaptive Management Actions
Survival: Quantitative assessment of the establishment and survivorship of planted woody and herbaceous material. The survivorship of woody material should be assessed according to each size category of plan material used.	• Throughout site • Permanent monitoring plots	75% survival rate for planted material.	≥75% of planted material has survived.	• Report findings; no further action required.
			<75% of planted material has survived.	• Investigate causes of plant mortality and document findings. • Remediate causes of plant mortality. • Replace planting material as required within warranty period.
			Unbalanced survivorship among some plant types and/or species.	• Investigate causes of unbalanced survivorship and document findings. • Remediate causes of imbalance. • Provide mitigation measures such as increased rodent protection, invasive species removal, etc. • Replace planting material within warranty period.
Growth Rate: Quantitative assessment of the growth rate (e.g. last year's growth) of planted woody material. Growth rate should be assessed according to each size category of plan material used.	• Throughout site • Permanent monitoring plots	Establish and achieve varied height and cover targets to achieve structural diversity.	Structural diversity evident after 5 years.	• Report findings; no further action required.
			Unbalanced growth performance of some plant species and/or sizes. Structural diversity not evident after 5 years.	• Investigate causes of unbalanced survivorship and document findings. • Remediate causes of imbalance. • Provide mitigation measures such as increased rodent protection, invasive species removal, competition control, etc.
Free to Grow (FTG) Performance: Quantitative assessment of the percentage of woody plants that achieve FTG status.	• Throughout site • Permanent monitoring plots	FTG status achieved within 5 years after planting.	FTG status achieved within 5 years.	• Report findings; no further action required.
			FTG status not achieved within 5 years.	• Investigate possible causes of poor performance; document findings. • Remediate causes. • Provide mitigation measures such as increased rodent protection, invasive species removal, competition control, mulching, etc.
Invasive Species: Invasive species have the potential to outcompete planted material and negatively affect the structural diversity and ecology of the RNHS. Several invasive species, such as Garlic Mustard, Periwinkle, and European Buckthorn, have been identified on site.	• Throughout site • Permanent monitoring plots	Less than 5% of planted areas colonized by invasive species.	<5% of restored areas colonized by invasive species.	• Report findings; no further action required.
			≥5% of restored areas colonized by invasive species.	• Document, map, and photograph incident location(s); describe and map details of current extent. • Advise applicable review agencies of findings within 2 weeks of discovery. • Assess the risk of the species spreading. • Undertake invasive species removals as soon as possible. • Report observations and follow-up actions. • Monitor outcomes of control measures.

Performance Measures	Location	Targets	Potential Outcomes	Adaptive Management Actions
Erosion: Quantitative and qualitative measurement of erosion sites, especially near watercourse.	• Throughout site	Erosion location and severity identified and addressed.	Erosion sites and erosion severity identified.	• Document, map, and photograph incident location(s); describe details. • Remediate cause(s) of erosion. • Report observations and follow-up actions. • Advise applicable review agencies of findings within 2 weeks of discovery. • Monitor outcomes of control measures.
Disturbance and Encroachment: Encroachments and disturbance (e.g. dumping, unauthorized trails, vandalism, etc.) should be documented and mapped.	• Throughout site	Encroachments identified and addressed.	Encroachments within restoration areas identified.	• Document, map, and photograph incident location(s); describe details. • Identify potential negative impacts. • Report observations and follow-up actions. • Advise applicable review agencies of findings within 2 weeks of discovery. • Monitor outcomes of control measures.

8 CONCLUSIONS AND RECOMMENDATIONS

This study followed the Class Environmental Assessment for Municipal Water and Wastewater Projects, and is subject to the requirements of the Environmental Assessment Act. This document, as presented, provides relevant information with respect to Phases 1 and 2 of the Environmental Assessment Process. Subsequent phases of the process will involve detailed design, completion of contract drawings and documents for all proposed works, and appropriate monitoring requirements.

8.1 Conclusions

The following points are key conclusions drawn from this study:

- Flooding within the study area can be significantly reduced for storms up to the 100-year event. Implementation of the preferred alternative (upgrades to 3 existing watercourse crossings and widening of the channel) will provide a reduction in building flooding of 95% within the study area for this storm.
- Flooding within the study area for the Regional storm cannot be eliminated through works within the study area alone. However, implementation of the preferred alternative provides a reduction in building flooding of 38% within the study area for this storm.
- LID measures will only have a notable effect on return period flows if implemented throughout the Tuck Creek watershed.
- Implementation of the preferred alternative will protect the majority of the study area for the 100-year event and will assist in reducing the impact of the Regional.
- The flood reduction works should be implemented in phases, based on availability of City funding. Proposed phasing is outlined in Section 7.2.
- Opportunities for terrestrial and aquatic habitat improvements exist through implementation of the preferred alternative.

8.2 Recommendations

It is recommended that the following actions be taken:

1. That the proposed flood reduction measures be undertaken as outlined in this document.
2. That the implementation strategy outlined in this document be followed when undertaking the flood reduction measures.
3. That future implementation of LID measures within the watershed be undertaken as the opportunity arises.
4. Tree retention should be maximized to the extent possible through detailed design.
5. Impacts to the RNHS be minimized to the extent possible through detailed design.

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Appendix A:
Photographs of Existing Conditions in the Study Area



Figure A1: Looking upstream towards the Lakeshore Road crossing



Figure A2: Looking downstream towards the Lakeshore Road crossing



Figure A3: Creek corridor upstream of Lakeshore Road



Figure A4: Creek corridor downstream of Spruce Avenue



Figure A5: Looking downstream from Spruce Avenue crossing

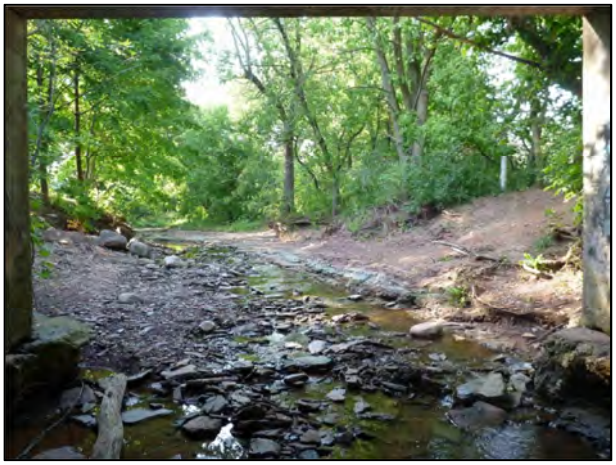


Figure A6: Looking upstream from Spruce Avenue crossing



Figure A7: Creek corridor upstream of Spruce Avenue



Figure A8: Creek corridor downstream of Regal Road



Figure A9: Looking upstream at the Regal Road crossing



Figure A10: Looking upstream from the Regal Road crossing



Figure A11: Looking downstream towards the New Street Crossing



Figure A12: Looking upstream towards the Hydro ROW



Figure A13: Looking downstream at the recreational trail crossing at the Hydro ROW



Figure A14: Looking upstream from the recreational trail crossing

Appendix B:
Hydraulic Modeling Information

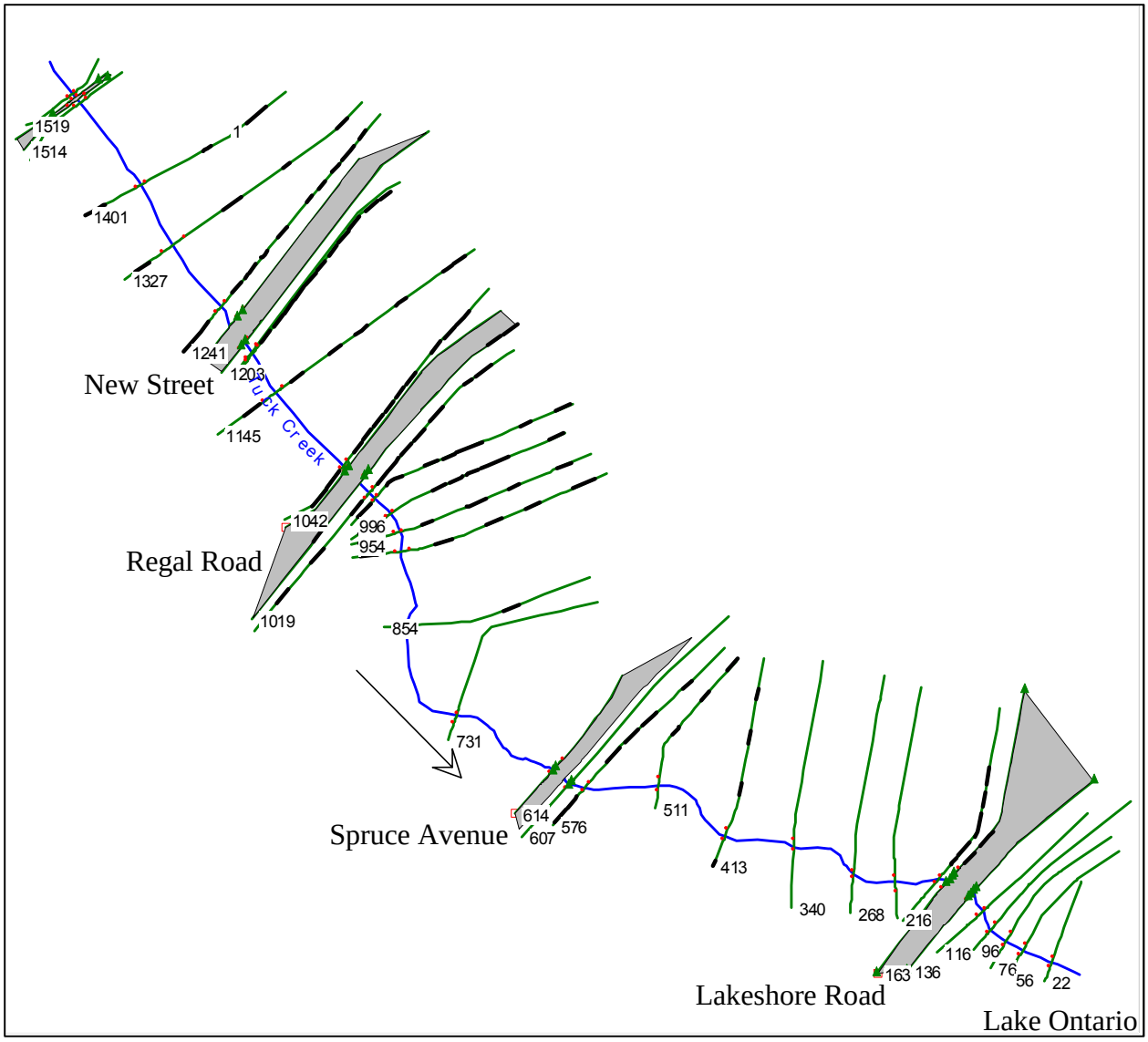


Figure B1: Location of River Stations in HEC-RAS Model

Table B1: Comparison of Hydraulic Model Results for 2012 and Updated Existing Conditions

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
1519	Regional	91.79	91.47	-0.32
1519	100 Yr	91.43	90.51	-0.92
1519	50 Yr	91.37	90.51	-0.86
1519	25 Yr	91.28	90.49	-0.79
1519	10 Yr	91.14	90.42	-0.72
1519	5 Yr	91	90.34	-0.66
1519	2 Yr	90.57	90.16	-0.41
1516	Regional	91.84	91.11	-0.73
1516	100 Yr	91.45	90.78	-0.67
1516	50 Yr	91.38	90.71	-0.67
1516	25 Yr	91.3	90.63	-0.67
1516	10 Yr	91.15	90.51	-0.64
1516	5 Yr	91.01	90.4	-0.61
1516	2 Yr	90.57	90.2	-0.37
1515	Recreational Trail			
1514	Regional	91.2	91.32	0.12
1514	100 Yr	90.96	90.84	-0.12
1514	50 Yr	90.9	90.76	-0.14
1514	25 Yr	90.84	90.68	-0.16
1514	10 Yr	90.71	90.55	-0.16
1514	5 Yr	90.58	90.44	-0.14
1514	2 Yr	90.32	90.22	-0.1
1508	Regional	91.18	91.25	0.07
1508	100 Yr	90.58	90.77	0.19
1508	50 Yr	90.49	90.7	0.21
1508	25 Yr	90.38	90.62	0.24
1508	10 Yr	90.21	90.5	0.29
1508	5 Yr	90.08	90.39	0.31
1508	2 Yr	89.94	90.19	0.25
1401	Regional	89.81	90.58	0.77
1401	100 Yr	89.19	90.13	0.94
1401	50 Yr	89.12	90.07	0.95
1401	25 Yr	89.04	90	0.96
1401	10 Yr	88.9	89.85	0.95

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
1401	5 Yr	88.75	89.72	0.97
1401	2 Yr	88.6	89.37	0.77
1327	Regional	89.73	89.55	-0.18
1327	100 Yr	89.05	89	-0.05
1327	50 Yr	88.98	88.94	-0.04
1327	25 Yr	88.91	88.9	-0.01
1327	10 Yr	88.78	88.8	0.02
1327	5 Yr	88.63	88.69	0.06
1327	2 Yr	88.11	87.94	-0.17
1241	Regional	89.48	88.95	-0.53
1241	100 Yr	88.9	88.73	-0.17
1241	50 Yr	88.85	88.72	-0.13
1241	25 Yr	88.81	88.73	-0.08
1241	10 Yr	88.71	88.67	-0.04
1241	5 Yr	88.57	88.58	0.01
1241	2 Yr	88.02	87.55	-0.47
1229	Regional	89.5	88.98	-0.52
1229	100 Yr	88.9	88.78	-0.12
1229	50 Yr	88.85	88.75	-0.1
1229	25 Yr	88.81	88.06	-0.75
1229	10 Yr	88.71	88.36	-0.35
1229	5 Yr	88.57	88.38	-0.19
1229	2 Yr	87.97	87.27	-0.7
1216	New Street			
1203	Regional	88.83	88.99	0.16
1203	100 Yr	88.3	87.93	-0.37
1203	50 Yr	88.17	87.84	-0.33
1203	25 Yr	88.09	87.55	-0.54
1203	10 Yr	87.97	87.45	-0.52
1203	5 Yr	87.85	87.46	-0.39
1203	2 Yr	87.64	86.86	-0.78
1196	Regional	88.93	88.6	-0.33
1196	100 Yr	88.31	87.94	-0.37
1196	50 Yr	88.17	87.85	-0.32
1196	25 Yr	88.09	87.76	-0.33
1196	10 Yr	87.96	87.66	-0.3

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
1196	5 Yr	87.83	87.6	-0.23
1196	2 Yr	87.6	86.8	-0.8
1194	Regional	88.93	88.7	-0.23
1194	100 Yr	88.18	87.99	-0.19
1194	50 Yr	88.05	87.89	-0.16
1194	25 Yr	87.87	87.79	-0.08
1194	10 Yr	87.47	87.68	0.21
1194	5 Yr	87.12	87.61	0.49
1194	2 Yr	86.71	86.78	0.07
1145	Regional	88.91		
1145	100 Yr	88.2		
1145	50 Yr	88.06		
1145	25 Yr	87.88		
1145	10 Yr	87.51		
1145	5 Yr	87.16		
1145	2 Yr	86.7		
1042	Regional	88.68	88.23	-0.45
1042	100 Yr	87.74	87.62	-0.12
1042	50 Yr	87.59	87.57	-0.02
1042	25 Yr	87.4	87.53	0.13
1042	10 Yr	87.02	87.5	0.48
1042	5 Yr	86.66	87.48	0.82
1042	2 Yr	86.22	86.49	0.27
1037	Regional	88.71	88.02	-0.69
1037	100 Yr	87.81	87.74	-0.07
1037	50 Yr	87.66	87.67	0.01
1037	25 Yr	87.45	87.6	0.15
1037	10 Yr	87.01	87.54	0.53
1037	5 Yr	86.66	87.28	0.62
1037	2 Yr	86.22	85.84	-0.38
1028	Regal Road			
1019	Regional	88.15	87.96	-0.19
1019	100 Yr	86.99	87.47	0.48
1019	50 Yr	86.82	87.15	0.33
1019	25 Yr	86.66	86.89	0.23
1019	10 Yr	86.43	86.52	0.09

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
1019	5 Yr	86.23	86.26	0.03
1019	2 Yr	85.91	85.92	0.01
1015	Regional	88.14	87.78	-0.36
1015	100 Yr	86.98	87.46	0.48
1015	50 Yr	86.81	87.16	0.35
1015	25 Yr	86.65	86.88	0.23
1015	10 Yr	86.41	86.51	0.1
1015	5 Yr	86.21	86.24	0.03
1015	2 Yr	85.89	85.82	-0.07
996	Regional	87.63	87.74	0.11
996	100 Yr	86.74	86.5	-0.24
996	50 Yr	86.62	86.41	-0.21
996	25 Yr	86.5	86.29	-0.21
996	10 Yr	86.29	86.09	-0.2
996	5 Yr	86.11	85.88	-0.23
996	2 Yr	85.81	85.56	-0.25
974	Regional	87.4	87.51	0.11
974	100 Yr	86.58	86.72	0.14
974	50 Yr	86.46	86.54	0.08
974	25 Yr	86.35	86.37	0.02
974	10 Yr	86.16	86.11	-0.05
974	5 Yr	85.99	85.88	-0.11
974	2 Yr	85.7	85.53	-0.17
954	Regional	87.24	87.43	0.19
954	100 Yr	86.28	86.06	-0.22
954	50 Yr	86.19	85.89	-0.3
954	25 Yr	86.15	85.71	-0.44
954	10 Yr	85.98	85.46	-0.52
954	5 Yr	85.82	85.26	-0.56
954	2 Yr	85.57	84.98	-0.59
934	Regional	86.96	86.36	-0.6
934	100 Yr	86.13	85.72	-0.41
934	50 Yr	86	85.65	-0.35
934	25 Yr	85.84	85.56	-0.28
934	10 Yr	85.7	85.39	-0.31
934	5 Yr	85.6	85.22	-0.38
934	2 Yr	85.41	84.92	-0.49

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
854	Regional	85.86	86.07	0.21
854	100 Yr	85.48	85.21	-0.27
854	50 Yr	85.07	85.08	0.01
854	25 Yr	84.87	84.95	0.08
854	10 Yr	84.68	84.7	0.02
854	5 Yr	84.5	84.53	0.03
854	2 Yr	84.19	84.31	0.12
731	Regional	85.51	85.16	-0.35
731	100 Yr	85.42	84.67	-0.75
731	50 Yr	84.97	84.61	-0.36
731	25 Yr	84.73	84.54	-0.19
731	10 Yr	84.29	84.14	-0.15
731	5 Yr	83.87	83.85	-0.02
731	2 Yr	83.26	83.47	0.21
614	Regional	85.55	85.08	-0.47
614	100 Yr	85.43	84.6	-0.83
614	50 Yr	84.99	84.54	-0.45
614	25 Yr	84.76	84.47	-0.29
614	10 Yr	84.32	83.17	-1.15
614	5 Yr	83.91	82.86	-1.05
614	2 Yr	83.29	82.42	-0.87
608	Spruce Avenue			
607	Regional	85.55	84.9	-0.65
607	100 Yr	83.43	82.98	-0.45
607	50 Yr	83.85	82.78	-1.07
607	25 Yr	83.93	82.56	-1.37
607	10 Yr	83.7	82.27	-1.43
607	5 Yr	83.36	82.03	-1.33
607	2 Yr	82.86	81.66	-1.2
576	Regional	83.1	83.49	0.39
576	100 Yr	82.34	82.4	0.06
576	50 Yr	82.26	82.24	-0.02
576	25 Yr	82.19	82.07	-0.12
576	10 Yr	82.07	81.84	-0.23
576	5 Yr	81.95	81.63	-0.32
576	2 Yr	81.77	81.33	-0.44

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
511	Regional	82.53	82.07	-0.46
511	100 Yr	81.82	81.36	-0.46
511	50 Yr	81.74	81.26	-0.48
511	25 Yr	81.62	81.15	-0.47
511	10 Yr	81.46	81.02	-0.44
511	5 Yr	81.32	80.83	-0.49
511	2 Yr	81.04	80.63	-0.41
413	Regional	81.04	81.26	0.22
413	100 Yr	80.31	80.3	-0.01
413	50 Yr	80.25	80.18	-0.07
413	25 Yr	80.12	80.08	-0.04
413	10 Yr	79.96	79.87	-0.09
413	5 Yr	79.82	79.79	-0.03
413	2 Yr	79.61	79.57	-0.04
340	Regional	80.46	80.52	0.06
340	100 Yr	79.62	79.45	-0.17
340	50 Yr	79.46	79.31	-0.15
340	25 Yr	79.38	79.18	-0.2
340	10 Yr	79.2	79.1	-0.1
340	5 Yr	79.07	78.86	-0.21
340	2 Yr	78.84	78.65	-0.19
268	Regional	80.54	80.55	0.01
268	100 Yr	79.52	78.71	-0.81
268	50 Yr	79.04	78.6	-0.44
268	25 Yr	78.68	78.38	-0.3
268	10 Yr	78.48	77.98	-0.5
268	5 Yr	78.36	77.93	-0.43
268	2 Yr	78.17	77.68	-0.49
216	Regional	80.48	80.6	0.12
216	100 Yr	79.51	78.53	-0.98
216	50 Yr	79.03	78.26	-0.77
216	25 Yr	78.68	78	-0.68
216	10 Yr	78.38	77.6	-0.78
216	5 Yr	77.46	77.31	-0.15
216	2 Yr	77.18	76.93	-0.25
173	Regional	80.52	80.59	0.07

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
173	100 Yr	79.54	78.53	-1.01
173	50 Yr	79.08	78.25	-0.83
173	25 Yr	78.75	77.98	-0.77
173	10 Yr	78.45	77.56	-0.89
173	5 Yr	77.51	77.25	-0.26
173	2 Yr	77.16	76.89	-0.27
163	Regional	80.48	80.6	0.12
163	100 Yr	79.39	78.22	-1.17
163	50 Yr	78.92	78	-0.92
163	25 Yr	78.6	77.79	-0.81
163	10 Yr	78.33	77.49	-0.84
163	5 Yr	77.35	77.25	-0.1
163	2 Yr	77.09	76.9	-0.19
136	Regional	78.37	78.36	-0.01
136	100 Yr	77.34	77.35	0.01
136	50 Yr	77.36	77.2	-0.16
136	25 Yr	77.33	77.06	-0.27
136	10 Yr	77.23	76.86	-0.37
136	5 Yr	77.14	76.71	-0.43
136	2 Yr	77	76.49	-0.51
116	Regional	78.38	78.2	-0.18
116	100 Yr	77.68	77.27	-0.41
116	50 Yr	77.62	77.16	-0.46
116	25 Yr	77.53	77.05	-0.48
116	10 Yr	77.37	76.87	-0.5
116	5 Yr	77.24	76.71	-0.53
116	2 Yr	77.06	76.46	-0.6
96	Regional	78.37	78.27	-0.1
96	100 Yr	77.48	77.38	-0.1
96	50 Yr	77.29	77.24	-0.05
96	25 Yr	77.13	77.1	-0.03
96	10 Yr	77.02	76.87	-0.15
96	5 Yr	76.9	76.67	-0.23
96	2 Yr	76.5	76.39	-0.11
76	Regional	77.93	77.81	-0.12
76	100 Yr	77.33	76.88	-0.45
76	50 Yr	77.26	76.76	-0.5

River Station	Profile	2012 Model: Water Surface Elevation (m)	Updated Model: Water Surface Elevation (m)	Difference in Water Surface Elevation (m)
76	25 Yr	77.16	76.63	-0.53
76	10 Yr	76.93	76.43	-0.5
76	5 Yr	76.76	76.25	-0.51
76	2 Yr	76.49	76.01	-0.48
56	Regional	77.84	77.84	0
56	100 Yr	77.14	76.6	-0.54
56	50 Yr	77.12	76.43	-0.69
56	25 Yr	77.04	76.24	-0.8
56	10 Yr	76.81	75.97	-0.84
56	5 Yr	76.65	75.76	-0.89
56	2 Yr	76.39	75.44	-0.95
22	Regional	77.63	77.1	-0.53
22	100 Yr	76.98	75.88	-1.1
22	50 Yr	76.81	75.73	-1.08
22	25 Yr	76.49	75.59	-0.9
22	10 Yr	76.38	75.37	-1.01
22	5 Yr	76.2	75.21	-0.99
22	2 Yr	75.92	75.16	-0.76

Table B2: Hydraulic Modeling Results for Alternatives

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1519	Regional	91.47	91.47	0	91.47	0	91.47	0	91.47	0
1519	100 year	90.51	90.52	0.01	90.39	-0.12	90.36	-0.15	90.36	-0.15
1519	50 year	90.51	90.51	0	90.42	-0.09	90.22	-0.29	90.22	-0.29
1519	25 year	90.49	90.49	0	90.42	-0.07	90.06	-0.43	90.06	-0.43
1519	10 year	90.42	90.42	0	90.24	-0.18	89.99	-0.43	89.85	-0.57
1519	5 year	90.34	90.33	-0.01	90.09	-0.25	89.93	-0.41	89.68	-0.66
1519	2 year	90.16	90.16	0	89.83	-0.33	89.76	-0.4	89.44	-0.72
1516	Regional	91.11	91.11	0	91.44	0.33	91.03	-0.08	91.44	0.33
1516	100 year	90.78	90.78	0	90.71	-0.07	90.51	-0.27	90.41	-0.37
1516	50 year	90.71	90.71	0	90.64	-0.07	90.41	-0.3	90.29	-0.42
1516	25 year	90.63	90.63	0	90.58	-0.05	90.31	-0.32	90.16	-0.47
1516	10 year	90.51	90.51	0	90.36	-0.15	90.16	-0.35	89.97	-0.54
1516	5 year	90.4	90.4	0	90.18	-0.22	90.04	-0.36	89.8	-0.6
1516	2 year	90.2	90.2	0	89.88	-0.32	89.81	-0.39	89.48	-0.72
1515	Recreational Trail									
1514	Regional	91.32	91.32	0	91.28	-0.04	91.27	-0.05	91.27	-0.05
1514	100 year	90.84	90.84	0	90.78	-0.06	90.61	-0.23	90.55	-0.29
1514	50 year	90.76	90.76	0	90.71	-0.05	90.51	-0.25	90.43	-0.33
1514	25 year	90.68	90.68	0	90.63	-0.05	90.41	-0.27	90.3	-0.38
1514	10 year	90.55	90.55	0	90.41	-0.14	90.24	-0.31	90.1	-0.45

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1514	5 year	90.44	90.43	-0.01	90.23	-0.21	90.11	-0.33	89.93	-0.51
1514	2 year	90.22	90.22	0	89.93	-0.29	89.87	-0.35	89.64	-0.58
1508	Regional	91.25	91.25	0	91.16	-0.09	90.96	-0.29	90.97	-0.28
1508	100 year	90.77	90.77	0	90.69	-0.08	90.43	-0.34	90.09	-0.68
1508	50 year	90.7	90.7	0	90.63	-0.07	90.35	-0.35	89.99	-0.71
1508	25 year	90.62	90.62	0	90.56	-0.06	90.25	-0.37	89.88	-0.74
1508	10 year	90.5	90.5	0	90.34	-0.16	90.12	-0.38	89.7	-0.8
1508	5 year	90.39	90.39	0	90.16	-0.23	90.01	-0.38	89.53	-0.86
1508	2 year	90.19	90.19	0	89.86	-0.33	89.79	-0.4	89.29	-0.9
1401	Regional	90.58	90.58	0	90.49	-0.09	89.89	-0.69	88.9	-1.68
1401	100 year	90.13	90.13	0	89.85	-0.28	89.18	-0.95	88.46	-1.67
1401	50 year	90.07	90.07	0	89.69	-0.38	89.11	-0.96	88.38	-1.69
1401	25 year	90	90	0	89.32	-0.68	89.03	-0.97	88.31	-1.69
1401	10 year	89.85	89.85	0	89.09	-0.76	88.93	-0.92	88.19	-1.66
1401	5 year	89.72	89.72	0	88.93	-0.79	88.84	-0.88	88.1	-1.62
1401	2 year	89.37	89.37	0	88.7	-0.67	88.72	-0.65	87.97	-1.4
1327	Regional	89.55	89.55	0	89.28	-0.27	88.95	-0.6	88.36	-1.19
1327	100 year	89	88.81	-0.19	88.25	-0.75	87.88	-1.12	87.32	-1.68
1327	50 year	88.94	88.69	-0.25	87.99	-0.95	87.78	-1.16	87.25	-1.69
1327	25 year	88.9	88.55	-0.35	87.86	-1.04	87.67	-1.23	87.18	-1.72
1327	10 year	88.8	88.34	-0.46	87.74	-1.06	87.54	-1.26	87.07	-1.73
1327	5 year	88.69	88.17	-0.52	87.64	-1.05	87.45	-1.24	86.99	-1.7

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1327	2 year	87.94	87.91	-0.03	87.49	-0.45	87.29	-0.65	86.87	-1.07
1241	Regional	88.95	88.95	0	88.76	-0.19	88.56	-0.39	88.38	-0.57
1241	100 year	88.73	88.07	-0.66	87.92	-0.81	87.41	-1.32	86.81	-1.92
1241	50 year	88.72	87.92	-0.8	87.69	-1.03	87.26	-1.46	86.62	-2.1
1241	25 year	88.73	87.72	-1.01	87.48	-1.25	87.11	-1.62	86.43	-2.3
1241	10 year	88.67	87.5	-1.17	87.14	-1.53	86.89	-1.78	86.13	-2.54
1241	5 year	88.58	87.35	-1.23	86.87	-1.71	86.7	-1.88	85.88	-2.7
1241	2 year	87.55	87.15	-0.4	86.44	-1.11	86.54	-1.01	85.53	-2.02
1229	Regional	88.98	89.03	0.05	88.91	-0.07	88.63	-0.35	88.38	-0.6
1229	100 year	88.78	88.28	-0.5	88	-0.78	87.47	-1.31	86.81	-1.97
1229	50 year	88.75	88.13	-0.62	87.77	-0.98	87.33	-1.42	86.62	-2.13
1229	25 year	88.06	87.94	-0.12	87.55	-0.51	87.18	-0.88	86.43	-1.63
1229	10 year	88.36	87.71	-0.65	87.2	-1.16	86.97	-1.39	86.13	-2.23
1229	5 year	88.38	87.54	-0.84	86.92	-1.46	86.8	-1.58	85.88	-2.5
1229	2 year	87.27	87.29	0.02	86.49	-0.78	86.56	-0.71	85.52	-1.75
1216	New Street									
1203	Regional	88.99	89.02	0.03	88.91	-0.08	88.54	-0.45	88.24	-0.75
1203	100 year	87.93	88.21	0.28	87.97	0.04	87.47	-0.46	86.81	-1.12
1203	50 year	87.84	88.08	0.24	87.77	-0.07	87.32	-0.52	86.61	-1.23
1203	25 year	87.55	87.91	0.36	87.55	0	87.18	-0.37	86.42	-1.13
1203	10 year	87.45	87.71	0.26	87.2	-0.25	86.97	-0.48	86.12	-1.33

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1203	5 year	87.46	87.54	0.08	86.92	-0.54	86.8	-0.66	85.88	-1.58
1203	2 year	86.86	87.29	0.43	86.48	-0.38	86.56	-0.3	85.52	-1.34
1196	Regional	88.6	88.6	0	88.62	0.02	88.39	-0.21	88.22	-0.38
1196	100 year	87.94	87.9	-0.04	87.77	-0.17	87.34	-0.6	86.79	-1.15
1196	50 year	87.85	87.77	-0.08	87.55	-0.3	87.2	-0.65	86.6	-1.25
1196	25 year	87.76	87.56	-0.2	87.32	-0.44	87.06	-0.7	86.41	-1.35
1196	10 year	87.66	87.16	-0.5	86.93	-0.73	86.85	-0.81	86.11	-1.55
1196	5 year	87.6	87.05	-0.55	86.65	-0.95	86.68	-0.92	85.87	-1.73
1196	2 year	86.8	86.81	0.01	86.24	-0.56	86.44	-0.36	85.51	-1.29
1194	Regional	88.63	88.63	0	88.65	0.02	88.39	-0.24	88.22	-0.41
1194	100 year	88.01	87.97	-0.04	87.81	-0.2	87.35	-0.66	86.79	-1.22
1194	50 year	87.92	87.85	-0.07	87.61	-0.31	87.21	-0.71	86.6	-1.32
1194	25 year	87.82	87.65	-0.17	87.38	-0.44	87.06	-0.76	86.41	-1.41
1194	10 year	87.71	87.33	-0.38	87.01	-0.7	86.86	-0.85	86.11	-1.6
1194	5 year	87.63	87.1	-0.53	86.73	-0.9	86.69	-0.94	85.87	-1.76
1194	2 year	86.88	86.79	-0.09	86.31	-0.57	86.45	-0.43	85.51	-1.37
1145	Regional	88.7	88.7	0	88.68	-0.02	88.33	-0.37	88.08	-0.62
1145	100 year	87.99	87.95	-0.04	87.78	-0.21	87.06	-0.93	86.54	-1.45
1145	50 year	87.89	87.82	-0.07	87.56	-0.33	86.9	-0.99	86.35	-1.54
1145	25 year	87.79	87.6	-0.19	87.32	-0.47	86.74	-1.05	86.16	-1.63
1145	10 year	87.68	87.24	-0.44	86.93	-0.75	86.52	-1.16	85.88	-1.8
1145	5 year	87.61	86.98	-0.63	86.64	-0.97	86.37	-1.24	85.65	-1.96

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1145	2 year	86.78	86.62	-0.16	86.19	-0.59	86.15	-0.63	85.31	-1.47
1042	Regional	88.23	88.23	0	87.58	-0.65	87.33	-0.9	87.56	-0.67
1042	100 year	87.62	87.52	-0.1	87.46	-0.16	86.18	-1.44	86.19	-1.43
1042	50 year	87.57	87.44	-0.13	87.23	-0.34	86.02	-1.55	86.04	-1.53
1042	25 year	87.53	87.19	-0.34	86.98	-0.55	85.86	-1.67	85.87	-1.66
1042	10 year	87.5	86.72	-0.78	86.6	-0.9	85.61	-1.89	85.62	-1.88
1042	5 year	87.48	86.44	-1.04	86.31	-1.17	85.39	-2.09	85.4	-2.08
1042	2 year	86.49	86.01	-0.48	85.89	-0.6	85.08	-1.41	85.06	-1.43
1037	Regional	88.02	88.02	0	88.01	-0.01	87.63	-0.39	87.73	-0.29
1037	100 year	87.74	87.66	-0.08	87.56	-0.18	86.24	-1.5	86.22	-1.52
1037	50 year	87.67	87.55	-0.12	87.3	-0.37	86.08	-1.59	86.06	-1.61
1037	25 year	87.6	87.27	-0.33	87.06	-0.54	85.91	-1.69	85.9	-1.7
1037	10 year	87.54	86.83	-0.71	86.67	-0.87	85.66	-1.88	85.64	-1.9
1037	5 year	87.28	86.54	-0.74	86.38	-0.9	85.44	-1.84	85.41	-1.87
1037	2 year	85.84	86.11	0.27	85.95	0.11	85.13	-0.71	85.07	-0.77
1028	Regal Road									
1019	Regional	87.96	87.99	0.03	87.99	0.03	87.29	-0.67	87.51	-0.45
1019	100 year	87.47	87.58	0.11	87.46	-0.01	86.28	-1.19	86.21	-1.26
1019	50 year	87.15	87.42	0.27	87.23	0.08	86.11	-1.04	86.05	-1.1
1019	25 year	86.89	87.18	0.29	87.01	0.12	85.95	-0.94	85.89	-1
1019	10 year	86.52	86.83	0.31	86.67	0.15	85.69	-0.83	85.63	-0.89

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
1019	5 year	86.26	86.55	0.29	86.38	0.12	85.47	-0.79	85.41	-0.85
1019	2 year	85.92	86.12	0.2	85.95	0.03	85.14	-0.78	85.06	-0.86
1015	Regional	87.78	87.78	0	87.76	-0.02	87.29	-0.49	87	-0.78
1015	100 year	87.46	87.46	0	87.17	-0.29	86.1	-1.36	86.13	-1.33
1015	50 year	87.16	87.16	0	86.9	-0.26	85.95	-1.21	85.98	-1.18
1015	25 year	86.88	86.88	0	86.67	-0.21	85.8	-1.08	85.82	-1.06
1015	10 year	86.51	86.51	0	86.34	-0.17	85.56	-0.95	85.58	-0.93
1015	5 year	86.24	86.24	0	86.07	-0.17	85.35	-0.89	85.36	-0.88
1015	2 year	85.82	85.82	0	85.66	-0.16	85.03	-0.79	85.03	-0.79
996	Regional	87.74	87.74	0	87.73	-0.01	86.64	-1.1	86.82	-0.92
996	100 year	86.5	86.5	0	86.63	0.13	85.96	-0.54	86.07	-0.43
996	50 year	86.41	86.41	0	86.5	0.09	85.83	-0.58	85.92	-0.49
996	25 year	86.29	86.29	0	86.35	0.06	85.68	-0.61	85.77	-0.52
996	10 year	86.09	86.09	0	86.12	0.03	85.44	-0.65	85.53	-0.56
996	5 year	85.88	85.88	0	85.89	0.01	85.23	-0.65	85.32	-0.56
996	2 year	85.56	85.56	0	85.55	-0.01	84.91	-0.65	84.99	-0.57
974	Regional	87.51	87.51	0	87.51	0	86.64	-0.87	86.72	-0.79
974	100 year	86.72	86.72	0	86.66	-0.06	85.94	-0.78	86.01	-0.71
974	50 year	86.54	86.54	0	86.49	-0.05	85.8	-0.74	85.87	-0.67
974	25 year	86.37	86.37	0	86.31	-0.06	85.66	-0.71	85.72	-0.65
974	10 year	86.11	86.11	0	86.05	-0.06	85.43	-0.68	85.49	-0.62
974	5 year	85.88	85.88	0	85.81	-0.07	85.22	-0.66	85.28	-0.6

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
974	2 year	85.53	85.53	0	85.46	-0.07	84.89	-0.64	84.96	-0.57
954	Regional	87.43	87.43	0	87.41	-0.02	86.49	-0.94	86.59	-0.84
954	100 year	86.06	86.06	0	85.99	-0.07	85.88	-0.18	85.96	-0.1
954	50 year	85.89	85.89	0	85.82	-0.07	85.75	-0.14	85.82	-0.07
954	25 year	85.71	85.71	0	85.65	-0.06	85.61	-0.1	85.68	-0.03
954	10 year	85.46	85.46	0	85.39	-0.07	85.38	-0.08	85.45	-0.01
954	5 year	85.26	85.26	0	85.19	-0.07	85.18	-0.08	85.25	-0.01
954	2 year	84.98	84.97	-0.01	84.9	-0.08	84.85	-0.13	84.93	-0.05
934	Regional	86.36	86.36	0	86.32	-0.04	86.22	-0.14	86.26	-0.1
934	100 year	85.72	85.69	-0.03	85.7	-0.02	85.42	-0.3	85.4	-0.32
934	50 year	85.65	85.62	-0.03	85.62	-0.03	85.31	-0.34	85.3	-0.35
934	25 year	85.56	85.54	-0.02	85.53	-0.03	85.19	-0.37	85.18	-0.38
934	10 year	85.39	85.37	-0.02	85.36	-0.03	84.98	-0.41	84.97	-0.42
934	5 year	85.22	85.21	-0.01	85.19	-0.03	84.78	-0.44	84.77	-0.45
934	2 year	84.92	84.92	0	84.9	-0.02	84.45	-0.47	84.42	-0.5
854	Regional	86.07	86.07	0	86.07	0	86.02	-0.05	86.02	-0.05
854	100 year	85.21	85.31	0.1	85.31	0.1	85.2	-0.01	85.2	-0.01
854	50 year	85.08	85.15	0.07	85.15	0.07	85.03	-0.05	85.03	-0.05
854	25 year	84.95	85.03	0.08	85.03	0.08	84.89	-0.06	84.89	-0.06
854	10 year	84.7	84.83	0.13	84.83	0.13	84.67	-0.03	84.67	-0.03
854	5 year	84.53	84.67	0.14	84.67	0.14	84.49	-0.04	84.49	-0.04
854	2 year	84.31	84.41	0.1	84.41	0.1	84.17	-0.14	84.17	-0.14

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
731	Regional	85.16	85.16	0	85.16	0	85.16	0	85.16	0
731	100 year	84.67	83.94	-0.73	83.94	-0.73	83.94	-0.73	83.94	-0.73
731	50 year	84.61	83.92	-0.69	83.92	-0.69	83.92	-0.69	83.92	-0.69
731	25 year	84.54	83.79	-0.75	83.79	-0.75	83.79	-0.75	83.79	-0.75
731	10 year	84.14	83.62	-0.52	83.62	-0.52	83.62	-0.52	83.62	-0.52
731	5 year	83.85	83.48	-0.37	83.48	-0.37	83.48	-0.37	83.48	-0.37
731	2 year	83.47	83.17	-0.3	83.17	-0.3	83.17	-0.3	83.17	-0.3
614	Regional	85.08	84.75	-0.33	84.75	-0.33	84.62	-0.46	84.7	-0.38
614	100 year	84.6	83.42	-1.18	83.42	-1.18	83.23	-1.37	83.42	-1.18
614	50 year	84.54	83.22	-1.32	83.22	-1.32	83.02	-1.52	83.22	-1.32
614	25 year	84.47	83.02	-1.45	83.02	-1.45	82.8	-1.67	83.02	-1.45
614	10 year	83.17	82.7	-0.47	82.7	-0.47	82.47	-0.7	82.7	-0.47
614	5 year	82.86	82.43	-0.43	82.43	-0.43	82.19	-0.67	82.43	-0.43
614	2 year	82.42	82.02	-0.4	82.02	-0.4	81.74	-0.68	82.02	-0.4
608	Spruce Avenue									
607	Regional	84.9	84.64	-0.26	84.64	-0.26	84.49	-0.41	84.61	-0.29
607	100 year	82.98	83.43	0.45	83.43	0.45	83.24	0.26	83.42	0.44
607	50 year	82.78	83.23	0.45	83.23	0.45	83.03	0.25	83.23	0.45
607	25 year	82.56	83.02	0.46	83.02	0.46	82.81	0.25	83.02	0.46
607	10 year	82.27	82.7	0.43	82.7	0.43	82.48	0.21	82.7	0.43
607	5 year	82.03	82.44	0.41	82.44	0.41	82.2	0.17	82.44	0.41

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
607	2 year	81.66	82.02	0.36	82.02	0.36	81.75	0.09	82.02	0.36
576	Regional	83.49	83.49	0	83.49	0	83.41	-0.08	83.49	0
576	100 year	82.4	82.4	0	82.4	0	82.16	-0.24	82.4	0
576	50 year	82.24	82.24	0	82.24	0	81.99	-0.25	82.24	0
576	25 year	82.07	82.07	0	82.07	0	81.82	-0.25	82.07	0
576	10 year	81.84	81.84	0	81.84	0	81.56	-0.28	81.84	0
576	5 year	81.63	81.63	0	81.63	0	81.34	-0.29	81.63	0
576	2 year	81.33	81.33	0	81.33	0	81.02	-0.31	81.33	0
511	Regional	82.07	82.07	0	82.07	0	81.96	-0.11	82.07	0
511	100 year	81.36	81.36	0	81.36	0	81.26	-0.1	81.36	0
511	50 year	81.26	81.26	0	81.26	0	81.15	-0.11	81.26	0
511	25 year	81.15	81.15	0	81.15	0	81.04	-0.11	81.15	0
511	10 year	81.02	81.02	0	81.02	0	80.9	-0.12	81.02	0
511	5 year	80.83	80.83	0	80.83	0	80.71	-0.12	80.83	0
511	2 year	80.63	80.63	0	80.63	0	80.5	-0.13	80.63	0
413	Regional	81.26	81.26	0	81.26	0	81.26	0	81.26	0
413	100 year	80.3	80.3	0	80.3	0	80.3	0	80.3	0
413	50 year	80.18	80.18	0	80.18	0	80.18	0	80.18	0
413	25 year	80.08	80.08	0	80.08	0	80.08	0	80.08	0
413	10 year	79.87	79.87	0	79.87	0	79.87	0	79.87	0
413	5 year	79.79	79.79	0	79.79	0	79.79	0	79.79	0
413	2 year	79.57	79.57	0	79.57	0	79.57	0	79.57	0

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
340	Regional	80.52	80.52	0	80.52	0	80.52	0	80.52	0
340	100 year	79.45	79.45	0	79.45	0	79.45	0	79.45	0
340	50 year	79.31	79.31	0	79.31	0	79.31	0	79.31	0
340	25 year	79.18	79.18	0	79.18	0	79.18	0	79.18	0
340	10 year	79.1	79.1	0	79.1	0	79.1	0	79.1	0
340	5 year	78.86	78.86	0	78.86	0	78.86	0	78.86	0
340	2 year	78.65	78.65	0	78.65	0	78.65	0	78.65	0
268	Regional	80.55	80.55	0	80.55	0	80.55	0	80.55	0
268	100 year	78.71	78.71	0	78.71	0	78.71	0	78.71	0
268	50 year	78.6	78.6	0	78.6	0	78.6	0	78.6	0
268	25 year	78.38	78.38	0	78.38	0	78.38	0	78.38	0
268	10 year	77.98	77.98	0	77.98	0	77.98	0	77.98	0
268	5 year	77.93	77.93	0	77.93	0	77.93	0	77.93	0
268	2 year	77.68	77.68	0	77.68	0	77.68	0	77.68	0
216	Regional	80.6	80.6	0	80.6	0	80.6	0	80.6	0
216	100 year	78.53	78.53	0	78.53	0	78.53	0	78.53	0
216	50 year	78.26	78.26	0	78.26	0	78.26	0	78.26	0
216	25 year	78	78	0	78	0	78	0	78	0
216	10 year	77.6	77.6	0	77.6	0	77.6	0	77.6	0
216	5 year	77.31	77.31	0	77.31	0	77.31	0	77.31	0
216	2 year	76.93	76.93	0	76.93	0	76.93	0	76.93	0

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
173	Regional	80.59	80.59	0	80.59	0	80.59	0	80.59	0
173	100 year	78.53	78.53	0	78.53	0	78.53	0	78.53	0
173	50 year	78.25	78.25	0	78.25	0	78.25	0	78.25	0
173	25 year	77.98	77.98	0	77.98	0	77.98	0	77.98	0
173	10 year	77.56	77.56	0	77.56	0	77.56	0	77.56	0
173	5 year	77.25	77.25	0	77.25	0	77.25	0	77.25	0
173	2 year	76.89	76.89	0	76.89	0	76.89	0	76.89	0
163	Regional	80.6	80.6	0	80.6	0	80.6	0	80.6	0
163	100 year	78.22	78.22	0	78.22	0	78.22	0	78.22	0
163	50 year	78	78	0	78	0	78	0	78	0
163	25 year	77.79	77.79	0	77.79	0	77.79	0	77.79	0
163	10 year	77.49	77.49	0	77.49	0	77.49	0	77.49	0
163	5 year	77.25	77.25	0	77.25	0	77.25	0	77.25	0
163	2 year	76.9	76.9	0	76.9	0	76.9	0	76.9	0
149.5	Lakeshore Road									
136	Regional	78.36	78.36	0	78.36	0	78.36	0	78.36	0
136	100 year	77.35	77.35	0	77.35	0	77.35	0	77.35	0
136	50 year	77.2	77.2	0	77.2	0	77.2	0	77.2	0
136	25 year	77.06	77.06	0	77.06	0	77.06	0	77.06	0
136	10 year	76.86	76.86	0	76.86	0	76.86	0	76.86	0
136	5 year	76.71	76.71	0	76.71	0	76.71	0	76.71	0
136	2 year	76.49	76.49	0	76.49	0	76.49	0	76.49	0

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
116	Regional	78.2	78.2	0	78.2	0	78.2	0	78.2	0
116	100 year	77.27	77.27	0	77.27	0	77.27	0	77.27	0
116	50 year	77.16	77.16	0	77.16	0	77.16	0	77.16	0
116	25 year	77.05	77.05	0	77.05	0	77.05	0	77.05	0
116	10 year	76.87	76.87	0	76.87	0	76.87	0	76.87	0
116	5 year	76.71	76.71	0	76.71	0	76.71	0	76.71	0
116	2 year	76.46	76.46	0	76.46	0	76.46	0	76.46	0
96	Regional	78.27	78.27	0	78.27	0	78.27	0	78.27	0
96	100 year	77.38	77.38	0	77.38	0	77.38	0	77.38	0
96	50 year	77.24	77.24	0	77.24	0	77.24	0	77.24	0
96	25 year	77.1	77.1	0	77.1	0	77.1	0	77.1	0
96	10 year	76.87	76.87	0	76.87	0	76.87	0	76.87	0
96	5 year	76.67	76.67	0	76.67	0	76.67	0	76.67	0
96	2 year	76.39	76.39	0	76.39	0	76.39	0	76.39	0
76	Regional	77.81	77.81	0	77.81	0	77.81	0	77.81	0
76	100 year	76.88	76.88	0	76.88	0	76.88	0	76.88	0
76	50 year	76.76	76.76	0	76.76	0	76.76	0	76.76	0
76	25 year	76.63	76.63	0	76.63	0	76.63	0	76.63	0
76	10 year	76.43	76.43	0	76.43	0	76.43	0	76.43	0
76	5 year	76.25	76.25	0	76.25	0	76.25	0	76.25	0
76	2 year	76.01	76.01	0	76.01	0	76.01	0	76.01	0

River Station	Profile	Existing Conditions/ Alternative 1	Alternative 2		Alternative 3		Alternative 4		Alternative 5	
		Water Surface Elevation (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)	Water Surface Elevation (m)	Difference Compared to Existing (m)
56	Regional	77.84	77.84	0	77.84	0	77.84	0	77.84	0
56	100 year	76.6	76.6	0	76.6	0	76.6	0	76.6	0
56	50 year	76.43	76.43	0	76.42	-0.01	76.43	0	76.43	0
56	25 year	76.24	76.24	0	76.24	0	76.24	0	76.24	0
56	10 year	75.97	75.97	0	75.97	0	75.97	0	75.97	0
56	5 year	75.76	75.76	0	75.76	0	75.76	0	75.76	0
56	2 year	75.44	75.44	0	75.44	0	75.44	0	75.44	0
22	Regional	77.1	77.1	0	77.1	0	77.1	0	77.1	0
22	100 year	75.88	75.88	0	75.88	0	75.88	0	75.88	0
22	50 year	75.73	75.73	0	75.73	0	75.73	0	75.73	0
22	25 year	75.59	75.59	0	75.59	0	75.59	0	75.59	0
22	10 year	75.37	75.37	0	75.37	0	75.37	0	75.37	0
22	5 year	75.21	75.21	0	75.2	-0.01	75.21	0	75.21	0
22	2 year	75.16	75.16	0	75.16	0	75.16	0	75.16	0

Fisheries and Oceans Canada

Historical Monthly Mean Water Levels from the Coordinated network for each of the Great Lakes

Lake Superior | Lake Michigan-Huron | Lake St. Clair | Lake Erie | Lake Ontario | Montreal Harbour

Lake Ontario monthly mean water levels in metres referred to IGLD 1985

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Average	Minimum Monthly	Maximum Monthly	Range
1918	74.74	74.72	74.92	75.10	75.09	75.06	74.99	74.87	74.78	74.74	74.74	74.72	74.87	74.72	75.10	0.38
1919	74.76	74.72	74.76	74.92	75.18	75.36	75.28	75.16	75.01	74.87	74.78	74.67	74.96	74.67	75.36	0.69
1920	74.54	74.44	74.46	74.60	74.64	74.62	74.66	74.64	74.59	74.53	74.51	74.58	74.57	74.44	74.66	0.22
1921	74.61	74.58	74.70	74.88	74.96	74.92	74.84	74.71	74.56	74.46	74.39	74.38	74.67	74.38	74.96	0.58
1922	74.36	74.34	74.47	74.76	74.92	74.96	75.02	74.90	74.75	74.61	74.47	74.32	74.66	74.32	75.02	0.70
1923	74.30	74.27	74.36	74.54	74.62	74.72	74.68	74.55	74.44	74.32	74.24	74.28	74.44	74.24	74.72	0.48
1924	74.34	74.40	74.39	74.55	74.76	74.82	74.79	74.75	74.62	74.56	74.41	74.30	74.56	74.30	74.82	0.52
1925	74.20	74.26	74.50	74.62	74.62	74.56	74.49	74.40	74.30	74.22	74.23	74.28	74.39	74.20	74.62	0.42
1926	74.20	74.15	74.16	74.41	74.55	74.55	74.49	74.44	74.41	74.41	74.50	74.56	74.40	74.15	74.56	0.41
1927	74.50	74.52	74.65	74.73	74.73	74.77	74.74	74.66	74.52	74.44	74.40	74.62	74.61	74.40	74.77	0.37
1928	74.74	74.73	74.72	74.87	74.93	74.93	74.97	74.94	74.79	74.67	74.64	74.68	74.80	74.64	74.97	0.33
1929	74.68	74.67	74.79	75.14	75.45	75.49	75.46	75.34	75.18	75.03	74.92	74.87	75.08	74.67	75.49	0.82
1930	74.98	75.08	75.24	75.36	75.38	75.39	75.37	75.19	75.00	74.82	74.64	74.52	75.08	74.52	75.39	0.87
1931	74.42	74.36	74.34	74.43	74.48	74.57	74.51	74.42	74.30	74.20	74.14	74.12	74.36	74.12	74.57	0.45
1932	74.26	74.46	74.51	74.69	74.79	74.76	74.70	74.61	74.44	74.32	74.26	74.23	74.50	74.23	74.79	0.56
1933	74.24	74.21	74.20	74.39	74.54	74.57	74.48	74.38	74.26	74.10	73.98	73.96	74.28	73.96	74.57	0.61
1934	74.04	74.05	74.06	74.24	74.29	74.22	74.14	74.00	73.91	73.82	73.75	73.74	74.02	73.74	74.29	0.55
1935	73.81	73.86	73.94	74.03	74.11	74.19	74.24	74.16	74.04	73.92	73.88	73.87	74.00	73.81	74.24	0.43
1936	73.84	73.78	73.98	74.45	74.53	74.48	74.38	74.23	74.16	74.08	74.06	74.00	74.16	73.78	74.53	0.75
1937	74.14	74.34	74.39	74.47	74.70	74.77	74.76	74.69	74.55	74.40	74.40	74.34	74.50	74.14	74.77	0.63
1938	74.28	74.38	74.54	74.70	74.74	74.72	74.66	74.64	74.52	74.46	74.36	74.27	74.52	74.27	74.74	0.47
1939	74.24	74.26	74.42	74.68	74.80	74.78	74.74	74.66	74.51	74.38	74.26	74.18	74.49	74.18	74.80	0.62
1940	74.12	74.08	74.08	74.37	74.62	74.73	74.75	74.66	74.54	74.42	74.36	74.38	74.43	74.08	74.75	0.67
1941	74.50	74.52	74.53	74.62	74.60	74.53	74.46	74.37	74.28	74.18	74.16	74.14	74.41	74.14	74.62	0.48
1942	74.14	74.14	74.30	74.58	74.70	74.79	74.74	74.69	74.60	74.52	74.50	74.50	74.52	74.14	74.79	0.65
1943	74.64	74.72	74.89	75.06	75.33	75.60	75.54	75.44	75.29	75.10	75.06	74.94	75.13	74.64	75.60	0.96
1944	74.80	74.72	74.72	74.88	75.06	75.12	75.11	75.00	74.88	74.73	74.59	74.54	74.85	74.54	75.12	0.58
1945	74.53	74.54	74.76	75.04	75.22	75.34	75.33	75.24	75.12	75.22	75.18	75.20	75.06	74.53	75.34	0.81
1946	75.16	75.10	75.20	75.16	75.11	75.13	75.10	74.98	74.84	74.76	74.72	74.66	74.99	74.66	75.20	0.54
1947	74.68	74.78	74.80	75.07	75.28	75.63	75.66	75.58	75.41	75.18	75.02	74.94	75.17	74.68	75.66	0.98
1948	74.86	74.84	75.02	75.32	75.42	75.46	75.38	75.24	75.05	74.88	74.78	74.72	75.08	74.72	75.46	0.74
1949	74.74	74.84	74.94	75.03	75.06	74.98	74.85	74.70	74.57	74.48	74.36	74.34	74.74	74.34	75.06	0.72
1950	74.52	74.68	74.78	75.10	75.17	75.15	75.09	74.99	74.88	74.78	74.74	74.82	74.89	74.52	75.17	0.65
1951	74.89	74.98	75.18	75.47	75.62	75.59	75.56	75.39	75.24	75.06	74.98	75.00	75.25	74.89	75.62	0.73
1952	75.10	75.27	75.37	75.62	75.72	75.76	75.64	75.48	75.32	75.15	74.98	74.98	75.37	74.98	75.76	0.78
1953	74.94	74.94	75.00	75.17	75.30	75.34	75.23	75.12	74.98	74.82	74.69	74.65	75.02	74.65	75.34	0.69

1954	74.62	74.68	74.89	75.09	75.32	75.30	75.18	75.02	74.92	74.90	74.92	74.94	74.98	74.62	75.32	0.70
1955	75.02	74.98	75.18	75.44	75.49	75.42	75.27	75.14	74.98	74.94	74.98	74.91	75.15	74.91	75.49	0.58
1956	74.78	74.69	74.76	74.95	75.23	75.30	75.20	75.06	74.99	74.82	74.68	74.60	74.92	74.60	75.30	0.70
1957	74.55	74.56	74.61	74.70	74.78	74.84	74.88	74.78	74.65	74.50	74.38	74.37	74.63	74.37	74.88	0.51
1958	74.42	74.38	74.45	74.55	74.60	74.59	74.54	74.46	74.39	74.32	74.25	74.19	74.43	74.19	74.60	0.41
1959	74.16	74.30	74.46	74.79	74.86	74.80	74.69	74.51	74.34	74.25	74.22	74.32	74.48	74.16	74.86	0.70
1960	74.45	74.56	74.59	74.87	75.11	75.14	75.00	74.80	74.61	74.50	74.49	74.43	74.71	74.43	75.14	0.71
1961	74.33	74.23	74.43	74.66	74.94	75.00	74.96	74.82	74.69	74.52	74.40	74.38	74.61	74.23	75.00	0.77
1962	74.33	74.27	74.32	74.62	74.85	74.93	74.88	74.85	74.74	74.69	74.62	74.60	74.64	74.27	74.93	0.66
1963	74.49	74.33	74.31	74.65	74.92	75.06	75.02	74.96	74.80	74.58	74.41	74.33	74.66	74.31	75.06	0.75
1964	74.18	74.02	74.02	74.27	74.54	74.67	74.68	74.57	74.43	74.20	74.00	73.86	74.29	73.86	74.68	0.82
1965	73.83	73.88	74.04	74.25	74.51	74.63	74.71	74.66	74.60	74.54	74.52	74.58	74.40	73.83	74.71	0.88
1966	74.56	74.53	74.66	74.74	74.79	74.91	74.90	74.82	74.72	74.58	74.50	74.57	74.69	74.50	74.91	0.41
1967	74.59	74.60	74.53	74.77	74.97	75.09	75.15	75.10	74.96	74.90	74.87	74.77	74.86	74.53	75.15	0.62
1968	74.67	74.69	74.70	74.90	74.90	75.02	75.08	74.98	74.86	74.66	74.53	74.60	74.80	74.53	75.08	0.55
1969	74.62	74.69	74.62	74.81	75.02	75.15	75.08	74.93	74.68	74.50	74.45	74.44	74.75	74.44	75.15	0.71
1970	74.42	74.44	74.46	74.69	74.89	74.94	74.99	74.90	74.74	74.64	74.56	74.56	74.69	74.42	74.99	0.57
1971	74.58	74.57	74.71	74.87	75.02	74.98	74.93	74.82	74.74	74.59	74.44	74.43	74.72	74.43	75.02	0.59
1972	74.54	74.63	74.73	74.95	75.21	75.26	75.34	75.25	75.02	74.78	74.71	74.80	74.94	74.54	75.34	0.80
1973	75.05	75.21	75.33	75.65	75.73	75.70	75.52	75.27	75.01	74.78	74.64	74.63	75.21	74.63	75.73	1.10
1974	74.83	75.02	75.10	75.29	75.50	75.59	75.50	75.25	74.96	74.68	74.53	74.54	75.07	74.53	75.59	1.06
1975	74.56	74.71	74.84	75.01	75.10	75.10	74.98	74.83	74.73	74.70	74.60	74.56	74.81	74.56	75.10	0.54
1976	74.62	74.71	75.07	75.37	75.54	75.54	75.42	75.22	75.00	74.83	74.67	74.54	75.04	74.54	75.54	1.00
1977	74.50	74.44	74.62	74.86	74.90	74.82	74.85	74.86	74.82	74.83	74.75	74.85	74.76	74.44	74.90	0.46
1978	75.08	75.12	74.98	75.22	75.32	75.23	75.04	74.89	74.73	74.58	74.44	74.42	74.92	74.42	75.32	0.90
1979	74.59	74.64	74.77	75.05	75.16	75.13	75.02	74.92	74.86	74.75	74.61	74.58	74.84	74.58	75.16	0.58
1980	74.60	74.61	74.60	74.99	75.14	75.13	75.12	75.06	74.88	74.66	74.55	74.54	74.82	74.54	75.14	0.60
1981	74.51	74.51	74.75	74.74	74.84	74.95	75.01	74.98	74.93	74.80	74.76	74.65	74.79	74.51	75.01	0.50
1982	74.59	74.60	74.62	74.91	75.00	75.07	75.03	74.85	74.71	74.58	74.53	74.54	74.75	74.53	75.07	0.54
1983	74.64	74.76	74.77	74.87	75.15	75.17	75.00	74.92	74.79	74.64	74.53	74.62	74.82	74.53	75.17	0.64
1984	74.73	74.76	74.90	75.12	75.30	75.32	75.21	75.02	74.82	74.63	74.52	74.49	74.90	74.49	75.32	0.83
1985	74.66	74.63	74.86	75.09	75.18	75.17	75.11	74.93	74.80	74.64	74.67	74.79	74.88	74.63	75.18	0.55
1986	74.90	74.98	75.06	75.29	75.29	75.34	75.33	75.25	75.11	75.16	75.04	75.02	75.15	74.90	75.34	0.44
1987	75.00	75.04	75.00	75.21	75.13	75.02	74.93	74.75	74.62	74.51	74.44	74.54	74.85	74.44	75.21	0.77
1988	74.53	74.59	74.59	74.75	74.88	74.92	74.86	74.80	74.68	74.56	74.54	74.46	74.68	74.46	74.92	0.46
1989	74.42	74.43	74.39	74.70	74.99	75.22	75.19	75.02	74.84	74.70	74.65	74.58	74.76	74.39	75.22	0.83
1990	74.54	74.62	74.77	74.98	75.11	75.14	75.01	74.87	74.70	74.64	74.62	74.65	74.80	74.54	75.14	0.60
1991	74.93	75.00	75.06	75.20	75.29	75.18	75.04	74.86	74.64	74.49	74.36	74.39	74.87	74.36	75.29	0.93
1992	74.44	74.45	74.56	74.84	75.11	75.05	75.00	75.03	74.98	74.85	74.82	74.86	74.83	74.44	75.11	0.67
1993	75.04	75.16	75.14	75.42	75.61	75.46	75.24	75.01	74.75	74.60	74.52	74.56	75.04	74.52	75.61	1.09
1994	74.55	74.52	74.55	74.87	75.10	75.08	75.02	74.93	74.78	74.62	74.54	74.50	74.76	74.50	75.10	0.60
1995	74.54	74.72	74.72	74.70	74.80	74.90	74.91	74.88	74.70	74.65	74.70	74.65	74.74	74.54	74.91	0.37
1996	74.62	74.75	74.77	74.82	75.13	75.23	75.15	74.99	74.83	74.74	74.72	74.73	74.87	74.62	75.23	0.61
1997	74.81	74.90	75.01	75.17	75.33	75.30	75.19	75.01	74.87	74.74	74.63	74.59	74.96	74.59	75.33	0.74
1998	74.82	75.06	75.15	75.42	75.35	75.18	75.14	74.93	74.73	74.51	74.34	74.29	74.91	74.29	75.42	1.13

1999	74.32	74.43	74.50	74.63	74.71	74.78	74.81	74.73	74.58	74.47	74.43	74.47	74.57	74.32	74.81	0.49
2000	74.50	74.45	74.58	74.82	75.10	75.26	75.24	75.06	74.81	74.61	74.46	74.47	74.78	74.45	75.26	0.81
2001	74.49	74.55	74.65	74.84	74.93	74.99	74.97	74.82	74.63	74.53	74.47	74.52	74.70	74.47	74.99	0.52
2002	74.56	74.68	74.79	74.98	75.22	75.33	75.19	74.91	74.65	74.49	74.36	74.32	74.79	74.32	75.33	1.01
2003	74.33	74.29	74.35	74.73	74.95	75.12	75.05	74.99	74.75	74.63	74.64	74.73	74.71	74.29	75.12	0.83
2004	74.83	74.75	74.72	74.89	75.04	75.14	75.09	75.02	74.95	74.70	74.50	74.55	74.85	74.50	75.14	0.64
2005	74.74	74.85	74.84	75.03	75.11	75.02	74.94	74.79	74.69	74.60	74.58	74.55	74.81	74.55	75.11	0.56
2006	74.63	74.86	74.82	74.83	74.84	74.89	74.98	74.95	74.81	74.74	74.79	74.83	74.83	74.63	74.98	0.35
2007	74.98	74.97	74.85	75.01	75.05	74.98	74.86	74.71	74.56	74.42	74.31	74.32	74.75	74.31	75.05	0.74
2008	74.56	74.75	74.87	75.18	75.30	75.19	75.12	75.06	74.81	74.60	74.51	74.55	74.88	74.51	75.30	0.79
2009	74.76	74.82	74.92	75.12	75.19	75.16	75.12	75.03	74.78	74.60	74.50	74.48	74.87	74.48	75.19	0.71
2010	74.51	74.54	74.55	74.66	74.71	74.85	74.97	74.90	74.72	74.61	74.50	74.52	74.67	74.50	74.97	0.47
2011	74.49	74.41	74.61	74.85	75.23	75.33	75.14	74.94	74.76	74.66	74.58	74.62	74.80	74.41	75.33	0.92
2012	74.80	74.99	74.97	74.92	74.91	74.90	74.79	74.65	74.50	74.34	74.29	74.28	74.70	74.28	74.99	0.71
2013	74.38	74.52	74.57	74.72	74.88	75.10	75.14	74.99	74.79	74.64	74.60	74.53	74.74	74.38	75.14	0.76

All-Time

Average	74.56	74.60	74.68	74.88	75.01	75.05	75.00	74.88	74.74	74.61	74.53	74.52	74.75	74.42	75.08	0.66
Minimum	73.81	73.78	73.94	74.03	74.11	74.19	74.14	74.00	73.91	73.82	73.75	73.74	74.00	73.74	74.24	0.22
Maximum	75.16	75.27	75.37	75.65	75.73	75.76	75.66	75.58	75.41	75.22	75.18	75.20	75.37	74.98	75.76	1.13

2004-2013

Average	74.67	74.75	74.77	74.92	75.03	75.06	75.02	74.90	74.74	74.59	74.52	74.52

Lake Ontario water levels in metres referred to Chart Datum

2013	0.18	0.32	0.37	0.52	0.68	0.90	0.94	0.79	0.59	0.44	0.40	0.33
All-Time												
Average	0.36	0.40	0.48	0.68	0.81	0.85	0.80	0.68	0.53	0.41	0.33	0.32
Minimum	-0.39	-0.42	-0.26	-0.17	-0.09	-0.01	-0.06	-0.20	-0.29	-0.38	-0.45	-0.46
Maximum	0.96	1.07	1.17	1.45	1.53	1.56	1.46	1.38	1.21	1.02	0.98	1.00

Date Modified: 2014-12-12

Appendix C:
Vegetation Community Classification
Field Data Sheets
&
Annotated List of Flora

Tuck Creek Flooding EA

ELC COMMUNITY DESCRIPTION & CLASSIFICATION

SITE: Tuck Creek, S. of Spruce Ave | POLYGON: 1

SURVEYOR(S): A. Baron | DATE: 1 Sept '15 | TIME: start / finish

UTMZ: 17 | UTME: 599890 | UTMN: 4799963

POLYGON DESCRIPTION

SYSTEM	SUBSTRATE	TOPOGRAPHIC FEATURE	HISTORY	PLANT FORM	COMMUNITY
(G) TERRESTRIAL	G ORGANIC	G LACUSTRINE	G NATURAL	G PLANKTON	G LAKE
G WETLAND	(G) MINERAL SOIL	G RIVERINE	(G) CULTURAL	G SUBMERGED	G POND
G AQUATIC	G PARENT MIN.	G BOTTOMLAND		G FLOATING-LVD.	G RIVER
	G ACIDIC BEDRK.	G TERRACE		G GRAMINOID	G STREAM
SITE	G BASIC BEDRK.	(G) VALLEY SLOPE	**COVER**	G FORB	G MARSH
G OPEN WATER	G CARB. BEDRK.	G TABLELAND	G OPEN	G LICHEN	G SWAMP
G SHALLOW WATER		G ROLL. UPLAND	G SHRUB	G BRYOPHYTE	G FEN
(G) SURFICIAL DEP.		G CLIFF	(G) TREED	(G) DECIDUOUS	G BOG
G BEDROCK		G TALUS		G CONIFEROUS	G BARREN
		G CREVICE / CAVE		G MIXED	G MEADOW
		G ALVAR			G PRAIRIE
		G ROCKLAND			G THICKET
		G BEACH / BAR			G SAVANNAH
		G SAND DUNE			(G) WOODLAND
		G BLUFF			(G) FOREST
					G PLANTATION

STAND DESCRIPTION:

	LAYER	HT	CVR	SPECIES IN ORDER OF DECREASING DOMINANCE (up to 4 sp) (>> MUCH GREATER THAN; > GREATER THAN; = ABOUT EQUAL TO)
1	CANOPY	3	3	JUGNIG.R > FRAPENN > ACENEGU
2	SUB-CANOPY	3	3	RHACATH > ACENEGU = FRAPENN = JUGNIGR
3	UNDERSTOREY	4	3	RHACATH > ACENEGU > FRAPENN
4	GRD. LAYER	5	3	RHACATH = GEUALEP > ACENEGU > ALIPET

HT CODES: 1 = >25 m 2 = 10<HT≤25 m 3 = 2<HT≤10 m 4 = 1<HT≤2 m 5 = 0.5<HT≤1 m 6 = 0.2<HT≤0.5 m 7 = HT<0.2 m

CVR CODES 0 = NONE 1 = 0% < CVR ≤ 10% 2 = 10 < CVR ≤ 25% 3 = 25 < CVR ≤ 60% 4 = CVR > 60%

STAND COMPOSITION: | BA:

	< 10	10 - 24	25 - 50	> 50
SIZE CLASS ANALYSIS:				
STANDING SNAGS:				
DEADFALL / LOGS:				

ABUNDANCE CODES: N = NONE R = RARE O = OCCASIONAL A = ABUNDANT

COMM. AGE	PIONEER	YOUNG	MID-AGE	MATURE	OLD GROWTH
		✓	✓		

SOIL ANALYSIS:

TEXTURE: SiC	DEPTH TO MOTTLES / GLEY	g = 47 cm	G= n/a
MOISTURE: 4 (mod. moist)	DEPTH OF ORGANICS:	0 (cm)	
~~HOMOGENEOUS~~ / VARIABLE	DEPTH TO BEDROCK:	>120 (cm)	

COMMUNITY CLASSIFICATION:

		ELC CODE
COMMUNITY CLASS:	Cultural	CU
COMMUNITY SERIES:	Cultural Woodland	CUW
ECOSITE:	Mineral Cultural Woodland	CUW1
VEGETATION TYPE:	n/a	n/a
X INCLUSION	Raspberry Cultural Thicket	CUT1-5
COMPLEX		

Notes: 1998 ELC codes used.

ELC STAND CHARACTERISTICS

SITE: Tuck Creek

POLYGON:

DATE:

SURVEYOR(S):

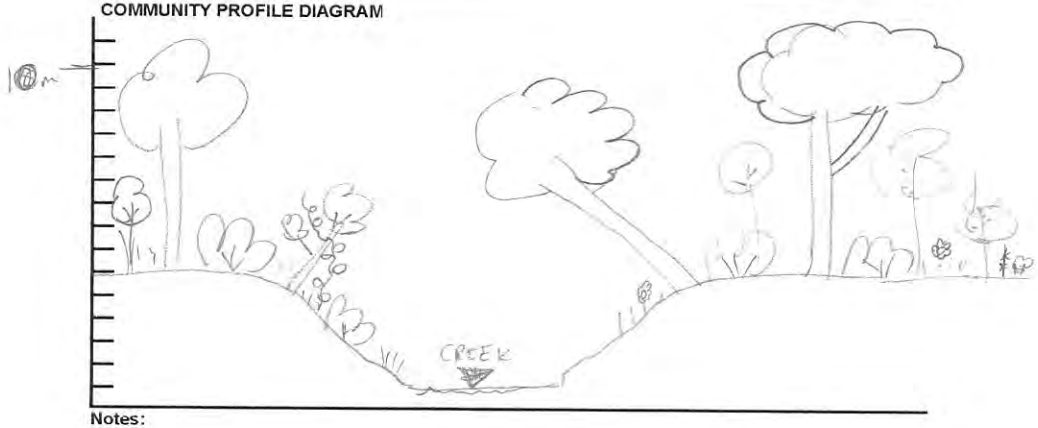
TREE TALLY BY SPECIES

PRISM FACTOR

SPECIES	TALLY 1	TALLY 2	TALLY 3	TALLY 4	TALLY 5	TOTAL	REL. AVG
TOTAL							100
BASAL AREA (BA)							
DEAD							

STAND COMPOSITION:

COMMUNITY PROFILE DIAGRAM



Notes:

ELC
SOILS ONTARIO

SITE: Tuck Creek
POLYGON: 1
DATE: 1 Sept 2015
SURVEYOR(S): A. Baron

	P/A	PP	Dr	Position	Aspect	Slope %	Type	Class	UTM Z	EASTING	NORTHING
1									17	599867	4799957
2											
3											
4											
5											

± 3.3m

SOIL	1	2	3	4	5
TEXTURE x HORIZON	A 0 — 120				
A TEXTURE	SiC				
COURSE FRAGMENTS	none				
B TEXTURE					
COURSE FRAGMENTS					
C TEXTURE					
COURSE FRAGMENTS					
EFFECTIVE TEXTURE	SiC				
SURFACE STONINESS	none				
SURFACE ROCKINESS	none				
DEPTH TO / OF					
MOTTLES	47cm				
GLEY	none				
BEDROCK	7120				
WATER TABLE	>120				
CARBONATES	4				
DEPTH OF ORGANICS	0				
PORE SIZE DISC #1					
PORE SIZE DISC #2					
MOISTURE REGIME	4 mod. moist				
SOIL SURVEY MAP					
LEGEND CLASS					

(DS4)
0600167
4799870
±3.0m
≈3cm DBH
(DS3)
≈16cm DBH
0600169
4799873
±3.7m
≈6cm DBH
0600168
4799873
±3.9m (DS2)
sprouting
(DS1)
0599987
4799920
±3.4m
approx 20cm DBH (sprouts)

→ White walnut 12 m to east in private yard

ELC
PLANT SPECIES LIST

SITE: Tuck Creek
POLYGON: 1
DATE: 1 Sept 2015
SURVEYOR(S): A. Baron

LAYERS: 1 = CANOPY 2 = SUB-CANOPY 3 = UNDERSTOREY 4 = GROUND (GRD.) LAYER
ABUNDANCE CODES: R = RARE O = OCCASIONAL A = ABUNDANT D = DOMINANT

SPECIES CODE	LAYER 1	2	3	4	COL.
TILCORD	O	O			
MORALBA	O	O	R		
QUEMACR	R				
JUGNIGR	D	A	O		
FRAPENN	A	A	O	O	
ACEPLAT	A	O		O	
tree of heaven	R				
PINSTRO	R				
SALALBA	O				
ACENEGU	A	A	A	A	
FRAEXEL			R		
ACESACC	R				
TILAMER	O	R			
PICABIE	R				
RUBODOR			R		
RHACATH		D	D	A	
trout lily			O		
CORSTOL			O		
SYRVULG		O			
LONTATA			O		
PRUPENN			O		
SALAMAL		R			
THUOCCI		R			
JUGCINE		R			X
Rose of Sharon			R		
CORALTE		R			
QUERUBR	O				
ULMAMER		R			
RUBIDID			O		
PARININ			A	O	
VITRIPA			O		
MAL PUMI			R		

SPECIES CODE	LAYER 1	2	3	4	COL.
GEUALEP				A	
ARCMINI				A	
ALIPETI				A	
DAUCARO				O	
CIRARVE				O	
SOLCANA				O	
MELALBA				O	
GENBIEN				R	
gill-over-ground				R	
HESMATR				O	
CAR-SP				R	
POAPRAT				A	
cocklebur				O	
DACGLOM				O	
TAROFFI				R	
URTDIOI				A	
PLAMAJO				O	
CONARVE				R	
nipplewort					
SOLDULC				O	
PHAARUN				R	
RANACRI				R	
ASTLAT				O	
goutweed				R	
POLLAPA				R	
ATRPATU				R	
VINMIND				O	
CIRLUTE				O	
AMBTRIF				R	
ROBPSEU	A	A			
CRAMACR		R			
PIL_SP (green seeds)					

ECHLOBA is 0 in Layer 3

Page ..... of .....

house to the west has a pool, a shed to the south
- cankers have healed, no sooties on leaves/some on branches, leaves just starting to yellow, dk brown pith/no notch or scar, [illegible]

ELC

MANAGEMENT / DISTURBANCE

SITE: Tuck Creek
POLYGON: 1
DATE: 1 Sept. 2015
SURVEYOR(S): A. Baron

DISTURBANCE / EXTENT	0	1	2	3	SCORE †
TIME SINCE LOGGING	> 30 YRS	15 - 30 YRS	5 - 15 YRS	0 - 5 YEARS	0
INTENSITY OF LOGGING	NONE	FUEL WOOD	SELECTIVE	DIAMETER LIMIT	0
EXTENT OF LOGGING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
SUGAR BUSH OPERATIONS	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF OPERATIONS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
GAPS IN FOREST CANOPY	NONE	SMALL	INTERMEDIATE	LARGE	2
EXTENT OF GAPS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
LIVESTOCK (GRAZING)	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF LIVESTOCK	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
ALIEN SPECIES	NONE	OCCASIONAL	ABUNDANT	DOMINANT	6
EXTENT OF ALIEN SPECIES	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
PLANTING (PLANTATION)	NONE	OCCASIONAL	ABUNDANT	DOMINANT	1
EXTENT OF PLANTING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
TRACKS AND TRAILS	NONE	FAINT TRAILS	WELL MARKED	TRACKS OR	2
EXTENT OF TRACKS/TRAILS	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
DUMPING (RUBBISH)	NONE	LIGHT	MODERATE	HEAVY	2
EXTENT OF DUMPING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
EARTH DISPLACEMENT	NONE	LIGHT	MODERATE	HEAVY	1
EXTENT OF DISPLACEMENT	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
RECREATIONAL USE	NONE	LIGHT	MODERATE	HEAVY	1
EXTENT OF RECR. USE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
NOISE	NONE	SLIGHT	MODERATE	INTENSE	2
EXTENT OF NOISE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
DISEASE/DEATH OF TREES	NONE	LIGHT	MODERATE	HEAVY	1
EXTENT OF DISEASE / DEATH	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
WIND THROW (BLOW DOWN)	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF WIND THROW	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
BROWSE (e.g. DEER)	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF BROWSE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
BEAVER ACTIVITY	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF BEAVER	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
FLOODING (pools & puddling)	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF FLOODING	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
FIRE	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF FIRE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
ICE DAMAGE	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT OF ICE DAMAGE	NONE	LOCAL	WIDESPREAD	EXTENSIVE	
OTHER	NONE	LIGHT	MODERATE	HEAVY	0
EXTENT	NONE	LOCAL	WIDESPREAD	EXTENSIVE	

† INTENSITY x EXTENT = SCORE

ELC

WILDLIFE

SITE: Tuck Creek
POLYGON: 1
DATE: 1 Sept 2015
SURVEYOR(S): A. Baron
START TIME: END TIME:

TEMP (°C): 22 | CLOUD (10th): 1 | WIND: 1 | PRECIPITATION: Ø

CONDITIONS:

POTENTIAL WILDLIFE HABITAT:

	VERNAL POOLS		SNAGS
	HIBERNACULA	X	FALLEN LOGS

SPECIES LIST:

TY	SP. CODE	EV	NOTES	#
B	AMRO	OB		2
B	chickadee	VO		2
M	Racoon	TK	in creek bed	1
M	G. Squirrel	OB		2
M	Beaver	OB	obs: by Anna and Carlos	2

TY	SP. CODE	EV	NOTES	#

FAUNAL TYPE CODES (TY):
B = BIRD M = MAMMAL H = HERPETOFAUNA L = LEPIDOPTERA F = FISH O = OTHER

EVIDENCE CODES (EV):

BREEDING BIRD - POSSIBLE:
SH = SUITABLE HABITAT SM = SINGING MALE

BREEDING BIRD - PROBABLE:
T = TERRITORY D = DISPLAY P = PAIR
A = ANXIETY BEHAVIOUR N = NEST BUILDING V = VISITING NEST

BREEDING BIRD - CONFIRMED:
DD = DISTRACTION NU = USED NEST FY = FLEDGED YOUNG
NE = EGGS NY = YOUNG FS = FOOD/FAECAL SACK
AE = NEST ENTRY

OTHER WILDLIFE EVIDENCE:
OB = OBSERVED VO = VOCALIZATION CA = CARCASS
DP = DISTINCTIVE PARTS HO = HOUSE/DEN FY = EGGS OR YOUNG
TK = TRACKS FE = FEEDING EVIDENCE SC = SCAT
SI = OTHER SIGNS (specify)

Family	Scientific Name	Common Name	CC[1]	CW[1]	Ranking					Introduced in Ontario 0=n 1=y
					COSEWIC[4]	COSSARO[5]	G-Rank[2]	S-Rank[3]	Halton Rare[6]	
ACERACEAE	Acer negundo	Manitoba Maple	0	-2			G5	S5		0
ACERACEAE	Acer platanoides	Norway Maple	0	5			G?	SE5		I
ACERACEAE	Acer saccharinum	Silver Maple	5	-3			G5	S5		0
APIACEAE	Aegopodium podagraria	Goutweed	0	0			G?	SE5		I
APIACEAE	Daucus carota	Wild Carrot	0	5			G?	SE5		I
APOCYNACEAE	Vinca minor	Periwinkle	0	5			G?	SE5		I
ASTERACEAE	Ambrosia trifida	Giant Ragweed	0	-1			G5	S5	HU	0
ASTERACEAE	Arctium minus ssp. minus	Common Burdock	0	5			G?	SE5		I
ASTERACEAE	Aster lateriflorus var. lateriflorus	One-sided Aster	3	-2			G5	S5		0
ASTERACEAE	Cirsium arvense	Canada Thistle	0	3			G?	SE5		I
ASTERACEAE	Lapsana communis	Nipplewort	0	5			G?	SE5		I
ASTERACEAE	Solidago canadensis var. canadensis	Canada Goldenrod	1	3			G5	S5		0
ASTERACEAE	Taraxacum officinale	Common Dandelion	0	3			G5	SE5		I
ASTERACEAE	Xanthium spinosum	Spiny Cocklebur	0	3			G?	SE2?		I
BRASSICACEAE	Alliaria petiolata	Garlic Mustard	0	0			G?	SE5		I
BRASSICACEAE	Hesperis matronalis	Dame's Rocket	0	5			G4G5	SE5		I
CAPRIFOLIACEAE	Lonicera tatarica	Tartarian Honeysuckle	0	3			G?	SE5		I
CHENOPODIACEAE	Atriplex patula	Spearscale	0	-2			G5	S5		0
CONVOLVULACEAE	Convolvulus arvensis	Field Bindweed	0	5			G?	SE5		I
CORNACEAE	Cornus alternifolia	Alternate-leaved Dogwood	6	5			G5	S5		0
CORNACEAE	Cornus stolonifera	Red-osier Dogwood	2	-3			G5	S5		0
CUCURBITACEAE	Echinocystis lobata	Wild Cucumber	3	-2			G5	S5		0
CUPRESSACEAE	Thuja occidentalis	Eastern White Cedar	4	-3			G5	S5		0
CYPERACEAE	Carex sp	Sedge Species								0

Family	Scientific Name	Common Name	CC[1]	CW[1]	Ranking					Introduced in Ontario 0=n 1=y
					COSEWIC[4]	COSSARO[5]	G-Rank[2]	S-Rank[3]	Halton Rare[6]	
FABACEAE	Melilotus alba	White Sweet-clover	0	3			G5	SE5		I
FABACEAE	Robinia pseudo-acacia	Black Locust	0	4			G5	SE5		I
FAGACEAE	Quercus macrocarpa	Bur Oak	5	1			G5	S5		0
FAGACEAE	Quercus rubra	Red Oak	6	3			G5	S5		0
HIBISCEAE	Hibiscus syriacus	Rose of Sharon								I
JUGLANDACEAE	Juglans cinerea	Butternut	6	2	END	END	G4	S4		0
JUGLANDACEAE	Juglans nigra	Black Walnut	5	3			G5	S4		0
LAMIACEAE	Glechoma hederacea	Ground Ivy	0	3			G?	SE5		I
LILIACEAE	Erythronium americanum ssp. americanum	Yellow Trout Lily	5	5			G5	S5		0
MORACEAE	Morus alba	White Mulberry	0	0			G?	SE5		I
OLEACEAE	Fraxinus excelsior	European Ash	0	5			G?	SE2		I
OLEACEAE	Fraxinus pennsylvanica	Red Ash	3	-3			G5	S5		0
OLEACEAE	Syringa vulgaris	Common Lilac	0	5			G?	SE5		I
ONAGRACEAE	Circaea lutetiana ssp. canadensis	Canada Enchanter's Nightshade	3	3			G5	S5		0
ONAGRACEAE	Oenothera biennis	Common Evening-primrose	0	3			G5	S5		0
PINACEAE	Picea abies	Norway Spruce	0	5			G?	SE3		I
PINACEAE	Pinus strobus	Eastern White Pine	4	3			G5	S5		0
PLANTAGINACEAE	Plantago major	Common Plantain	0	-1			G5	SE5		I
POACEAE	Dactylis glomerata	Orchard Grass	0	3			G?	SE5		I
POACEAE	Phalaris arundinacea	Reed Canary Grass	0	-4			G5	S5		0
POACEAE	Poa pratensis ssp. pratensis	Kentucky Blue Grass	0	1			G?	S5		0
POLYGONACEAE	Polygonum lapathifolium	Pale Smartweed	2	-4			G5	S5	HU	0
RANUNCULACEAE	Ranunculus acris	Tall Buttercup	0	-2			G5	SE5		I

Family	Scientific Name	Common Name	CC[1]	CW[1]	Ranking					Introduced in Ontario 0=n 1=y
					COSEWIC[4]	COSSARO[5]	G-Rank[2]	S-Rank[3]	Halton Rare[6]	
RHAMNACEAE	Rhamnus cathartica	Common Buckthorn	0	3			G?	SE5		I
ROSACEAE	Crataegus macracantha	Long-spined Hawthorn	4	5			G?	S5	HU	0
ROSACEAE	Geum aleppicum	Yellow Avens	2	-1			G5	S5		0
ROSACEAE	Malus pumila	Common Apple	0	5			G5	SE5		I
ROSACEAE	Prunus pensylvanica	Pin Cherry	3	4			G5	S5	HU	0
ROSACEAE	Rubus idaeus ssp. idaeus	Red Raspberry	0	5			G5	SE1		I
ROSACEAE	Rubus odoratus	Purple Flowering Raspberry	3	5			G5	S5		0
SALICACEAE	Salix alba	White Willow	0	-3			G5	SE4		I
SALICACEAE	Salix amygdaloides	Peach-leaved Willow	6	-3			G5	S5		0
SIMAROUBACEAE	Ailanthus altissima	Tree-of-heaven	0	5			G?	SE5		I
SOLANACEAE	Solanum dulcamara	Bittersweet Nightshade	0	0			G?	SE5		I
TILIACEAE	Tilia americana	Basswood	4	3			G5	S5		0
TILIACEAE	Tilia cordata	Litteleaf Linden						SE1		I
ULMACEAE	Ulmus americana	White Elm	3	-2			G5?	S5		0
URTICACEAE	Pilea sp	Clearweed Species								0
URTICACEAE	Urtica dioica ssp. dioica	European Stinging Nettle	0	-1			G5T?	SE2		I
VITACEAE	Parthenocissus inserta	Thicket Creeper	3	3			G5	S5		0
VITACEAE	Vitis riparia	Riverbank Grape	0	-2			G5	S5		0

Legend

[1]Coefficient of Conservatism and Coefficient of Wetness

CC = Coefficient of Conservatism. Rank of 0 to 10 based on plants degree of fidelity to a range of synecological parameters: (0-3) Taxa found in a variety of plant communities; (4-6) Taxa typically associated with a specific plant community but tolerate moderate disturbance; (7-8) Taxa associated with a plant community in an advanced successional stage that has undergone minor disturbance; (9-10) Taxa with a high fidelity to a narrow range of synecological parameters.

CW = Coefficient of Wetness. -Value between 5 and –5. A value of –5 is assigned to Obligate Wetland (OBL) and 5 to Obligate Upland (UPL), with intermediate values assigned to the remaining categories (Oldham et al., 1995).

[2]G-Rank (global)
Global ranks are assigned by a consensus of the network of Conservation Data Centres (CDCs), scientific experts, and the Nature Conservancy to designate a rarity rank based on the range-wide status of a species, subspecies, or variety.

G1 Extremely rare—usually 5 or fewer occurrences in the overall range or very few remaining individuals; or because of some factor(s) making it especially vulnerable to extinction.
G2 Very rare—usually between 5 and 20 occurrences in the overall range or with many individuals in fewer occurrences; or because of some factor(s) making it vulnerable to extinction.
G3 Rare to uncommon—usually between 20 and 100 occurrences; may have fewer occurrences, but with a large number of individuals in some populations; may be susceptible to large-scale disturbances.
G4 Common—usually more than 100 occurrences; usually not susceptible to immediate threats.
G5 Very common—demonstrably secure under present conditions.

[3]S-Ranks (provincial)
Provincial (or Subnational) ranks are used by the Natural Heritage Information Centre (NHIC) to set protection priorities for rare species and natural communities. These ranks are not legal designations. Provincial ranks are assigned in a manner similar to that described for global ranks, but consider only those factors within the political boundaries of Ontario.

S1 Critically Imperiled—Critically imperiled in the nation or state/province because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state/province.
S2 Imperiled—Imperiled in the nation or state/province because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the nation or state/province.
S3 Vulnerable—Vulnerable in the nation or state/province due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
S4 Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5 Secure—Common, widespread, and abundant in the nation or state/province.
S#S# Range Rank —A numeric range rank (e.g., S2S3) is used to indicate any range of uncertainty about the status of the species or community. Ranges cannot skip more than one rank (e.g., SU is used rather than S1S4).
SX Apparently extirpated from Ontario, with little likelihood of rediscovery. Typically not seen in the province for many decades, despite searches at known historic sites.
SE Exotic; not believed to be a native component of Ontario's flora.

[4]COSEWIC (Committee on the Status of Endangered Wildlife in Canada)
(federal status from COSEWIC April 2008)

EXT Extinct - A species that no longer exists.
EXP Extirpated - A species no longer existing in the wild in Canada, but occurring elsewhere.
END Endangered - A species facing imminent extirpation or extinction.
THR Threatened - A species likely to become endangered if limiting factors are not reversed.

SC Special Concern (formerly vulnerable) - A species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
NAR Not At Risk - A species that has been evaluated and found to be not at risk of extinction given the current circumstances.
DD Data Deficient (formerly Indeterminate) - Available information is insufficient to resolve a species' eligibility for assessment or to permit an assessment of the species' risk of extinction.
* - Species on Schedule 1 of Species At Risk Act (SARA)

[5]OMNRF (Ontario Ministry of Natural Resources and Forestry)
(*provincial status from MNRF June 2008)*
The provincial review process is implemented by the MNRF's Committee on the Status of Species at Risk in Ontario (COSSARO).

EXT Extinct—A species that no longer exists anywhere.
EXP Extirpated—A species that no longer exists in the wild in Ontario but still occurs elsewhere.
END Endangered - A species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's Endangered Species Act (ESA).
THR Threatened—A species that is at risk of becoming endangered in Ontario if limiting factors are not reversed.
SC Special Concern (formerly Vulnerable) —A species with characteristics that make it sensitive to human activities or natural events.
NAR Not at Risk—A species that has been evaluated and found to be not at risk.
DD Data Deficient (formerly Indeterminate) —A species for which there is insufficient information for a provincial status recommendation.

[6] Regional Status –
from Halton Natural Areas Inventory 2006 (Dwyer 2006).
Codes are defined as follows:
HR – Rare in Halton (5 or fewer sites)
HU – Uncommon in Halton (6-15 sites)
HC – Common in Halton
Dwyer, J. 2006. Halton Natural Areas Inventory 2006. Halton-North Peel Naturalists' Club, Halton, ON.

Appendix D:
MNRF Correspondence

Ministry of
Natural Resources
and Forestry
Aurora District Office
50 Bloomington Road
Aurora, Ontario L4G 0L8

Ministère des
Richesses naturelles
et des Forets

Telephone: (905) 713-7400
Facsimile: (905) 713-7361

Ontario

September 10, 2015

Ash Baron, B.E.S., C.E.E.R.
Ecology Lead
Botanist, ISA Certified Arborist
Aquafor Beech Ltd.
55 Regal Road, Unit 3
Guelph, Ontario
Email: baron.a@aquaforbeech.com

RE: Tuck Creek Flood Study, City of Burlington

Dear Ms. Baron,

The Ministry of Natural Resources and Forestry (MNRF) understands that you are requesting species at risk information for the above-noted project. MNRF provides the following information in response to your request:

The Species at Risk in Ontario (SARO) List (http://www.ontario.ca/environment-and-energy/species-risk-ontario-list) is Ontario Regulation 230/08 issued under the *Endangered Species Act*, *2007* (ESA). The ESA came into force on June 30, 2008, and provides both species protection (section 9) and habitat protection (section 10) to species listed as endangered or threatened on the SARO List. The current SARO List can be found on e-laws (http://www.e-laws.gov.on.ca/navigation?file=home&lang=en).

An initial species at risk (SAR) screening has been completed for the above-noted project. There are known occurrences of SAR in the general project area, including:

- **CHIMNEY SWIFT (Threatened),** with general habitat protection

The following species listed below have the potential to occur on or adjacent to the project area and therefore further assessment or field studies may be required to determine their presence:

- **BANK SWALLOW (Threatened),** with general habitat protection
- **BARN SWALLOW (Threatened),** with general habitat protection
- **BUTTERNUT (Endangered),** with general habitat protection
- **LITTLE BROWN MYOTIS (Endangered)**, with general habitat protection
- **NORTHERN MYOTIS (Endangered),** with general habitat protection
- **EASTERN SMALL-FOOTED MYOTIS (Endangered),** with general habitat protection

Endangered and threatened species receive protection under the ESA and therefore, an approval from MNRF may be required if the work you are proposing could cause harm to these species and/or their habitats.

Please note that this is an initial screening for SAR and the absence of information provided by MNRF for a given geographic area, or lack of current information for a given area or element, does not categorically mean the absence of sensitive species or features. Many areas in Ontario have never been surveyed and new plant and animal species records are still being discovered for many localities. For these reasons, MNRF cannot provide a definitive statement on the presence, absence or condition of biological elements in any part of Ontario. Field assessments by a qualified professional may be necessary if there is a high likelihood for SAR species and/or habitat to occur within the project footprint.

It is important to also note the following:

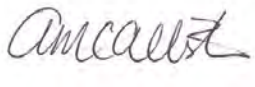
- Changes may occur in both species and habitat protection which could affect whether proposed projects may have adverse effects on SAR.
- The Committee on the Status of Species at Risk in Ontario (COSSARO) meets regularly to evaluate new species for listing and/or re-evaluate species already on the SARO List. As a result, species designations may change, which could in turn change the level of protection they receive under the ESA.
- Habitat protection provisions for a species may change if a species-specific habitat regulation comes into effect.

This species at risk information contained in this letter is highly sensitive and is not intended for any person or project unrelated to this undertaking. Please do not include any specific information in reports that will be available for public record. As you complete your fieldwork in these areas, please report all information related to any species at risk to our office. This will assist with updating our database and facilitate early consultation regarding your project.

Please be advised that it is your responsibility to be aware of and comply with all relevant federal or provincial legislation, municipal by-laws or other agency approvals.

If you have any questions or comments, please do not hesitate to contact me at aurora.mcallister@ontario.ca.

Sincerely,



Aurora McAllister
Management Biologist, Aurora District
Ministry of Natural Resources and Forestry

Anna Howes

From: McAllister, Aurora (MNRF) <Aurora.McAllister@ontario.ca>
Sent: November-25-15 12:08 PM
To: Anna Howes
Cc: Elisa Bernier; Leah Chishimba; Ash Baron; ESA Guelph (MNRF)
Subject: RE: Butternuts on Tuck Creek

Hi Anna,

- Butternut Health Assessments do not have to be conducted at the EA stage. It's likely better to wait until detailed design (closer to when they will potentially be removed or impacted) and go out again to identify any potential saplings/regen. The Butternut Health Assessments and any required genetic testing for possible hybrids can be undertaken at that time.
- MNRF has recently updated its approach to general habitat for Butternut. MNRF considers the general habitat of Butternut to include suitable areas within a 50 metre radius centred on the trunk or stem of each Butternut. This area is intended to protect the critical root zone of individual trees, immediate habitat conditions surrounding the tree that support the growth and persistence of the tree over its lifetime (25m) and the surrounding habitat conditions and the core seedling establishment areas up to 50m from a parent tree. Therefore, impacts to the habitat of this species will need to be considered at the detailed design stage. Depending on the significance of the impact, an authorization under the Endangered Species Act (ESA) may be required in order to proceed.
- Please note that the current exemption for 10 or fewer Butternut trees under subsection 23.7 of O.Reg/242 does not apply to an archivable Butternut (also known as a Catergory 3 tree). An authorization under the ESA would be required to harm or kill a Catergory 3 tree.

Please note that the Species at Risk in Ontario (SARO) List may be amended, and additional species may be listed and protected under the ESA or the status and protection levels of currently listed species may change. MNRF should be therefore be contacted again at the detailed design stage.

Regards,

AURORA McALLISTER | MANAGEMENT BIOLOGIST | ONTARIO MINISTRY of NATURAL RESOURCES and FORESTRY | AURORA DISTRICT OFFICE
50 Bloomington Road, Aurora, Ontario, L4G 0L8 | Email: aurora.mcallister@ontario.ca

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From: Anna Howes [mailto:howes.a@aquaforbeech.com]
Sent: 6-Nov-15 4:25 PM
To: McAllister, Aurora (MNRF)
Cc: Elisa Bernier; Leah Chishimba; Ash Baron
Subject: Butternuts on Tuck Creek

Hello Aurora

I am working with Conservation Halton and the City of Burlington on a flood control EA on a reach of Tuck Creek located between a hydro ROW (north of New Street) and Spruce Avenue. We previously conducted an erosion EA (2012) in this area and know there are Butternut trees within the creek corridor downstream of Regal road. These trees have been surveyed, but they have not been assessed by a BHA for retention or hybrid status since no creek works were to be undertaken in this area for the erosion EA. This new flood control EA was started this fall and the aggressive timeline is

such that the EA would be completed in January 2016. Accordingly, the project timeline precludes a BHA. However, the EA will recommend that butternuts be assessed by a BHA at the detailed design stage. If necessary, the IGF will be completed at that stage as well.

I understand from conversations with Elisa Bernier from Conservation Halton (CH) that this project will be on the agenda for your next monthly meeting. In advance of that meeting, I have provided you with a map showing the butternut locations, their canopy spread, and the 25 m radius from the bole of each tree. The UTM coordinates are as follows:

- For butternut B1, UTM coordinate are 599665.868 m east, 4800153.948 m north, zone 17N. This mature tree has exposed roots and is located on an eroding bank. This tree will likely be affected under the proposed option for the flood EA. We would note that due to ongoing erosion, the tree will eventually fall into the creek if left as is.

- Butternut B2, noted as being 60-70 cm in height in the 2012 erosion EA report, no longer exists. As noted in the report, this tree was located on the east bank where undercutting of the bank was resulting in exposed tree roots. The tree was likely lost due to bank erosion.

- For butternut B3, UTM coordinates are 599647.232 m east, 4800066.711 m north, zone 17N. This mature tree is in a residential back yard and will not be impacted by the proposed option.

One of the options under the EA includes widening of the creek channel to 11 m to control flooding. The widening will involve tree removals in the creek corridor and may affect Butternut B1 and be within 25 m of Butternut B3.

In advance of your meeting with CH in December, I would greatly appreciate your feedback. I have copied Elisa on this email. Could you please provide direction as to what should be done about the Butternut trees at this stage in the project? Any recommendations and requirements for this and future stages of the project would also be appreciated. Thanks

Anna

Anna Howes, M.Sc., P.Eng.
Water Resources Engineer

Aquafor Beech Ltd.
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howes.a@aquaforbeech.com

Appendix E:
Tree Inventory



Figure E1: Trees between New Street and the Hydro ROW

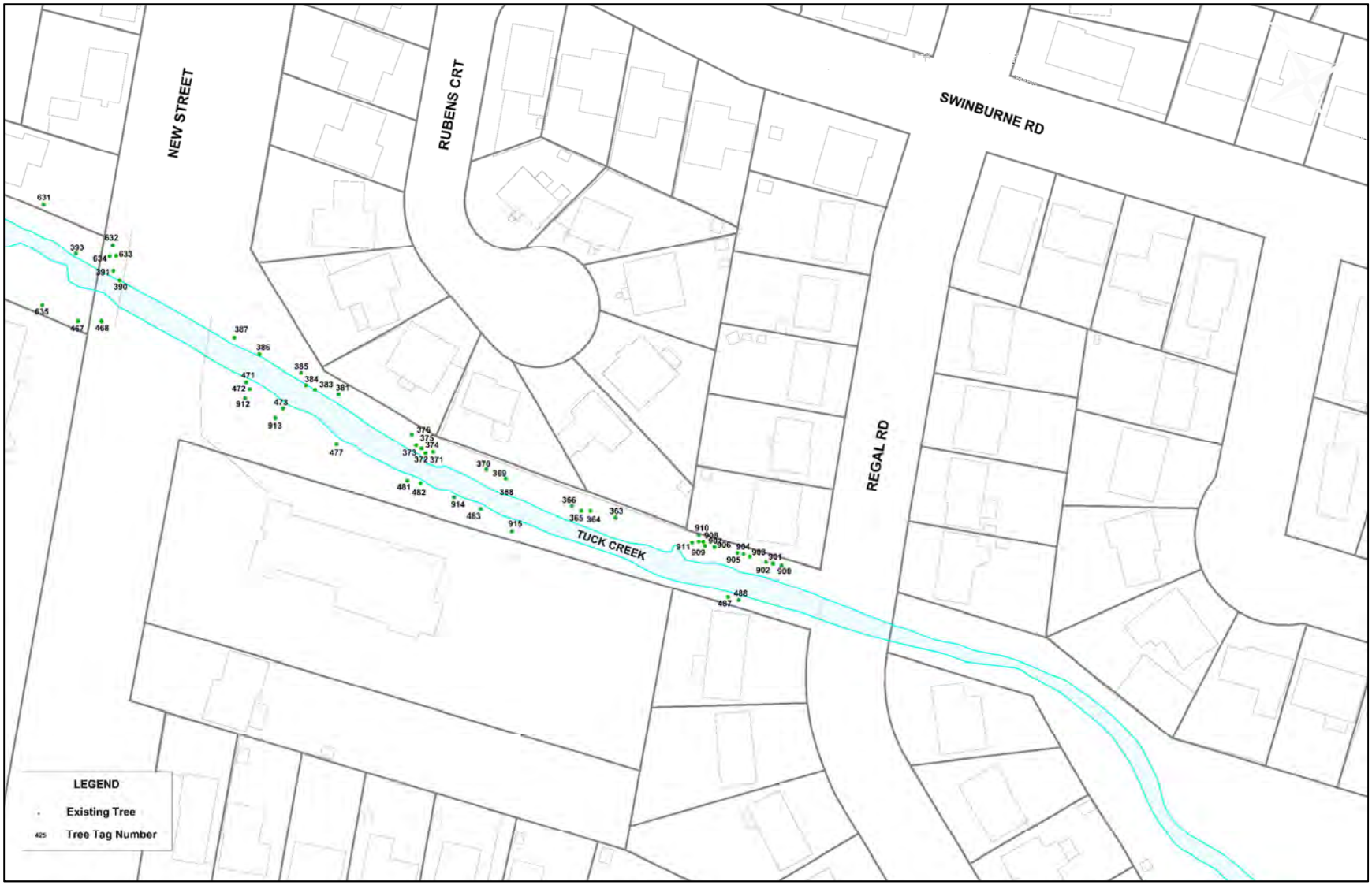


Figure E2: Trees between Regal Road and New Street

Table E1: Tree Inventory

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
363	Manitoba Maple	*Acer negundo*	22,24
364	Manitoba Maple	*Acer negundo*	22,12,19
365	Manitoba Maple	*Acer negundo*	34,25,25
366	Manitoba Maple	*Acer negundo*	33,27,17,16,24
368	Bebb Willow	*Salix bebbiana*	26
369	Bebb Willow	*Salix bebbiana*	34
370	Red Ash	*Fraxinus pennsylvanica*	14,10
371	Red Ash	*Fraxinus pennsylvanica*	18
372	Manitoba Maple	*Acer negundo*	35
373	Manitoba Maple	*Acer negundo*	26
374	Manitoba Maple	*Acer negundo*	26
375	Manitoba Maple	*Acer negundo*	26
376	White Mulberry	*Morus alba*	15,11
381	Manitoba Maple	*Acer negundo*	36,43
382	Red Ash	*Fraxinus pennsylvanica*	26
383	Red Ash	*Fraxinus pennsylvanica*	15
384	Manitoba Maple	*Acer negundo*	19,14,22
385	Manitoba Maple	*Acer negundo*	26,36,24,14,20,35
386	Red Ash	*Fraxinus pennsylvanica*	16
387	Manitoba Maple	*Acer negundo*	33,28,28,28
390	Manitoba Maple	*Acer negundo*	21,12,11
391	Silver Maple	*Acer saccharinum*	20,40,17,16,10
393	Weeping Willow	*Salix babylonica*	36,35,17
400	Black Walnut	*Juglans nigra*	26
401	Manitoba Maple	*Acer negundo*	32
402	Manitoba Maple	*Acer negundo*	24
404	Manitoba Maple	*Acer negundo*	37
405	Manitoba Maple	*Acer negundo*	23,15,11
406	Manitoba Maple	*Acer negundo*	29,12
407	Manitoba Maple	*Acer negundo*	31
408	Manitoba Maple	*Acer negundo*	24
409	Crack Willow	*Salix fragilis*	76
410	Manitoba Maple	*Acer negundo*	28
411	Manitoba Maple	*Acer negundo*	39
414	Manitoba Maple	*Acer negundo*	44
419	Manitoba Maple	*Acer negundo*	43
422	Red Ash	*Fraxinus pennsylvanica*	24

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
423	Manitoba Maple	*Acer negundo*	33,61
424	Eastern Cottonwood	*Populus deltoides*	86
425	Manitoba Maple	*Acer negundo*	67
427	Crack Willow	*Salix fragilis*	63
428	Crack Willow	*Salix fragilis*	52
430	Norway Maple	*Acer platanoides*	75
431	Black Walnut	*Juglans nigra*	12
432	Red Ash	*Fraxinus pennsylvanica*	15
433	White Ash	*Fraxinus americana*	54
436	Crack Willow	*Salix fragilis*	19,29,21,24,25,55,11,12
437	Red Ash	*Fraxinus pennsylvanica*	10,20
440	Black Walnut	*Juglans nigra*	39
442	Norway Maple	*Acer platanoides*	27
444	Silver Maple	*Acer saccharinum*	28
445	Red Ash	*Fraxinus pennsylvanica*	18
447	Red Ash	*Fraxinus pennsylvanica*	44,35,32
449	White Ash	*Fraxinus americana*	22
450	Red Ash	*Fraxinus pennsylvanica*	31
451	Red Ash	*Fraxinus pennsylvanica*	30
452	Red Ash	*Fraxinus pennsylvanica*	35
453	White Ash	*Fraxinus americana*	18
456	Crack Willow	*Salix fragilis*	80
457	Manitoba Maple	*Acer negundo*	50
458	Manitoba Maple	*Acer negundo*	55
459	Manitoba Maple	*Acer negundo*	45
461	Manitoba Maple	*Acer negundo*	52
463	Manitoba Maple	*Acer negundo*	28,13
467	Silver Maple	*Acer saccharinum*	40,36,47
468	Silver Maple	*Acer saccharinum*	47,37,22,22,22
471	White Elm	*Ulmus americana*	16
472	White Elm	*Ulmus americana*	21
473	Red Ash	*Fraxinus pennsylvanica*	24
477	Manitoba Maple	*Acer negundo*	37,26
481	Manitoba Maple	*Acer negundo*	18,20
482	Manitoba Maple	*Acer negundo*	20,16,21,22
483	Manitoba Maple	*Acer negundo*	21,22,23
487	Manitoba Maple	*Acer negundo*	55
488	Manitoba Maple	*Acer negundo*	27

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
595	Black Walnut	*Juglans nigra*	14
596	Black Walnut	*Juglans nigra*	11
597	Black Walnut	*Juglans nigra*	24
598	Black Walnut	*Juglans nigra*	19
599	Black Walnut	*Juglans nigra*	23
600	Red Ash	*Fraxinus pennsylvanica*	22,13
601	Manitoba Maple	*Acer negundo*	15,15
602	Apple sp.	*Malus spp.*	10,10,10,7
603	Red Ash	*Fraxinus pennsylvanica*	11,12
604	White Ash	*Fraxinus americana*	13
605	Black Walnut	*Juglans nigra*	17
606	Red Ash	*Fraxinus pennsylvanica*	16,16
607	White Mulberry	*Morus alba*	14,13
608	Red Ash	*Fraxinus pennsylvanica*	10,9,8,5,5
609	Black Walnut	*Juglans nigra*	15
610	Manitoba Maple	*Acer negundo*	10
611	Red Ash	*Fraxinus pennsylvanica*	24,23
612	Manitoba Maple	*Acer negundo*	10,15,9
613	Red Ash	*Fraxinus pennsylvanica*	10,10
614	Manitoba Maple	*Acer negundo*	11
615	Norway Maple	*Acer platanoides*	46
616	White Mulberry	*Morus alba*	13
617	Norway Maple	*Acer platanoides*	15
618	White Mulberry	*Morus alba*	12,19
619	Norway Maple	*Acer platanoides*	17
620 (429)	Norway Maple	*Acer platanoides*	22,36
621	Manitoba Maple	*Acer negundo*	24
622 (426)	Manitoba Maple	*Acer negundo*	24,30,12
623	Horsechestnut	*Aesculus hippocastanum*	14
624	White Spruce	*Picea glauca*	20
625	Manitoba Maple	*Acer negundo*	19
626	Manitoba Maple	*Acer negundo*	14
627	Manitoba Maple	*Acer negundo*	17
628	Red Ash	*Fraxinus pennsylvanica*	48
629	Manitoba Maple	*Acer negundo*	20
630	Manitoba Maple	*Acer negundo*	21,21

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
631	Crack Willow	*Salix fragilis*	71
632	Horsechestnut	*Aesculus hippocastanum*	11
633	White Elm	*Ulmus americana*	10,9,8,5,5
634	Manitoba Maple	*Acer negundo*	21
635	Silver Maple	*Acer saccharinum*	55,40,30,26,35
636	Silver Maple	*Acer saccharinum*	31,33,41,38,29
637	Silver Maple	*Acer saccharinum*	39,28
638	White Mulberry	*Morus alba*	11
639	Silver Maple	*Acer saccharinum*	48
640	White Mulberry	*Morus alba*	14
641	Bur Oak	*Quercus macrocarpa*	45
642	Basswood	*Tilia americana*	8,6,9,13
643 (464)	White Elm	*Ulmus americana*	24
644 (462)	Manitoba Maple	*Acer negundo*	56
645 (460)	Manitoba Maple	*Acer negundo*	61,38
646	Norway Maple	*Acer platanoides*	14
647	Manitoba Maple	*Acer negundo*	14
648	Manitoba Maple	*Acer negundo*	65
649	Manitoba Maple	*Acer negundo*	54
650	Red Ash	*Fraxinus pennsylvanica*	43
651	Red Ash	*Fraxinus pennsylvanica*	43
652	Norway Maple	*Acer platanoides*	12
653	White Elm	*Ulmus americana*	12
654	White Ash	*Fraxinus americana*	15
655	White Ash	*Fraxinus americana*	22
656	Red Ash	*Fraxinus pennsylvanica*	34,21,38
657	Sugar Maple	*Acer saccharum*	17
658	White Elm	*Ulmus americana*	15
659	Red Ash	*Fraxinus pennsylvanica*	37
660	Red Ash	*Fraxinus pennsylvanica*	36
661	Red Ash	*Fraxinus pennsylvanica*	22
662	Red Ash	*Fraxinus pennsylvanica*	34
663	White Elm	*Ulmus americana*	14
664	Red Ash	*Fraxinus pennsylvanica*	23,15
665	Manitoba Maple	*Acer negundo*	14,14

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
666 (448)	Black Walnut	*Juglans nigra*	92
667	Red Ash	*Fraxinus pennsylvanica*	28
668	Red Ash	*Fraxinus pennsylvanica*	45,17
669	Norway Maple	*Acer platanoides*	10
670	Red Ash	*Fraxinus pennsylvanica*	23,11
671	Manitoba Maple	*Acer negundo*	10
672	Manitoba Maple	*Acer negundo*	23
673	Red Ash	*Fraxinus pennsylvanica*	29
674	White Elm	*Ulmus americana*	17,10
675	Norway Maple	*Acer platanoides*	11
676	Red Ash	*Fraxinus pennsylvanica*	25
677	Red Ash	*Fraxinus pennsylvanica*	36
678	Red Ash	*Fraxinus pennsylvanica*	23
679	Red Ash	*Fraxinus pennsylvanica*	31
680	Red Ash	*Fraxinus pennsylvanica*	23
681	Red Ash	*Fraxinus pennsylvanica*	33,24,34,33
682	Red Ash	*Fraxinus pennsylvanica*	31
683	Red Ash	*Fraxinus pennsylvanica*	15
684	Red Ash	*Fraxinus pennsylvanica*	60
685	Red Ash	*Fraxinus pennsylvanica*	14
686	Norway Maple	*Acer platanoides*	12
687	Red Ash	*Fraxinus pennsylvanica*	31,39
688	Red Ash	*Fraxinus pennsylvanica*	34,11
689	Norway Maple	*Acer platanoides*	11
690	Norway Maple	*Acer platanoides*	11
691	Norway Maple	*Acer platanoides*	11
692	Red Ash	*Fraxinus pennsylvanica*	32
693	Red Ash	*Fraxinus pennsylvanica*	26
694	Norway Maple	*Acer platanoides*	13
695	Norway Maple	*Acer platanoides*	12
696	Red Ash	*Fraxinus pennsylvanica*	29
697	Red Ash	*Fraxinus pennsylvanica*	20
698	White Elm	*Ulmus americana*	17
699	Red Ash	*Fraxinus pennsylvanica*	24
700	Basswood	*Tilia americana*	8,8,13
701	Black Walnut	*Juglans nigra*	48
702	Norway Maple	*Acer platanoides*	11

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
703	Manitoba Maple	*Acer negundo*	25
704	Norway Maple	*Acer platanoides*	11
705	Norway Maple	*Acer platanoides*	11,10
706	Red Ash	*Fraxinus pennsylvanica*	23
707	Red Ash	*Fraxinus pennsylvanica*	28
708	White Ash	*Fraxinus americana*	31
709	Black Walnut	*Juglans nigra*	48
710	Red Ash	*Fraxinus pennsylvanica*	20
711	Red Ash	*Fraxinus pennsylvanica*	31
712	Norway Maple	*Acer platanoides*	11
713	Norway Maple	*Acer platanoides*	11
714	Red Ash	*Fraxinus pennsylvanica*	28
715	Red Ash	*Fraxinus pennsylvanica*	26
716	Red Ash	*Fraxinus pennsylvanica*	30
717	Manitoba Maple	*Acer negundo*	13
718	Norway Maple	*Acer platanoides*	13
719	Norway Maple	*Acer platanoides*	15
720 (446)	Silver Maple	*Acer saccharinum*	61
721	White Ash	*Fraxinus americana*	17
722	Norway Maple	*Acer platanoides*	12
723	Red Ash	*Fraxinus pennsylvanica*	43
724	Manitoba Maple	*Acer negundo*	12
725	Manitoba Maple	*Acer negundo*	12
726	Crack Willow	*Salix fragilis*	48
727	Crack Willow	*Salix fragilis*	105
728	Red Ash	*Fraxinus pennsylvanica*	11
729	Red Ash	*Fraxinus pennsylvanica*	13
730	Manitoba Maple	*Acer negundo*	34,34
731	Norway Maple	*Acer platanoides*	10,13
732	Apple sp.	*Malus spp.*	44
733	Norway Maple	*Acer platanoides*	41
734	White Ash	*Fraxinus americana*	22
735	Norway Maple	*Acer platanoides*	20
736	Norway Maple	*Acer platanoides*	13,11,14
737	Norway Maple	*Acer platanoides*	11,14
738	Norway Maple	*Acer platanoides*	46
739	White Ash	*Fraxinus americana*	56

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
740	White Ash	*Fraxinus americana*	14
741	Red Ash	*Fraxinus pennsylvanica*	15
742	Manitoba Maple	*Acer negundo*	14
743	Red Ash	*Fraxinus pennsylvanica*	42
744	Manitoba Maple	*Acer negundo*	15,8
745	Red Ash	*Fraxinus pennsylvanica*	28,18
746	Manitoba Maple	*Acer negundo*	54
747	Manitoba Maple	*Acer negundo*	10
748	White Ash	*Fraxinus americana*	28
749	White Ash	*Fraxinus americana*	21
750	White Ash	*Fraxinus americana*	40
751	Apple sp.	*Malus spp.*	15
752	Hawthorn Sp.	*Crataegus spp.*	13
753	Manitoba Maple	*Acer negundo*	11
754	Black Walnut	*Juglans nigra*	20
755	Red Ash	*Fraxinus pennsylvanica*	12
756	Red Ash	*Fraxinus pennsylvanica*	10
757	Red Ash	*Fraxinus pennsylvanica*	10,10
758	Black Walnut	*Juglans nigra*	20
759	White Ash	*Fraxinus americana*	15,10,6
760	Red Ash	*Fraxinus pennsylvanica*	12,15,7
761	Red Ash	*Fraxinus pennsylvanica*	14,15
762	Red Ash	*Fraxinus pennsylvanica*	10,13,12
763	Silver Maple	*Acer saccharinum*	10
764	Red Ash	*Fraxinus pennsylvanica*	14
765	Silver Maple	*Acer saccharinum*	15
766	Silver Maple	*Acer saccharinum*	12
767	Red Ash	*Fraxinus pennsylvanica*	23
768	Red Ash	*Fraxinus pennsylvanica*	13,10,13
769	Silver Maple	*Acer saccharinum*	12
900	Spruce	*Picea glauca*	<15
901	Spruce	*Picea glauca*	<15
902	Spruce	*Picea glauca*	<15
903	Spruce	*Picea glauca*	<15
904	Spruce	*Picea glauca*	<15
905	Spruce	*Picea glauca*	<15
906	Spruce	*Picea glauca*	<15
907	Spruce	*Picea glauca*	<15

Tag #	Species Common Name	Speices Botanical Name	DBH (cm)
908	Spruce	*Picea glauca*	<15
909	Spruce	*Picea glauca*	<15
911	Spruce	*Picea glauca*	<15
912	Manitoba Maple	*Acer negundo*	21
913	Manitoba Maple	*Acer negundo*	20
914	Black Walnut	*Juglans nigra*	16
915	Norway Maple	*Acer planatoides*	15

Appendix F:
Fish Collection Record Details

Fish Collection Record Details

Station	Location	Easting	Northing	Common Name	Scientific Name	Date		
						19-Oct-02	01-Oct-03	28-Sep-04
TUK-2	Downstream of Harvester road just west of Walkers Line	598434.310	4801655.160	White sucker	Catostomus commersoni		32	78
				Blacknose dace	Rhinichthys atratulus	68	116	101
				Creek chub	Semotilus atromaculatus	69	58	28
				Common shiner	Luxilus cornutus		1	
				Fathead minnow	Pimephales promelas		1	
				Carps and minnows	Cyprinidae			

						15-Jul-08	2010	2012
TUK-5	Upstream of Lakeshore Road just east of Lakeview Avenue	600176.280	4799858.600	Longnose dace	Rhinichthys cataractae	1		
				Blacknose dace	Rhinichthys atratulus	1		
				Fathead minnow	Pimephales promelas	1	1	
				Common shiner	Luxilus cornutus	3		
				White sucker	Catostomus commersoni	13	27	7
				Carps and minnows	Cyprinidae	1		
				Creek chub	Semotilus atromaculatus	10		
				Mottled sculpin	Cottus bairdi			
				Pumpkinseed	Lepomis gibbosus			
				Bluegill	Lepomis macrochirus			
				Rainbow trout	Oncorhynchus mykiss		1	9
				Bluntnose minnow	Pimephales notatus			
				Brook Stickleback	Culaea inconstans			1
				Threespine Stickleback	Gasterosteus aculeatus		1	

						17-Apr-01	27-Jul-01
TUK-1	Downstream of Lakeshore Road between Lakeview Road and Walkers Line	600236.280	4799842.600	White sucker	Catostomus commersoni	6	4
				Fathead minnow	Pimephales promelas		2
				Blacknose dace	Rhinichthys atratulus		2
				Longnose dace	Rhinichthys cataractae		9
				Creek chub	Semotilus atromaculatus		18

Data Source Information from Conservation Halton

Station	Date	Collectors	Source	Data format	Comments
TUK-2	03-May-91	A. Timmerman (OMNR)	OMNR	Handwritten note	
TUK-2	01-Oct-03	G. Coker, J. Reid	OMNR	Copied data sheets	
TUK-2	19-Oct-02	G. Coker, C. Portt	OMNR	Photocopied FCR	
TUK-2	28-Sep-04	G. Coker, J. Reid	OMNR	Photocopied FCR	
TUK-1	27-Jul-01	D. Featherstone	Conservation Halton	Field sheets	
TUK-1	17-Apr-01	M. Colavecchia, G. Fodor	OMNR	Field sheets	Collected milt and eggs, fish released
TUK-5	15-Jul-08	R. Martens, S. Hogg, K. Rundle, L. Stephenson	Conservation Halton	Field Sheets	Channelized
TUK-5	10-Sep-98	D. Featherstone, T. Giangregorio	Conservation Halton	Field sheets	

Appendix G:
Public Information Centre Material



Welcome to the Public Information Centre for the Municipal Class Environmental Assessment:

Flood Assessment and Crossing Upgrades between New Street and Spruce Avenue

View displays and discuss the study with project staff

Feel free to ask questions and fill out a comment sheet

CITY OF Burlington

Aquafor Beech Limited

Background

August 4, 2014 Storm

Heavy rainfall during the afternoon and evening of August 4, 2014 caused significant flooding in the City of Burlington. Lands within the Tuck Creek, Shoreacres Creek, Roseland Creek, and Appleby Creek watersheds were hardest hit.

Summary of Storm

- 190 mm of rain
- Road and highway flooding and closures
- 3,000+ homes flooded
- Debris build up in creeks

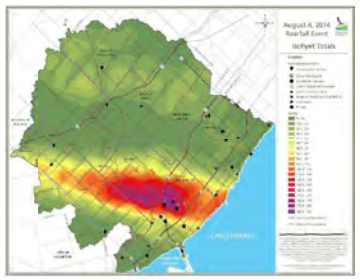
Impacts within Tuck Creek Watershed

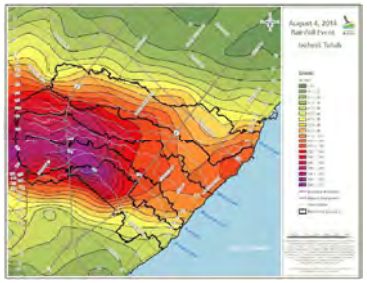
- Approximately 65 buildings reported flooding
- 13 culverts overtopped including New Street, Regal Road, and Spruce Avenue

Following the flood, the City undertook an assessment and analysis of its storm water management system. Findings of this study identified 75 riverine flood-vulnerable areas and 132 flood-vulnerable roads. Flood mitigation opportunities were identified on Tuck Creek between New Street and Regal Road.

The study findings led the City to undertake the current Municipal Class Environmental Assessment for flooding and crossing upgrades from the Hydro right-of-way north of New Street to Lake Ontario.

Rainfall Totals from August 4, 2015





Source: Conservation Halton and Environmental Water Resources Group Ltd. (2015) August 4th, 2014 Storm Event, Burlington


Tuck Creek

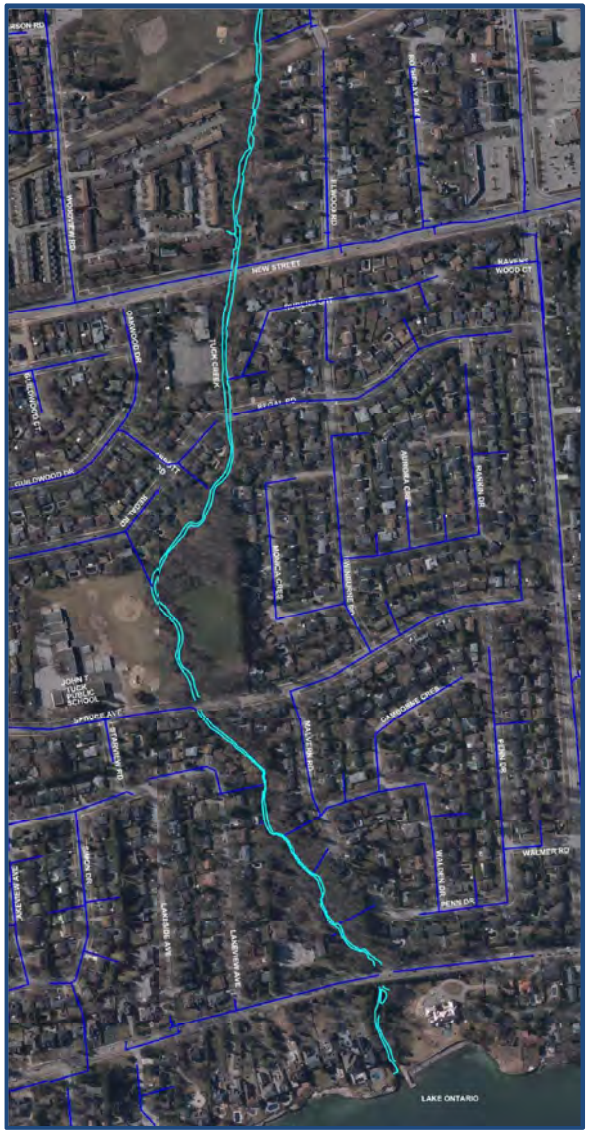

407 south of Dundas Street


Tuck Creek upstream of Regal Road

Problem Identification

Study Area

The study area for the current flood EA extends from the Hydro right-of-way north of New Street to Lake Ontario.



Problems in the Study Area

Flooding/Channel Capacity

Number of buildings in the floodplain

- Regional storm – 99+
- 100 year storm – 56+

As water is predicted to spill from the channel onto the roads for these events, the exact number of houses within the floodplain is not known.

Building flooding reported from the August 4, 2014 storm

- New Street and Elwood Road – 11 residences
- Rubens Court and Swinburne Road – 20 residences
- Regal Road and Abbott Road – 28 residences

Bridge Capacity

Under currently available modeling, bridge overtopping is as follows

- New Street – 10 year storm
- Regal Road – 10 year storm
- Spruce Avenue – 25 year storm
- Lakeshore Road – Regional storm

Bridge overtopping during the August 4, 2014 storm

- New Street
- Regal Road
- Spruce Avenue

Opportunities

All or some of the following opportunities exist to reduce flooding in the study area:

- Increase bridge capacity
- Increase channel capacity
- Reduce flow entering the watercourse

The 3 alternatives explored as part of this EA addressed the first 2 opportunities. These are opportunities that exist within the study area. The third opportunity extends throughout the watershed. It may be addressed subsequently.


Tuck Creek at Elwood Drive

Existing Conditions - Flooding



Tuck Creek – Aug 4, 2014

Tuck Creek at Elwood Drive
Aug 4, 2014

Existing Conditions – Environmental Constraints



Environmental Constraints within the Study Area

Butternut trees

- Two (2) of these trees were identified in the study area and are protected under the *Endangered Species Act*, administered by the Ministry of Natural Resources and Forestry.

Woodlands

- The Tuck Creek corridor consists of a Key Feature in Halton's Regional Natural Heritage System. Mature trees would be impacted by alterations to the channel.

Property ownership

- Residential development abuts the creek corridor and may be impacted by alterations to the channel. Downstream of the Hydro ROW, the creek traverses private property.

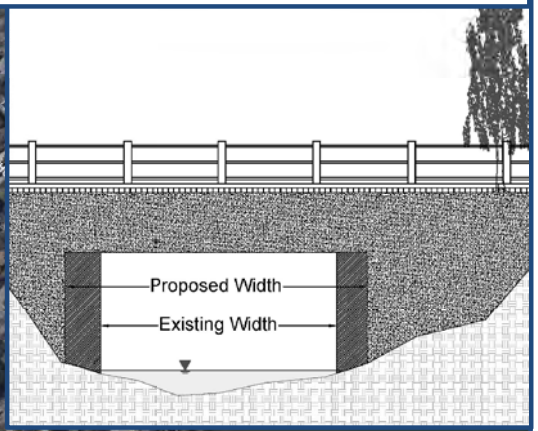
Alternative 1

Bridge Upgrades

This alternative modeled bridge widening at New Street, Regal Road, and Spruce Avenue within the existing road right-of-way and creek corridor.

Number of buildings in floodplain

- Regional storm – 99+ (no reduction)
- 100 year storm – 44+ (21% reduction)



Regional Floodplain

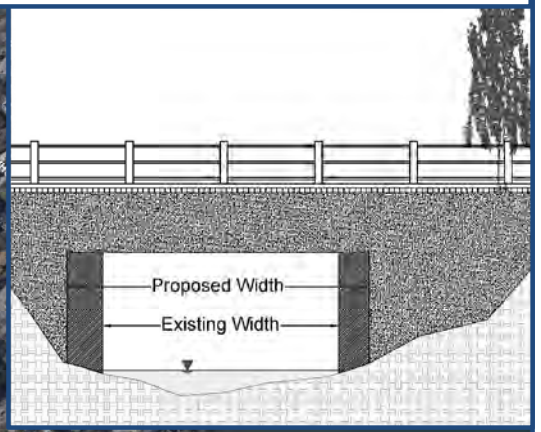
Alternative 1

Bridge Upgrades

This alternative modeled bridge widening at New Street, Regal Road, and Spruce Avenue within the existing road right-of-way and creek corridor.

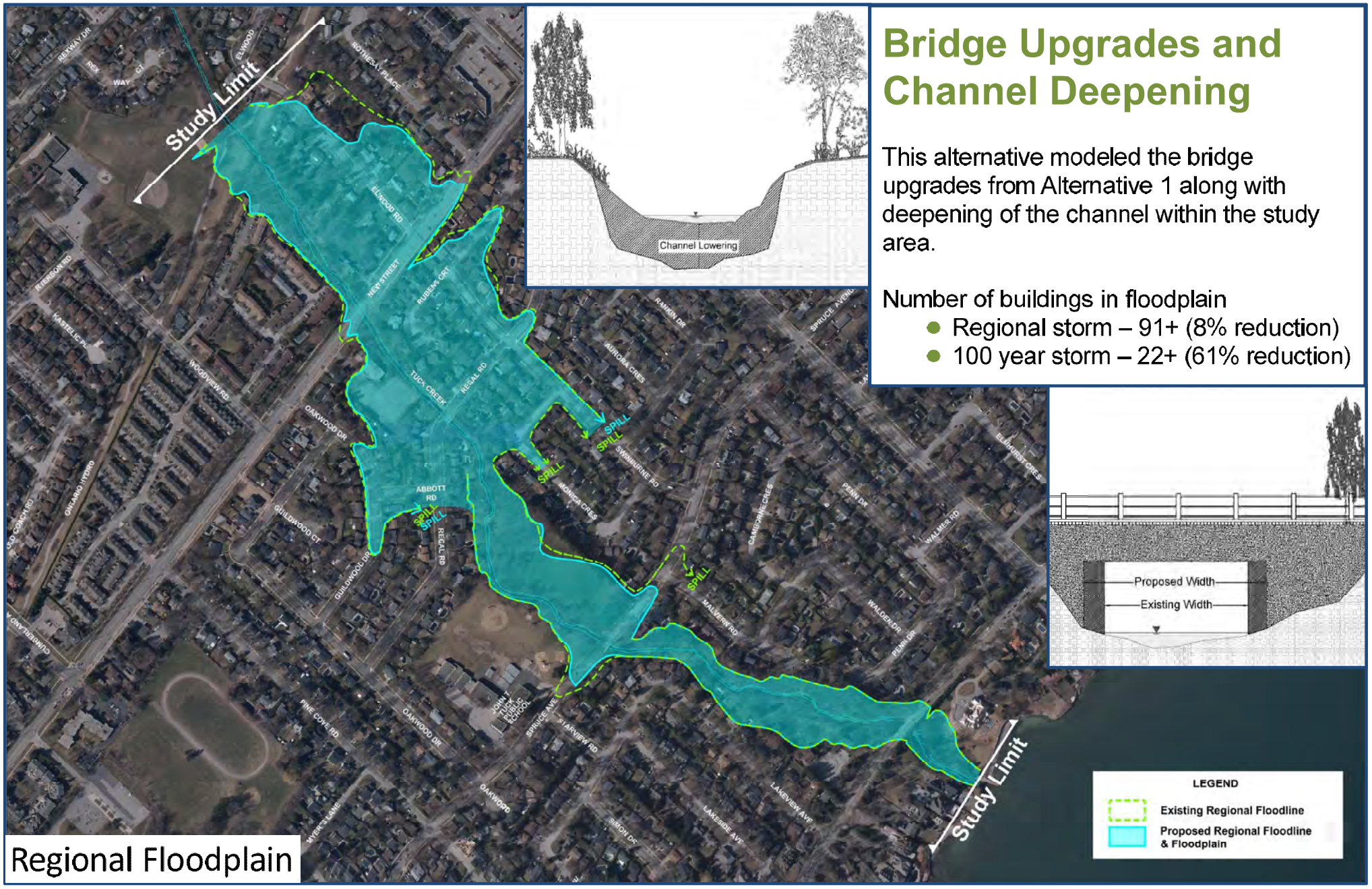
Number of buildings in floodplain

- Regional storm – 99+ (no reduction)
- 100 year storm – 44+ (21% reduction)



100-Year Floodplain

Alternative 2



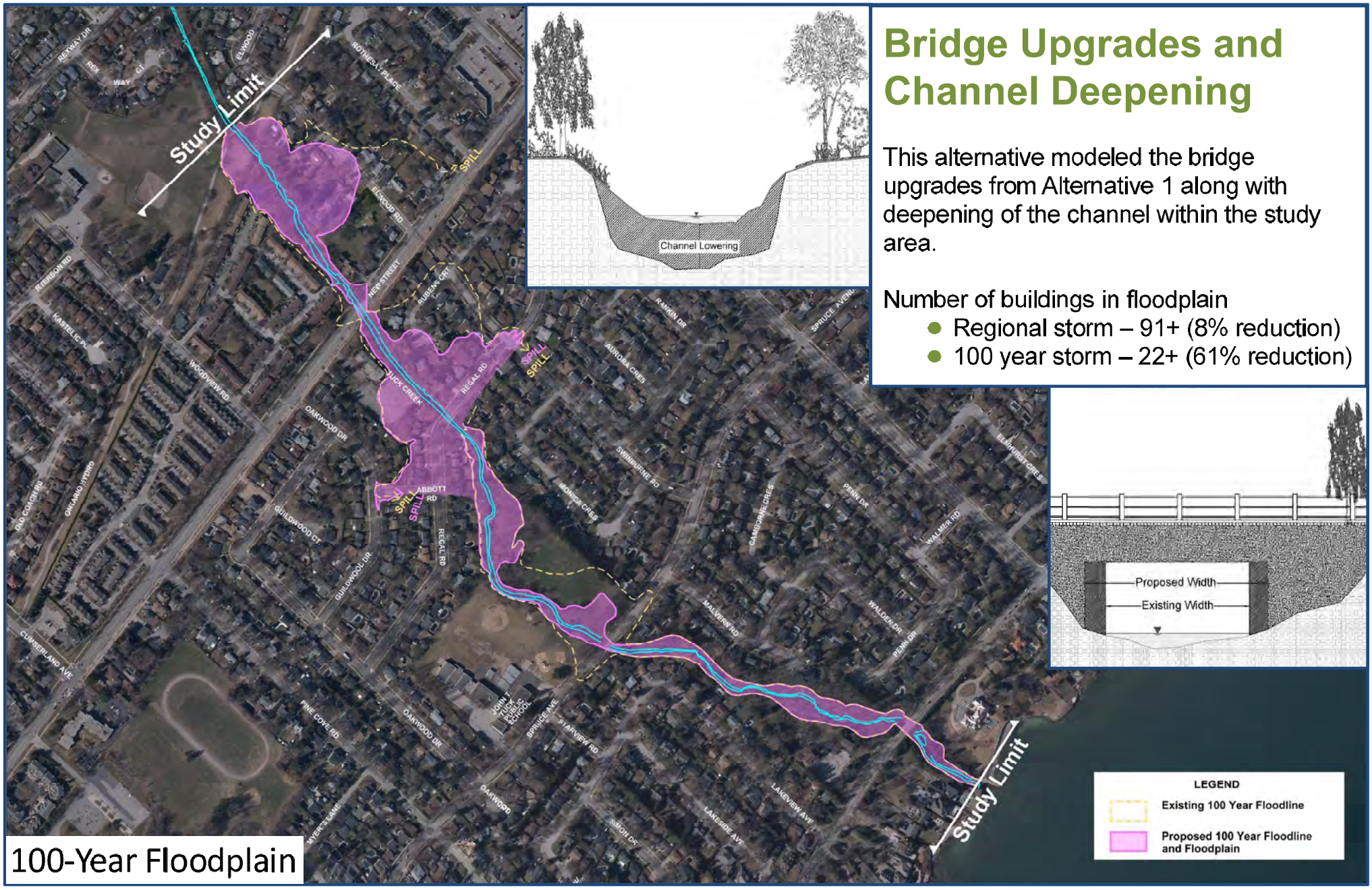
Bridge Upgrades and Channel Deepening

This alternative modeled the bridge upgrades from Alternative 1 along with deepening of the channel within the study area.

Number of buildings in floodplain

- Regional storm – 91+ (8% reduction)
- 100 year storm – 22+ (61% reduction)

Alternative 2



Bridge Upgrades and Channel Deepening

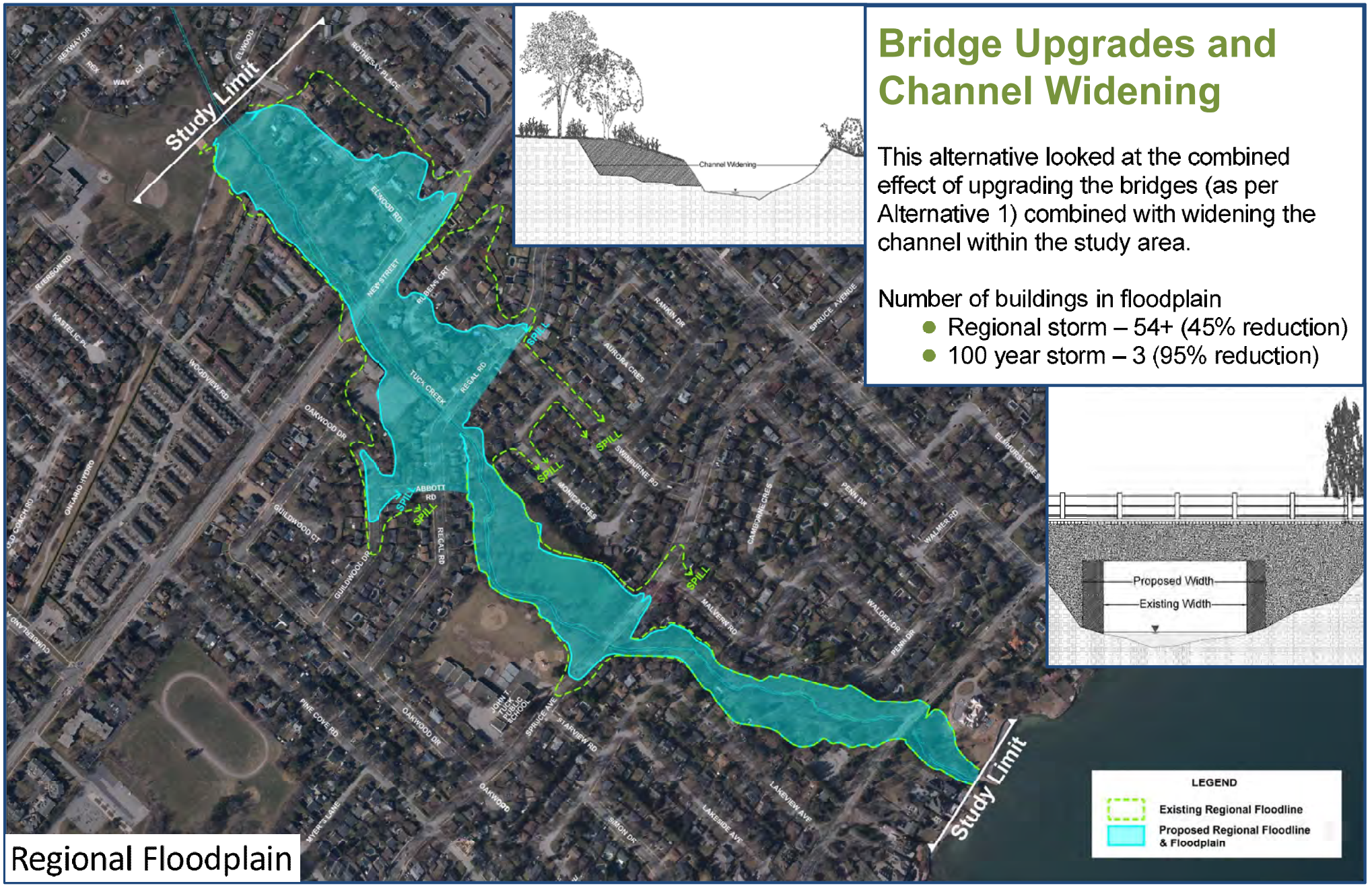
This alternative modeled the bridge upgrades from Alternative 1 along with deepening of the channel within the study area.

Number of buildings in floodplain

- Regional storm – 91+ (8% reduction)
- 100 year storm – 22+ (61% reduction)

100-Year Floodplain

Alternative 3



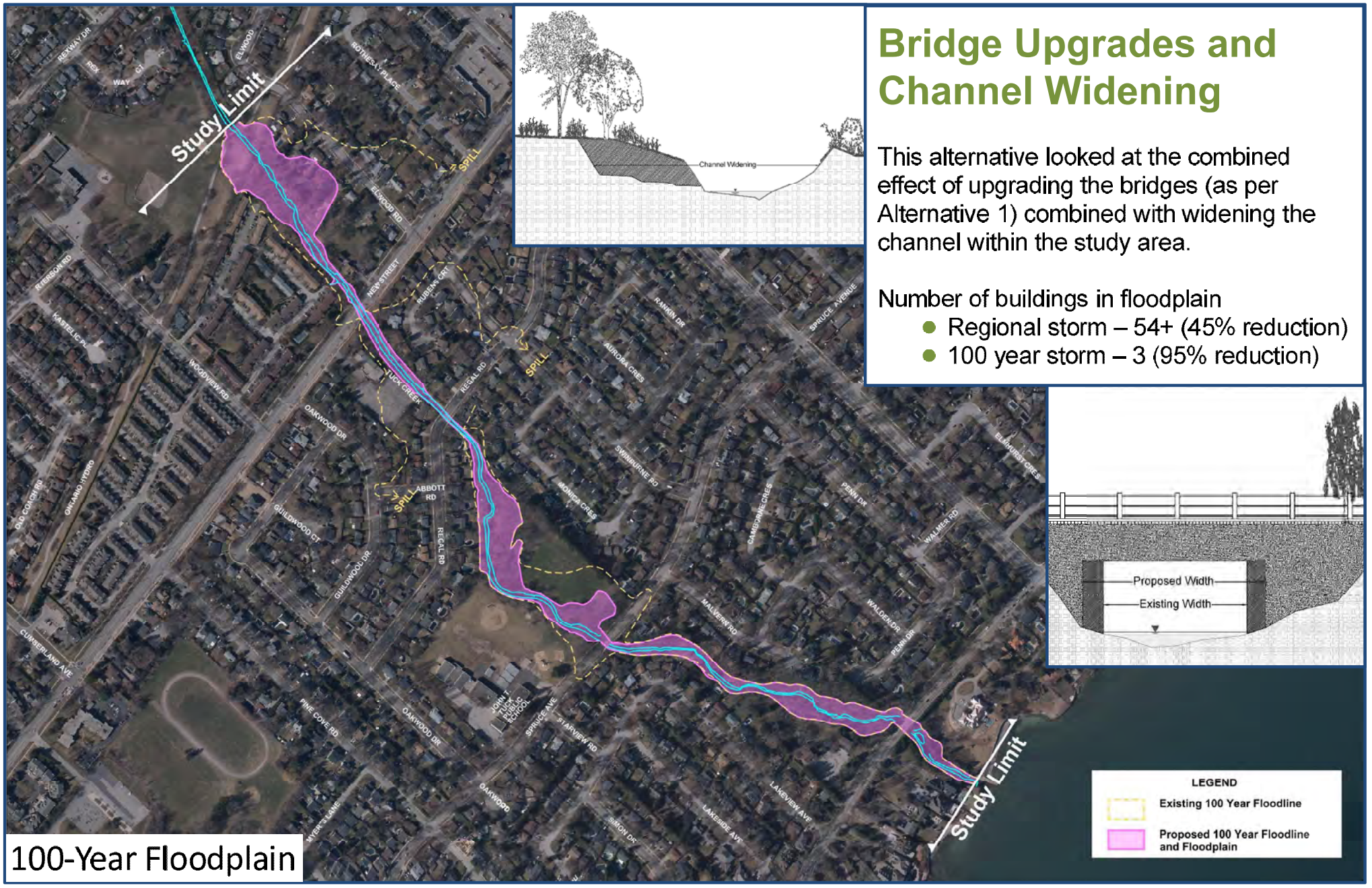
Bridge Upgrades and Channel Widening

This alternative looked at the combined effect of upgrading the bridges (as per Alternative 1) combined with widening the channel within the study area.

Number of buildings in floodplain

- Regional storm – 54+ (45% reduction)
- 100 year storm – 3 (95% reduction)

Alternative 3



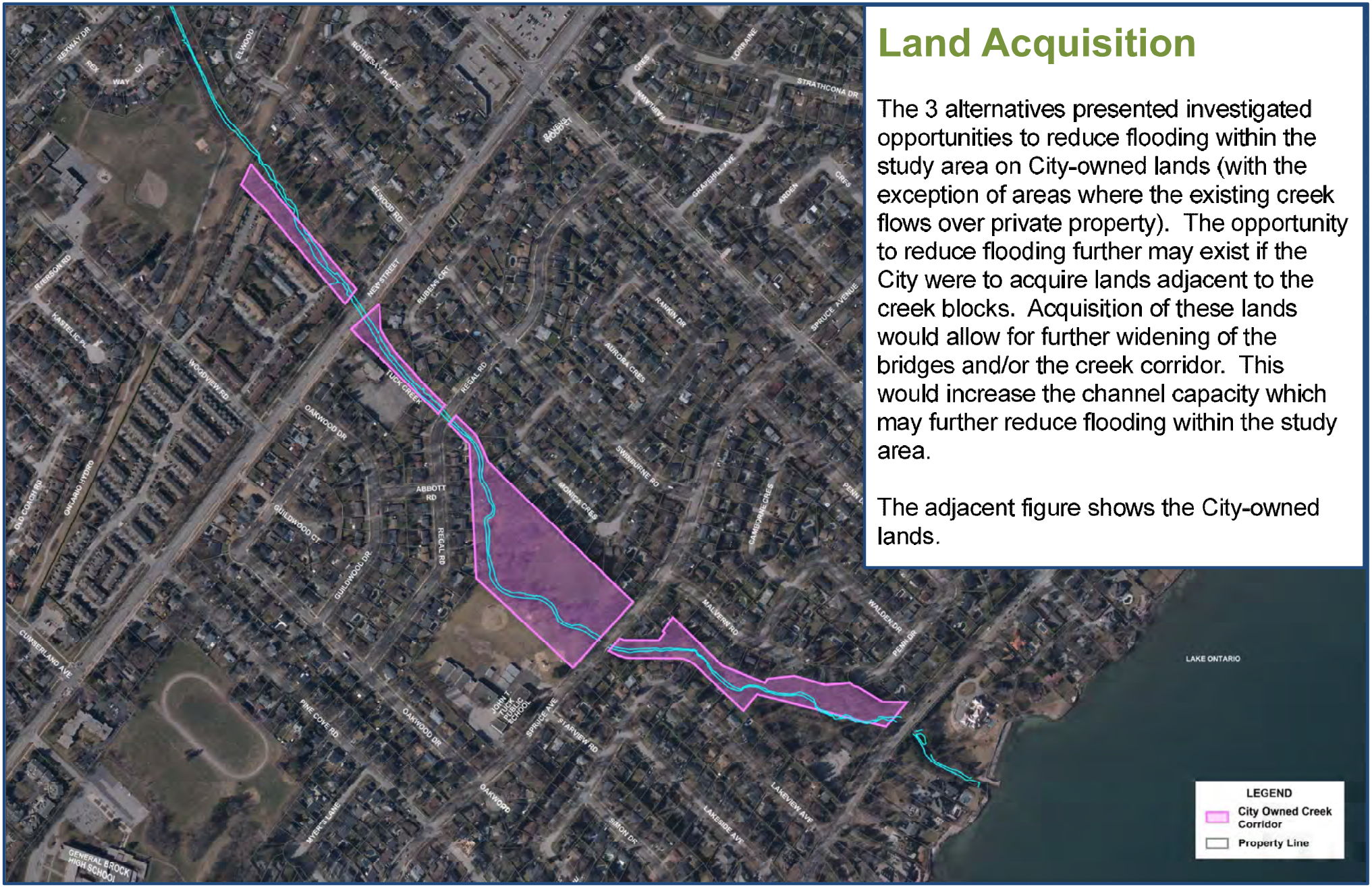
Bridge Upgrades and Channel Widening

This alternative looked at the combined effect of upgrading the bridges (as per Alternative 1) combined with widening the channel within the study area.

Number of buildings in floodplain

- Regional storm – 54+ (45% reduction)
- 100 year storm – 3 (95% reduction)

Land Acquisition



Land Acquisition

The 3 alternatives presented investigated opportunities to reduce flooding within the study area on City-owned lands (with the exception of areas where the existing creek flows over private property). The opportunity to reduce flooding further may exist if the City were to acquire lands adjacent to the creek blocks. Acquisition of these lands would allow for further widening of the bridges and/or the creek corridor. This would increase the channel capacity which may further reduce flooding within the study area.

The adjacent figure shows the City-owned lands.

Preliminary Evaluation

Evaluation Criteria	Do Nothing	Alternative 1	Alternative 2	Alternative 3	Land Acquisition
Natural Environment • Terrestrial Habitat • Aquatic Habitat	• Continued loss of trees through bank erosion and Emerald Ash Borer • Rip rap remaining in fish habitat	• Minor additional loss of trees at bridge work sites • Compensation with native tree plantings • Rip rap remaining in fish habitat	• Minor additional loss of trees at bridge work sites and along existing creek corridor • Compensation with native tree plantings • Increasing creek entrenchment will degrade fish habitat	• Minor additional loss of trees at bridge work sites • Significant loss of trees in creek corridor upstream of New Street and downstream of Regal Road • Compensation with native tree plantings • Opportunity to replace ash trees succumbing to the Emerald Ash Borer • Opportunity for low flow channel to promote fish passage	• Additional loss of trees for increased bridge and/or channel capacity • Compensation with native tree plantings • Opportunity to replace ash trees succumbing to the Emerald Ash Borer • Opportunity for low flow channel to promote fish passage
Economic • Construction Costs • Operation & Maintenance (O&M) Costs • Flood damage	• No construction cost • Highest O&M costs • Highest potential flood damages costs	• Lowest construction costs • Mid-range O&M costs • Higher-end potential flood damages costs	• Higher-end construction costs • Mid-range O&M costs • Higher-end potential flood damages costs	• Higher-end construction costs • Mid-range O&M costs • Lower-end potential flood damages costs	• Highest construction costs • Lowest O&M costs • Lowest potential flood damages costs
Social/Cultural • Effect on Flooding • Aesthetics • Community Disruption	• No reduction in flooding • Mature trees maintained unless at risk from erosion or Emerald Ash Borer • Disruption during O&M activities	• Least potential reduction in flooding • Mature trees maintained in creek corridor unless at risk from erosion or Emerald Ash Borer • Disruption during bridge replacements • Disruption during future erosion restoration works	• Low potential reduction in flooding • Some loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor but no subsequent erosion works	• High potential reduction in flooding • Loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor but no subsequent erosion works	• Greatest potential reduction in flooding • Loss of mature trees but opportunity for replacement as well as replacement of ash succumbing to Emerald Ash Borer • Disruption during works throughout corridor but no subsequent erosion works
Technical • Feasibility • Implementation Time	• Low feasibility as it does not address flooding • No time required to implement	• High feasibility since works would be within City-owned lands • Bridges can be upgraded one at a time	• Low feasibility as further incising channel can lead to erosion issues • Works can be implemented in phases	• Higher feasibility since works would be within City-owned lands • Works can be implemented in phases	• Lower feasibility since works would occur on lands not currently owned by City • Time required to acquire land • Works can be implemented in phases
Preliminary Overall Rank					

Most Preferred  Least Preferred

Additional Considerations

Non-Traditional Alternatives

The 3 alternatives presented explored the opportunities to increase channel and bridge capacity. As can be seen on the floodline mapping presented, these alternatives reduce but do not eliminate flooding within the study area. An additional opportunity exists to reduce flow entering the creek. Alternatives to achieve this goal include the following:

- Upstream storage
- In-channel storage
- Conveyance control measures
- Source control measures
- Relief storm sewer

These alternatives can be considered in a subsequent study. In concert with the increases to channel and bridge capacities, these non-traditional alternatives can be used to further reduce the risk of flooding within the study area.

Conveyance Control Measures

- These measures are implemented within the municipal right-of-way and include bioretention units or perforated pipes. The measures encourage infiltration or evapotranspiration thereby reducing runoff and peak flows.

Source Control Measures

- These measures are implemented on private property and include roof downspout disconnection, rain barrels, pervious driveways, and rain gardens. The measures encourage infiltration or evapotranspiration thereby reducing runoff and peak flows.

Upstream Storage

- Storage within parks or vacant properties upstream of the study area could be used to reduce peak flows in Tuck Creek.

In-Channel Storage

- In upstream drainage areas where Tuck Creek is contained in a valley, storage in the channel could be used to reduce peak flows.











Next Steps

Thank you for your participation!

After tonight's meeting, the study team will undertake the following steps:

- Gather your comments
- Review your feedback
- Finalize the alternative ranking
- Complete the EA document
- Prepare a notice of completion
- Have the EA document available for review

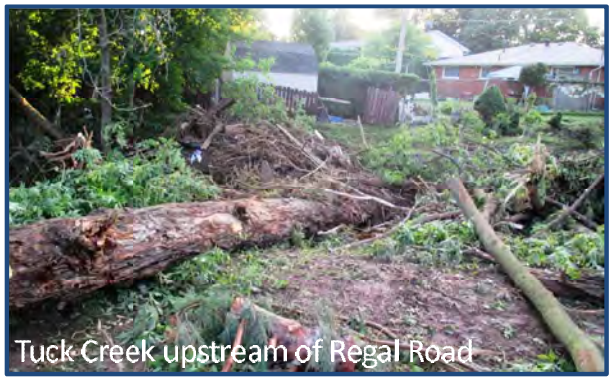

Debris Clean Up

For additional information, please contact one of the study team members

Mr. Arif Shahzad, M.Eng., P.Eng.
Senior Environmental Engineer
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arif.shahzad@burlington.ca

Mr. Dave Maunder, M.Sc., P.Eng.
Project Manager
Aquafor Beech ltd.
#6-202-2600 Skymark Avenue
Mississauga, ON L4W 5B2
905.629.0099 x290
maunder.d@aquaforbeech.com


Clean Up


Tuck Creek upstream of Regal Road


Tuck Creek upstream of Regal Road

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area, and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: WE WERE NEARLY AFFECTED BY AUG 4 FLOOD.

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing 4

Alternative # 1 – Bridge Upgrades 3

Alternative # 2 – Bridge Upgrades and Channel Deepening 2

Alternative # 3 – Bridge Upgrades and Channel Widening 1

Please provide any comments regarding the alternatives:

SIGNS ACCURATE AND APPROPRIATE FOR FEEDBACK.

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

YES.
ADDED COSTS AND POSSIBLE IMPACT TO TAXES.
TIMING TO IMPLEMENT.

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

(2) CONCERNED ABOUT ROAD CULVERT DRAINAGE ON REGAL ESPECIALLY @ WEST SIDE OF REGAL BRIDGE.

(1) POSSIBLE EFFECT OF MORE DEVELOPMENT NORTH OF STUDY LIMIT.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.
Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area. and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: Mitigating future flood impacts in my neighbourhood.

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing	4
Alternative # 1 – Bridge Upgrades	3
Alternative # 2 – Bridge Upgrades and Channel Deepening	2
Alternative # 3 – Bridge Upgrades and Channel Widening	1

Please provide any comments regarding the alternatives:

Alt 3 seems to be only one that makes meaningful impact. Seems like a no brainer.

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

Yes

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

Seems unclear whether there's sufficient room to widen the creek around Regal Rd pinch point. We should not be afraid to acquire private property if necessary to do the work right.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area, and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: TROUT That run upstream from ice melt until the end of may, sometimes longer. crayfish etc... living in the creek. New trees to replace ones being cut down.

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing	4
Alternative # 1 – Bridge Upgrades	4
Alternative # 2 – Bridge Upgrades and Channel Deepening	4
Alternative # 3 – Bridge Upgrades and Channel Widening	1

Please provide any comments regarding the alternatives:

The bridges and creek must be widened to handle the new levels of water flowing down the creek

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

YES

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area, and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: Our property abuts the Creek at Spruce Avenue (East Side).
We are most concerned about a) the trees being preserved; and b) the natural look of the Creek, both above & below Spruce being preserved.

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing ☐

Alternative # 1 – Bridge Upgrades ☑

Alternative # 2 – Bridge Upgrades and Channel Deepening ☐

Alternative # 3 – Bridge Upgrades and Channel Widening ☐

Please provide any comments regarding the alternatives:

We are concerned that Alternatives 2 & 3 especially 3 will be extremely intrusive, & result in the destruction of beautiful old trees along the Creek (mature adult Lot lapped with Rosedale Creek) as well as taking away from the "naturalness" of the Creek and the environment around it.

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

Effect on trees / naturalness of sides/edges of Creek being preserved

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

It would be helpful to have input from the Halton Conservation Authority as to their role/concerns regarding this process

Thank you for many considerations

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area, and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: HOMEOWNER WHOSE PROPERTY ABUTS THE CREEK BLOCK

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing	4
Alternative # 1 – Bridge Upgrades	3
Alternative # 2 – Bridge Upgrades and Channel Deepening	2
Alternative # 3 – Bridge Upgrades and Channel Widening	1

Please provide any comments regarding the alternatives:

I WOULD LIKE TO KNOW WHETHER THE CITY IS PREPARED TO ACQUIRE THE PROPERTIES SET OUT ON PAGE 60 OF THE CW-09-15 JULY 6/15 PRESENTATION, AS THIS SEEMS TO BE THE ONLY OPTION TO REMEDY THE 50 YEAR FLOOD CREEK BLOCK ISSUE.

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

THIS QUESTION SHOULD BE EXPLAINED BY THE PROFESSIONALS IN AN OPEN SETTING

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

A PUBLIC MEETING WITH A FULL PRESENTATION OF THE 3 OPTIONS SHOULD BE HELD WITH A FULL QUESTION + ANSWER FORMAT. THIS PIC IS INSUFFICIENT GIVEN THE SEVERITY OF THE DAMAGE DONE TO THIS AREA.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area. and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: ALL ENVIRONMENTAL CONCERNS SHOULD BE OBSERVED AND MAINTAINED IF POSSIBLE, BUT PRIORITY SHOULD BE PLACED ON PROPER CREEK INFRASTRUCTURE/MAINTENANCE AND DIVERSION OF STORM WATER.

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing [4]

Alternative # 1 – Bridge Upgrades [2] + REGULAR CREEK MAINTENANCE.

Alternative # 2 – Bridge Upgrades and Channel Deepening [3]

Alternative # 3 – Bridge Upgrades and Channel Widening [1]

Please provide any comments regarding the alternatives:

-WIDENING THE BRIDGE UNDERPASSES, ALTHOUGH NICE, WOULD NOT DO MUCH IF THE DERIS THAT GETS WASHED DOWN THE CREEK IS LONGER THAN THE BRIDGE IS WIDER (LARGE TREES). IS THE WIDENING WIDE ENOUGH?

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

- PROPER MONTHLY CREEK MAINTENANCE SCHEDULES, SINCE THE DAM THAT WAS CREATED WAS DUE TO POOR CREEK MAINTENANCE.
- THE BERMS THAT HAVE BEEN DISMANTLED OVER THE YEARS SHOULD BE BUILT BACK UP... AT OWNERS EXPENSE IF NECESSARY.
- DUMPING OF DEBRIS (LEAVES, BRANCHES, ETC) AT CREEK EDGE SHOULD BE MADE ILLEGAL. (IF NOT ALREADY)

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

-THANK YOU FOR PRESENTING THIS. LET'S KEEP WORKING AND DEVELOP SOLUTIONS..... SOON.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!

Participant Worksheet

Contact Information (Optional)

We would appreciate it if you could take a few minutes to provide comments on the material presented at the meeting. The purpose of this worksheet is to provide an opportunity for members of the community to review and provide input on the following items:

- Options for reducing flooding in the Tuck Creek study area, and
- Evaluation process and criteria for alternatives.

What are your environmental interests with respect to the Tuck Creek watershed?

Please list interests: We were flooded via the storm sewer - I enjoy walking the Tuck Creek watershed

Which of the flood reduction alternatives do you prefer (1 = most preferred, 4 = least preferred)

Do nothing ☐

Alternative # 1 – Bridge Upgrades ☐

Alternative # 2 – Bridge Upgrades and Channel Deepening ☐

Alternative # 3 – Bridge Upgrades and Channel Widening ☑

Please provide any comments regarding the alternatives:

- please try and maintain the natural environment as much as possible including trees

Do you agree with the evaluation criteria? Are there any criteria you would like to see added?

Please provide any additional comments on any other material presented tonight. Use additional paper if necessary.

In the interim - Love Region / City employees walk the Creek on a Regular basis. There are trees down across the Creek even now which could cause another dam effect. These need to be removed on a Regular basis

Also the Tuck Creek wall south of Regal Road, is eroding and breaking away again so this should be looked at. Feel free to call me.

Please leave the worksheet with staff at the meeting. Should you require further information, or wish to be kept informed, please ensure that your name, address and telephone number or email is provided.

Thank you for your time in completing this worksheet!