Project File Report

Michael Boulevard Flood Mitigation Strategy

Final Report ▪ December 2020

Report Prepared For

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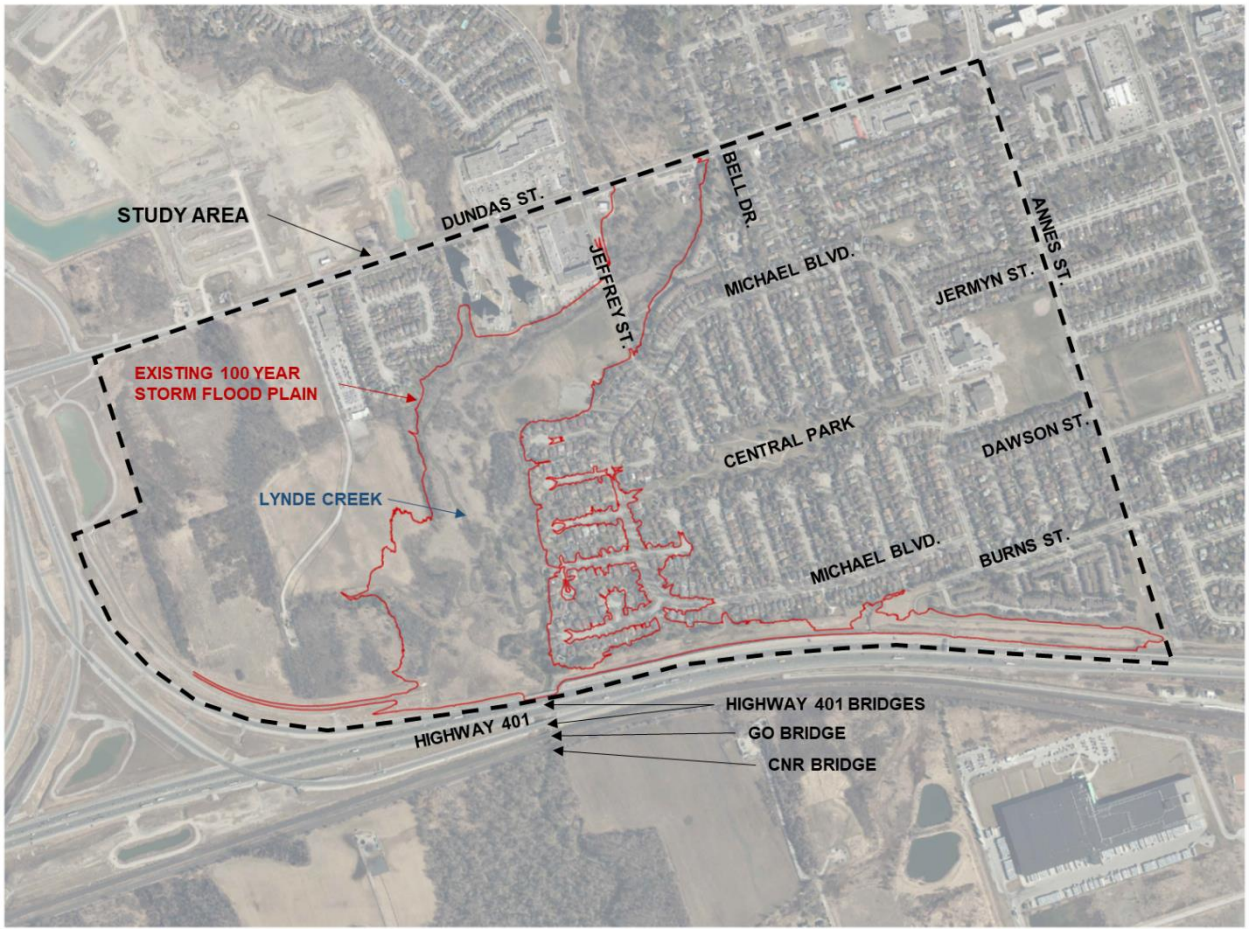
Executive Summary

The Municipal Infrastructure Group Limited (TMIG), along with team member Palmer Environmental Consulting Group (PECG), were retained by the Town of Whitby to determine the most appropriate means of reducing flooding and flood damages to the Michael Boulevard residential area. The Michael Boulevard study area, illustrated in **Figure ES-1**, is generally bounded by Highway 401 to the south, Highway 412 to the west, Dundas Street to the north and Annes Street to the east.

Lynde Creek flows through the study area, and previous studies have determined that a large number of residential properties to the east of the watercourse are potentially at risk of flooding during severe storm events. To date there have been no reports of homes damaged by flooding from Lynde Creek, but there is evidence that floodwater extended up to and even into private properties during recent severe storm events.

Figure ES-1 Study Area



Land use within the study area is primarily residential, with some commercial development along Dundas Street, schools adjacent Annes Street and several parks. The majority of the study area was developed in the 1970's, prior to the adoption of modern strategies for stormwater management and flood protection. The Town of Whitby Official Plan also designates a portion of the undeveloped lands west of Lynde Creek for industrial uses, and identifies a future extension of Burns Street West from its existing limit west of Annes Street along the north side of Highway 401, crossing Lynde Creek before turning north to intersect with Dundas Street east of Highway 412.

A natural heritage investigation was completed, which confirmed that Lynde Creek serves as a migratory route for a range of species including trout and salmon, and confirmed that the Provincially Significant Lynde Creek Coastal Wetland Complex (Lynde Creek Marsh) extends north of Highway 401 into the study area. The investigation determined that the study area potentially contains habitat for a number of Species at Risk, though none were identified in the field investigations.

The Lynde Creek Master Drainage Plan Update (MDPU) (AECOM, currently under study) included refinements to the Lynde Creek watershed hydrology model. This model is used to estimate the peak flow rates throughout Lynde Creek in response to storm events ranging from a 2 year return period event to a 100 year return period event as well as Hurricane Hazel. The model was prepared in accordance with the Technical Guide - River & Stream Systems: Flooding Hazard Limit (MNRF, 2002), which includes a number of very conservative assumptions to develop a 'worst-case' scenario for the purposes of establishing the extent of the Regulatory flood plain. This includes not accounting for any man-made storage in formal stormwater management facilities as well as ignoring the storage and attenuation of flows behind undersized roadway and rail culverts and embankments. For this study, the hydrology model from the Lynde Creek MDPU was further refined to relax some of these conservative assumptions and account for the most significant storage areas behind road and rail culverts in order to provide a better estimate of the actual flows and flood risk in Lynde Creek under current watershed conditions.

The Lynde Creek MDPU also included refinements to the HEC-RAS hydraulic model used to estimate the depth and extent of flooding in Lynde Creek for different storm events. The HEC-RAS hydraulic model was updated based on more detailed topographic information for the study area, and was further refined to more accurately represent flow conditions through the road and rail bridges in the study area. The flows from the refined hydrology model were then input to the model to determine the depth and extent of flooding for different storm events.

The modelling confirmed that the existing bridges under the CN and Metrolinx rail embankments south of Highway 401 represent the most significant restrictions along

Lynde Creek that contribute to the high flood levels upstream of Highway 401. The updated flood plain mapping determined that 24 homes are potentially at risk of flooding in a 50 year return storm event, 45 homes are potentially at risk of flooding in a 100 year return period storm event, and over 500 homes are potentially at risk of flooding if Hurricane Hazel were to reoccur over the Lynde Creek watershed. Flood damages are estimated to be approximately $2.3 Million in a 100 year storm event, and $64,000 per year on an average annualized basis.

A range of alternative solutions were developed to mitigate the potential for flooding from Lynde Creek. These are briefly summarized below:

Status Quo (Do Nothing): This solution does not propose any measures to reduce flooding or flood damages. However, flood risk will continue to be managed through the Central Lake Ontario Conservation Authority's (CLOCA) jurisdiction-wide flood forecasting and warning and the Town's and Region's current emergency management plans.

CNR and Metrolinx Relief Culverts: Previous investigations have recommended installing additional culverts under the CNR and Metrolinx rail embankments to pass more flow and reduce upstream flood levels for up to the 100 year return period storm event. Building on the most recent study, this alternative involves installing 8 – 1.8 m diameter pipes under the two railway embankments using trenchless methods. This would reduce upstream flood levels sufficient to prevent flood damages in a 100 year return period storm event, but would not reduce the depth of flooding in the Regional (Hurricane Hazel) storm event.

Flood Protection Berm with Storm Sewer Backflow Prevention Devices: The refined flood plain mapping determined that under existing conditions, floodwater from Lynde Creek initially reaches the residential areas to the east by backing up and out of the storm sewer systems discharging to Lynde Creek, and by floodwater flowing east through the open area between Highway 401 and the residential lots to the north, and then flowing into the residential area through a low area in the vicinity of Michael Boulevard and Flemington Court. This alternative includes the construction of a low berm in the Town-owned open area north of Highway 401 to prevent water from Lynde Creek from flowing eastward and northward into the residential area, and backflow prevention devices on 4 storm sewer outfalls to prevent floodwater from Lynde Creek from backing up through the storm sewer systems and into the study area. The combination of the berm and backflow prevention devices would protect 44 of the 45 homes currently at risk of flooding in a 100 year storm, but would not reduce flooding or flood damages from larger storms including the Regional storm event.

Flood Proofing and Education Program: This alternative would reduce flood damages through physical works completed by homeowners to reduce the risk of

floodwater from entering their homes, and through practices implemented by residents to minimize damages when floodwater enters a home. At a minimum, the program would include the preparation and distribution of an information package to residents informing them of the current flood risks in the study area, and descriptions of a range of best practices for works inside and outside flood vulnerable homes to minimize the risk of water entering the structure and to minimize damages in the event of flooding. It could be augmented by inspections by Town staff, who would then prepare a list of recommendations tailored to each property, and could be further enhanced through a program that would provide a rebate or other financial incentive to homeowners to cover a portion of the cost of physical improvements to a home to reduce flood risk and damages. The cost and effectiveness of this solution would depend on how many homeowners voluntarily implement works to reduce flood damages on their property. These works would not be completed by or mandated by the Town.

Emergency Management Planning: The final alternative considered is an enhancement to the existing flood forecasting and warning systems and emergency management plans, tailored specifically to Lynde Creek north of Highway 401. It would include a forecasting system developed based on local streamflow characteristics, and a warning system that would send messages to local residents alerting them to potential and actual flooding conditions. It would also involve the development of a site specific plan to evacuate residents before flooding renders the roads in the study area impassable. The program would not reduce flood levels or flood damages from Lynde Creek.

The above alternative solutions were evaluated against a number of criteria considering the natural environment, social and cultural impacts, technical effectiveness, construction challenges, costs and benefits. The preferred solution to reduce flood damages from Lynde Creek is the **Flood Protection Berm with Storm Sewer Backflow Prevention Devices**. It is further recommended that this solution be augmented with elements of a **Flood Proofing and Education Program**. The evaluation of alternatives is summarized in **Table ES-1**.

The flood protection berm solution was selected because it can be implemented relatively quickly on Town owned lands with few challenges or approvals, and can protect almost all of the homes currently at risk of flooding in a 100 year return period storm event. It is also much less expensive than the CNR and Metrolinx Relief Culverts alternative, resulting in a much higher benefit: cost ratio and much shorter payback period for nearly the same level of flood protection. The Flood Proofing and Education Program may be sufficient to protect the remaining vulnerable home from flooding in a 100 year storm event, and could reduce flood impacts and flood damages from larger storm events.

Site specific recommendations have been prepared for the single home that remains at risk of flooding in a 100 year event. The recommendations include re-grading an existing Town-owned pathway leading from Evans Court to minimize the risk of floodwater spilling from Lynde Creek towards Evans Court, replacing two vulnerable basement windows with water-tight windows or protecting them with raised window wells, and raising the grades along the roadside edge of the reverse slope driveway to minimize the potential for floodwater to enter the garage.

Figure ES-2 and **Figure ES-3** include the preliminary design of the berm, locations of locations of the storm sewer outlets where backflow prevention devices are to be installed, the extent of flooding following implementation of the berm and backflow prevention devices, and the remaining property where on-site flood proofing measures are recommended to provide full protection from the 100 year return period flood.

Table ES-1 Evaluation Summary

Alternative	Capital Cost	Number of At Risk Homes Protected in a 100 Year Flood	Benefit Cost Ratio	Evaluation Notes
Status Quo	$0	None	n/a	Not recommended as it does not flooding or flood damages
CNR and Metrolinx Relief Culverts	$8.4 Million	45 of 45	0.8:1	Not recommended due to the high risks and costs for implementation of the relief culverts (challenges to secure approvals from CN and Metrolinx and to install the culverts without disturbing the active rail lines, challenges and environmental impacts to access the construction area)

Alternative	Capital Cost	Number of At Risk Homes Protected in a 100 Year Flood	Benefit Cost Ratio	Evaluation Notes
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	$500 Thousand	44 of 45	6:1	**Recommended:** Protects all but one home from flooding in a 100 year storm event and can be implemented relatively quickly and economically on Town owned land
Flood Proofing and Education Program	Up to $500 Thousand depending on program elements and uptake by residents	Depends on the degree of uptake by residents	n/a	Not Recommended as a standalone solution due to challenges to ensure implementation of flood proofing measures by homeowners, **but elements of this program of this alternative are recommended to complement other flood reduction solutions**

Alternative	Capital Cost	Number of At Risk Homes Protected in a 100 Year Flood	Benefit Cost Ratio	Evaluation Notes
Emergency Management Planning	Up to $130,000 per year, depending on staffing requirements to administer the program	None	n/a	Not recommended due to challenges to maintain a resident contact database and additional staff needed on a permanent basis despite a relatively low risk of flooding

Figure ES-2 Location of Flood Protection Berm and Storm Sewer Backflow Prevention Devices

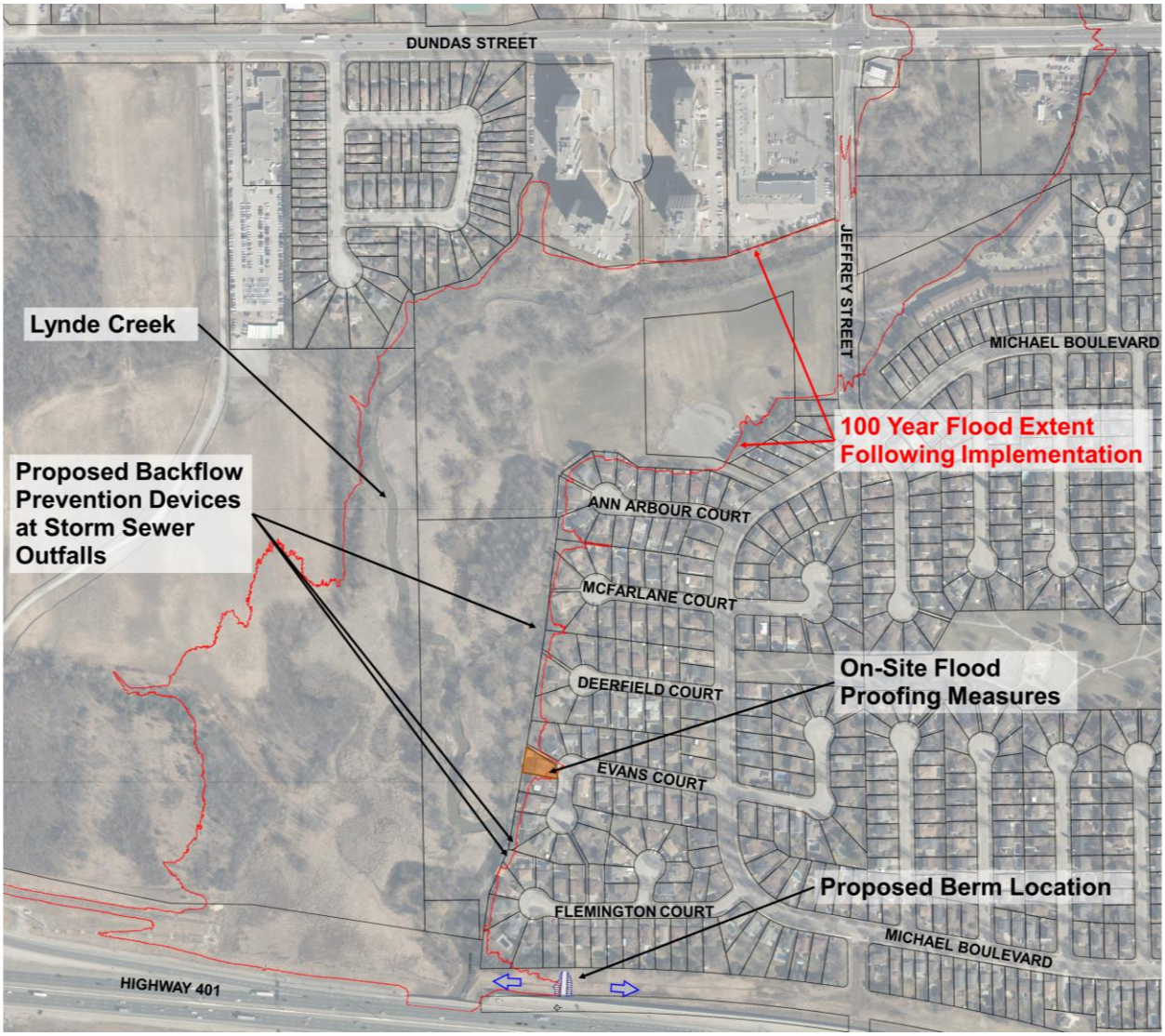
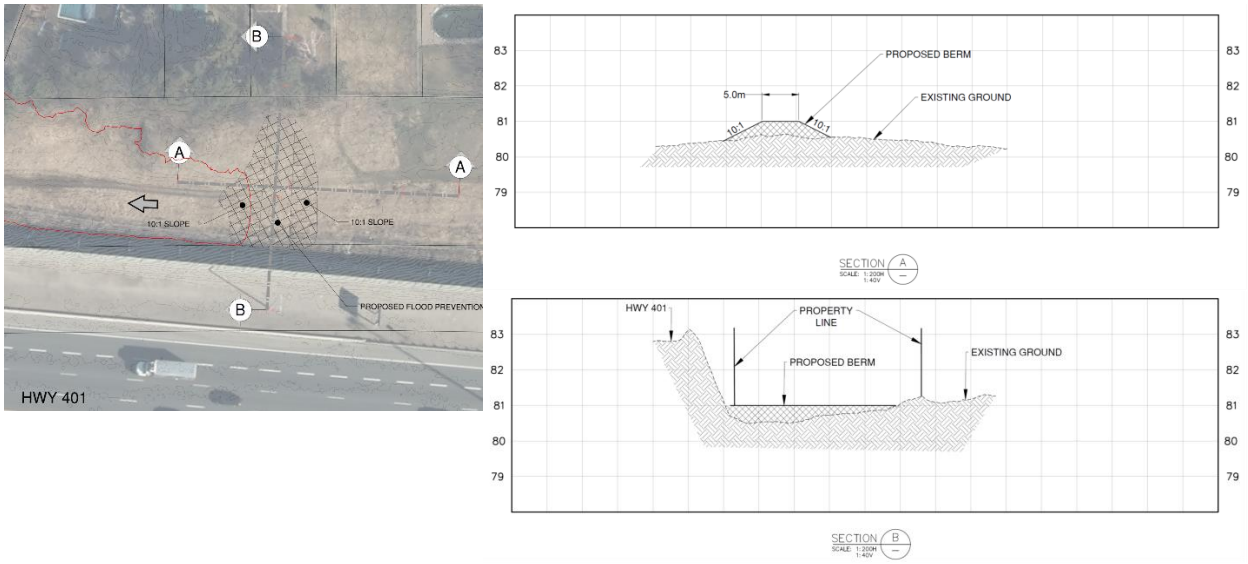


Figure ES-3 Preliminary Berm Design



A number of additional studies are recommended to facilitate implementation of the preferred solution, including detailed topographic surveys, a geotechnical investigation to inform the design of the flood protection berm, a vegetation inventory for areas potentially disturbed for construction of the berm, and a video inspection of the Region's sanitary overflow sewer that is aligned in the open area north of Highway 401 between the Michael Boulevard sanitary pumping station and emergency outlet to Lynde Creek.

A drainage investigation is also recommended to improve drainage of the area north of Highway 401 between the high point east of Lynde Creek and a concrete box culvert under Highway 401 near the west limit of Burns Street. Finally, it is recommended that a preliminary design be advanced for the future Burns Street extension, which will be aligned within the Town-owned lands on the north side of Highway 401. The preliminary design can avoid potential conflicts and ensure that the future roadway can be configured to continue to contain flooding from Lynde Creek.

The Michael Boulevard Flood Mitigation Strategy has been completed in accordance with the Municipal Class Environmental Assessment process, as is required for the planning of all major municipal projects or activities. Considerable consultation with the public, agencies and other stakeholders has taken place throughout the project, including two Community Open Houses to provide opportunities for the public to provide input to the characterization of existing conditions and the development and evaluation of alternative solutions.

All concerns raised by the public and agency staff, including Indigenous Communities, have been considered in the evaluation of alternative solutions and have been addressed in this final Project File Report.

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1 Introduction and Background

1.1 Study Overview and Purpose

The Municipal Infrastructure Group Limited (TMIG), along with team member Palmer Environmental consulting Group (PECG), were retained by the Town of Whitby to determine the most appropriate means of reducing flooding and flood damages to the Michael Boulevard residential area. The Michael Boulevard study area, illustrated in **Figure 1-1,** is generally bounded by Highway 401 to the south, Highway 412 to the west, Dundas Street to the north and Annes Street to the east.

Lynde Creek flows through the study area, and flooding from Lynde Creek is predicted to inundate a significant number of residential properties to the east of the watercourse. Previous studies have estimated that up to 155 homes are at risk of flooding during a 100 year return period, and up to 185 homes could be impacted by flooding if a storm of the magnitude of Hurricane Hazel were to occur over the watershed.

Figure 1-1 Study Area

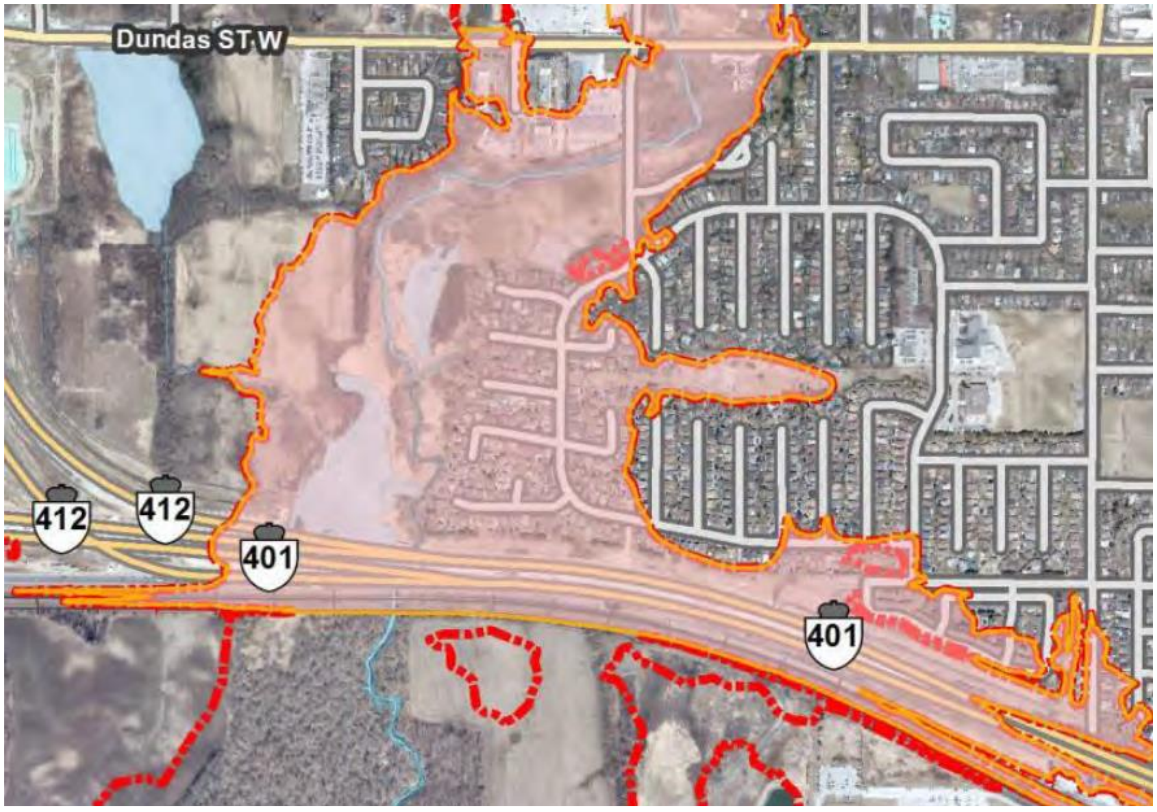
To date there have been no reports of homes damaged by flooding from Lynde Creek, but there is evidence that floodwater extended up to and even into private properties during recent severe storm events. If not properly managed, future development in the Lynde Creek watershed and climate change could alter the flow

regime in Lynde Creek and potentially increase the frequency and severity of flooding in the future. This Project File Report documents the development and evaluation of a range of potential alternatives to reduce flooding and flood damages from Lynde Creek within the study area. It further presents a preliminary design and a framework for the funding, approvals and other activities needed for implementation of the recommended works.

1.2 Project Background

The Lynde Creek watershed is regulated by the Central Lake Ontario Conservation Authority (CLOCA). As part of their mandate, CLOCA is responsible for establishing the limit of the regulatory flood plain and regulating activities to manage risks associated with flooding and erosion. The Regulatory flood plain is based on the flow resulting from the 100 year return period or Regional storm event, whichever is larger. For Lynde Creek, the Regional storm event, representing the largest storm on record that could potentially re-occur over the study area, is Hurricane Hazel. CLOCA has overseen the preparation and update of Regulatory flood plain mapping for Lynde Creek, in accordance with the many conservative assumptions set out in the Technical Guide - River & Stream Systems: Flooding Hazard Limit (MNRF, 2002). The extent of the Regulatory flood plain established by CLOCA for Lynde Creek is illustrated in **Figure 1-2**.

Figure 1-2 Lynde Creek Regulatory Flood Plain



From Central Lake Ontario Conservation Watershed Flood-Risk Assessment, CLOCA, April 2017)

CLOCA's mapping shows a considerable number of homes in the Regulatory flood plain in the Michael Boulevard area. The hydraulic model used to determine the depth and extent of the flood plain indicates that the large extent of the flood plain is primarily due to a significant backwater condition caused by the CN and Metrolinx rail culverts and embankments immediately south (downstream) of Highway 401. Previous studies have determined that up to 185 homes are partially to entirely within the Regulatory flood plain.

A number of studies have been completed over the past 30 years to predict the flow rates and flood levels in Lynde Creek and assess different options to reduce flooding in the Michael Boulevard area. These findings from these studies are summarized in the following sections.

1.2.1 Whitby Stormwater Management Strategy

The potential for flooding in the study area was initially quantified in the Whitby Stormwater Management Strategy (Dillon, 1982). The study included the development of a HYMO watershed hydrology model to estimate peak flow rates in

Lynde Creek, and a HEC-2 hydraulic model to determine the resulting flood levels along Lynde Creek. The hydrologic and hydraulic modelling showed that the Michael Boulevard area was at risk of flooding during severe storm events, and concluded that flooding was primarily due to the insufficient capacity of the (former) Highway 401 culvert and the CN and Metrolinx rail crossings over Lynde Creek.

1.2.2 Lynde Creek Master Drainage Plan

The Lynde Creek Master Drainage Plan (GM Sernas, 1988) was prepared to comprehensively examine water quality, erosion and flooding in the Lynde Creek watershed, provide direction to future developments regarding stormwater management and develop a cost-sharing framework to mitigate erosion and flooding problems in the watershed.

The study reviewed and confirmed that the HYMO hydrology model remained appropriate for the study. A flood frequency analysis of available streamflow records resulted in peak flow rates significantly less than those from the HYMO hydrology model, but recommended conservatively maintaining the larger flow estimates from the HYMO model for the purposes of managing flooding in the watershed.

The study also relied on the HEC-2 hydraulic model from the 1982 study, and estimated that approximately 24 homes would be at risk of flooding in the 100 year return period storm, and an additional 183 buildings would be impacted by flooding in the Regional storm event.

The study examined different alternatives to reduce flooding, including a large on-line flood storage facility upstream of Highway 401, diversion of flows to Pringle Creek and/or Corbett Creek, and measures to contain flooding to the Lynde Creek valley corridor (berms or flood walls). The study recommended adding 5.4 m wide x 3.0 m high concrete box culverts next to the existing Highway 401, CN and Metrolinx rail culverts to increase conveyance capacity and reduce flood levels, at an estimated cost of $6.35 Million in 1982 dollars. The conveyance improvements were predicted to reduce flood levels in a 100 year storm event by 0.64 m in the 100 year storm event (80.96 m existing to 80.34 m proposed), but would have no impact on Regional storm flood levels (82.06 m).

1.2.3 Lynde Creek Water Resource Management Strategy

The Lynde Creek Water Resource Management Strategy (Gartner Lee Limited, 1994) was prepared to assist the Town of Whitby in the review of development proposals in the Lynde Creek watershed. The study included an update and refinement to the Lynde Creek watershed hydrology model, using the more

sophisticated OTTHYMO89 hydrology model instead of the HYMO model prepared for the 1982 study.

The study confirmed that the area upstream of Highway 401 was at risk of flooding during severe storm events, but concluded that future development in areas upstream of Highway 401 would have a negligible impact on flow rates and flood levels in this reach of Lynde Creek. As the study was primarily focussed on stormwater management for future development in the watershed, it did not examine potential solutions to mitigate flooding in the Michael Bouelvard area.

1.2.4 Lynde Creek CNR and GO Transit Culverts Feasibility Assessment

The Lynde Creek CNR and GO Transit Culverts Functional Feasibility Assessment ('Feasibility Assessment') (AECOM, 2018) examined the potential to reduce flood levels through the Michael Boulevard study area through improvements to the culverts under the rail lines. As part of the study, design and as-built drawings were obtained from MTO, CN and Metrolinx and the information was verified through a limited topographic survey. This information was used to update the HEC-RAS hydraulic model of Lynde Creek and associated flood plain mapping. The study confirmed that the undersized bridges under the CN and Metrolinx railways are primarily responsible for the extensive flood plain upstream of Highway 401. Flood plain mapping prepared for the Feasibility Assessment determined that 105 homes would be at risk of flooding in a 100 year return period storm event, and 185 homes would be at risk of flooding in a Regional storm (Hurricane Hazel) event.

The study explored two primary options to reduce flooding through the Michael Boulevard area. The first was improvements to the CN and Metrolinx culverts to improve capacity, and the second was a flood protection berm to contain flooding away from the Michael Boulevard residential area.

The alternative solution to increase the capacity of the railway culverts was to install 8 new 1.8 m diameter pipe culverts through the rail embankments. The large number of smaller diameter culverts was necessary due to the limited depth from the base of the Lynde Creek valley to the top of the rail embankments, and to allow for trenchless construction such that rail operations would not be interrupted during construction.

The second flood protection alternative involved the construction of a berm along the west limit of the residential area, extending from Jeffery Street near the intersection with Michael Boulevard all the way south to Highway 401, with additional flood protection along the north side of Highway 401 east of Lynde Creek. The berm was proposed at an elevation of 81.0 m, providing a 0.3 m freeboard above the 100 year

flood level. It was determined that protection to the elevation of the Regional (Hurricane Hazel) storm event was not feasible. Construction of the berm would require a realignment of Lynde Creek for a short distance north of Highway 401, as there is currently no room for a berm between Lynde Creek and the abutting residential lots at Flemington Court and Evans Court.

The study selected the relief culverts under the railway embankments as the preferred alternative, at a cost of approximately $6 Million.

The HEC-RAS model that was updated through the feasibility study has been maintained as the base hydraulic model for this Class EA project, and both the culvert improvement and flood protection berm alternatives have been carried forward as flood mitigation alternatives to be explored through this study.

1.2.5 Lynde Creek Master Drainage Plan Update

The original Lynde Creek Master Drainage Study was completed in 1988 to guide drainage and stormwater management activities in the Lynde Creek watershed. The Town of Whitby undertook an update to the Master Drainage Plan, following the Municipal Class EA process, to recent and emerging policies, guidelines and best practices for stormwater management and natural heritage systems, and recent and planned development in the watershed. The Lynde Creek Master Drainage Plan Update (MDPU) (AECOM, currently under study) included an update to the Lynde Creek watershed hydrology model, a re-examination of erosion issues along the various watercourses within the Lynde Creek watershed, a hydrogeological assessment and water balance, and an assessment of the aquatic and terrestrial habitat conditions in the watershed.

The MDPU will be recommending new guidelines and enhancements to existing guidelines to include Low Impact Development (LID) practices for stormwater management and channel restoration, and will also recommend a number of projects to restore or enhance ecological, hydrologic and hydrogeological conditions in the watershed. The recommended projects relative to the Michael Boulevard study area include

- Construction of the relief culverts through the CN and Metrolinx rail embankments as recommended by the Feasibility Assessment to improve conveyance and prevent flooding of the Michael Boulevard for up to the 100 year storm event.
- Modifications to the Dundas Street, Jeffrey Street and rail bridges to improve fish and wildlife passage, increase conveyance and allow for natural migration of the Lynde Creek channel.

- Plantings and bank stabilization along Lynde Creek to improve riparian habitat conditions
- Construction of the SWM facilities north of Dundas Street for future development as recommended through the West Whitby secondary plan
- Restoration of several erosion sites along Lynde Creek between Highway 401 and Dundas Street

1.2.6 Town Wide Urban Flooding Study

The Town of Whitby is nearing completion of this Schedule B Municipal Class EA study to comprehensively evaluate the capacity of the existing storm sewer and overland flow systems within the Town of Whitby, under both current and potential future climate conditions. The study, which is nearing completion, has also developed and evaluated a range of alternatives to improve systems that do not meet current Town design criteria and to mitigate urban flooding issues.

Information on existing flooding issues and the preliminary preferred alternatives were presented on the Town's website through an on-line public consultation in March 2020. The study found that a number of storm sewers in the Michael Boulevard study area are predicted to be surcharged during a 5 year return period storm event, which is the Town's design storm for the minor drainage system. The study also noted that flooding was observed on Annes Street during a storm in August 2008 which was comparable to a 5 year return period event.

The preliminary preferred solution includes a number of improvements to the storm sewer systems within the Michael Boulevard study area, including several storm sewers to be replaced with larger pipes, high capacity catchbasin inlet grates and in-line pipe storage to control peak flow rates in the storm sewer system.

This Municipal Class EA study is expected to be completed in 2020, but timing for implementation of the recommended works has not yet been determined.

1.2.7 Stormwater Quality and Erosion Control Enhancement Study Update

The Town of Whitby Stormwater Quality and Erosion Control Enhancement Study Update (Ecosystem Recovery, May 2019) built upon a previous study completed in 2001. The update included inspections of existing storm sewer outfalls, recommendations for maintenance at damaged or degraded outfalls and an examination of options to incorporate water quality and erosion control facilities at existing uncontrolled storm outfalls.

The study recommended a new stormwater management facility in the Lynde Creek valley to treat runoff from a portion of the Michael Boulevard study area. The facility, located in the Lynde Creek valley west of Deerfield Court, would provide Enhanced water quality treatment and extended detention of the runoff from a 25 mm storm event for a 56 ha drainage area. The cost of the facility is estimated to be approximately $2.6 Million. While the Lynde Creek retrofit facility was the second highest ranked project, there is no timeline established for detailed design and construction of the facility.

1.3 Municipal Class Environmental Assessment Process

The planning of major municipal projects or activities is subject to the Ontario Environmental Assessment (EA) Act, R.S.O. 1990, and requires the proponent to complete an Environmental Assessment, including an inventory and description of the existing environment in the area affected by the proposed activity.

The Municipal Class EA process was developed by the Municipal Engineers Association and approved by the Ministry of the Environment, now Ministry of the Environment, Conservation and Parks (MECP), as an alternative method to Individual Environmental Assessments for recurring municipal projects that were similar in nature, usually limited in scale and with predictable ranges of environmental effects which were responsive to mitigating measures. The latest Municipal Class EA document (October 2000, amended 2007, 2011 & 2015) has been used for this study.

The Class EA provides for the following designations of projects depending upon potential impacts:

Schedule A: Projects are limited in scale, have minimal adverse environmental effects and include a number of municipal maintenance and operational activities. These projects are pre-approved. Schedule A projects generally include normal or emergency operational and maintenance activities.

Schedule A^{+}: Projects are within existing buildings, utility corridors, rights-of-way, and have minimal adverse environmental effects. These projects are pre-approved; however, the public is to be notified prior to project implementation.

Schedule B: Projects have the potential for some adverse environmental effects. The proponent is required to undertake a screening process, involving mandatory contact with directly affected public and relevant review agencies, to ensure they are

aware of the project and that their concerns are addressed. If there are no outstanding concerns, then the proponent may proceed to implementation.

Schedule C: Projects have the potential for significant environmental effects and must proceed under the full planning and documentation procedures specified in the Class EA document. Schedule C projects require that an Environmental Study Report be prepared and filed for review by the public and review agencies.

The Michael Boulevard Flood Mitigation Strategy has the potential for some adverse environmental impacts, and therefore follows the planning procedure for Schedule B activities. The following Class EA planning phases apply:

Phase 1: Identify the problem (deficiency) or opportunity.

Phase 2: Identify and evaluate alternative solutions to address the problem or opportunity by taking into consideration the existing environment, and establish the preferred solution taking into account public and review agency input.

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 facility.

The Class EA process also provides an appeal process to change the project status. Under the provisions of the Environmental Assessment Act, there is an opportunity under the Class EA planning process for the Minister to review the status of a project. Members of the public, interest groups and review agencies may request the Minister to require a proponent to comply with Part II of the EA Act, before proceeding with a proposed undertaking. This is known as a “Part II Order” (formerly called “Bump-Up Request”).

The Environmental Assessment Act was recently amended through Bill 197, the Covid-19 Economic Recovery Act, 2020. Among other things, the amendments focus the Part II Order request process to issues relating to Aboriginal and treaty rights and set timelines for when the Minister can intervene on his/her own initiative to impose conditions on or bump up a class environmental assessment project.

Any outstanding concerns are to be directed to the proponent for a response, and in the event there are outstanding concerns regarding potential adverse impacts to constitutionally protected Aboriginal and treaty rights, Part II Order requests on those matters may be addressed in writing to the Minister of the Environment, Conservation and Parks and the Director of the Environmental Assessment Branch. The Director will issue a Notice of Proposed Order to the proponent if the Minister is considering an order for the project within 30 days after the conclusion of the

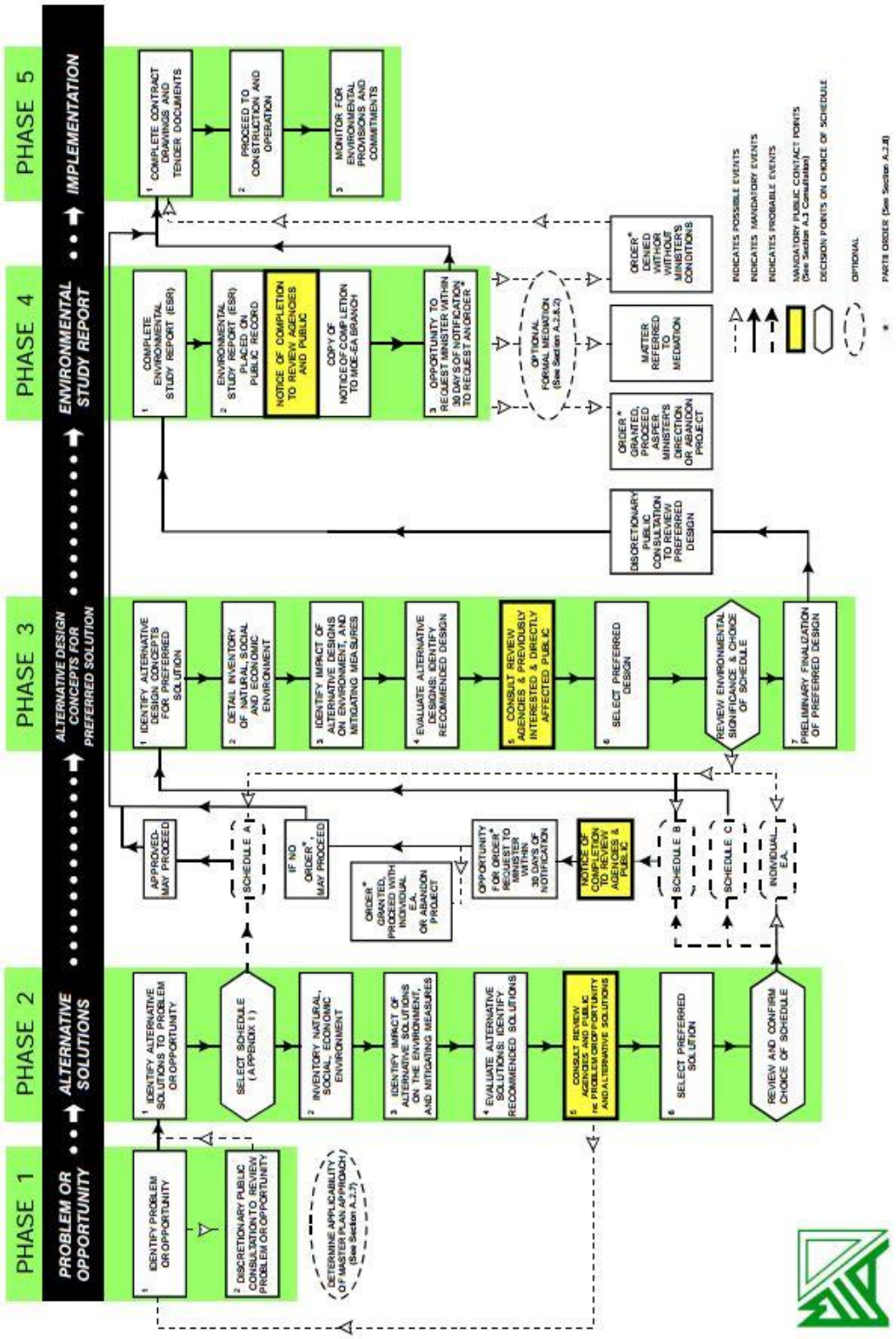
comment period on the Notice of Completion. At this time, the Director may request additional information from the proponent. Once the requested information has been received, the Minister will have 30 days within which to make a decision or impose conditions on the project.

The proponent cannot proceed with the project until at least 30 days after the end of the comment period provided for in the Notice of Completion. Further, the proponent may not proceed after this time if:

- A Part II Order request has been submitted to the Minister regarding potential adverse impacts to constitutionally protected Aboriginal and treaty rights, or;
- The Director has issued a Notice of Proposed Order regarding the project.

A flow chart describing the Class EA planning and design process is shown in **Figure 1-3**. Note that the flow chart has not been updated to reflect the recent amendments to the Environmental Assessment Act described above.

Figure 1-3 Municipal Class EA Planning Flow Chart



1.4 Project Team Organization

The project was completed by a multi-disciplinary team led by TMIG. Key staff involved in the Study are listed in **Table 1-1**. The project was completed under the direction of a technical working group comprised primarily of staff from the Town of Whitby and CLOCA.

Table 1-1 Study Team

Name	Organization	Role
Antony Manoharan, P.Eng	Town of Whitby	Proponent Project Manager
Lucy Benham, P.Eng	CLOCA	Project Steering Committee Member
Steven Hollingworth, P.Eng.	TMIG	Consultant Project Manager and Water Resources Engineer
Dirk Janas, B.Sc.	Palmer Environmental Consulting Group Inc	Senior Ecologist

1.5 Problem and Opportunity Statement

Current flood plain mapping indicates that the Michael Boulevard residential area is at risk of flooding from Lynde Creek during severe storm events. The flood risk is primarily due to undersized culverts under the CN and Metrolinx rail lines downstream of the study area, immediately south of Highway 401. The problem and opportunity statement is as follows:

To determine the preferred method(s) of managing storm runoff to reduce or eliminate flooding and/or flood risk to the Michael Boulevard residential area from Lynde Creek, considering the full range of potential future storm events, while maintaining or improving water quality, erosion and aquatic and terrestrial habitat associated with the Lynde Creek natural heritage system.

2 Existing Environments

2.1 Planning Environment

The Michael Boulevard study area is located in the Town of Whitby, and land use within the study area is primarily residential. There is some commercial development along Dundas Street, two schools near the east limit of the study area and several municipal parks. The protected Lynde Creek valley corridor is located immediately west of the residential area, and the lands between Lynde Creek and Highway 412 to the west are used for agriculture. Whitby Fire Station No. 4 is located on the north side of Dundas Street, west of Annes Street and is safely outside of the Regional storm flood plain.

2.1.1 Provincial Policy Statement

The Provincial Policy Statement (PPS) (May 2020) provides broad land use planning and development policy direction, particularly as it relates to matters of provincial interest including but not limited to the natural environment and natural hazards. The Natural Hazard policies (Section 3.1 of the PPS) generally prohibit development in areas at risk of flooding from riverine systems as well as areas that cannot be safely accessed due to excessive flood depths and velocities during severe storm events. The PPS contains some exemptions to these policies, such as designated Special Policy Areas and flood fringe areas where separate policies apply. At this time, the Study Area is not designated as a Special Policy Area nor managed as a two-zone area where new development in the flood fringe could be permitted.

The PPS also includes policies generally promoting intensification and redevelopment in existing built-up areas (Section 1.1). The significant extent of the Lynde Creek Regulatory flood plain is currently a constraint to redevelopment and intensification in the study area.

2.1.2 Growth Plan for the Greater Golden Horseshoe

The Growth Plan for the Greater Golden Horseshoe (GPGGH) (May 2017) is another provincial policy document intended to guide future growth in the area. The latest GPGGH took effect on July 1, 2017 and is generally intended to direct future population and employment growth to existing urban areas. The Michael Boulevard study area is not considered an Urban Growth Centre, but it is located between the Downtown Pickering and Downtown Oshawa Urban Growth Centres. However, the study area has a number of desirable characteristics for redevelopment and

intensification, including the close proximity to the Whitby GO station, Dundas Street Bus Rapid Transit, and Highways 401 and 412.

The GPGGH directs growth away from areas at risk from flooding and erosion, and also contains policies for the long term protection of natural heritage and biodiversity, including protection of key hydrologic features (such as the Lynde Creek valley corridor) and their functions.

2.1.3 Greenbelt Plan (2017)

The 2017 update to the Greenbelt Plan added a number of major Urban River Valleys, including Lynde Creek. Policies in the Greenbelt Plan encourage municipalities to create systems of parkland and trails in Urban River Valleys while protecting or enhancing key natural heritage features, key hydrologic features and farmland.

New development and redevelopment in or adjacent Urban River Valleys are expected to protect or improve the quality and quantity of natural vegetation, improve fish and wildlife habitat and mitigate any impacts to the quality and quantity of urban runoff delivered to the protected riverine systems.

Municipal infrastructure is permitted within Urban River Valleys, provided that it is approved under the Environmental Assessment Act or similar legislation, and provided that it supports the needs of adjacent settlement areas and is consistent with the overall goals and objectives of the Greenbelt Plan.

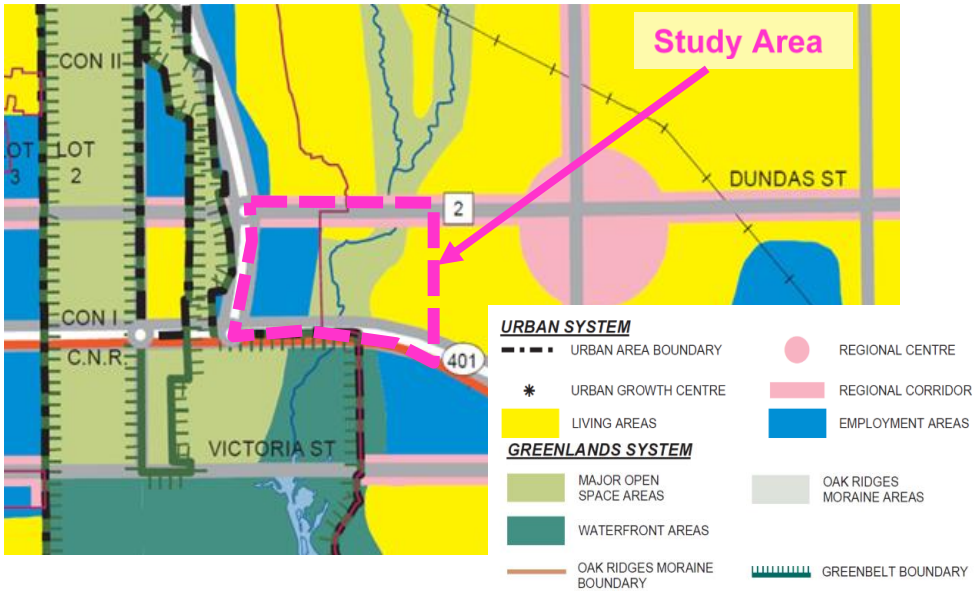
2.1.4 Durham Region Official Plan

The Durham Region Official Plan was initially approved in 1993, and was last consolidated in May 2017 with all amendments to date. The Region has initiated ‘Envision Durham’ to establish a new official plan for the Region to 2041.

The current Official Plan generally designates the lands west of Lynde Creek as Employment Area and lands east of the creek as Living Area, with Dundas Street considered a Regional Corridor. The Lynde Creek Valley Corridor is designated as Major Open Space and a Key Natural Heritage and Hydrologic Feature.

Schedule ‘B’ of the Region’s Official Plan designates the study area as a High Aquiver Vulnerability Area. Policies in the plan require a contaminant management plan for new development within urban areas to demonstrate how water resources will be protected. Best management practices are also encouraged for existing uses that pose a high risk to groundwater.

Figure 2-1 Durham Region Official Plan - Regional Structure



2.1.5 Town of Whitby Official Plan

The Town of Whitby Official Plan was initially adopted by council in 1994, and was last consolidated in July 2018, incorporating all amendments to date.

Consistent with the Regional plan, the Town's Official Plan generally designates the areas east of Lynde Creek as Residential and areas west of Lynde Creek as Prestige Industrial. The main Lynde Creek valley corridor is protected as Open Space and Natural Heritage / Natural Hazard, and a large area associated with a smaller tributary of Lynde Creek to the west, adjacent Highway 412 is also designated as Open Space and Natural Heritage. There are also areas designated as Commercial and Mixed Use along Dundas Street, which is designated as an Intensification Corridor.

Consistent with the Regional Official Plan, the majority of the study area is designated Highly Vulnerable Aquifer and applicable to the requirements of the Durham Regional Official Plan. In addition, portions of the study area are considered Significant Groundwater Recharge Area (SGRA). New development in SGRAs must demonstrate that groundwater quality and quantity, including groundwater flow paths, will be maintained or enhanced.

The Transportation Schedule to the Official Plan also shows a future arterial road through the study area. The roadway is shown extending westward from the existing terminus of Burns Street west of Annes Street and continuing west across Lynde Creek immediately north of Highway 401 before turning north to join Dundas Street east of Highway 412 (see **Figure 2-4**). The need for this road was demonstrated in

the Town of Whitby Transportation Master Plan (Dillon, 2010) to alleviate traffic congestion along Dundas Street through downtown Whitby. A Municipal Class Environmental Assessment remains required to refine the preferred alignment and configuration of the future road connection.

Figure 2-2 Whitby Official Plan - Land Use

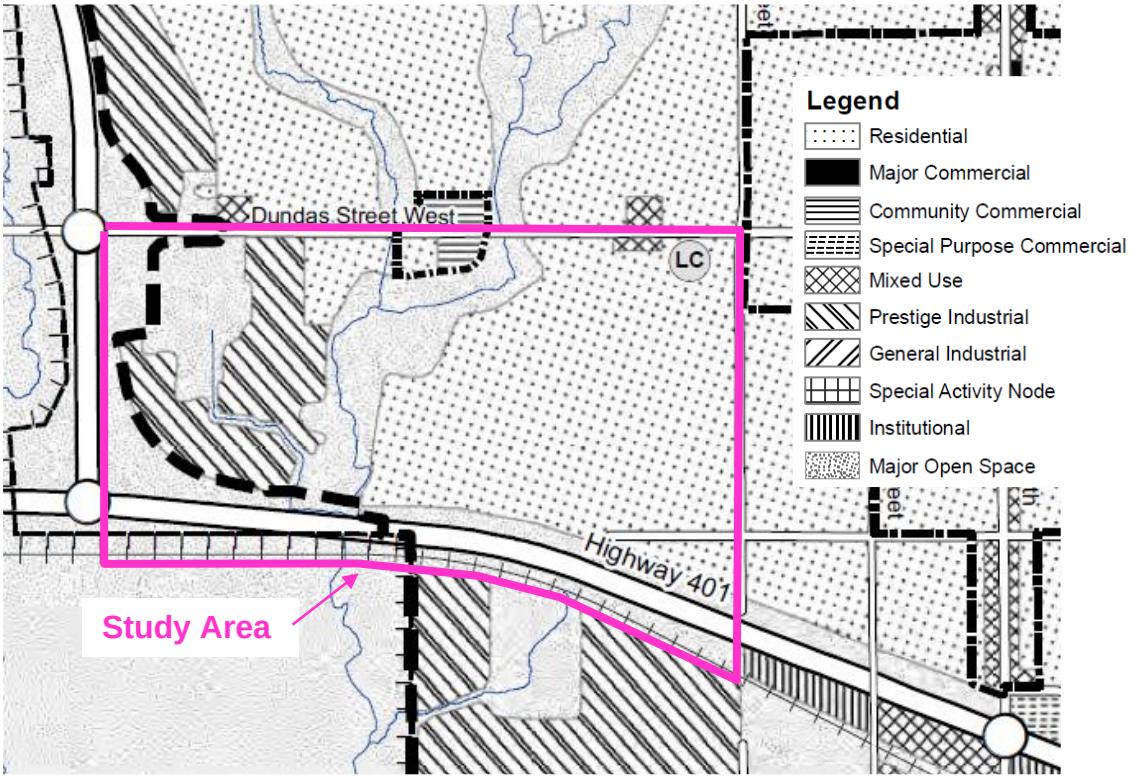


Figure 2-3 Whitby Official Plan - Water Resources

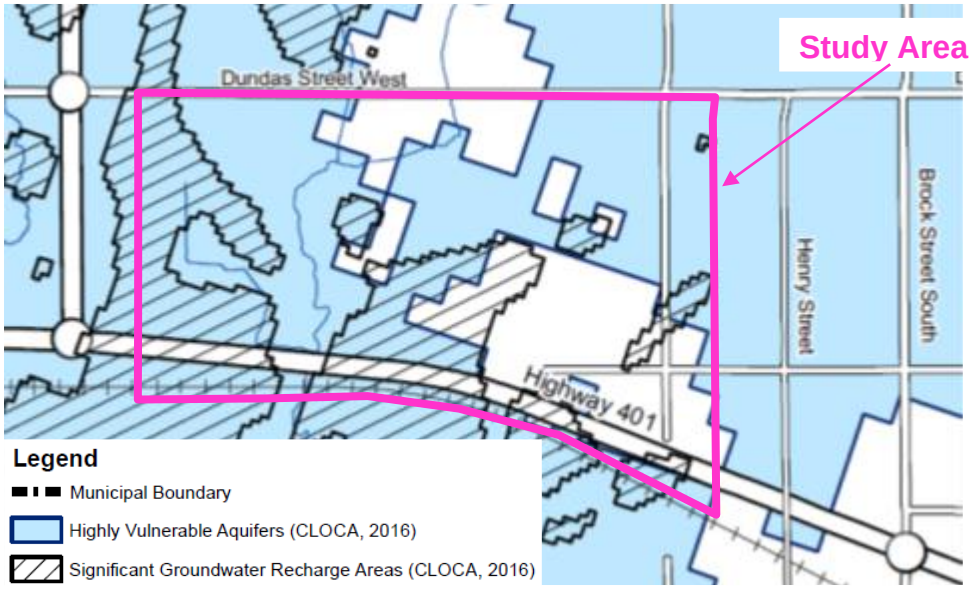
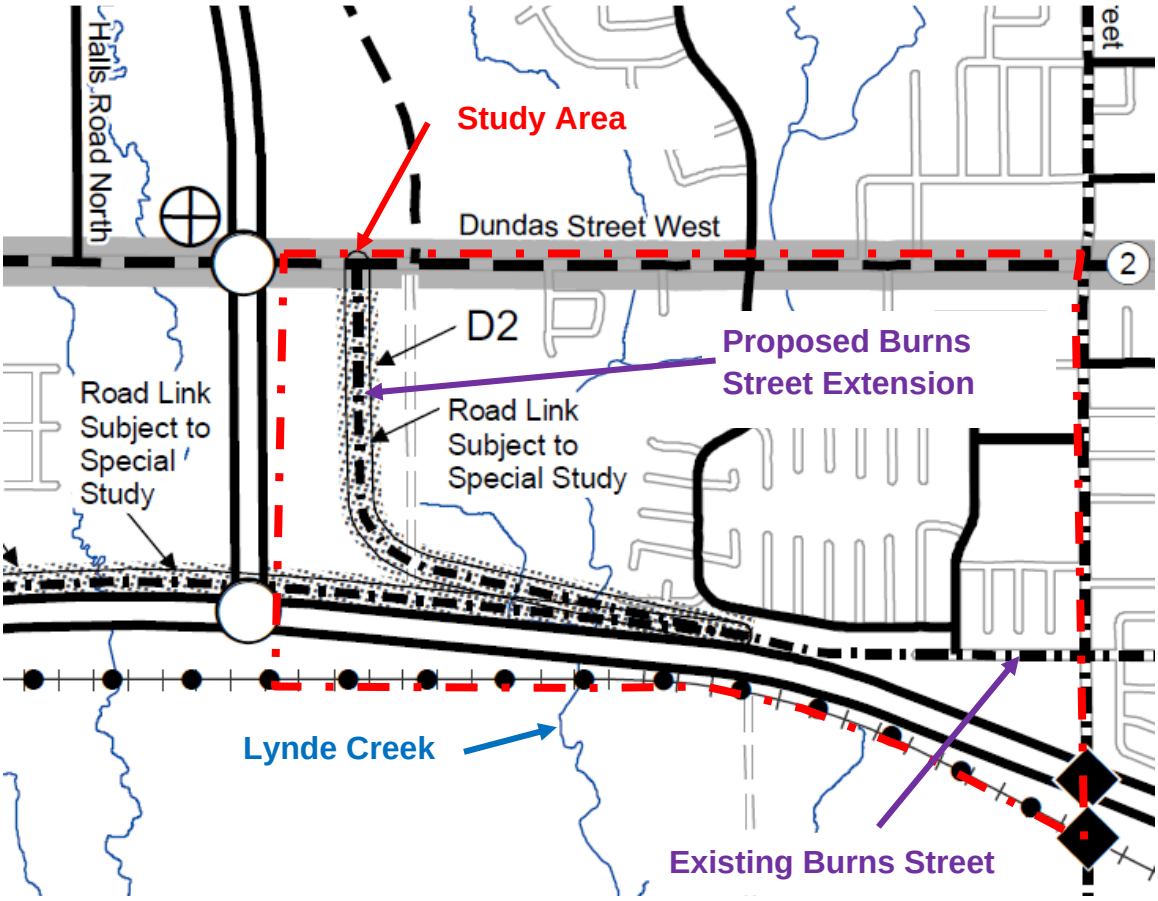


Figure 2-4 Potential Burns Street Extension Alignment



From Town of Whitby Official Plan

2.1.6 Central Lake Ontario Conservation Authority

Lynde Creek is regulated by CLOCA under Ontario Regulation 42/06. Approvals are required from CLOCA for all activities within 15 m of the limit of the flood plain or stable top-of-slope associated with the Lynde Creek valley corridor, as well as within 120 m of Provincially Significant Wetlands (PSWs) and 30 m of all other wetlands.

Figure 2-5 shows that a considerable portion of the study area is regulated, primarily due to the extent of the Lynde Creek Regional storm flood plain, and also due to the presence of the Lynde Creek Marsh PSW in the base of the Lynde Creek valley corridor.

The Michael Boulevard study area is considered a Flood Damage Centre due to the number of homes in the flood plain, and is managed accordingly in CLOCA's Flood Warning and Forecasting program and watershed planning initiatives.

Figure 2-5 CLOCA Regulation Limit

2.1.7 Source Water Protection

The Source Protection Plan for the CTC Source Protection Region, which includes the study area, was approved in 2015. The study area is not designated as a significant groundwater quality or quantity threat area, and lies outside of the Intake Protection Zones associated with Lake Ontario intakes. However, Lynde Creek itself through the study area is considered an 'event based area' as a conduit for potential spills to reach Lake Ontario and water treatment plant intakes.

The majority of the study area is also considered Highly Vulnerable Aquifer and/or Significant Groundwater Recharge Area in the Durham and Whitby Official Plans (**Section 2.1.5**).

2.2 Physiographic Environment

2.2.1 Physiography and Topography

The study area is located within the Iroquois Plain physiographic region (Chapman and Putnam, 1984). This region extends as a narrow band about five kilometers in width along the lowland bordering Lake Ontario. Although the dominant soil texture is comprised mainly of permeable sands and gravels, which were deposited along the shores of glacial Lake Iroquois about 12,500 years ago, the underlying deposits

of clayey silt till are commonly found at surface. The topography of the region is characterized by rolling topography due to the presence of numerous northeast-southwest trending drumlins.

Locally, the Lynde Creek valley corridor is the dominant topographic feature, with lands to both the east and west gently sloping toward the Lynde Creek valley. Natural fluvial processes have resulted in the Lynde Creek channel migrating closer to the residential lots to the east, particularly at Flemington Court and Evans Court. Restoration works were recently undertaken to stabilize the slope and protect a residential property abutting Lynde Creek at Evans Court.

2.2.2 Soils and Groundwater

The Lynde Creek Interim Watershed Characterization Report (CLOCA, 2007) and other general sources for soils information show the majority of the study area underlain by clay loam soils, with pockets of sandy loam soils on the east side of the study area.

Borehole records from MTO and Metrolinx investigations show primarily silty clay soils, interspersed with layers of more granular soils starting several metres below ground surface. Bedrock was encountered at elevations of 68 m to 70 m, and groundwater was measured at an elevations of approximately 77 m. For reference, the invert of the Lynde Creek channel is at an elevation of approximately 76 m at Highway 401, rising to approximately 77.8 m at Dundas Street, and the residential areas immediately east of Lynde Creek are generally at or above 80.0 m. It is expected that the local groundwater table in the study area has a gradient sloping toward Lynde Creek.

Despite the relatively low permeable silt and clay soils in the study area, it has been identified as a Significant Groundwater Recharge Area in the Town of Whitby Official Plan. This is due to the presence of the Lynde Creek Marsh provincially significant wetland in the Lynde Creek valley within and downstream of the study area, which relies on groundwater discharge from a large area that includes portions of the Michael Boulevard study area. More information on the wetland can be found in **Section 2.2.5**.

2.2.3 Natural Heritage

Extensive inventories of natural heritage conditions through the study area were completed as part of the Lynde Creek CNR and GO Transit Functional Feasibility Assessment (AECOM, 2018). The findings from these past investigations have been

verified through site inspections and consultation with Ministry of Natural Resources and Forestry (MNRF) and CLOCA, and are summarized below.

2.2.4 Fisheries and Aquatic Habitat

Given its proximity to Lake Ontario, Lynde Creek within the study area provides habitat for a large and diverse fish community. It serves as a migration route for cold/coolwater species such as salmon and trout, with a year-round population of a range of warmwater species.

Fish and fish habitat were assessed as part of the Feasibility Assessment (AECOM, 2018). Fish sampling conducted a short distance downstream of the study area near Victoria Street found Chinook Salmon (Oncorhynchus tshawytscha), White Sucker (Catostomus commersonii), Brown Bullhead (Ameiurus nebulosus), Brook Stickleback (Culaea inconstans), Bluntnose Minnow (Pimephales notatus), Creek Chub (Semotilus atromaculatus), Golden Shiner (Notemigonus crysoleucas), Spotfin Shiner (Cyprinella spiloptera), Johnny Darter (Etheostoma nigrum), Logperch (Percina caprodes), Rock Bass (Ambloplites rupestris) and Round Goby (Neogobius melanostomus).

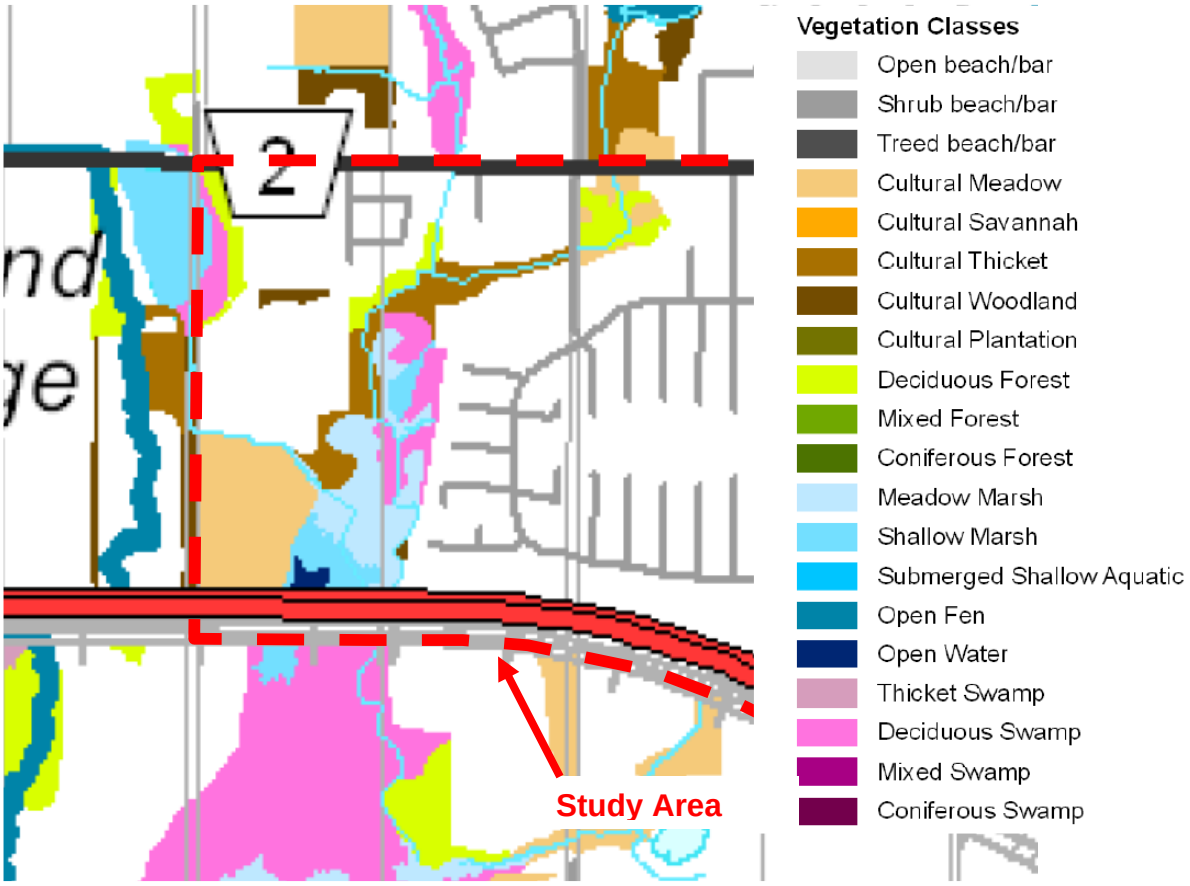
2.2.5 Vegetation and Terrestrial Habitat

The Feasibility Assessment (AECOM, 2018) included assessments of the vegetation and wildlife habitat within the study area, based on field investigations and agency consultation. Ecological Land Classification (ELC) mapping was also prepared as part of the Lynde Creek Watershed Existing Conditions Report - Chapter 17 - Terrestrial Natural Heritage (CLOCA, 2008).

Within the study area, the Lynde Creek watercourse corridor is comprised primarily of wetland vegetation communities, including meadow marsh, shallow marsh and deciduous swamp. Lynde Creek immediately downstream of the rail corridor was surveyed in 2013, and consisted of a green ash dominated deciduous forest and swamp, a large cattail swamp with open water and a willow deciduous swamp (AECOM, 2018). The 2013 survey found two regionally rare plant species, but no federally or provincially rare plants.

In the vicinity of Jeffrey Park, the Lynde Creek valley narrows and transitions to a cultural thicket community, and then to a deciduous forest community between Jeffrey Street and Dundas Street. The undeveloped lands to the west of Lynde Creek are characterized as cultural meadow.

Figure 2-6 ELC Vegetation Community Mapping



From Lynde Creek Watershed Existing Conditions Report - Chapter 17 - Terrestrial Natural Heritage (CLOCA, 2008)

2.2.6 Wetlands

The wetland vegetation communities described in **Section 2.2.5** represent the upstream limit of the Lynde Creek Coastal Wetland Complex, a Provincially Significant Wetland (PSW) more commonly referred to as the Lynde Creek Marsh. The Feasibility Assessment (AECOM, 2018) summarized CLOCA's 2006 evaluation report for the wetland complex. Near the rail corridor and study area, the dominant vegetation community is a Willow Mineral Deciduous Swamp Type (SWD4-1). The canopy consists of Basket Willow (Salix Xrubens), with a sub-canopy comprised of Manitoba Maple (Acer negundo) and Himalyan Balsam (Impatiens glandulifera). Outside of the cattail areas (Typha Xglauca), Golden Creeping Jenny dominates the ground layer of vegetation.

The Lynde Creek Marsh has been monitored since 2002 as part of the Durham Region Coastal Wetland Monitoring Project, and now the CLOCA Integrated

Watershed Monitoring Program. The wetland scores as Poor to Very Poor for all indicators except Bird Community, which scored as Good (from https://camaps.maps.arcgis.com/apps/MapSeries/index.html).

2.2.7 Wildlife

The Lynde Creek valley corridor is an important linkage between natural areas north and south of Highway 401, and the vegetation communities within the study area provide suitable habitat for a wide variety of species. The Feasibility Assessment (AECOM, 2018) noted that evidence of Deer, Snapping Turtles, American Beaver, Muskrat, Coyote and Red Fox were observed during previous field investigations.

2.2.8 Species at Risk

Existing Species at Risk (SAR) records were queried through correspondence with the Aurora office of MNRF and the Natural Heritage Information Centre (NHIC) database. A formal response was received from MNRF on January 22, 2019 with respect to SAR records and potential SAR occurrences within or adjacent to the project study area. Information obtained from MNRF identified potential SAR in the entire Town of Whitby municipal limits. As the information provided by MNRF is not specific to the study area, a pre-screening was completed to remove those species that are historic records (i.e., greater than 25 years old) or do not have any feasible habitat opportunities.

Based on correspondence with MNRF, review of the NHIC database and professional experience on habitat preferences, a desktop screening exercise was completed based on potential suitable habitat in the study area. The screening, summarized in **Table 2-1**, determined that there is potential suitable habitat for twelve SAR species in the study area.

Table 2-1 Habitat Screening for MNRF SAR Records

Species	Habitat Requirement Overview	Habitat Suitability	SARO Status
Bank Swallow	The Bank Swallow readily breeds in a wide variety of low-elevation, natural and anthropogenic habitats, including: lake and ocean bluffs; stream and river banks; sand and gravel pits; piles of sand, and other materials.	Potential – foraging habitats, Lynde Creek corridor	Threatened

Species	Habitat Requirement Overview	Habitat Suitability	SARO Status
	Aerial foraging occurs at open terrestrial habitats such as meadows, pastures, grasslands and agricultural cropland near breeding sites.		
Barn Swallow	Prefers farmland; lake/river shorelines; wooded clearings; urban populated areas; rocky cliffs; and wetlands. They nest inside or outside buildings; under bridges and in road culverts; on rock faces and in caves etc.	Potential – foraging and man-made structures	Threatened
Blanding's Turtle	Occur in a wide variety of wetland types. Females nest in open upland areas by wandering many hundreds of metres from their resident wetlands.	Potential – wetland areas in northeast corner of study area	Threatened
Bobolink	Generally prefers open grasslands and hay fields. In migration and in winter uses freshwater marshes and grasslands	Potential – old field, pasture fields	Threatened
Butternut	Butternut grows best on rich, moist, well-drained loams often found on stream bank sites but may be found on well-drained gravelly sites, especially those of limestone origin.	Potential – Woodlands, hedgerows, Lynde Creek corridor	Endangered
Chimney Swift	Typically found in and surrounding urban settlements where they nest	Potential – manmade structures	Threatened

Species	Habitat Requirement Overview	Habitat Suitability	SARO Status
	and roost in chimneys and other manmade structures.		
Eastern Meadowlark	Generally, prefers grassy pastures, meadows and hay fields. Nests are always on the ground and usually hidden in or under grass clumps.	Potential – old field pasture fields	Threatened
Eastern Wood-pewee	The Eastern Wood-pewee is mostly associated with the mid-canopy layer of forest clearings and edges of deciduous and mixed forests. It is most abundant in forest stands of intermediate age and in mature stands with little understory vegetation.	Potential – Lynde Creek corridor and wooded areas through western portion of study area	Special Concern
Red-headed Woodpecker	The Red-headed Woodpecker is found in a wide variety of habitats, including open oak and beech forests, grasslands, forest edges, orchards, pastures, riparian forests, roadsides, urban parks, golf courses, cemeteries, as well as along beaver ponds and brooks.	Potential through western portion of the study area	Special Concern
Snapping Turtle	Snapping turtles spend most of their lives in water. They prefer shallow waters so they can hide under the soft mud and leaf litter, with only their noses exposed to the surface to breathe.	Potential – Wetland area through western portion of study area, Lynde Creek corridor	Special Concern

Species	Habitat Requirement Overview	Habitat Suitability	SARO Status
Wood Thrush	The Wood Thrush is found in moist, deciduous hardwood or mixed stands, often previously disturbed (e.g., small-scale logging and ice storm damage), with a dense deciduous undergrowth and with tall trees for singing perches.	Potential – Lynde Creek corridor and wooded areas through western portion of the study area	Special Concern
Yellow-breasted Chat	In Ontario, Yellow-breasted Chats use regenerating old fields, forest edges, railway and hydro rights-of-way, young coniferous reforestations and, occasionally, wet thickets bordering wetlands. Tangles of grape (Vitis spp.) and raspberry (Rubus spp.) are a frequent feature.	Potential – forested and wetland communities through western portion of the study area	Endangered

Available records from CLOCA and DFO have confirmed that the reach of Lynde Creek through the study area is not managed for Species at Risk. However, the reaches north of Dundas Street are considered occupied or recovery habitat for Redside Dace, and the creek and wetland areas downstream of the Metrolinx and CN rail corridors are protected habitat for Eastern Pondmussel.

2.2.9 Significant Natural and Environmentally Sensitive Areas

The Lynde Shores Conservation Area is located to the south of the study, generally covering Lynde Creek and the lands west to Halls Road, between Highway 401 and Lake Ontario. The 272 ha conservation area includes the provincially significant Cranberry Marsh and Lynde Creek Coastal Wetland Complex.

The Cranberry Marsh is located on the north shore of Lake Ontario, generally between Halls Road and Eastbourne Beach Road. It is also classified as the Lynde

Shores Coastal Wetlands, an Area of Natural and Scientific Interest (ANSI). However, there does not appear to be a hydrologic connection between the study area and the coastal wetland ANSI.

2.3 Cultural Heritage

2.3.1 Archaeology

A Stage 1 Archaeological Assessment (AA) was completed as part of the Feasibility Assessment (AECOM, 2018), but was restricted to a relatively small area surrounding the Highway 401, Metrolinx and CN crossings of Lynde Creek. The study determined that areas immediately north of Highway 401 and south of the railways had been previously assessed and cleared as part of past assessments, but recommended a Stage 2 AA for any previous undisturbed areas along the Lynde Creek valley corridor. A copy of the Stage 1 AA is included as **Appendix G.**

It is expected that these conclusions would also apply to the remainder of the study area, where past development along Dundas Street and through the residential areas to the east of Lynde Creek have already been disturbed, but the Lynde Creek valley corridor and undeveloped lands between Lynde Creek and Highway 412 (excluding steep slopes and open water / wetland areas) retain some potential for archaeological resources. A Stage 2 AA (i.e. test pits) would be required prior to detailed design of any works in these previously undisturbed areas.

2.3.2 Built Heritage

There are no known heritage buildings in the study area, but a building on the north side of Dundas Street (#7254) has been listed (but not designated) as a heritage building.

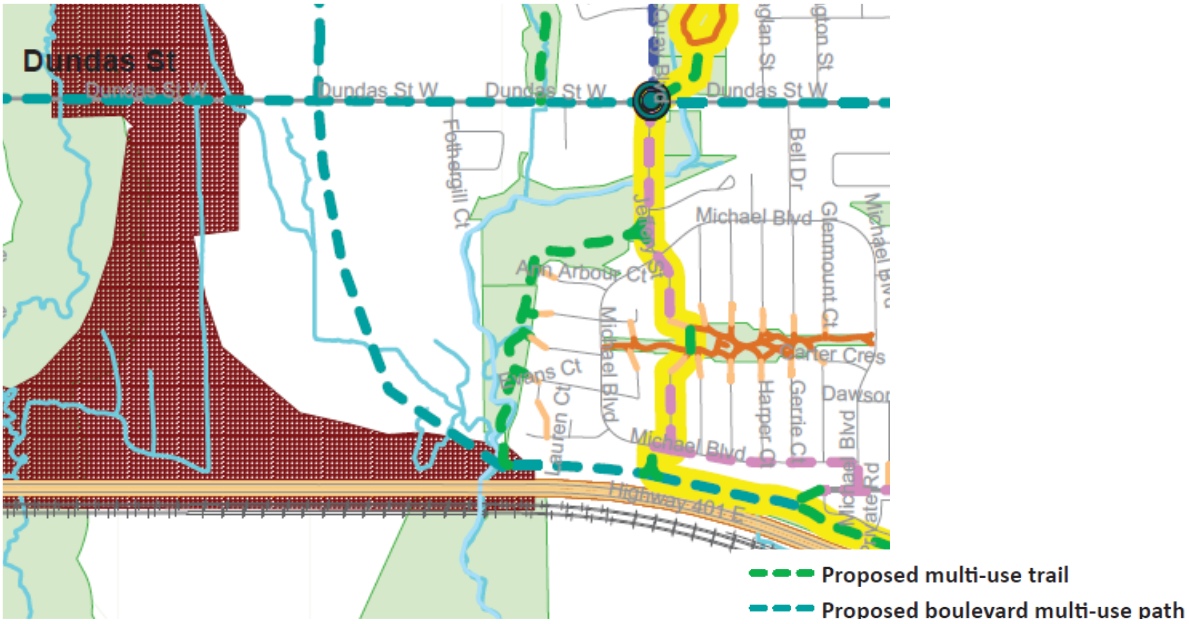
2.3.3 Recreation

There are several parks in the study area, including Jeffrey Street Park located on the south side of Lynde Creek, west of Jeffrey Street. The Town of Whitby recently completed improvements to Jeffrey Park, including a splash pad, a new playground a multi-use court, and a pedestrian bridge over Lynde Creek to connect to White Oaks Court to the north. The entrance, parking lot and soccer fields were maintained. The entire Jeffrey Park is located in the Regional storm flood plain.

There is a formal trail extending from Annes Street to the west end of Burns Street, and an informal walking trail continuing westward to connect to the unopened road right-of-way on the south side of Michael Boulevard near Marbury Court.

The Town of Whitby Cycling and Leisure Trails Master Plan (IBI, 2010) proposes integrated bike lanes within the future Burns Street extension across Lynde Creek (refer to **Section 2.1.5**), and a multi-use trail along the east side of the Lynde Creek valley corridor to connect to the future Burns Street extension to Jeffrey Street Park.

Figure 2-7 Proposed Active Transportation



From Town of Whitby Cycling and Leisure Trails Plan (IBI Group, 2010)

Correspondence received from the Durham Region Cycling Coalition through this Municipal Class EA and the Lynde Creek Master Drainage Plan Update have endorsed the multi-use trail connection to Jeffrey Park and recommended an interim trail west of Burns Street as an interim measure until the future roadway is constructed. The Durham Region Cycling Coalition has further advocated for a formal trail connection under the Highway 401 and rail corridors, connecting to the waterfront trail system to the south.

2.4 Engineering Environment

2.4.1 Watershed Hydrology

2.4.1.1 Hydrologic Modelling

The study area is located near the outlet of the Lynde Creek watershed to Lake Ontario. The total drainage area upstream of the study area is approximately 10,400 ha. The recently completed Lynde Creek Master Drainage Plan Update (MDPU)

(AECOM, currently under study), included a comprehensive update to the Lynde Creek watershed hydrology model. The Visual OTTHMYMO (VO) event-based hydrology model was updated to reflect existing land use conditions through the watershed and incorporated the existing stormwater management facilities that have been constructed to control the flow rates from recent developments in the watershed. The updated VO model was then used to simulate the peak flows resulting from the 2 year through 100 year return period storms and Regional storm (Hurricane Hazel) events under existing and future development conditions. The 2 year through 100 year storm events are based on a 12 hour Chicago storm distribution.

The Lynde Creek MDPU VO modelling also included a future climate change scenario. For the future climate change scenario, four different methods were used to predict the impact of future climate conditions on peak flow rates in Lynde Creek. The results from the different methods ranged from a slight increase in rainfall intensities to a more than doubling of rainfall intensities. The MDPU selected the 'Western University Approach' to represent future climate conditions. This approach uses projections from the Representative Concentration Pathways scenarios from the Intergovernmental Panel on Climate Change 5th Assessment Report, and the resulting rainfall intensities are close to the average of the four methods tested.

For the Regional (Hurricane Hazel) storm event, initial soil conditions were converted to saturated (AMC III), and the final 12 hours of the historic storm were simulated. The Technical Guide - River & Stream Systems: Flooding Hazard Limit ('Technical Guide') (MNRF, 2002) recognizes that rainfall is rarely distributed evenly over a very large watershed, and specifies areal reduction factors that reduce rainfall intensities for the Regional storm event as the upstream drainage area increases. Areal reduction factors are based on an equivalent circular area to account for elongated watersheds. At the study area, the equivalent circular area is approximately 285 km^2 (based on watershed diameter of 19 km), and therefore the Hurricane Hazel rainfall amounts can be reduced by a factor of 0.894.

The Technical Guide (MNRF, 2002) also recommends a number of conservative assumptions be applied to a hydrology model used to generate flows for Regulatory flood plain mapping. This includes a recommendation to not consider any 'man made' storage attenuation facilities in the modelling, including stormwater management ponds, dams and storage behind restrictive culverts and bridges. The VO model created for the Lynde Creek MDPU conforms to these guidelines, with all stormwater management facilities and other man-made storage excluded from the Regional storm model.

For this study, an additional hydrology model scenario was created to reflect the actual flood risk at the site under existing watershed conditions, considering both formal and informal storage that has the effect of potentially reducing flows in Lynde Creek. For this scenario, all existing stormwater management facilities were retained in the VO hydrology model for all storm events, and additional, informal storage behind road and rail culverts was considered.

Storage areas were initially screened through a review of the Lynde Creek watershed flood plain mapping and HEC-RAS hydraulic model (See **Section 2.4.2**). Locations with a significant extent of flooding upstream of a road crossing, with a height of several metres from the culvert invert elevation to the top-of-road or maximum flood elevation were selected for analyses.

For each flooding area, storage volumes were estimated from the topographic mapping provided by the Town of Whitby (1 m contour intervals), and the discharge at each stage was determined from the HEC-RAS hydraulic model. **Figure 2-8** shows the ponding locations considered, and the total storage volume available and downstream control feature for each storage area are summarized in **Table 2-2**. Detailed calculations for the storage volume and discharge at each flood stage are included in **Appendix B.**

Table 2-2 Lynde Creek On-Line Storage Elements

Storage Location	Storage Available Before Overtopping	Downstream Flow Restriction
LYNDE 2 AT HIGHWAY 401	881,000 m^3 at 81.0 m	15.3 m span bridge under GO rail line and 13.3 m span bridge under CNR rail line
LYNDE 4 AT RAILWAY	665,000 m^3 at 97.0 m	Twin 4.6 m diameter culverts
LYNDE 4 AT TAUNTON ROAD	440,000 m^3 at 119.0 m	10.0 m wide x 4.7 m high arch culvert
LYNDE 4 AT BALDWIN STREET	112,000 m^3 at 139.0 m	9.6 m wide x 5.1 m high bridge
MYRTLE 1 AT BRAWLY ROAD	65,000 m^3 at 197.0 m	4.9 m wide x 3 m high pipe-arch culvert
MYRTLE 3 AT MYRTLE ROAD	45,000 m^3 at 234.0 m	6.0 m wide x 3.3 m high arch culvert
MYRTLE 3 AT RAILWAY	366,000 m^3 at 267.0 m	1.7 m wide x 1.9 m high arch culvert
MYRTLE T2-1 AT MYRTLE ROAD	58,000 m^3 at 242.0 m	1.2 m diameter culvert
HEBER 1 AT RAILWAY	326,000 m^3 at 93.0 m	36 m span bridge
HEBER 1 AT TAUNTON ROAD	190,000 m^3 at 105.0 m	16 m span bridge
HEBER 2 AT MACEDONIAN VILLAGE	19,000 m^3 at 114.0 m	12 m span bridge
HEBER 4 AT WINCHESTER ROAD	24,000 m^3 at 147.0 m	7.4 m wide x 2.1 m high bridge

These storage areas were added to the Lynde Creek VO hydrology model for existing watershed conditions, which was then simulated for the same storm events as the base model from the Lynde Creek MDPU. The results are summarized in **Table 2-3**. The inclusion of the informal storage areas behind undersized road and

rail culverts results in reductions in peak flow rates ranging from 6% for the 2 year storm to 20% for the 100 year storm, and 26% for the Regional storm event.

Note that only the existing conditions Lynde Creek VO hydrology model was updated with the storage behind roadway and rail embankments. The Lynde Creek MDPU (AECOM, currently under study) also included a VO model representing future land use conditions in the watershed, based on current Official Plans and approved Secondary Plans for the Town of Whitby and other municipalities in the watershed. However, the future conditions hydrologic modelling for the Lynde Creek MDPU did not size or include stormwater management facilities to mitigate the impacts of future development on peak flow rates in Lynde Creek. The modelling predicted that without mitigation, flow rates in Lynde Creek would increase by 10% to 20% for up to the 100 year storm event. It then stated that stormwater management works associated with future development would mitigate these impacts such that ‘there should be no change in peak flows due to land development.’ The Lynde Creek MDPU also concluded that for the Regional storm event, future development would only increase peak flow rates by 1% to 2% in the lower reaches of Lynde Creek.

Given the above, future development upstream in the Lynde Creek watershed should have a negligible impact on flow rates and flood levels in Lynde Creek within the study area. As such, the assessments of current flood risk and development of alternative flood mitigation solutions have been based on the existing conditions hydrologic and hydraulic models for the watershed.

Table 2-3 Hydrology Model Output - Lynde Creek at Highway 401

Storm Event	Peak Flow Rates (m^3/s) from Lynde Creek MDPU [1]	Peak Flow Rates (m^3/s) from Michael Boulevard Flood Mitigation Refinements [2]
2 Year	36.0	33.9
5 Year	67.6	62.1
10 Year	85.1	77.1
25 Year	122.2	101.6
50 Year	152.9	122.0
100 Year	176.9	141.0
100 Year Future Climate Scenario [3]	213.8	165.1
Regional [4]	695.1	514.7

[1] Including existing stormwater management facilities for the 2 year through 100 year storm events but excluding storage behind road and rail crossings

[2] Including existing stormwater management facilities and including storage behind road and rail crossings for all storm events

[3] Based on the Western University approach to account for potential future climate conditions

[4] Based on AMC III soil conditions and Areal Reduction Factor of 0.894

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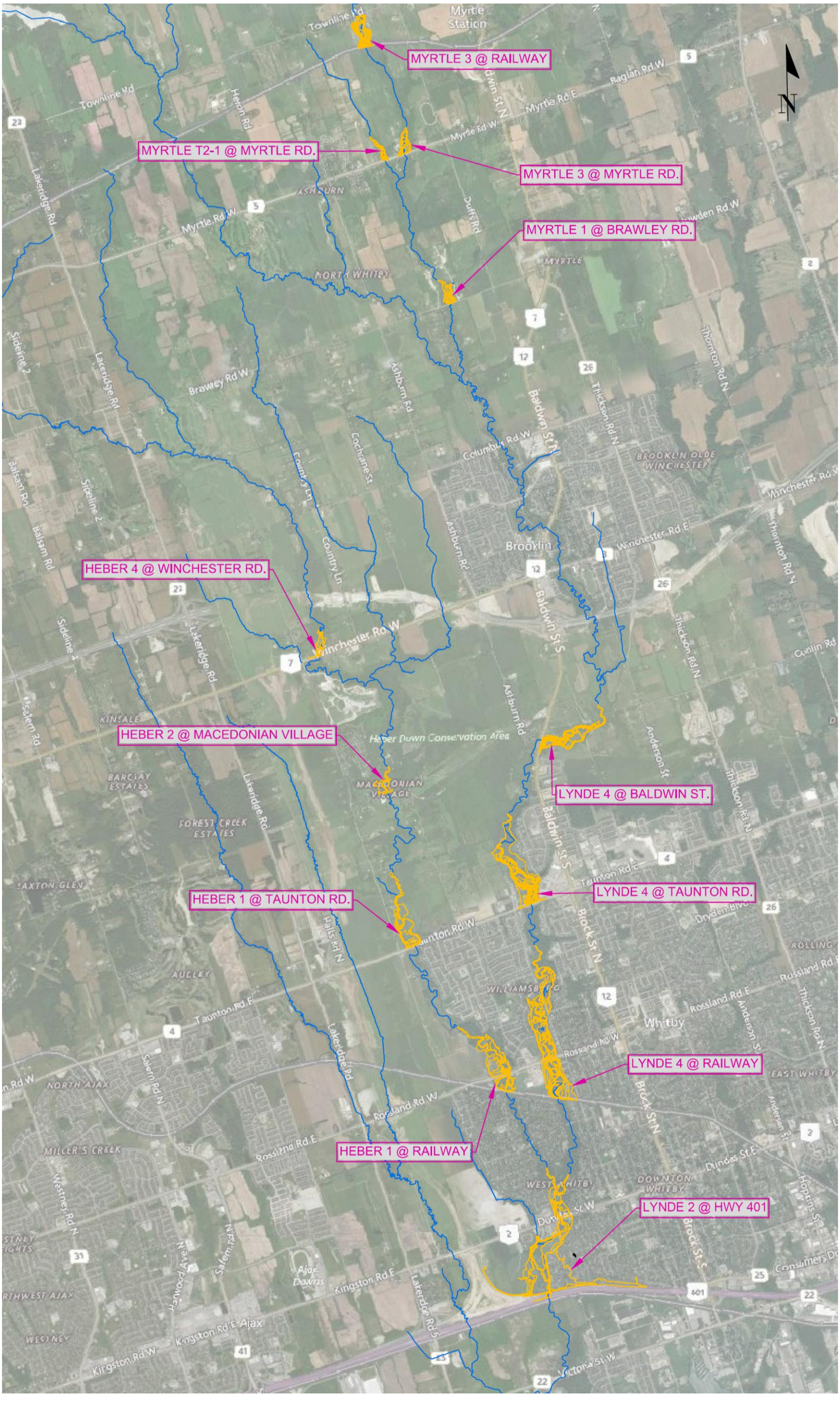
Figure 2-8 Lynde Creek On-Line Storage Area Locations



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2.4.1.2 Flood Frequency Analysis

The output from the updated Lynde Creek watershed hydrology model was compared against historic flow monitoring data for Lynde Creek. The Water Survey of Canada (WSC) maintains a streamflow gauge on Lynde Creek at Dundas Street (02HC018). Maximum instantaneous streamflow records are available dating back to the late 1960's, with the largest flow of 54.2 m^3/s recorded in 2006.

A flood frequency analysis was performed on the 38 years for which data was available, yielding a 100 year return period peak flow rate of approximately 60 m^3/s. This is comparable to the 5 year storm from the hydrology model, and is approximately ⅓ of the 100 year storm peak flow predicted by the hydrology model. Thus, even when accounting for additional, informal storage behind undersized road and rail crossings, the peak flow rates from the Lynde Creek watershed hydrology model remain very conservative. The flood frequency analysis is included in **Appendix C.**

2.4.1.3 Climate Change Considerations

Adaptation and resiliency to future climate change are key considerations in any infrastructure project, and of particular importance to flood mitigation projects. The 2018 Companion Guide for the Municipal Class EA Manual encourages proponents to consider both climate change mitigation and adaptation in Municipal Class EA undertakings, but recognizes that the degree to which climate change is considered will vary depending on the type and complexity of the undertaking. Further direction is provided in the MECP on-line guide 'Considering Climate Change in the Environmental Assessment Process' (CC Guide) and Ontario's Long Term Infrastructure Plan (LTIP) (Ministry of Infrastructure, 2017). The LTIP includes the following guidance related to consideration of climate change:

- 'Infrastructure, both new and existing, should be resilient, support the resilience of the surrounding community, and be able to adapt to the impacts that Ontario experiences.'
- 'Infrastructure investments require the application of a "risk lens" to protect their future. Infrastructure planning, design and construction require an understanding of future climatic conditions, vulnerabilities and potential risks to ensure that infrastructure, and infrastructure budgets, will not be compromised by climate change impacts.'

The CC Guide reinforces this position with the following statement:

- 'In order to reduce future climate-related risks to the local environment, a proponent could consider climate change adaptation measures that increase

resilience of any aspect of the proposed project's design, operation and function which could be susceptible to climate variability.'

Climate change is also discussed in the 'Technical Guidelines for Flood Hazard Mapping' (EWRG, March 2017), a document that was prepared under the guidance of a steering committee comprised of staff from six Southern Ontario conservation authorities. The guideline notes that future climate change may impact local rainfall intensity-duration-frequency (IDF) curves, which form the basis for return period design storm events that are typically used for the design of water resources infrastructure.

The City of Markham recently completed a review of past and current climate data and a number of other climate change resources during an update to the City's IDF curves for storm drainage infrastructure. The findings were summarized in the Don Mills Channel Flood Reduction Study (TMIG, 2018). The review showed a slightly decreasing trend in rainfall intensities at Environment Canada's Toronto Pearson Airport gauge (3% average decrease since 1990), and a slight (1% average) increase in rainfall intensities for the Buttonville Airport rainfall gauge. However, it is recognized that these analyses were based on trends in historic data and not predictions for future climate conditions.

The study further noted that different design storm hyetographs in watershed hydrologic modelling (i.e. 1 hour vs 24 hour storm duration, AES vs SCS vs Chicago distributions) had the potential to influence peak flow rates as much or more than consideration of potential future climate conditions.

As noted in **Section 2.4.1.1**, the Lynde Creek MDPU accounted for potential future climate change impacts by including a scenario based on the Western University Approach to develop input rainfall hyetographs for the VO modelling. This results in a 17% increase in peak flow rates in Lynde Creek for the 100 year return period storm event relative to the storm hyetograph based on current rainfall statistics.

Many conservation authorities in the Greater Toronto Area recommend increasing rainfall intensities by 20% to represent potential future climate change conditions, based on past climate change research that suggested that average annual rainfall amounts could increase by as much as 20% under future climate conditions. A second scenario was developed to increase the 100 year rainfall intensities by 20% over the standard 12 hour Chicago Storm hyetograph. With this approach, the peak flow in Lynde Creek at Highway 401 is predicted to increase by 35% over the standard 100 year event.

For further context, a flood frequency analysis was completed on the output from the Lynde Creek watershed hydrology model. For the 100 year storm event, the peak

flow from the Lynde Creek MDPU future climate change scenario is comparable to the 200 year return period storm projected from the 2 to 100 year storm events without considering climate change. If the rainfall intensities are increased by 20%, the resulting peak flow rate is comparable to a 500 year return period storm.

Recall that the flood frequency analysis described in **Section 2.4.1.2** found that even without considering climate change, the 100 year peak flow rate predicted by the hydrology model is already approximately 3 times higher than that predicted by the statistical analysis of the Lynde Creek historical streamflow data.

As the Lynde Creek watershed model output already appears sufficiently conservative relative to observed data, it was decided to adopt the Western University approach described in the Lynde Creek MDPU to estimate rainfall intensities and flow rates in Lynde Creek under predicted future climate conditions, as opposed to the more conservative 20% increase in rainfall intensity approach. .

Regardless of the above, the development and evaluation of alternative solutions to reduce flooding in the Michael Boulevard study area have considered improvements to offer protection above the 100 year storm flood level where feasible to maximize resiliency to flooding, regardless of potential future climate conditions.

Note finally that the Lynde Creek MDPU is currently being revised to consider climate change data from an ongoing study led by Durham Region and the Ontario Climate consortium. The findings from these studies should be considered during any future design of the flood reduction measures recommended through the Michael Boulevard Flood Mitigation Strategy.

Table 2-4 Comparison of Climate Change Approaches

Scenario	100 Year Peak Flow Rate at Highway 401 (m^3/s)	Equivalent Return Period
Current climate conditions	141.0	100 Year Flood
Western University Approach	165.1	200 Year Flood
20% Increase in Rainfall Intensities	190.3	500 Year Flood

Based on the watershed hydrology model incorporating the Michael Boulevard Flood Mitigation refinements

2.4.2 Hydraulics and Flood Plain Mapping

2.4.2.1 Hydraulic Model Refinements

The HEC-RAS hydraulic model for Lynde Creek was recently updated as part of the Feasibility Assessment (AECOM, 2018), as described in **Section 1.2.4**. The Highway 401, Metrolinx and CNR culverts and embankments were coded into the model on the basis of design and as-constructed drawings and a limited topographic survey. Further refinements were completed for the Lynde Creek MDPU (AECOM, currently under study)

Given the number of homes potentially in the flood plain and the estimated cost of some of the previously proposed flood mitigation solutions, the previous HEC-RAS models were further refined through this Municipal Class EA study. The HEC-RAS model was comprehensively updated from downstream of the CN rail corridor (Reach Lynde-2, Section 3232) to downstream of Dundas Street (Reach Lynde-3, Section 313) as follows.

- A detailed topographic survey was completed to more accurately measure the low flow channel, underside of bridge openings and pier locations through the Highway 401, Highway 401 ramp, Metrolinx and CN bridge openings. This information was used to refine the 8 cross sections defining the upstream and downstream faces of the 4 bridges, as well as the top of each bridge opening (i.e. low chord). Note that the top of the rail embankments and Highway 401 pavement elevations were not surveyed due to access restrictions.
- CLOCA provided LiDAR topographic mapping developed from imaging completed in the fall of 2018. Note that the LiDAR topographic mapping was prepared using the CGVD2013 vertical datum, whereas all previous mapping, design drawings and surveys have been based on the CGVD28:78 datum. To ensure consistency with the Lynde Creek HEC-RAS model outside of the study area, the LiDAR mapping provided by CLOCA was adjusted to the CGVD28:78 datum. All LiDAR points were increased by 393 mm, based on the difference between the 2 vertical datums at nearby MNRF Control Survey Information Exchange (COSINE) stations. The adjusted LiDAR mapping was used to update all cross sections in the HEC-RAS model, with the exception of the sections at the rail and highway bridge faces described above.
- The adjusted LiDAR mapping was also used to represent the top of rail and top of road at the Jeffrey Street, Highway 401 and rail bridges (i.e. high chord)
- The ineffective flow area options at the Highway 401 and rail bridge crossings were adjusted to more accurately reflect flow conditions upstream and downstream of each crossing prior to and after overtopping

- The 'Bridge Modelling Approach' was revised for the 2 rail bridges to calculate flood levels for pressure and/or weir flow as well as the energy method for high flow conditions. For the 2 Highway 401 bridges, the bridge modelling approach was updated to also calculate flood levels using the Momentum and Yarnel methods to better account for the bridge piers under low flow conditions, and to also calculate flood levels for pressure and/or weir flow for high flow conditions
- Cross sections 3250 and 3253 (between the CNR and Metrolinx bridges) and cross sections 3271 and 3275 (between the Metrolinx and Highway 401 ramp bridges) were deleted from the model to better represent the contracted flow conditions along Lynde Creek between bridge openings. All reach lengths and bridge lengths were re-measured from the detailed topographic survey and adjusted accordingly.
- Cross section 3383 was deleted to better represent the contraction of effective flow area upstream of the Highway 401 bridge, and the reach lengths from the upstream face of the Highway 401 bridge (3324) and upstream section (3462) were measured from the survey and topographic mapping and updated accordingly
- Manning's 'n' values were updated to more accurately reflect current and future naturalization of the Lynde Creek valley corridor. In general, a Manning's 'n' value of 0.035 was applied to the bankfull channel, and a value of 0.075 was applied to vegetated areas within the Lynde Creek valley. Through the Highway 401 and Highway 401 ramp bridge openings, an 'n' value of 0.040 was applied to reflect the lack of vegetation and rip-rap protection under the bridge between the bankfull channel and bridge abutments. A Manning's 'n' value of 0.200 was applied to the cross sections within the built-up urban areas on either side of the valley corridor. This is based on guidance and past studies by the Manitoba Water Stewardship Water Branch for the Red River Floodway (Acres, 2004), and accounts for the various homes and other structures that block or impede flows once flooding extends beyond the top of bank and into the residential areas.

2.4.2.2 Hydraulic Model Output

The flows from the Lynde Creek VO model updated as part of this study were input to the refined Lynde Creek HEC-RAS model for the reaches from upstream of Dundas Street to downstream of the Highway 401 and railway crossings (Lynde-2, Lynde-3). The resulting flood elevations in Lynde Creek upstream of Highway 401 are summarized and compared to the flood levels from the Lynde Creek MDPU (AECOM, currently under study) in **Table 2-5**. The extent of flooding for the 100 Year and Regional storm events are shown on **Figure 2-11**.

Table 2-5 Predicted Flood Levels Upstream of Highway 401

Storm Event	Flow Rate (m^3/s)	Flood Elevation (m)
2 Year	33.9	78.04
5 Year	62.1	78.61
10 Year	77.1	78.87
25 Year	101.6	79.58
50 Year	122.0	80.53
100 Year	141.0	80.70
100 Year - Future Climate Scenario	165.1	80.90
Regional	514.7	82.81

Flood Elevations are taken at HEC-RAS section 3462, located approx. 100 m upstream of Highway 401

Even with the reduced flow rates representing current, actual watershed conditions, the rail bridges continue to act as a severe bottleneck in the system. The modelling predicts that homes in the Michael Boulevard will be impacted in a 50 year storm event, with a significant number of homes at risk of flooding during a Regional storm event.

More detailed maps showing the extent of flooding for each storm event are included in **Appendix D,** along with the output from the HEC-RAS hydraulic model.

2.4.2.3 Comparison to Past Studies

The results from the updated HEC-RAS model are compared to the flow rates and flood levels from past studies in **Table 2-6**.

Table 2-6 Comparison of Flood Levels Upstream of Highway 401

Model	100 Year Storm Flow Rate (m^3/s)[1]	100 Year Storm Flood Level (m)[1]	Regional Storm Flow Rate (m^3/s)[1]	Regional Storm Flood Level (m)[1]
Lynde Creek Master Drainage Plan (Sernas, 1988)	172	80.96	658	82.06
Lynde Creek Water Resources Management Strategy (Gartner Lee, 1994)	183 existing 178 future	n/a	718 existing 674 future	n/a
CLOCA Flood Plain Mapping (2008 Update) [2]	177.4	81.28	730.6	81.71
Lynde Creek CNR and GO Transit Culverts Feasibility Assessment (AECOM, 2018) [3]	177.4	80.67	730.6	81.99
Lynde Creek Master Drainage Plan Update (AECOM, currently under study)	177.4	80.63	730.6	82.02
Michael Boulevard Flood Reduction Strategy: Unreduced Flows (TMIG, 2019)	177.4	81.16	730.6 695.1 [5]	83.17 83.11
Michael Boulevard Flood Reduction Strategy: Reduced Flows (TMIG, 2019) [4]	141.0	80.71	514.7 [5]	82.81

[1] Based on existing land use conditions, not considering future potential climate change

[2] The 2008 Update reflected the former Highway 401 bridge (prior to construction of the Highway 401/412 interchange)

[3] The Feasibility Assessment was based on design drawings and a limited survey of the Highway 401 and rail bridges

[4] Flows were reduced to reflect storage and attenuation behind undersized road and rail bridges in the study area

[5] With Areal Reduction Factor applied as per MNRF guidelines

Table 2-6 shows that the refinements to the HEC-RAS model resulted in a relatively small change in water levels for the 100 year storm compared to the previous modelling by AECOM, but a significant increase in flood levels for the Regional storm event. Upstream of Highway 401, the Regional storm flood level is approximately 0.8 m higher than the previous modelling by AECOM, and more than 1 m higher than the flood elevation currently used in CLOCA's regulatory flood plain mapping. Many of the refinements to the HEC-RAS model described in **Section 2.4.2.1** were completed in stages, and through most of the refinements the Regional storm flood level upstream of Highway 401 remained at or close to an elevation of 82.0 m. The final refinement to the model was the update to the Metrolinx and CN bridge decks / top of rail profiles based on the adjusted LiDAR mapping. The bridge deck / top of rail profiles are compared in **Figure 2-9** (CNR Bridge) and **Figure 2-10** (Metrolinx Bridge). For further verification, the profile information (vertical curve data) from the original design drawings are also included on the comparison figures.

The modelling completed for the Feasibility Assessment and Lynde Creek MDPU generally maintained the rail deck profiles from the 2008 HEC-RAS modelling completed by CLOCA. **Figure 2-9** and **Figure 2-10** indicate that the deck profile used in those prior hydraulic models is significantly lower than the deck profile generated from the LiDAR mapping. The limited profile information on the design drawings for the rail bridges agrees with the LiDAR mapping much more than the previous deck profiles, confirming the accuracy of the LiDAR mapping. The previous models therefore significantly overestimated the amount of water flowing over the CN and Metrolinx embankments at lower elevations. For example, at the CNR bridge, the previous modelling resulted in a weir flow width of approximately 600 m and maximum weir flow depth of approximately 0.2 m at an elevation of 81.0 m. At the same elevation of 81.0 m, the LiDAR mapping shows a weir flow width of approximately 60 m and a maximum weir flow depth of only 0.05 m. These corrections to the rail deck profiles are therefore the primary causes of the increase in Regional flood elevations in Lynde Creek, and result in a more accurate prediction of the elevation and extent of the Regional storm flood plain through the study area.

Given the significant discrepancies in the modelling and impacts on the extent of flooding, a comprehensive update of the entire Lynde Creek flood plain mapping is recommended, or at least an update through the most flood prone areas in the watershed. The flood plain mapping should be based on the latest LiDAR topographic mapping and accurate as-built drawings and/or surveys of road and rail culverts and bridges.

Figure 2-9 Top of Rail Profile - CNR Bridge

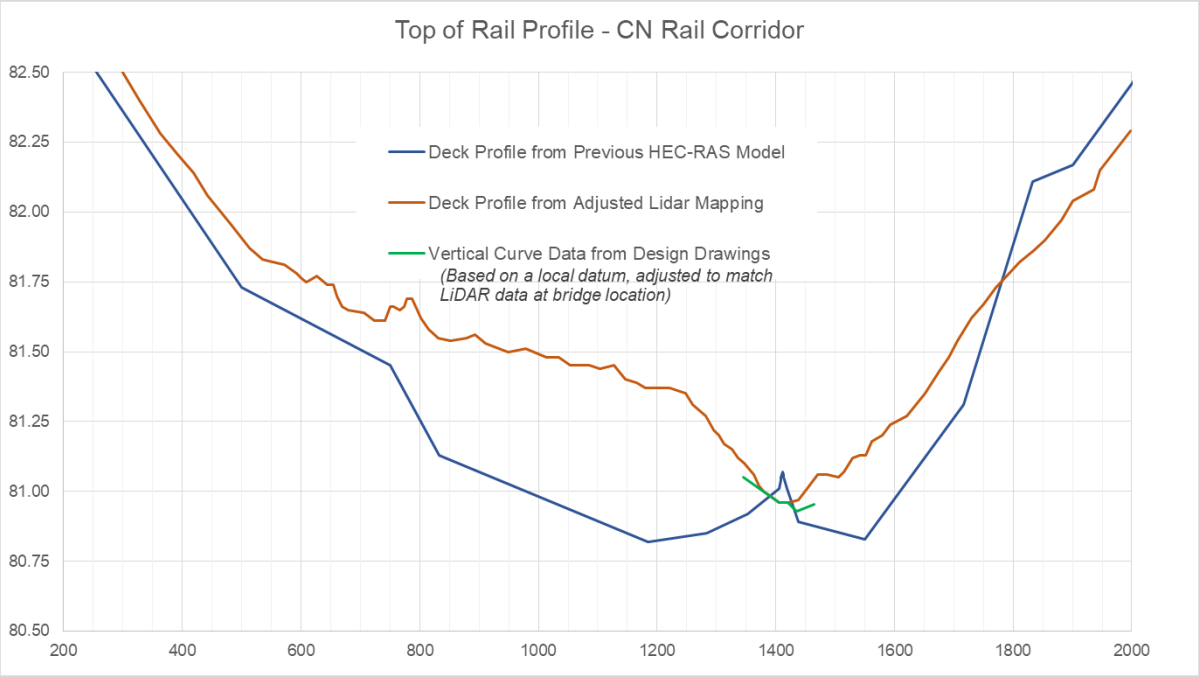

Figure 2-10 Top of Rail Profile - Metrolinx Bridge

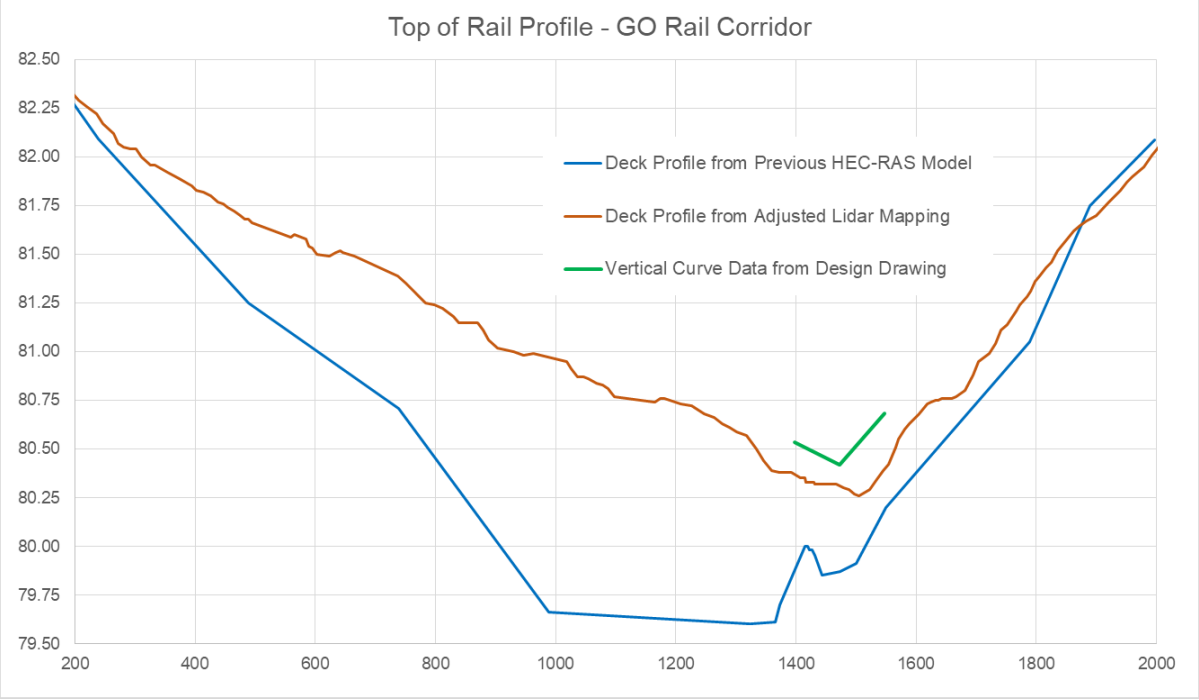

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Figure 2-11 Lynde Creek Flood Extents

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2.4.3 Flood Damages

Damages to buildings impacted by surface flooding are difficult to estimate. The Ontario Ministry of Natural Resources (MNR) and other agencies previously developed tables and curves to correlate flood depth against a structure to flood damages. However, there are many factors influencing potential flood damages other than water depth against a structure. The height of basement windows or other building openings above existing grades varies by structure, and therefore depth is not directly related to the potential for floodwater to enter a building. A detailed survey of each home potentially within the flood plain would be needed to accurately determine the elevation at which water would begin to enter each home. Furthermore, an unfinished masonry basement will suffer significantly less damage during a flood than a finished basement being used as a living space.

Through the residential areas east of Lynde Creek, flood depths in a 100 year storm event are predicted to be up to 1.2 m on the roadways, but generally less than 0.6 m within the residential lots. At these depths, flood damages will be primarily related to floodwater entering homes and filling basements, damaging flooring, drywall, furniture, etc., as opposed to major structural damage to or failure of exterior walls and foundations. The Insurance Bureau of Canada completed an analysis of flood claims following an extreme storm event that hit Toronto in July 2013, and determined that the average flood damages claim was approximately $43,000 per impacted home (Moudrak and Feltmate, January 2019).

For the Michael Boulevard study, a standard flood damage value of $50,000 was applied to each home partially to entirely within the flood plain, regardless of depth. This approach is informed by past flood claims provided by the insurance industry, is simple and consistent in its application, and avoids the house-by-house inspection that would be needed to fully utilize a depth/damage approach. It also allows for relatively simple updates to damage values in future flood reduction studies.

For each storm event, the number of homes potentially impacted by flooding were tabulated and multiplied by $50,000 to estimate the corresponding flood damages. Flood damages begin to be incurred during a 50 year storm, with 24 buildings potentially impacted by flooding, with a corresponding damage estimate of $1.2 Million. For the 100 year return period storm (under current climate conditions), a total of 45 buildings are predicted to be impacted by flooding, with a corresponding damage estimate of $2.3 Million. For the Regional storm event, over 500 buildings are potentially impacted by flooding, with predicted damages of more than $28 Million.

Average annualized flood damages were then calculated as the product of risk of flooding and corresponding flood damages. A 2 year storm has a 50% risk of occurring in any year. A 100 year storm is expected to result in much higher flood damages, but only has a 1% risk of occurring in any year. The sum of the product of risk x damages across all storm events is calculated as follows:

$$D_{TOT} = 0.50 * \frac{D_2}{2} + 0.30 * \frac{(D_2+D_5)}{2} + 0.10 * \frac{(D_5+D_{10})}{2} + 0.06 * \frac{(D_{10}+D_{25})}{2} + 0.02 * \frac{(D_{25}+D_{50})}{2} + 0.01 * \frac{(D_{50}+D_{100})}{2}$$

Where D_{TOT} = Average annualized flood damages, and;
D_N = Flood damages associated with N-year return period event

Note that the estimated damages from the Regional storm have not been included in the above calculation for average annualized flood damages. The probability of a Regional storm occurring in any year cannot be quantified, but is significantly less than the probability of a 100 year storm. When the extremely small risk of the Regional storm is multiplied by the anticipated damages, the product of risk x damage is negligible relative to the overall average annual damage estimate calculated using the 2 year through 100 year storm damages.

The average annualized flood damages from Lynde Creek within the study area are estimated to be approximately **$64,000 per year**. The flood damage calculations are included in **Appendix F**.

Note finally that this study only considers the potential for flooding and flood damages associated with high water levels in Lynde Creek. Homes in the study area could also potentially be at risk of basement flooding from the sanitary sewer system during severe storm events. However, the Region of Durham is responsible for the maintenance of the sanitary sewer systems in the Town of Whitby, and the analysis of the sanitary sewer systems in the study area is beyond the scope of this project.

2.4.3.1 Flood Duration

For further insight into flood risk in the study area and to inform future emergency management planning, the duration of flooding in the Michael Boulevard residential area was investigated. The hydrograph for Lynde Creek for the 100 year storm event is presented in **Figure 2-12** and the hydrograph for the Regional storm event is presented in **Figure 2-13.**

The lowest point within the residential area is Michael Boulevard itself in the vicinity of Flemington Court, at an elevation of 79.5 m. The majority of the properties backing onto Lynde Creek are at an elevation of approximately 80.5 m or higher, and floodwater will flow into the residential area via the open area between the residential properties and Highway 401 when water levels in Lynde Creek exceed an

elevation of approximately 80.5 m. For flood levels in Lynde Creek between approximately 79.5 m and 80.5 m, any flooding in the study area would be from water in Lynde Creek backing up though the storm sewer systems connected to the creek and onto the streets.

Figure 2-12 100 Year Return Period Storm Hydrograph

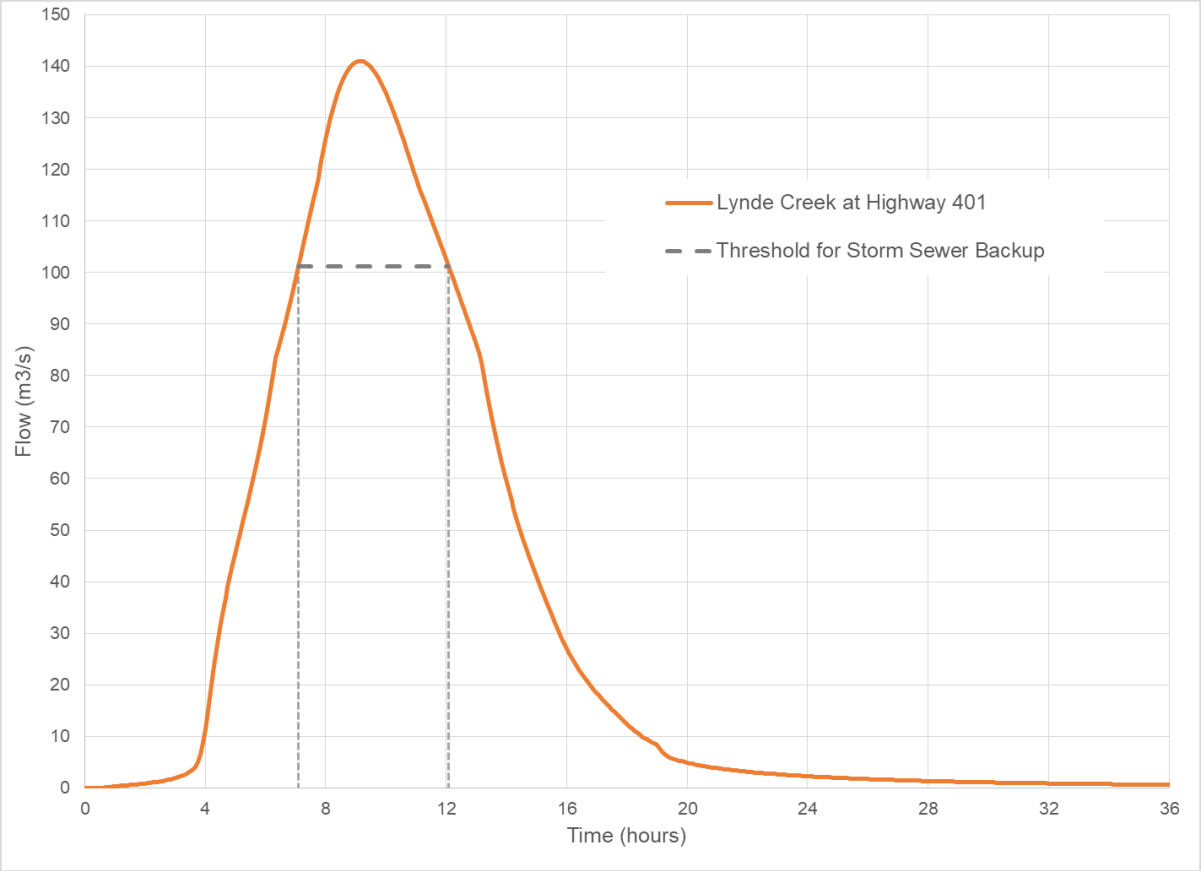
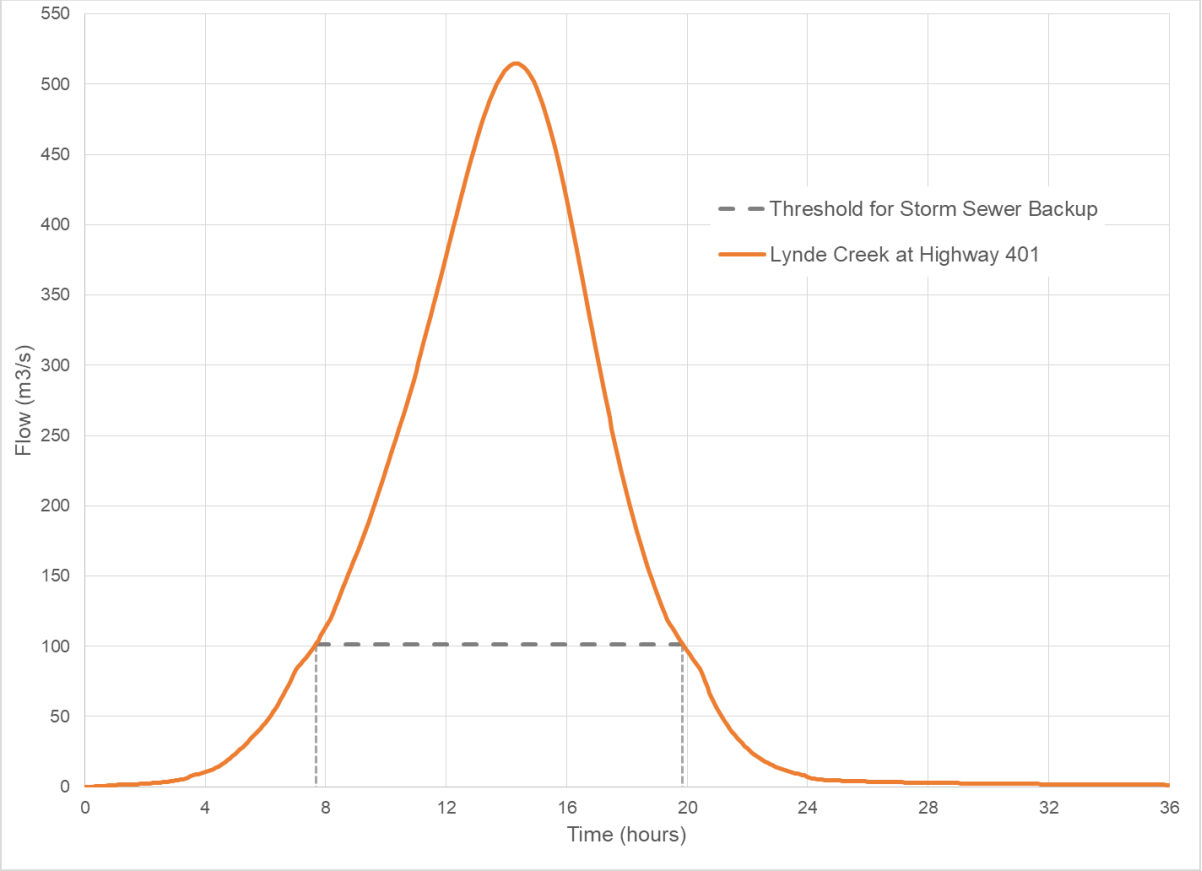


Figure 2-13 Regional Storm Hydrograph



For the 100 year storm, the water level would be above an elevation of 79.5 m for a duration of approximately 5 hours and would be above an elevation of 80.5 m for a duration of approximately 3 hours. The modelling therefore indicates that during a 100 year flood, the roads in the study area would only be inaccessible to passenger and emergency vehicles for a relatively short duration.

For the Regional storm event, floodwater will be above an elevation of 79.5 m for a duration of approximately 12 hours and above an elevation of 80.5 m for a duration of approximately 11 hours. This much longer duration of flooding conditions during a Regional storm event should be considered in any emergency management planning, as it is a relatively long period of time during which emergency vehicles could not easily access residents with potential health issues or otherwise needing evacuation.

2.4.4 Study Area Storm Drainage

2.4.4.1 Minor Drainage Systems

The study area is serviced by a number of storm drainage systems that eventually discharge to Lynde Creek. These are briefly summarized below, and illustrated on **Figure 2-14**.

- Dundas Street: Local drainage from Dundas Street west of the Lynde Creek is collected by a 300 mm diameter storm sewer discharging to Lynde Creek. A 1200 mm diameter storm sewer discharging on the east side of the creek drains a relatively large area on the north side of Dundas Street, extending as far east as Euclid Street and as far north as Mary Street.
- Mozart Court: Runoff from the residential area south of Dundas Street and west of Annes Street is collected by a 1200 mm diameter storm sewer that discharges to Lynde Creek via Mozart Court
- Jeffrey Street: Local runoff from Jeffrey Street drains to Lynde Creek via a 600 mm diameter storm sewer on the north side of the crossing and a 375 mm diameter storm sewer on the south side.
- Easement between McFarlane and Deerfield Courts: Two storm sewers discharge to Lynde Creek via an easement between McFarlane and Deerfield Courts. A 750 mm diameter storm sewer services the local area of Ann Arbour, McFarlane and Gail Courts, while a 1650 mm diameter storm sewer conveys runoff from a larger area generally located north of Central Park and south of Michael Boulevard, extending as far east as Henry Street.
- Easement between Evans and Flemington Courts: A 750 mm diameter storm sewer conveys local drainage from Deerfield, Evans and Heda Courts to Lynde Creek, and a 675 mm diameter storm sewer services the Flemington Court area. These storm sewer outlets are potentially threatened by erosion, as the Lynde Creek channel has migrated eastward to near the property limit of the homes abutting the valley.
- **Highway 401 Culvert at Burns Street:** Several storm drainage systems outlet to a short length of open channel west of the west limit of Burns Avenue, which then enters a concrete box culvert under Highway 401. A 1050 mm diameter storm sewer conveys runoff to this outlet via an easement south of Michael Boulevard near Harper Court, servicing the lands south of Central Park and west of Michael Boulevard. A 1200 mm diameter storm sewer on Burns Avenue conveys runoff from an area north of Burns Street, both east and west of Annes Street. Finally, a 1050 mm diameter storm sewer draining the McCullough Drive area east of

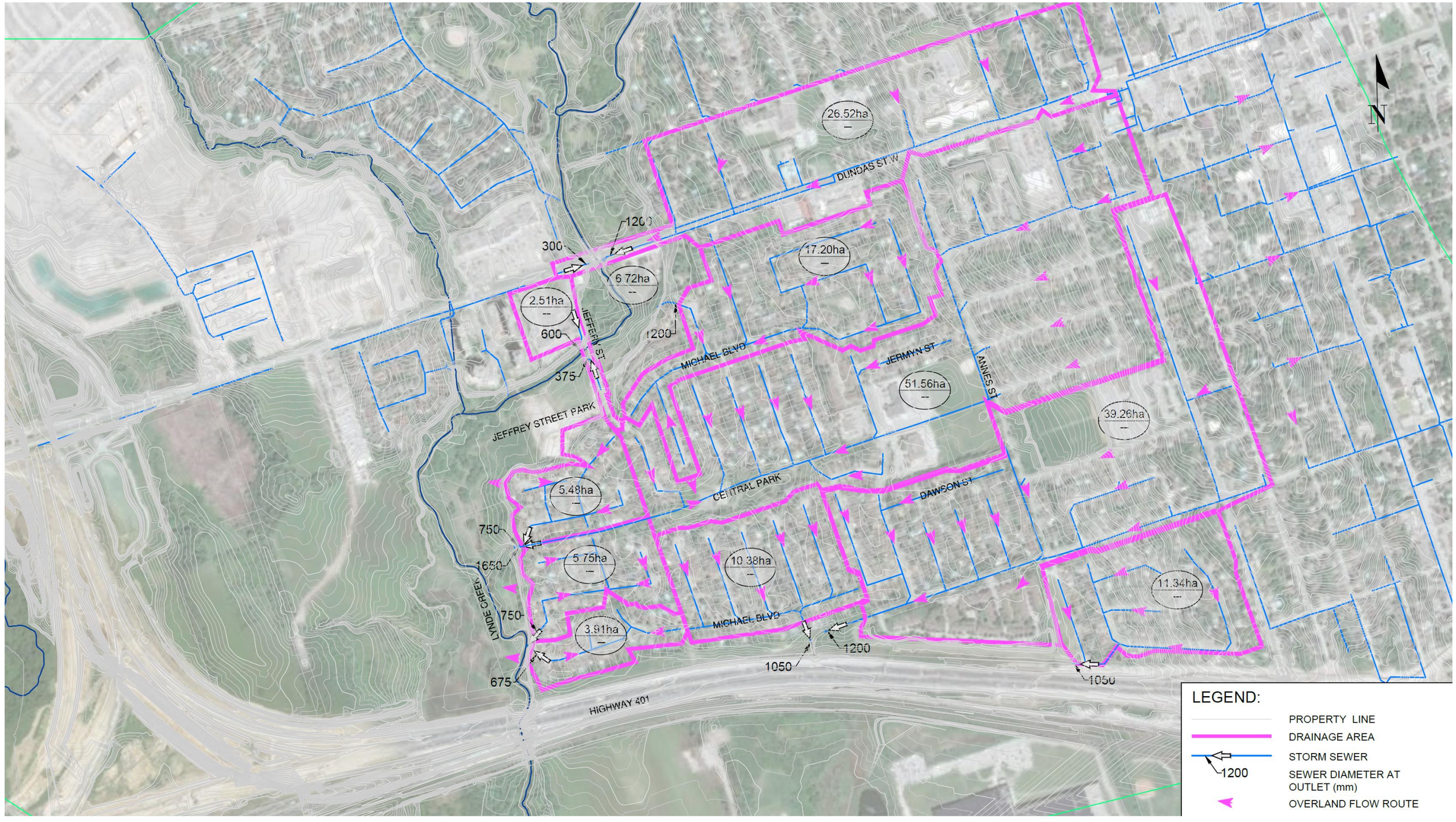
Annes Street discharges to an open ditch north of Highway 401 flowing west from Annes Street to the Highway 401 culvert.

2.4.4.2 Major Drainage Systems

The original grading design for the residential subdivision was completed in the early 1970's, and did not appear to consider conveyance of overland flows beyond the capacity of the catchbasins and storm sewer systems. The study area generally slopes in a south-westerly direction, but there are few defined and protected overland flow routes to convey major system drainage to Lynde Creek. The lowest point within the residential area is located near the intersection of Michael Boulevard and Flemington Court. During large storm events that exceed the capacity of the storm sewer systems, it is expected that stormwater would build to a depth of more than 1 m at this low point before flowing beginning to flow southward through the residential lots to the open area on the north side of Highway 401, and then eastward to the culvert under Highway 401 near the west limit of Burns Street.

Improvements to storm drainage in this area have been identified through the Town of Whitby's Town Wide Urban Flooding Study (Jacobs, currently under study) as noted in **Section 1.2.6**. The preliminary preferred solution to mitigate urban drainage problems in the area of Michael Boulevard and Flemington Court is a combination of high capacity catchbasin inlets, larger storm sewers and in-line pipe storage.

Figure 2-14 Michael Boulevard Storm Drainage Systems



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2.4.4.3 Stormwater Management

The majority of the lands within and draining through the study area were developed prior to the adoption of modern stormwater quantity and quality controls. As such, there are no traditional stormwater management ponds to control the quantity and quality of runoff discharged to Lynde Creek, nor are there any apparent on-site controls to manage stormwater quality and peak flow rates at the source, with the exception of some oil-grit separators installed in some of the more recent commercial developments on the south side of Dundas Street and road reconstruction projects on or near Dundas Street (from Lynde Creek MDPU[AECOM, currently under study]).

The Lynde Creek MDPU (AECOM, currently under study) recommends 2 new stormwater management facilities on the north side of Dundas Street for future development, consistent with the West Whitby Secondary Plan. The MDPU does not include any recommendations to improve the quality and quantity of storm runoff from the Michael Boulevard area.

The Town of Whitby Stormwater Quality and Erosion Control Enhancement Study Update (Ecosystem Recovery, May 2019) recommends a new water quality facility in the Lynde Creek valley at the outlet the storm sewers from MacFarlane Court and Central Park (refer to **Section 1.2.7**). The recommended facility would provide Enhanced water quality treatment and extended detention of the runoff from a 25 mm storm event for a 56 ha drainage area. The proposed water quality facility is not currently funded, and it is not clear at this time if or when the facility will be constructed.

2.4.5 Utilities

All utility owners with infrastructure potentially within the study area were contacted to obtain information on the type and location of their utilities. Responses were received from most utility providers, indicating that their infrastructure was located within the road right-of-ways in the residential areas, and crossing under Lynde Creek via the Dundas Street and Jeffrey Street bridges.

Drawings obtained from Durham Region show a sanitary sewer within the open space between Highway 401 and the residential properties to the north. The 600 mm diameter sewer connects the Michael Boulevard Sanitary Pumping Station (SPS) to Lynde Creek, and serves as an emergency overflow in the event of an extended power outage or pump failure at the SPS. Without the overflow, sanitary flows would back up into houses if the pump station failed. The general location of the Michael Boulevard SPS and overflow sewer are shown on **Figure 2-15**.

Figure 2-15 Michael Boulevard SPS Overflow Sewer

Approximate alignment based on 1974 design drawings

3 Description of Alternative Solutions

3.1 Overview

Simply stated, flooding occurs when the runoff generated by rainfall and/or snowmelt exceeds the capacity of the drainage conveyance system. Flooding becomes a concern when water in excess of the conveyance system capacity flows onto private property, and flood damages result when floodwater enters structures or otherwise negatively impacts public and private infrastructure.

The analyses and investigations documented in **Section 2.4.2** demonstrate that flooding is a concern in the study area. Floodwater extends beyond the Lynde Creek channel corridor into private property during a 50 year storm, with up to 45 homes potentially flooded during a 100 year storm and more than 500 homes potentially impacted during the Regional storm event.

Given the above simple definition of flooding, there are only three general approaches to reducing flooding and flood damages. The first option is to increase the capacity of the undersized drainage conveyance systems. This could include larger or additional storm sewers, improved or new overland flow routes, enlarging or improving open channel systems, and enlarging culverts and bridges.

The second option is to reduce the rate and volume of water entering the drainage systems. This could be achieved by reducing the amount of rainfall that is transformed to runoff (increased infiltration and evapotranspiration, rainwater capture for re-use in irrigation or greywater systems, etc.), creating flood attenuation storage in the system (stormwater management ponds, tanks, surface ponding, etc.), or diverting water away from the undersized segments of the drainage conveyance system.

The last option is to allow flooding to continue, and implement structural and non-structural improvements to minimize the risk to life and property during flood events. Structural solutions could include constructing berms or otherwise re-grading around structures, or installing water-tight windows and doors at all openings to structures that lie below the anticipated maximum flooding elevation. Non-structural solutions could include education programs to encourage homeowners and businesses to minimize the amount and value of goods stored in areas at risk of flooding, or warning systems to alert the public of impending flooding.

These general flood reduction and flood protection concepts were applied to the study area to generate several potential feasible solutions to address the problem of flooding in the Michael Boulevard study area.

3.2 Status Quo (Do Nothing)

The Do Nothing alternative should always be considered in the environmental assessment process. There may be situations where all feasible alternatives will cause unacceptable impacts to the natural, social and/or cultural environments, or are prohibitively expensive. In such instances, the Do Nothing alternative may be preferred.

For this study, the Do Nothing, or Status Quo solution would mean allowing flooding to continue as it does today, and acknowledging and accepting the potential damages to flood prone buildings and infrastructure during future severe storm events. Homes would continue to be at risk of flooding during the 50 year storm event, with no reduction in the risk of flooding and flood damages.

The Status Quo alternative does not imply a complete lack of flood risk mitigation for the study area. CLOCA operates a flood forecasting and warning system, which monitors weather information, creek flows, snow and ice conditions. This monitoring system is used to predict when flooding might occur and to monitor flooding conditions during flood events. Depending on the predicted (or actual) severity of flooding, CLOCA issues messages to the Town, Region, media outlets, school boards and other organizations with information on the risk of flooding and general recommendations to prepare for potential flooding.

Thus, residents in the study area would continue to receive advance notice of flooding through the media, and staff at the Town and Region, including the police, fire and paramedical services, could continue to take appropriate action during flood events. However, the flood warning messages currently issued by CLOCA typically apply to their entire jurisdiction rather than messages specific to individual watersheds or flood damage centres.

3.3 CNR and Metrolinx Relief Culverts

It is clear that the potential for flooding in the study area is primarily due to the CN and Metrolinx rail bridges over Lynde Creek, which do not have adequate capacity to convey the flows from severe storm events. The Feasibility Assessment (AECOM, 2018) developed concept designs to increase the flow conveyance capacity of the rail bridges.

The Feasibility Assessment initially prepared concept designs for replacing the existing 13 m to 15 m span bridges with much larger bridges. It was determined that total spans in the order of 100 m would be needed to safely convey the Regional storm flow in Lynde Creek. Such spans are clearly not reasonable without significant

modifications to the rail corridors. Such large spans require relatively deep bridge girders, and it would therefore be necessary to significantly raise the track elevations such that the bottom of the bridge girders would be above the Regional flood level. It would also require significant closures and detours of the rail lines to install the bridges and raise the track elevations. Through consultation carried out during the Feasibility Assessment, both CN and Metrolinx indicated that such impacts to their rail corridors would not be acceptable.

Furthermore, additional hydraulic modelling completed through this study determined that, even if the rail bridges were replaced with much larger structures that did not influence upstream flood levels, the existing Highway 401 bridges (60 m and 70 m spans) could not convey the entire Regional storm flow and a significant portion of the residential area east of Lynde Creek would continue to be impacted by flooding in a Regional storm event.

The Feasibility Assessment also prepared concept designs for new bridges at the rail corridors to safely convey the 100 year storm peak flow rate, recognizing that the bridges would continue to be overtopped with a negligible reduction upstream flood levels for the Regional storm event. It was determined that replacement bridges would require spans in the order of 25 m to convey the 100 year storm peak flow. While this is a much more reasonable bridge span, it would still require track closures to remove the existing bridges and construct the replacement bridges. During the Feasibility Assessment, Metrolinx indicated that only short-term, limited disruptions to traffic on their corridor could be accommodated, while CN indicated that their rail corridor was critical infrastructure and even short term disruptions would need considerable time to schedule, if approved at all.

Consistent with the Feasibility Assessment, it is concluded that securing approvals from CN, Metrolinx and MTO (for works along Lynde Creek between Highway 401 and the Metrolinx rail corridor) would be extremely challenging and highly unlikely. For these reasons, the alternative of replacing the existing bridges at the Metrolinx and CN rail crossings with larger structures has not been considered further for this study.

The Feasibility Assessment also explored the alternative of installing culverts next to the existing bridges under the CN and Metrolinx rail lines to increase conveyance capacity and reduce upstream flood levels. These additional culverts could be installed using tunnelling methods (jack & bore, micro-tunneling, pipe ramming), which would not impact rail operations during construction.

The maximum size of pipe that can be installed under the rail embankments is limited. The top of the pipe must be safely below the rails to provide adequate cover over the pipe for structural purposes, and so that the pipe can be installed by

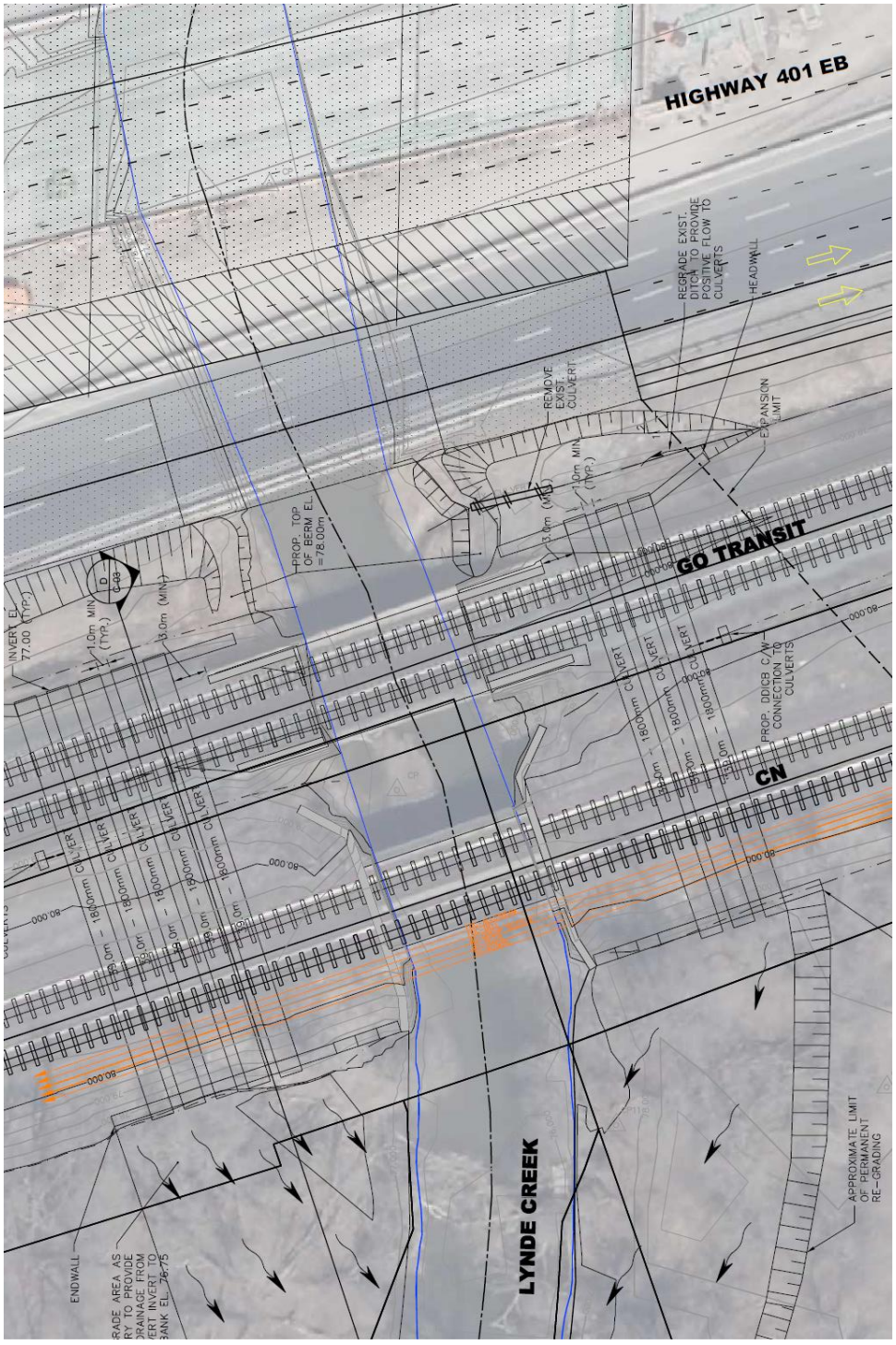
tunnelling without disturbing the active rail lines above. The invert of the pipes must be above the creek invert, and must also consider grading restrictions to allow the flow in Lynde Creek to get to the pipe inlets and for the pipe outlets to return the flows to the creek downstream of the CN rail line. There are also restrictions on culvert invert depth based on grading to the upstream Highway 401 bridge structure and approach embankments immediately north of the Metrolinx line. These restrictions were assessed during the Feasibility Study, which determined that the maximum height of a pipe under the rail embankment would be approximately 1.8 m. This was based on at least 1 m of cover below the Metrolinx tracks and an invert elevation approximately 1 m above the creek bed downstream of the CN rail line. It is recognized that for pipe crossings of their corridor, CN typically requires cover equivalent to at least twice the diameter of the pipe. With 1.8 m diameter pipes, the resulting 3.6 m cover would place the culverts below the existing creek invert and render them ineffective. However, both CN and Metrolinx were consulted during the Feasibility Study (AECOM, 2018), and therefore may consider some flexibility in their minimum cover requirements. The 1.8 m diameter pipe sizes have been maintained for this study.

The HEC-RAS model was updated with the proposed relief culverts under the railway. The modelling confirmed the findings from the Feasibility Assessment, in that a total of 8 - 1.8 m diameter pipes would be required under the rail embankments to prevent flood damages for up to the 100 year storm event.

The HEC-RAS model further concluded that the proposed relief culverts would have no impact on the depth and extent of flooding in a Regional storm event.

The concept design for the relief culvert alternative is presented in **Figure 3-1**, and additional details for this alternative are included in **Appendix E.**

Figure 3-1 CNR and Metrolinx Relief Culvert Alternative



Concept design maintained from the Feasibility Assessment (AECOM, 2018)

3.4 Flood Protection Berm

The Feasibility Assessment (AECOM, 2018) included a concept design for Flood Protection Berm to contain flooding to the Lynde Creek valley corridor as an alternative to reduce flood damages.

The Feasibility Assessment initially determined that a berm to contain the Regional flood was not feasible, as it would require a berm more than 3 m higher than the existing grades at the rear of residential properties backing onto Lynde Creek. Instead, the concept design was based on a berm to provide protection for up to the 100 year storm event, plus a freeboard of 0.3 m. The berm was designed to be continuous from Highway 401 to near Jeffrey Street, constructed within the Lynde Creek valley outside of but adjacent to the residential properties along the east side of the valley. There are two major complications with this berm design.

- While the berm would prevent floodwaters from flowing east into the residential areas, it would also block storm drainage from the residential areas from reaching Lynde Creek. The storm sewers currently discharging to Lynde Creek (refer to Section 2.4.4) would need to be blocked to prevent floodwater from backing up through the storm sewers into the residential areas, and the berm could block the existing overland flow routes that convey major system drainage to Lynde Creek. To mitigate these impacts, the Feasibility Assessment recommended two stormwater pumping stations to convey storm runoff from the residential areas east of the berm to Lynde Creek. As it was assumed that the berm would block both minor and major drainage system routes, the stormwater pumping stations were sized for the 100 year return period storm.
- The berm would be constructed outside of the existing residential properties, within the Lynde Creek valley corridor. This would result in extensive disturbances to the existing vegetation communities and wildlife habitat in the valleyland where the berm would be constructed. More significant is that this option would require re-alignment of approximately 200 m of Lynde Creek north of Highway 401, as there is currently no land available between the rear of the residential properties and the east bank of the Lynde Creek channel to construct a berm. Construction of the berm would also result in a significant volume of fill in the Lynde Creek flood plain, reducing the available flood storage in the valley and potentially increasing upstream flood levels and/or downstream flow rates for large storm events.

The flood protection berm option presented in the Feasibility Assessment would be very expensive (the cost estimate of $7 Million presented in the Feasibility Assessment appears underestimated), and would result in significant impacts to the

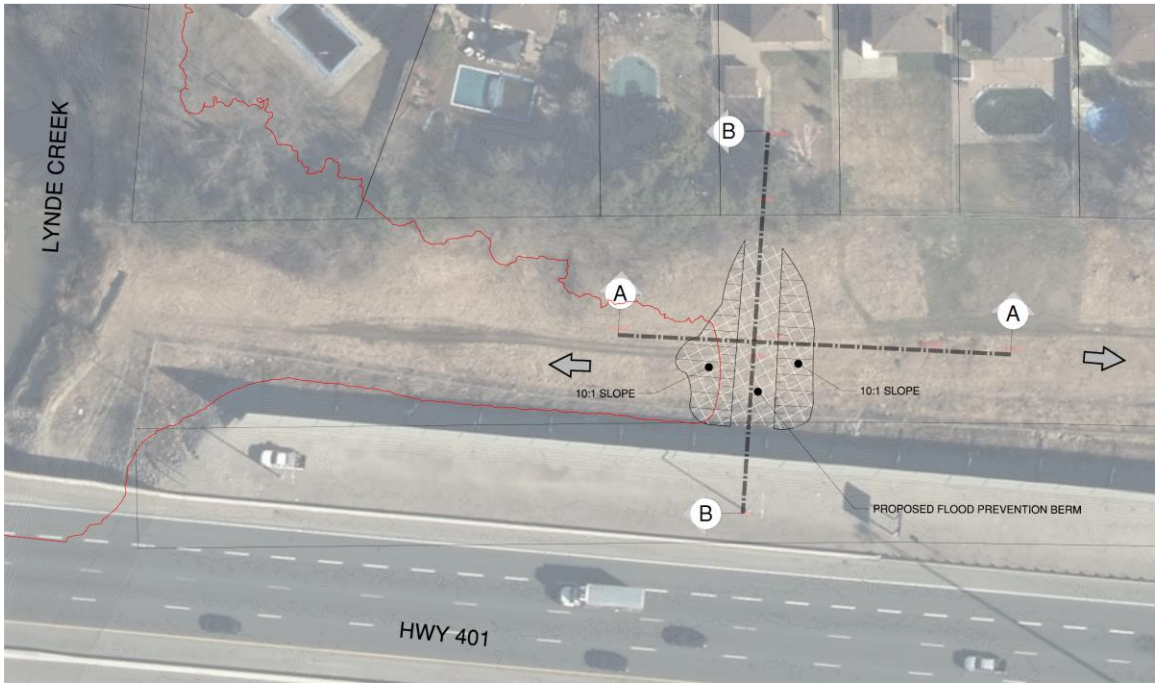
Lynde Creek valley. The solution relies on a pump station to drain local storm runoff from the study area, and the risk of flooding from a mechanical failure of the stormwater pumping station is likely comparable to the risk of flooding from Lynde Creek with no mitigation measures in place. Recall from **Section 2.4.2** that the residential area is at risk of flooding for the 50 year return period and larger storm events, equivalent to a 2% chance of flooding in any year. For these reasons, the flood protection berm option presented in the Feasibility Assessment has not been carried forward as a feasible alternative for the Michael Boulevard Flood Mitigation Strategy.

However, a different alternative for a flood protection berm has been developed for this study. Recall from **Section 2.4.3.1** that there are two primary routes for floodwater to enter the Michael Boulevard residential area during a 100 year flood. Floodwater from Lynde Creek can back up through the different storm sewer outfalls to the valley, exiting through catchbasins and manholes along Michael Boulevard once flood levels exceed an elevation of approximately 79.5 m. Once flood levels in Lynde Creek exceed an elevation of approximately 80.5 m, water can flow through the open area on the north side of Highway 401 east of Lynde Creek and then into the residential properties via the low area in the vicinity of Michael Boulevard and Flemington Court.

A relatively small berm could be constructed in the open area north of Highway 401, east of Lynde Creek to contain flooding from the Lynde Creek valley and protect the residential areas. A concept design has been prepared for this berm, which determined that it can be constructed with a crest elevation of approximately 81.0 m. The design of the berm is illustrated in **Figure 3-2**. The crest of the berm would be in a similar location as the existing high point in the open area north of Highway 401, and therefore will not block or trap drainage flowing into this open area from the residential areas to the north.

The berm would provide a 0.3 m freeboard above the predicted 100 year flood level, and a 0.1 m freeboard over the predicted 100 year flood level under future climate change conditions (equivalent to the 200 year storm event under current climate conditions).

Figure 3-2 Flood Protection Berm Alternative



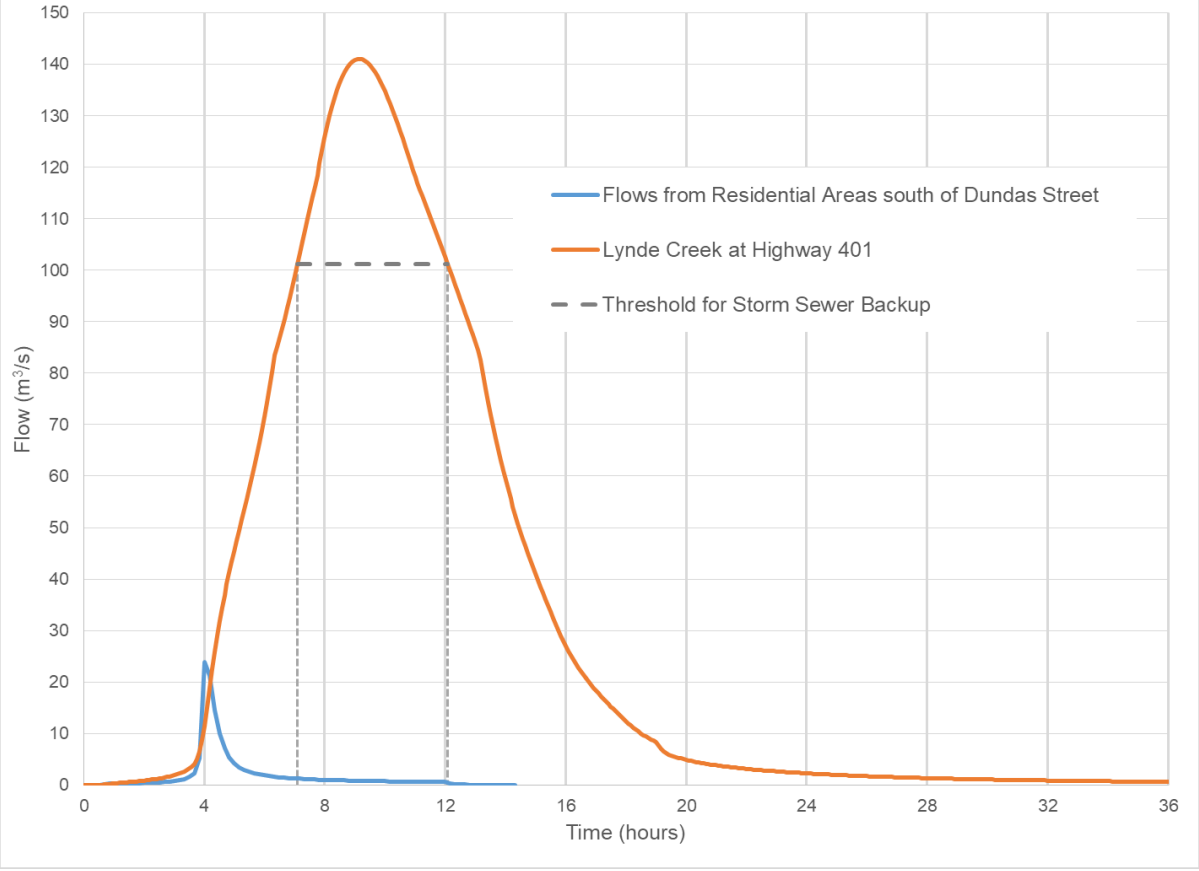
While this berm would prevent floodwater from Lynde Creek entering the study area via surface routes, floodwater could still enter the residential area via the storm sewer outfalls to the creek. To mitigate this risk, backflow prevention devices could be installed on the storm sewer outlets to Lynde Creek. Backflow prevention devices would be required on the two storm sewer outlets in the vicinity of Flemington Court (675 mm diameter and 750 mm diameter), and the two storm sewer outlets aligned between McFarlane Court and Deerfield Court (750 mm diameter and 1650 mm diameter) (See **Figure 2-14**).

Backflow prevention devices on the storm sewer outfalls will prevent the floodwater in Lynde Creek from entering the residential area, they will also prevent local storm runoff from the residential area from draining to Lynde Creek when flood levels in the creek exceed the elevations in the residential areas. However, due to the extensive upstream drainage area and timing effects, flows and flood levels in Lynde Creek will peak well after the rain has stopped and the local residential areas have drained to the creek. The hydrographs from the local drainage systems and Lynde Creek are compared in **Figure 3-3**. The figure shows that the flood levels in Lynde Creek would block the storm sewer outlets beginning approximately 3 to 4 hours after the peak flows from the study area have drained to the creek. The risk of flooding due to blocked drainage from the study area is therefore relatively small. Recall also from **Section 2.4.4** that major system flows from the low point near the intersection of Flemington Court and Michael Boulevard currently drain southward across the

residential lots and then eastward to the concrete box culvert under Highway 401 near the west limit of Burns Street. While this does not conform to current design practices, it does provide an outlet for overland flows from the study area, and the berm would not impact this overland flow route.

It is recognized that the proposed berm may be within the path of the future Burns Street extension. Recall from **Section 2.1.5** that the Town's Transportation Master Plan recommended that Burns Street be extended west with a new crossing over Lynde Creek before turning north to intersect with Dundas Street. Timing for design and construction for the Burns Street extension has not be confirmed, and has not been included in the Town of Whitby's long term capital budget plant. The flood protection berm would therefore be constructed as a permanent flood protection solution. If and when design and construction of the Burns Street extension is initiated, the roadway would need to be configured to provide the same or better performance as the berm in preventing flows in Lynde Creek from spilling eastward along the new roadway and into the Michael Boulevard residential area.

Figure 3-3 Hydrograph Comparison - 100 Year Storm Event



3.5 Flood Proofing and Education

Section 2.4.3 concluded that a significant number of homes are at risk of flooding during a Regional storm event. However, many of these homes, and particularly those near the edges of the flood plain, would experience relatively shallow flood depths on their property, particularly during the 50 year or 100 year return period storms. In these areas of relatively shallow flood depths, it is possible that relatively small changes around a property, such as minor regrading or extending window wells above the ground elevation, could prevent water from entering the home during a flood event. In areas with higher flood depths, damages could be minimized by elevating appliances off the basement floor and by moving electronics and valuables out of the basement (permanently or at least when flooding is protected). These are only a few of the recommendations to avoid or minimize flood damages, and there are numerous guides published by federal and provincial agencies and the insurance industry with additional information about avoiding or minimizing damages from flooding.

For the Michael Boulevard study area, a flood proofing and education program would primarily take the form of an information package that would be distributed to area residents. The package could include information such as:

- An overview of the Lynde Creek watershed and the mechanisms by which properties in the study area could be flooded
- Mapping showing the predicted depth and extent of flooding from Lynde Creek for different storm events, along with an explanation of the risk / probability of flooding written in simple terms that would be understood by homeowners
- Descriptions of a range of appropriate best practices for works inside and outside flood vulnerable homes to minimize the risk of water entering the structure and to minimize damages in the event of flooding

Adoption of these recommendations by homeowners in the study area could be enhanced if augmented by a home inspection with an appropriately qualified professional, who could review each flood prone property, measure the elevation of the lowest opening into the house and provide property-specific recommendations (verbally and/or in a report for each home) to minimize flood risk and flood damages.

Implementation could be further enhanced if the Town were to create a program to provide rebates or other financial incentives to cover a portion of the cost of building improvements such as replacing basement windows and installing window wells and other more expensive improvements to reduce flood risk.

3.6 Emergency Management Planning

As mentioned in **Section 3.2**, CLOCA currently operates a flood forecasting and warning system which monitors weather and watershed conditions and issues alerts to municipalities, media outlets and other organizations when flooding is predicted. However, the program is not specific to individual watersheds or flood damage centres. Emergency management staff and first responders may receive the flood warning messages from CLOCA, but there are no formal actions plans for municipal staff to follow upon receipt of these messages that are specific to each flood prone area in the Town and Region.

Flood risk could be further mitigated through an emergency management plan developed specifically for the Michael Boulevard area. While such a plan would not reduce the frequency or severity of flooding from Lynde Creek, it has the potential to reduce the risk to human life and property damage.

There are several components to a flood emergency management plan, including monitoring/forecasting, alerts and action plans.

The monitoring and forecasting component would be an enhancement to CLOCA's existing flood forecasting system, with a specific focus on monitoring real-time water levels in Lynde Creek at Dundas Street as well as at the real-time gauges located upstream at Kinsale and Brooklin. The rates of rise of water levels in Lynde Creek would need to be analyzed along with rainfall and temperature data (for snowmelt) to generate accurate, short term predictions regarding flooding in the study area. A webcam could also be installed at Dundas Street to verify water levels in Lynde Creek in real time.

Similarly, CLOCA's flood warning system would be enhanced with a messaging system set up specifically for the Michael Boulevard area. When flooding is predicted, messages would be issued to all residents in the flood prone area as well as staff at relevant departments at the Town and Region. These message would include details regarding current water levels in Lynde Creek, predicted severity of flooding and predicted time of flooding.

The most challenging component of the system would be the development and implementation of the action plans, with a range of responses and activities corresponding to different threat levels for flooding. These could include

- A system to deliver simple, understandable messages to residents in the Michael Boulevard area alerting them to the potential for flooding from Lynde Creek. Messages would likely be delivered through a mass communication system via

voice, text and/or e-mail. Considerable effort would be needed to initialize and regularly update the circulation list.

- Protocols and procedures for police and/or Town staff to evacuate residents from the flood prone areas and direct them to a safe, dry location before flood levels render the area impassable. Arrangements would be needed to ensure that the designated refuge areas could be opened by municipal staff at any hour of the day.

Information packages would need to be prepared and delivered to residents in the flood prone area informing them about the risk of flooding, encouraging them to provide contact information to receive messages, providing instructions to take appropriate actions based on the severity of flooding and providing details of one or more evacuation centres that will be made available during a flood emergency. These information packages would need to be re-issued at regular intervals such that residents moving into the area will be informed.

The communication system would need to be tested regularly, with training (i.e. mock flood disaster) carried out less frequently to practice the response and refine the evacuation protocols.

4 Evaluation of Alternative Solutions

4.1 Evaluation Criteria

The alternative solutions described in **Section 3** were comparatively and qualitatively evaluated based on criteria developed within the following main categories, which represent the broad definition of the environment from the Municipal Class Environmental Assessment:

- Natural Environment, which relates to potential impacts and benefits to the natural and physical components of the environment (i.e., air, land, water and biota) including natural and/or environmentally sensitive areas.
- Social Environment, which relates to potential impacts and benefits to residents, neighbourhoods, businesses, community character, social cohesion and community features.
- Cultural Environment, which relates to potential impacts to historical/archaeological remains, and heritage features.
- Technical Environment, which relates to the technical feasibility, effectiveness, constructability, operation and maintenance, and other engineering aspects of the alternative solutions.
- Financial Environment, which relates to the capital and maintenance costs of the alternative solutions and potential reductions in future flood damages

Within each main category, project-specific evaluation criteria were developed based on a review of the Municipal Class EA, the existing conditions of the study area and the alternative solutions being considered. The resulting evaluation criteria are summarized in **Table 4-1**.

Table 4-1 Evaluation Criteria

Category	Evaluation Criteria
Natural Environment	Potential impacts on fish habitat and aquatic ecosystems Potential impacts on terrestrial wildlife and ecosystems Potential impacts on known habitat for Species at Risk Potential impacts on groundwater quality and quantity
Social/Cultural Environment	Potential impacts to public safety Potential impacts to the community during construction (noise, dust, traffic restrictions) Potential impacts to the public realm (aesthetics, trails, recreational amenities) Potential for requiring private property Potential impacts to archaeological resources
Technical Environment	Effectiveness in reducing flooding Challenges to construct or implement the solution Challenges to secure permits and approvals Potential future maintenance requirements Potential conflicts with existing municipal services and utilities Resiliency to future climate conditions
Financial Environment	Estimated costs of implementation, including property acquisition costs Estimated operations and maintenance (O&M) costs Estimated reduction in future flood damages

4.2 Status Quo (Do Nothing)

Recall from **Section 3.2** that the Status Quo alternative does not include any new works or activities to reduce flood depths or flood damages. Flood risks to public safety will continue to be partially mitigated through CLOCA's flood forecasting and warning system which provides advance notice of potential flooding conditions in their jurisdiction.

As no physical works are associated with this alternative, there are no impacts (positive or negative) to the natural environment and no impacts to private property.

Flood levels in Lynde Creek will not be reduced, and flood damages through the study area will remain at $2.3 Million for the 100 year return period event and $64 Thousand per year on an average annualized basis.

4.3 CNR and Metrolinx Relief Culverts

The CNR and Metrolinx culvert improvement alternative was initially developed as part of the Feasibility Assessment (AECOM, 2018) and continued to be recommended to reduce flood levels in the Michael Boulevard area in the Lynde Creek MDPU (AECOM, 2019). This alternative was refined in **Section 3.3**, but continues to involve the installation of 8 - 1.8 m diameter culverts underneath the CN and Metrolinx rail lines.

Natural Environment: This alternative will result in temporary vegetation removals and impacts to the natural environment to create a construction access to the site and for the grading required upstream of the Metrolinx embankment and downstream of the CNR embankment to direct high flows in Lynde Creek to and from the additional culverts. There may also be impacts to aquatic habitat for one or more temporary crossings over Lynde Creek, as it would be very difficult to otherwise access the work areas from both the east and west sides of the creek.

Following installation, the additional crossings could improve wildlife passage through the rail corridors. However, given the approximately 40 m length of pipe needed to extend through both embankments, the openness ratio of each 1.8 m diameter pipe (culvert opening area ÷ culvert length) is less than 0.07 and therefore provides a negligible improvement over the existing bridge openings.

Social/Cultural Environment: Installation of the culverts has the potential to create short term impacts to the residents north of Highway 401 related to noise, vibrations and dust during construction.

Some members of the public have expressed an interest in using the relief culverts to create a pedestrian and/or cycling trail connection through the Highway and rail corridors. Unfortunately, the maximum feasible height and width of the relief culverts (1.8 m) would not meet minimum standards for trail widths and clearances. There would also be safety risks due to the relatively frequent flooding of the culverts. It is concluded that the relief culverts could not provide the desired trail connection.

Technical Environment: Once installed, the relief culverts would prevent flood damages for up to the 100 year return period storm event, protecting all 45 homes

currently at risk of flooding in a 100 year return period storm event. As the relief culverts would reduce flood levels in Lynde Creek for most storm events, they would also improve the resiliency of the Lynde Creek system to future potential climate change. However, the relief culverts would have no impact on flood levels in a Regional storm event.

There are numerous technical challenges to overcome for installation of the culverts under the rail embankments. Construction access to the north side of the Metrolinx embankment must come from the north and under the Highway 401 bridges which may limit the size of equipment that can access the work area. In addition, the available working area between the south embankment of the Highway 401 / Highway 412 ramp and north embankment of the Metrolinx corridor is only approximately 10 m, further complicating access and construction activities.

To access the south end of the CNR embankment, a temporary construction access road will need to be extended from Jeffrey Street. Durham Region recently constructed an access road to a tunnel shaft in the unopened Jeffrey Street right-of-way south of the CNR corridor for construction of the West Whitby Sanitary Trunk Sewer, but this access will need to be extended westward across private property to access the work area. As noted earlier in this section, temporary bridges will need to be constructed over Lynde Creek to access the proposed culverts on both sides of the existing bridges to avoid additional, longer construction access routes to the west side of the creek.

The Feasibility Assessment (AECOM, 2018) determined that the 1.8 m diameter pipes could reasonably be installed using trenchless methods without disturbing the active rail lines above. However, additional geotechnical investigations would be needed to understand the soils under the Metrolinx and CNR tracks and determine if and how the pipes could be installed without risk of impact (i.e. vertical movement) to the rail lines. The geotechnical investigation may recommend a more expensive construction methodology and/or smaller pipe sizes under the embankments.

A number of permits will be needed to construct the access roads and install the relief culverts. Securing permits and approvals from MTO for construction access under the Highway 401 bridges and permits from both CNR and Metrolinx for the culvert installations is expected to be challenging and take a considerable length of time, particularly given that it is not feasible to achieve typical minimum cover from the top of the proposed pipes to the base of the rails.

Permits will be required from CLOCA for the access roads, culverts and temporary bridges, and permits may also be needed from MECP and/or DFO for potential impacts to Lynde Creek and the downstream habitat for Eastern Pondmussel

(species of special concern), and from MNRF for the work areas within the Provincially Significant Lynde Creek Coastal Wetland Complex.

Financial Environment: Construction of the relief culverts is estimated to cost approximately **$8.4 Million**. Note that the refinement of the concept design for the relief culverts and considerations for construction and restoration of temporary roadways to access the rail embankments results in a larger cost estimate relative to the $6.1 Million estimate presented in the Feasibility Study (AECOM, 2018). Once constructed, the culverts would require very little inspection and maintenance.

With the culverts in place, there would be no flooding in a 100 year storm event and average annualized flood damages would be reduced to near $0.

This equates to a payback period of approximately 131 years. Over a 100 year time horizon, flood damages would be reduced by approximately $6.4 Million, resulting in a benefit:cost ratio of 0.8:1

4.4 Flood Protection Berm

The flood protection berm alternative has been significantly refined from the prior concept presented in the Feasibility Assessment (AECOM, 2018). Rather than a continuous berm along the entire east side of the Lynde Creek valley between Highway 401 and Jeffrey Boulevard, the flood protection berm would be a relatively small area of fill to prevent water from Lynde Creek from backing up through the ‘gap’ between the highway and residential properties to the north. Four storm sewer outlets would also need to be fitted with backflow prevention devices such that high water levels in Lynde Creek could not back up through the sewers to flood the low-lying areas in the study area.

Natural Environment: Construction of the flood protection berm could impact some of the existing trees at the rear of the residential lots on the south side of Flemington Court, as well as removal of the existing vegetation in the open area between the residential lots and Highway 401. However, this area has already been identified as the route for a future extension of Burns Street, and this vegetation would be disturbed regardless when the Burns Street extension is constructed.

There could also be temporary impacts to the vegetation on the east side of Lynde Creek to access the storm sewer outfalls for installation of the backflow prevention devices. However, storm sewer infrastructure, including storm outfalls, require inspection and occasional maintenance over their service life. It is expected that any vegetation disturbed for installation of the backflow prevention devices would be disturbed regardless during future maintenance and eventual replacement of the existing storm sewer outfalls.

Social/Cultural Environment: There could be temporary impacts to residents on Flemington Court during construction of the flood protection berm, including vegetation removals behind their properties, noise and dust. There could also be impacts to the residents at the ends of Flemington Court and/or Evans Court to access the storm sewer outfalls for installation of the backflow prevention devices. However, the Town has an easement to access the storm sewers and outlet headwalls, and recently accessed this area to repair the erosion protection at the rear of 26 Evans Court where it abuts Lynde Creek.

The berm is proposed in an area previously disturbed for construction of the sanitary overflow sewer from the Michael Boulevard pumping station in the 1970's. There is therefore minimal risk of impact to archaeological resources.

Technical Environment: The flood protection berm and storm sewer backflow prevention devices would protect 44 homes from flooding in a 100 year return period storm. These protected homes are primarily located in the low lying areas along Michael Boulevard that, under existing conditions, would be flooded from storm sewer back-ups and from floodwater backing up through the opening on the north side of Highway 401. The remaining home potentially at risk of flooding during a 100 year backs directly onto the Lynde Creek flood plain and therefore would not be protected by the berm or backflow prevention devices.

This alternative would not reduce flow rates or increase conveyance capacity, so there would be no reduction in the depth or extent of the Regional flood plain, and no significant improvement in the resiliency of the Lynde Creek system to the impacts of future potential climate change. There also remains some risk for flooding in the study area from blocked local drainage. With the backflow prevention devices installed, the storm sewers servicing the area would be blocked when flood levels in Lynde Creek exceed the lowest elevations in the Michael Boulevard residential areas. However, as noted in **Section 3.4**, this risk is very small due to time lag between local runoff and peak flow rates in Lynde Creek, and due to the relatively short duration where flood levels in Lynde Creek would be higher than the lowest areas within the residential development.

The works could be installed relatively quickly, as the flood protection berm would be located on lands owned by the Town of Whitby, and the Town has easements to allow access to the storm sewer outfalls for installation of the backflow prevention devices. However, there may be challenges to access the existing storm sewer outfalls for installation of the backflow prevention devices, considering both access via the easements over private property and the limited working area between the storm sewer outfalls and Lynde Creek channel.

There may be challenges securing approvals from MTO for construction of the flood protection berm adjacent to Highway 401. However, during the planning for the Highway 401 / 412 interchange, MTO was made of aware of and protected for the future Burns Street extension parallel to and immediately north of Highway 401. Furthermore, as the proposed berm generally maintains the existing drainage divide between Lynde Creek and the concrete box culvert under Highway 401 immediately west of the existing terminus of Burns Street, there should be no impacts on Highway 401 drainage.

Finally, the flood protection berm has the potential to complicate the design of the future Burns Street extension, as the roadway must be designed to maintain the elevation of the flood protection berm in order to continue to prevent water from Lynde Creek backing up through this area and into the Michael Boulevard and Flemington Court area during flood events.

Financial Environment: It is estimated the berm could be constructed and storm sewer backflow prevention devices installed for a cost of approximately $**500 Thousand.** The berm would require little to no long term maintenance, while the backflow prevention devices would require more frequent inspection and occasional maintenance such as debris removal.

With these works in place, 44 of the 45 currently flood vulnerable homes would be protected from flooding in a 100 year storm event, and average annual flood damages would be reduced to approximately $30,000 per year, a reduction of approximately $35,000 per year.

Assuming long term maintenance costs of $5,000 per year, on average, this equates to a payback period of approximately 17 years. Over a 100 year time horizon, flood damages would be reduced by approximately $3 Million for a beneft:cost ratio of 6:1.

4.5 Flood Proofing and Education

The flood proofing and education alternative was described in **Section 3.5**. The program would primarily consist of a package distributed to residents in the study area with information on current flooding conditions and a list of recommendations for physical works and actions that residents can take to prevent water from entering their home and/or minimizing damages during flood events.

The program could be augmented through consultation with individual homeowners in the flood-prone areas, and could be further enhanced if the Town were to provide rebates to offset the cost of improvements to homes in the study area to increase the level of flood protection.

Natural Environment: Any physical works arising from the program would be located within the private developed properties in the study area. There would be no impacts (positive or negative) to aquatic or terrestrial habitat within or downstream of the study area.

Social/Cultural Environment: The alternative would not involve works in the Lynde Creek valley corridor or other undisturbed areas and would therefore not disturb any archaeological resources. The program would be expected to result in works on private properties, but these works would be voluntary (potentially with financial assistance from the Town) and would be implemented by the homeowner.

Technical Environment: The flood proofing and education program would not reduce flood levels, but would instead reduce flood damages by preventing water from entering homes in areas of shallow flood depths and minimizing damages to homes in areas of higher flood depths. It is difficult to determine the effectiveness of a flood proofing and education program in reducing flood damages, as it is dependent on site specific constraints at each home and the degree to which homeowners in the study area implement the recommendations from the program.

As flood levels would not be reduced, this solution would not improve the resiliency of the system to climate change. However, the program could be updated and expanded to cover a larger area if future climate conditions result in an increase in flow rates, flood depths and the extent of flooding from Lynde Creek.

There are relatively few challenges to prepare and distribute an information package to residents in flood prone areas, and there are few, if any regulatory approvals or permits required for construction of the range of potential flood protection options provided to residents. However, there would be challenges to convince residents to implement the most appropriate flood protection works on their property, even with individual consultations by Town staff and financial incentives. There would also be challenges to ensure that the flood protection improvements and activities to minimize flood damages are maintained by homeowners, and that information on flood risk is relayed to new residents who move into the area in the future.

Financial Environment: It is estimated the information package could be prepared and distributed for a cost of approximately $25,000. If the program were augmented with individual consultations with homeowners in the flood prone areas, the Town would require a dedicated staff person or contract worker for up to a year at an estimated cost of $120,000. A program to rebate homeowners a portion of the cost of any significant upgrades to improve flood resiliency is difficult to estimate, as it is dependent on the cost of works most appropriate for each property, the degree to which homeowners implement the recommendations and apply for rebates, and the

percentage of the cost of works funded by the Town. With more than 500 homes located within the Regional storm flood plain, even a modest rebate of $500 per property on average would cost more than $250,000 plus additional costs for Town staff to administer the rebate program.

4.6 Emergency Management / Flood Response Plan

The Emergency Management and Flood Response Plan alternative was described in **Section 3.6**. It would involve a plan developed and implemented collaboratively with the Town, Region and CLOCA, specific to the Michael Boulevard study area. The system would issue alerts to municipal staff and residents in flood vulnerable areas when flooding is predicted, and would include protocols for how, when and where to evacuate residents before roads in the study area become impassable due to flooding.

Natural Environment: The program would not involve any physical works, so there would be no impacts (positive or negative) to aquatic or terrestrial habitat within or downstream of the study area.

Social/Cultural Environment: The alternative would not involve works in the Lynde Creek valley corridor or other undisturbed areas and would therefore not disturb and archaeological resources. There would be some inconvenience to local residents during testing of the alert system and during less frequent training exercises for evacuation of the study area (i.e. mock disaster training).

Technical Environment: The flood proofing and education program would not reduce flood levels, but would instead minimize flood risk through notifications to residents ahead of flooding and evacuation of the flood prone areas prior to flooding. The program would primarily minimize risks to public safety, with little to no reduction in property damages due to flooding.

As flood levels would not be reduced, this solution would not improve the resiliency of the system to climate change. However, the plan could be updated and expanded to cover a larger area if future climate conditions result in an increase in flow rates, flood depths and the extent of flooding from Lynde Creek.

There are a number of challenges for implementation of this alternative, including difficulties obtaining contact information for residents in flood prone areas and keeping the information updated as people move into and out of the study area. There are also challenges to implement a system capable of delivering messages to residents via voice, text and/or e-mail, but there are a number of companies that provide this service. The thresholds for sending messages to residents must also be carefully managed, as too frequent alerts without actually experiencing flooding may

lead to complacency when flooding actually threatens the study area. Recall that there is only a 2 % chance of flooding of the residential areas east of Lynde Creek in any given year. Finally, there would be challenges to train staff at the Town and Region and organize testing of the communication system and evacuation protocols.

Financial Environment: The costs associated with this alternative are primarily related to additional staffing at the Town, Region and/or CLOCA to monitor weather forecasts and flood levels in Lynde Creek, administer the contact database, and train emergency services personnel to respond to predicted flooding conditions in accordance with the protocols established by the emergency management plan. These costs are difficult to estimate, as they may require additional full-time staff or could possibly be completed using existing staff resources. This alternative would not achieve any reduction in flood damages to property and infrastructure.

4.7 Evaluation

The evaluations of the alternative solutions were described in **Section 4.2** to **Section 4.6**, and are summarized in **Table 4-2** through **Table 4-5**. The preferred solution is the **Flood Protection Berm with Storm Sewer Backflow Prevention Devices**. This solution involves the construction of a low berm in the open space between Highway 401 and the residential lots to the north to prevent floodwater from Lynde Creek from spilling eastward through this gap and then northward into the residential area. In addition, backflow prevention devices will be installed on the storm sewer outlets to Lynde Creek to prevent high water levels in the creek from backing up through the storm sewers and flooding the residential areas. This solution will protect all but one of the 45 homes currently predicted to be at risk of flooding in a 100 year return period storm event. The remaining home at risk backs onto the Lynde Creek valley, and will continue to be at risk of flooding from high water levels in the Lynde Creek valley corridor.

This solution will be augmented **with elements of a Flood Proofing and Education Program**. At a minimum, the Flood Proofing and Education Program will include an information package describing the current flood risk in the study area and a range of measures and practices that residents can implement both inside and outside their homes to prevent floodwater from entering and to minimize damages if water enters their home during a flood event. The program could be expanded to include individual consultations with homeowners to develop plans tailored to each property, and could be further expanded to include rebates or other financial incentives for homeowners who complete any of the recommended flood proofing measures. These flood proofing measures may be sufficient to protect the single home

remaining at risk of flooding in a 100 year storm event, and will reduce flood impacts and flood damages for all homes at risk from larger storm events.

The alternative of relief culverts under the railway embankments was not selected largely due to the significant technical and permitting challenges associated with tunnelling the large number of pipes under an active rail line and challenges to access the work areas at the upstream and downstream ends of the relief culverts. These challenges could take a considerable amount of time to resolve, and it will similarly take a long time for the Town to secure funding for this very expensive solution. The significant cost is also difficult to justify, as it results in a cost-benefit ratio of less than 1.0 based on reductions in future flood damages over a 100 year time horizon.

The Emergency Management and Response Plan was not selected because it would not reduce flood levels or damages, and the additional staffing and costs needed to administer a plan tailored for this area would not provide significantly better flood protection relative to CLOCA's current jurisdiction-wide flood forecasting and warning system and the Town's and Region's jurisdiction-wide emergency management plans. The messaging system and emergency response training could inconvenience residents, which is not justified given the relatively low risk of flooding and because the area has not experienced significant flooding from Lynde Creek in the past.

Table 4-2 Natural Environment Evaluation Summary

Alternative	Impacts	Benefits
Status Quo	No impacts, as no works are proposed	No benefits, as no works are proposed
CNR and Metrolinx Relief Culverts	Potential impacts to wetlands, vegetation and aquatic habitat for culvert installation and access road construction	Additional culverts under the rail embankment may slightly improve wildlife passage
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	Potential tree removals for berm construction	No benefits, as the berm will only be seeded and stabilized until the Burns Street extension is constructed
Flood Proofing and Education Program	No impacts, as any works would be on existing developed properties	No benefits, as any works would be on existing developed properties
Emergency Management and Flood Response Plan	No impacts, as no physical works are proposed	No benefits, as no physical works are proposed

Table 4-3 Social / Cultural Environment Evaluation Summary

Alternative	Impacts	Benefits
Status Quo	No impacts, as no works are proposed	No benefits, as no works are proposed
CNR and Metrolinx Relief Culverts	Potential for noise, vibration and dust over a long construction duration	No benefits, as relief culverts cannot be enlarged for a pedestrian or cycling trail connection
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	Potential for noise, vibration and dust over a short construction duration, potential for loss of trees and aesthetic impacts to residents abutting berm	No benefits
Flood Proofing and Education Program	Limited impacts to allow access to Town staff for inspections and for any works installed within private properties (installation by owners)	No benefits
Emergency Management and Flood Response Plan	Impacts to residents during testing of the alert system and training exercise for evacuation of the flood prone areas	No benefits

Table 4-4 Technical Environment Evaluation Summary

Alternative	Impacts	Benefits
Status Quo	No technical challenges, as no works are proposed	No reduction in flood risk or flood damages
CNR and Metrolinx Relief Culverts	Challenges to access upstream and downstream work areas, install culverts under active rail lines and secure approvals from numerous agencies	No flooding or flood damages for storms in excess of the 100 year return period event Increased conveyance capacity at the rail crossings improves the system's resiliency to future climate change
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	Challenges to access sewer outfalls, secure approvals from MTO and protect for a future Burns Street extension, slight risk of blocking local drainage during flood events	Protects 44 of the 45 homes currently at risk of flooding in a 100 year return period storm event
Flood Proofing and Education Program	Challenges to convince homeowners to adopt and maintain flood proofing measures	No reduction in the frequency and severity of flooding, but potentially reduced flood damages for all storm events
Emergency Management and Flood Response Plan	Challenges to develop and maintain a contact database for the alert system, implement a system to deliver messages prior to and during flood events, and to train municipal staff for evacuation of the flood prone areas	No reduction in flooding or flood damages, but risks to public safety due to flooding would be reduced

Table 4-5 Overall Evaluation Summary

Alternative	Recommendation	Financial Environment
Status Quo	**Not Recommended** Does not reduce flooding or flood damages from Lynde Creek	No capital costs, as no works are proposed No reduction in flood damages
CNR and Metrolinx Relief Culverts	**Not Recommended** This alternative has numerous risks and technical challenges to overcome to access the site and install the culverts, would take a relatively long time to secure approvals and construct, and costs significantly more than other alternatives	Capital costs of approximately $8.4 Million Average annual flood damages reduced to $0 Benefit:Cost = 0.8:1 Payback Period = 131 yrs
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	**Recommended** Protects all but 3 homes from flooding in the 100 year return period storm and can be implemented on Town-owned land in a relatively short period of time and for a reasonable cost	Capital costs of approximately $500 Thousand Average annual flood damages reduced by $35 Thousand per year Benefit:Cost = 6:1 Payback Period = 17 yrs
Flood Proofing and Education Program	**Recommended** Not recommended as a standalone solution due to implementation challenges, but elements of this program are recommended to complement other flood reduction solutions	Costs are dependent on the degree to which the Town will subsidize any improvements, and benefits are dependent on how many residents adopt and maintain flood proofing measures

Alternative	Recommendation	Financial Environment
Emergency Management and Flood Response Plan	**Not Recommended** There are significant challenges to implement this program, and it could require new, permanent staff positions at the Town, Region and/or CLOCA despite only a 2% risk of flooding in any year	Costs are dependent on how many additional staff are needed at the Town, Region and CLOCA to administer the program No reduction in flood damages

5 Description of the Preferred Alternative

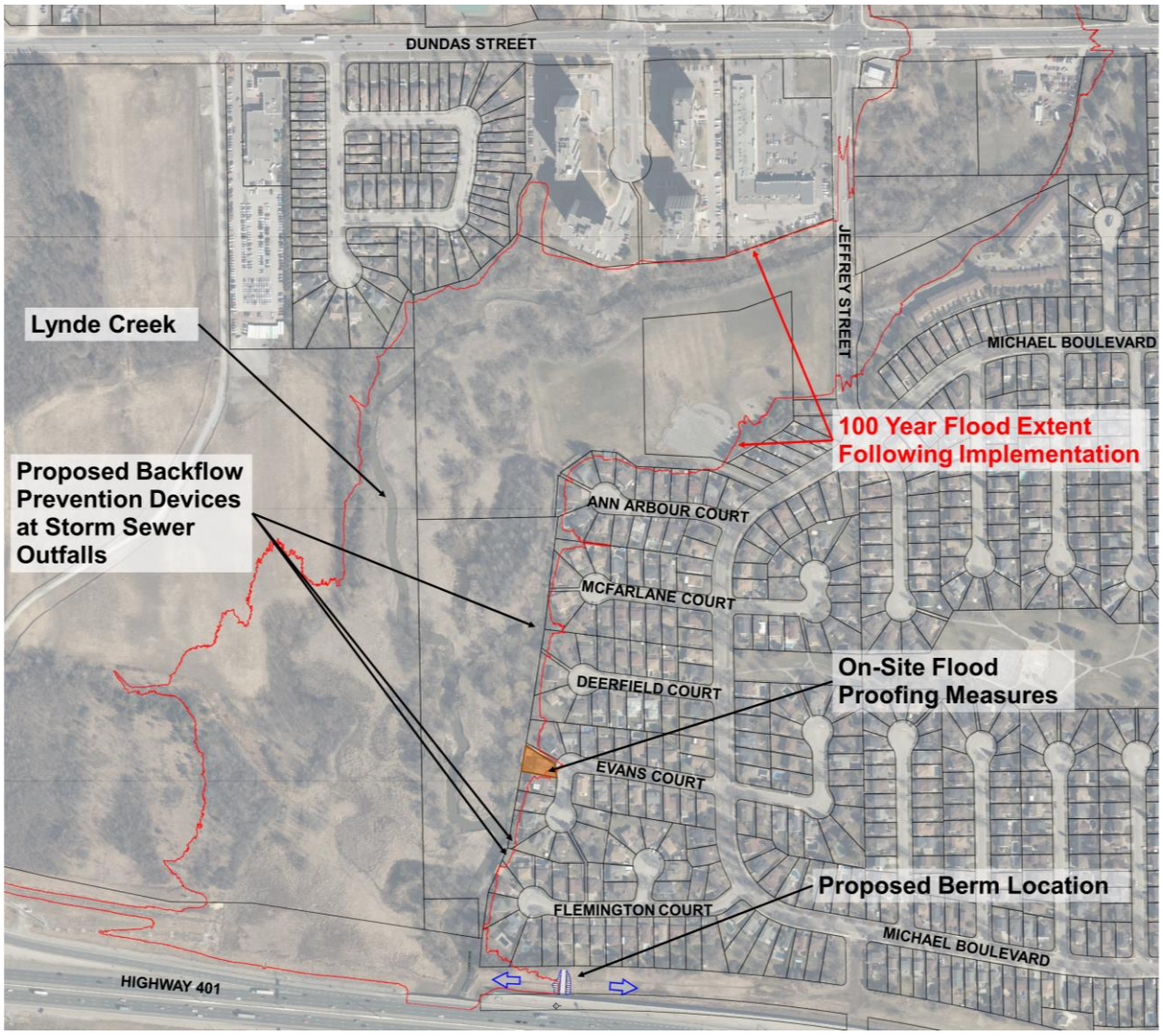
5.1 Preliminary Design

The preliminary preferred solution is a flood protection berm in the open space between Highway 401 and the residential lots to the north to prevent floodwater from Lynde Creek from backing up through this area and then northward into the Michael Boulevard residential area. Backflow prevention devices are required on four storm sewer outlets to prevent high water levels in Lynde Creek from flowing up through the storm sewers and into the Michael Boulevard residential area.

The flood protection berm will be augmented with a flood proofing and education program to provide additional protection to the home that is predicted to still be at risk of flooding from Lynde Creek in a 100 year storm event, and to reduce flood damages at all homes during storms greater than the 100 year return period event.

The locations of the berm, backflow prevention devices and homes to be flood proofed are shown in **Figure 5-1**, along with the limit of flooding in a 100 year storm event with the measures in place.

Figure 5-1 Preferred Alternative



5.1.1 Flood Protection Berm and Backflow Prevention Devices

A preliminary design has been prepared for the flood protection berm. A plan view of the berm is included as **Figure 5-2**, and cross sections illustrating the grading of the berm are provided in **Figure 5-3** and **Figure 5-4**. Larger drawings are included in **Appendix F**.

The berm has been generally located at the existing high point in the corridor north of Highway 401, where lands west of this location drain westward to Lynde Creek, and lands east of this point generally drain eastward to the concrete box culvert

under Highway 401 near the west limit of Burns Street. As such, the berm will not block any overland drainage routes.

The berm in intended to prevent water from Lynde Creek from backing up through the low lying area between Highway 401 and the residential areas to the north. The area isolated from flooding is not effective in conveying flows in Lynde Creek, and therefore the proposed flood protection berm will not have any impact on flood levels in Lynde Creek.

The berm has been designed with a 5 m wide crest at an elevation of 81.0 m, corresponding to 0.3 m freeboard over the predicted 100 year flood level and 0.1 m freeboard over the predicted 200 year flood level (equivalent to 100 year + climate change). The berm will be raised approximately 0.5 m over existing grades, with 10H:1V side slopes down to existing ground. This is generally consistent with the TRCA's 'Flood Protection Land Forming Technical Design Considerations (AECOM, 2018), even though the berm is not intended to function as a landform in the establishment of the Regulatory flood limit.

The berm footprint is largely contained in the Town's property, which has been secured for the future Burns Street extension (refer to **Section 2.1.5**), and can be accessed from Michael Boulevard via the unopened road allowance generally opposite Marbury Court. A limited amount of fill placement is required in the Highway 401 right-of-way to complete the berm. Consultation with staff from the Ministry of Transportation (MTO) regarding approvals for the berm construction is documented in **Section 7.6.1**.

Recall also from **Section 1.1.1** that there is a sanitary overflow sewer to Lynde Creek located within the corridor between Highway 401 and the residential lots to the north. The berm has been designed to avoid the existing maintenance holes along the sewer alignment, and the proposed 10H:1V side slopes will not impede Durham Region's ability to access the overflow outlet for inspection or maintenance. Consultation with Durham Region regarding the proposed berm construction over the overflow sewer is documented in **Section 7.6.2**.

Backflow prevention devices are proposed to be installed on the outlets of 4 storm sewer systems discharging to Lynde Creek. The size and location of these storm sewer outfalls are as follows:

- A 675 mm diameter storm sewer from Flemington Court
- A 750 mm diameter storm sewer from Evans Court
- A 1650 mm diameter storm sewer from Central Park
- A 750 mm diameter storm sewer from McFarlane Court

The location of these storm sewers and the associated drainage areas were presented on **Figure 2-14**. The Town of Whitby has easements over the storm sewers where they traverse residential lots between the road right-of-ways and the Lynde Creek valley corridor, but will still need to co-ordinate access through and restoration of these lots to allow personnel and equipment to access the storm sewer outfalls for installation of the backflow prevention devices.

At the second Community Open House (see **Section 7.4**), a resident noted that beavers may have built a dam across the channel that connects the Central Park / MacFarlane Court storm sewers to Lynde Creek. This beaver dam should be removed and appropriate action should be taken to prevent further blockage by beavers prior to installation of the backflow prevention devices.

Several different configurations of backflow prevention devices are available in a range of sizes. Tideflex check valves are available for all three storm sewer diameters and can be installed by bolting a flange onto the storm sewer outlet headwalls or sliding and securing the device over protecting storm sewer outfalls. Tideflex also manufactures the Checkmate check valves that are installed by sliding the devices into the storm sewer and securing them in place with clamps for flanges. Images for a traditional ‘curved duckbill’ device and Checkmate device are presented in **Figure 5-5**. During detailed design, a range of backflow prevention devices from different manufacturers will be explored for potential applicability to the storm sewer outfalls to Lynde Creek.

Note finally that the combination of the flood protection berm and backflow prevention devices do not meet the definition of permanent flood protection, as defined in the MNRF Technical Guidelines (2002). Recall from **Section 2.4.1.1** that the MNRF Technical Guidelines do not consider ‘man-made’ works such as dikes and berms in establishing the extent of the Regulatory Flood Plain for the purposes of regulating and permitting works in the flood plain.

For the Lynde Creek, the Regulatory Flood Plain corresponds to the extent of flooding from Hurricane Hazel, the regulatory storm. The analyses in **Section 3** confirmed that none of the alternative solutions considered as part of this study, nor any alternatives considered in past studies, would achieve a measurable reduction in the depth or extent of flooding in a Regional storm event, regardless of whether or not the solution could be considered under the MNRF Technical Guidelines.

While the combination of the flood protection berm and backflow prevention devices may not be considered in the preparation of regulatory flood plain mapping, they will achieve a significant reduction in real, actual flood risk and flood damages to the

homes in the study area with minimal long term maintenance to assure their effectiveness.

Figure 5-2 Preliminary Berm Design – Plan View

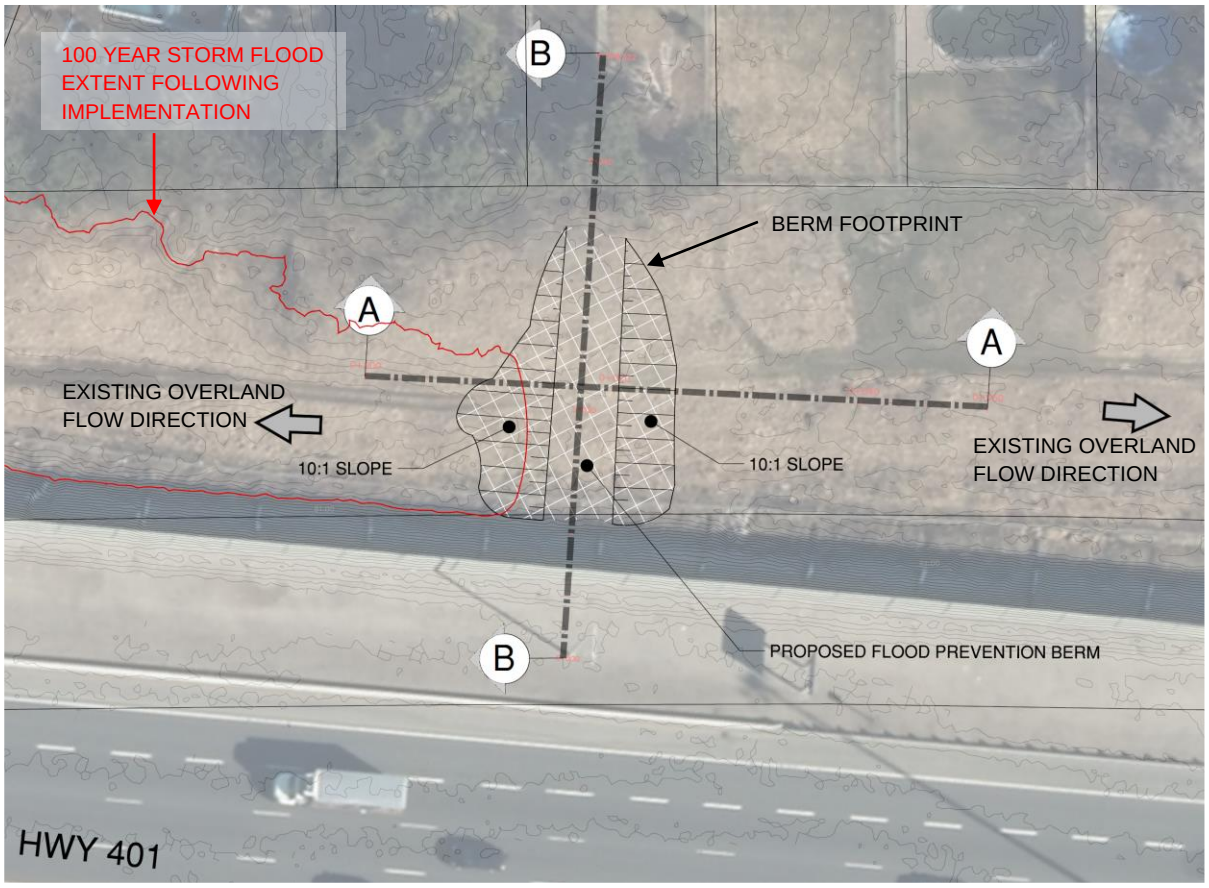


Figure 5-3 Preliminary Berm Design – East-West Section

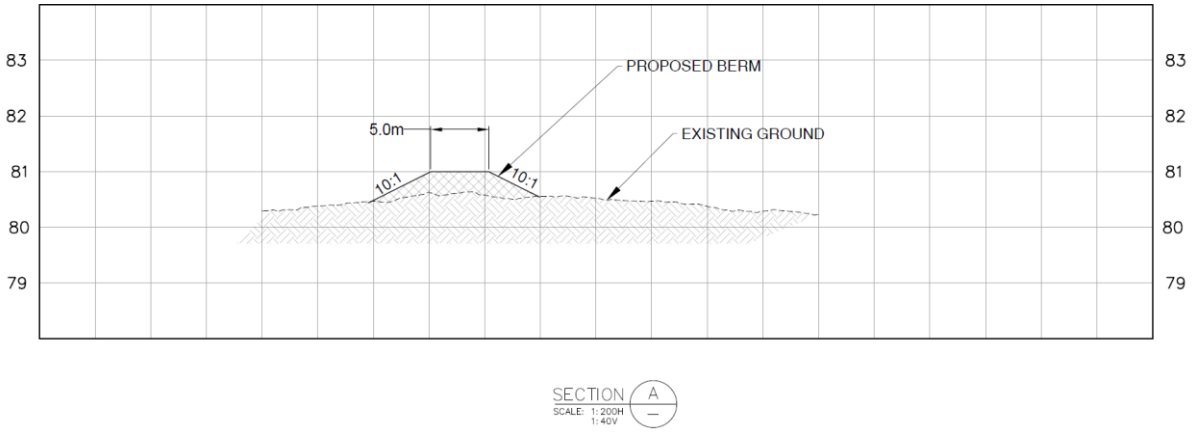


Figure 5-4 Preliminary Berm Design – North-South Section

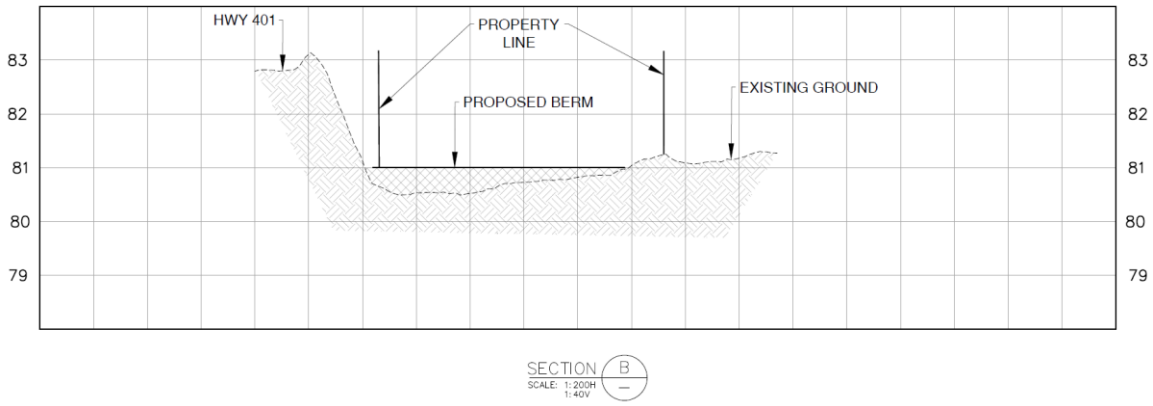
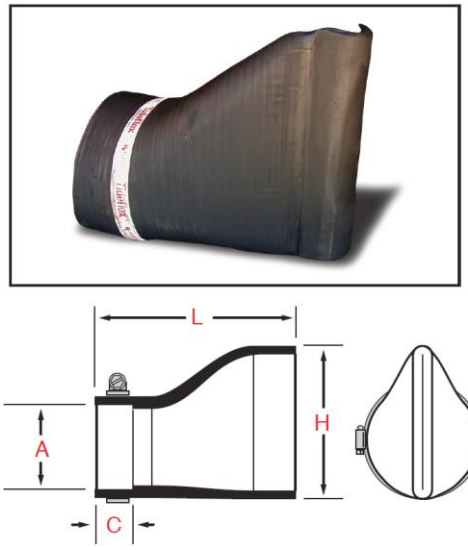
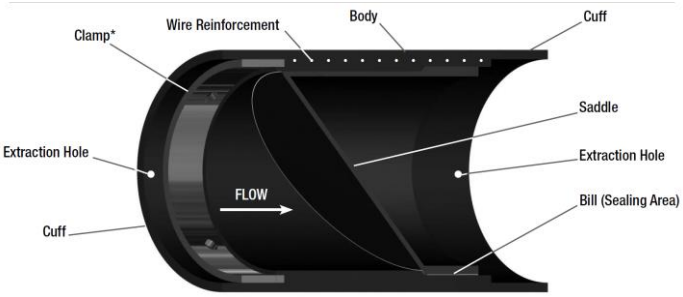


Figure 5-5 Tideflex Backflow Prevention Devices

Traditional Curved Bill Device



Checkmate Device



5.1.2 Flood Proofing and Education Program

The flood proofing and education program has not been selected as a standalone solution, but elements of the program could be applied to the study area to protect the home that remains at risk of flooding in a 100 year storm event and offer greater protection to homes in the study area for storms larger than the 100 year event. As noted in **Section 3.5**, the program is expected to include distribution of an information package to flood vulnerable residents describing the flood risk from Lynde Creek and a recommending a range of options that could be implemented inside and outside homes to minimize the risk of floodwater entering homes and minimizing damages in the event that floodwater does enter a home. It is expected

that the information package would be prepared with input from the Region, CLOCA, the insurance industry and relevant provincial and federal agencies responsible for management of flood risk.

Depending on available funding and interest from homeowners, the effectiveness of the program could be enhanced with one-on-one consultations with homeowners to understand the flood risk at each property and develop a tailored list of the most appropriate flood proofing measures for each property. Rebates or other financial incentives could be used to encourage homeowners to implement and maintain flood proofing retrofits to their homes.

5.1.2.1 Site Specific Flood Proofing Investigation and Recommendations

Initially, the hydraulic modelling and flood plain mapping prepared for the preliminary preferred solution determined that 3 homes backing onto Lynde Creek would continue to be at risk of flooding and flood damages in a 100 year storm event.

Detailed topographic surveys were completed for these properties to measure the elevations of the doors, windows and other openings into the houses and determine if floodwater could enter the homes in a 100 year storm event.

The detailed survey determined that two of the three homes were safe from flooding, with all doors and windows located well above the predicted 100 year flood elevation. However, the basement windows at the third home were found to be at or slightly below the predicted 100 year flood elevation, and it was further determined that water could enter the home and garage via a reverse slope driveway.

A concept plan has been prepared to demonstrate how this home could be protected from flooding in a 100 year storm event. It involves the following works.

- Installing window wells around the basement windows to above the level of the 100 year flood plain elevation with water-tight connections to the exterior walls, or replacing the existing basement windows with water-tight windows. Basement windows designed to protect against flooding are typically in the form of glass blocks grouted in place of a traditional window and frame, and;
- Raising the driveway slightly where it meets the curb, and extending the retaining walls on either side of the driveway to the raised curb to prevent floodwater from reaching the reverse slope driveway, and/or;
- Raising the grades along a portion of the Town owned pathway immediately north of the property to contain the 100 year flood and prevent it from reaching Evans Court.

These recommended flood proofing measures are illustrated in **Figure 5-6**.

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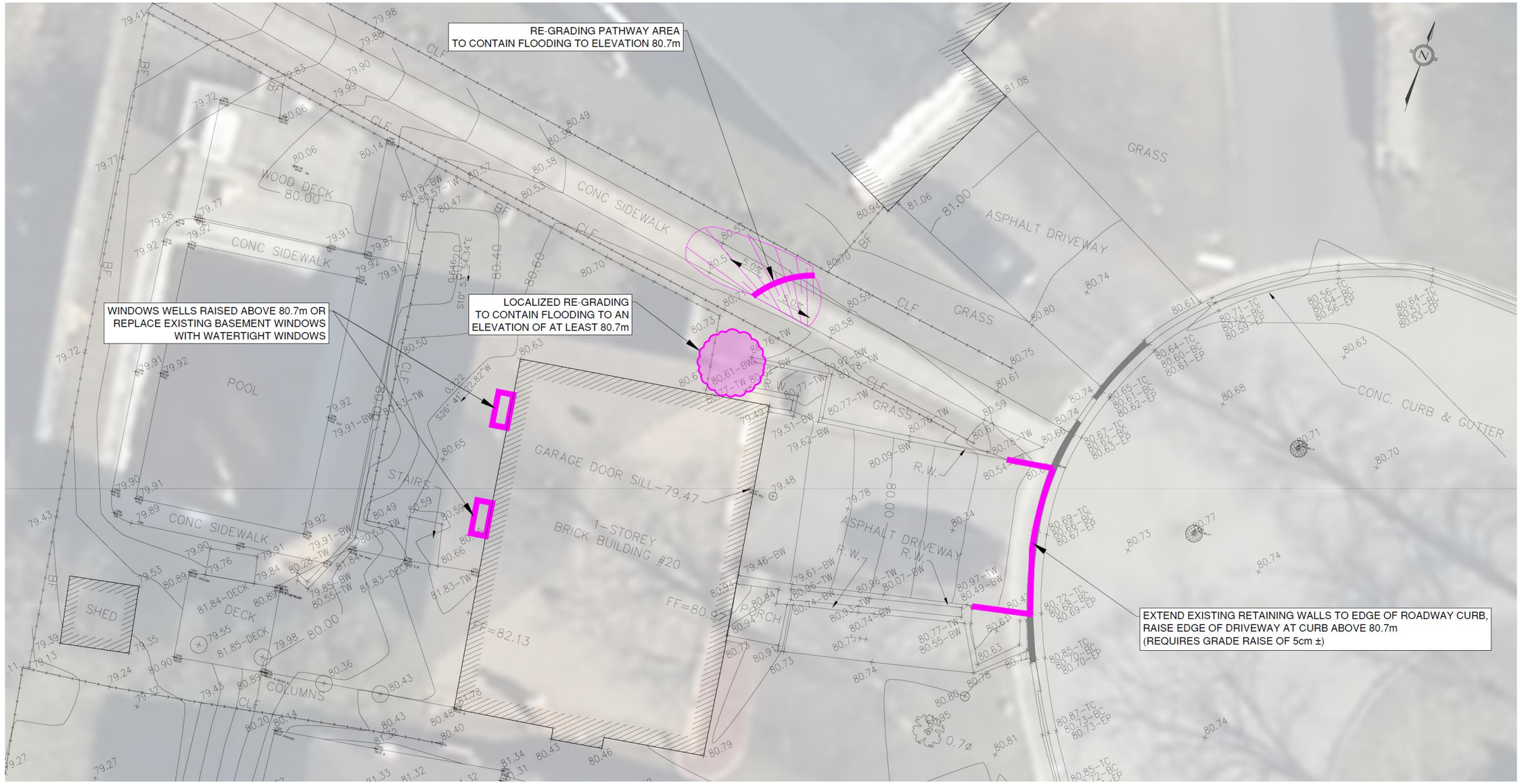
Figure 5-6 Flood Protection Options for Evans Court Property



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5.2 Recommended Future Studies

The previous section presented the preliminary design of the flood protection berm and backflow prevention devices. However, a number of additional studies are recommended to inform the detailed design, permitting and construction of the preferred solution.

5.2.1 Field Investigations

The following field investigations are recommended:

- A detailed topographic survey is recommended for the entire corridor between Highway 401 and the residential lots to the north. The survey should extend from Lynde Creek to the concrete box culvert under Highway 401 near the west limit of Burns Street. This survey would be used to inform the design of any grading or other works to improve drainage of this area (See **Section 5.2.3**).
- A geotechnical investigation is recommended to confirm topsoil depths and soils characteristics in the area of the proposed berm, including soil quality testing to determine options for off-site disposal of any excess material
- A vegetation inventory should be undertaken to confirm the species potentially impacted by the construction of the berm and construction access to the berm and storm sewer outfalls. The inventory will be needed to inform an appropriate tree preservation plan during detailed design.
- A video inspection of the Region's overflow sewer from the Michael Boulevard SPS should be completed prior to construction to confirm the condition of the pipe and inform any specific measures to protect the pipe during construction

5.2.2 Archaeological Assessment

As noted in **Section 2.3.1**, a Stage 1 Archaeological Assessment (AA) was completed for the Feasibility Study (AECOM, 2018). The study was limited to a relatively small area surrounding the CNR and Metrolinx bridge crossings, and recommended a Stage 2 AA for any works in what was assumed to be undisturbed land between Highway 401 and the residential area to the north. However, the area identified for the Stage 2 AA would have been previously disturbed for construction of the overflow sewer from the Michael Boulevard sanitary pumping station (Refer to **Section 1.1.1**). It is recommended that a new Stage 1 AA be prepared for the proposed works (or the previous Stage 1 AA be updated) to account for the past construction of the sanitary overflow sewer and confirm that there is no potential for

archaeological impacts associated with construction of the flood protection berm north of Highway 401.

In the event that the updated Stage 1 AA concludes that there is archaeological potential within the areas potentially disturbed for construction of the recommended works, the Town should provide an update to the Indigenous communities with a potential interest in the study area (See **Section 7.6.3**).

5.2.3 Drainage Investigation for the Area North of Highway 401

A drainage investigation is recommended for the area between Highway 401 and the residential lots to the north. The recent construction of the Highway 401 / Highway 412 interchange and noise wall on the north side of Highway 401 have potentially altered historic drainage patterns for the area to the north. Information was received from a homeowner on the south side of Michael Boulevard, showing standing water in their back yard in the spring of 2017.

A review of the LiDAR mapping for the area revealed that there isn't a well-defined drainage path to convey surface runoff from this area east of the high point (at the location of the proposed berm) eastward to the concrete box culvert under Highway 401 near the west limit of Burns Street. There are numerous undrained depressions in the undulating terrain on the north side of Highway 401 where water can pond, potentially backing up into the residential lots to the north before flowing eastward to the concrete box culvert.

Construction of a drainage swale and/or regrading portions of the corridor could significantly improve drainage and mitigate potential standing water in the rear yards of homes on the south side of Michael Boulevard.

5.2.4 Storm Drainage Investigation for the Michael Boulevard and Flemington Court Area

Recall from **Section 2.4.4** that the topographic mapping and original grading design for the residential development did not appear to include a major drainage system (overland flow) outlet to safely convey flows in excess of the capacity of the catchbasins and storm sewers to Lynde Creek. Once the capacity of the storm sewer system is exceeded, a considerable area will drain overland to a low point just west of the intersection of Michael Boulevard and Flemington Court. From this location, water would need to build up to a depth of more than 1 m before spilling south to the open corridor north of Highway 401, and then eventually eastward to the concrete box culvert under Highway 401. At this depth, storm runoff would be

expected to back up into several of the reverse slope driveways in area, potentially flooding garages and possibly even basements.

Recall also from **Section 2.4.4** that the Town of Whitby is nearing completion of the Town Wide Urban Flood Study. This study has identified the sub-standard drainage conditions near the intersection of Michael Boulevard and Flemington Court, as well as a number of potentially undersized storm sewers within the Michael Boulevard study area. The preliminary preferred solution for the area of Michael Boulevard and Flemington Court includes high capacity catchbasins, storm sewer replacements and in-line pipe storage. It is recommended that the solution for this area be prioritized in the Town's capital budget planning, and detailed design of the solution be advanced to confirm that recommended improvements will be sufficient to fully contain storm drainage to the road right-of-ways for up to the 100 year storm event, with consideration for future potential climate change.

5.2.5 Preliminary Design of the Burns Street Extension

Recall from **Section 2.1.5** that the Town of Whitby Official Plan includes the future extension of Burns Street westward within the Town's corridor between Highway 401 and the residential lots to the north. The roadway, also proposed in the Town's Transportation Master Plan, would continue westward across Lynde Creek before turning north to an intersection on Dundas Street east of Highway 412. Timing for design and construction of the Burns Street extension has not been determined by the Town, and is not included in the Town's 10 year capital budget forecast.

The proposed berm is located within the future Burns Street alignment, and the drainage improvements recommended for further study in **Section 5.2.3** would also take place within the future Burns Street right-of-way. It is recommended that the Town initiate the preliminary design of the future Burns Street extension. This design exercise would identify potential conflicts between the flood protection berm and any drainage improvements, and would allow the Town to proactively investigate design alternatives to ensure that the future Burns Street extension can be configured to continue to prevent Lynde Creek from flooding the roadway and residential areas to the north, and to adequately drain the roadway east of Lynde Creek to the concrete box culvert under Highway 401.

Note, however, that because construction of the Burns Avenue extension is not expected in the next 10 years, and because there is no commitment on the part of the Town to construct the roadway, the flood protection berm will be designed, constructed and maintained as a permanent structure.

5.2.6 Lynde Creek Regulatory Flood Plain Mapping Update

The updates to the HEC-RAS hydraulic model of Lynde Creek described in **Section 2.4.2** resulted in an increase in the elevation and extent of the Regional storm flood plain relative to the regulatory flood plain currently established by CLOCA to manage flood risk in the Lynde Creek watershed. However, the hydrologic modelling used to determine the extent of flooding for the Regional storm event for this study was based on actual watershed conditions, and does not adhere to the conservative modelling assumption required by the Technical Guide - River & Stream Systems: Flooding Hazard Limit (MNRF, 2002). It is recommended that the model update prepared for this study be reviewed, refined and updated as required to conform to the MNRF guidelines, and then adopted by CLOCA to establish the Regulatory flood limit for this section of Lynde Creek.

5.3 Implementation Strategy

The recommended flood mitigation strategy requires both the backflow prevention devices and the berm to be installed to provide appropriate flood protection to the homes in the Michael Boulevard area. While the works can be implemented independently, they must both be in place to protect the area from area from high flood levels in Lynde Creek. At this time, the Town of Whitby has included the Michael Boulevard flood protection berm and backflow prevention devices in its capacity budget plan for implementation in 2023.

The flood proofing and education can be implemented independently from the berm and backflow prevention devices, as it is intended to offer protection to vulnerable homes during events larger than the 100 year return period flood. However, given the relative ease of implementation and immediate benefits of the berm and backflow prevention devices relative to the flood proofing and education program, it is recommended that the berm and backflow prevention devices be prioritized for implementation, followed by the flood proofing and education program as funding becomes available.

5.4 Permits and Approvals

The complete list of required permits and approvals will be established during detailed design. However, it is expected that the following permits and approvals will be required for construction of the recommended option.

- Central Lake Ontario Conservation Authority: A permit will be required for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses (Ontario Regulation 42/06).
- Ontario Ministry of the Environment, Conservation, and Parks: While no approvals are anticipated to be required under the Endangered Species Act, it is recommended that this be confirmed through additional consultation with MECP staff during detailed design.
- Ministry of Transportation: Construction of the flood protection berm involves limited grading in the Highway 401 right-of-way, and the work area is within MTO's permit control area. A Building and Land Use Permit will be required from MTO under the under the Public Transportation and Highway Improvement Act. It is recommended that plans be circulated to MTO staff for review and acceptance prior to submitting the formal permit application through the Highway Corridor Management on-line portal.
- Utilities: Approvals will be required from utility owners for protection and/or relocation of any existing above and below ground utilities potentially impacted by the recommended works, including but not limited to Durham Region's sanitary overflow sewer to Lynde Creek.

5.5 Monitoring

The proposed berm and backflow prevention devices are relatively standard and simple practices, and do not warrant monitoring to verify their effectiveness.

However, it is recommended that CLOCA and the Water Survey of Canada consider adding another streamflow / water level gauge on Lynde Creek immediately upstream of Highway 401, or moving the existing gauge on the south side of Dundas downstream to Highway 401. While Highway 401 is only a little over 1 km south of Dundas Street, flood levels in Lynde Creek near the most vulnerable areas downstream of the Jeffrey Street crossing cannot be easily inferred from the existing streamflow gauge at Dundas Street.

Adding or moving the streamflow gauge down to Highway 401 could improve CLOCA's ability to predict the potential for flooding in Lynde Creek to approach the homes to the east and enhance the Town's and Region's overall emergency response plans for flooding.

6 Potential Construction Impacts and Mitigation

6.1 Vegetation and Terrestrial Habitat

Construction of the flood protection berm north of Highway 401 may require removal of some existing vegetation within the future Burns Street right of way, and may require pruning or removal of several trees where the berm will abut the Flemington Court properties to the north. Currently, the majority of the berm footprint appears to be covered with predominantly common and/or weedy herbaceous vegetation with limited trees and shrubs.

Regardless, detailed tree inventories and preservation plans will be prepared for all areas potentially impacted by construction of the flood protection berm, including the construction access route from Michael Boulevard to the berm location. Comprehensive restoration plans will also be prepared to comply with the Town and Region tree protection by-laws. Any restoration plantings will be located to avoid conflicts with the future Burns Street extension and existing Durham Region sanitary overflow sewer.

6.2 Breeding Birds

During detailed design, the need for tree removals will be refined, and assessments will be carried out on any trees that may be removed. The Migratory Bird Convention Act restricts tree removals or any other activity that could be construed as impacting the nesting or breeding of a range of bird species from April 15 to July 30. The nesting window should be confirmed during detailed design, and if tree removals cannot occur outside of this window, a qualified biologist will be required to complete a survey to determine the presence of any nesting activity prior to any removals.

6.3 Surface Water Protection

To prevent accidental introduction of debris into the water, the establishment and use of specific construction access routes is recommended, as well as the use of mitigation techniques that contain sediment and debris within the work site. In addition, a spills response plan should be developed and implemented in the event of a fuel spill or sediment release.

Best Management Practices (BMPs) for the protection of aquatic habitat and source water protection will be reviewed at the detailed design stage and incorporated into the detailed design package. The use of erosion and sediment control devices and techniques should adhere to the principles limiting soil mobilization and trapping sediment as close to the source as possible. The Erosion and Sediment Control Guideline for Urban Construction (TRCA, 2019) will be followed for the development and implementation of the comprehensive Erosion and Sediment Control (ESC) plan. BMPs to prevent contaminants from entering surface water and groundwater will also be in place, such as appropriate fuel storage and refueling methods during construction.

6.4 Groundwater Management

Given that excavation will be limited to topsoil stripping over the footprint of the proposed berm, no impacts to groundwater are anticipated during construction. Regardless, groundwater levels will be confirmed and the potential for dewatering will be assessed during detailed design. If required, appropriate strategies will be developed to minimize, treat and dispose of any dewatering discharge water.

Should construction site dewatering requirements be greater than 50,000 L/day, permitting with the MECP will be required. Construction site dewatering of more than 50,000 L/day but less than 400,000 L/day (under normal site conditions) will require registration on the MECP Environmental Activity and Sector Registry (EASR) and fulfillment of EASR regulation monitoring and mitigation requirements. A Permit to Take Water (PTTW) will be required if any of the construction requires dewatering of over 400,000 L/day.

6.5 Soils Management

The recommended works may involve topsoil stripping and importing suitable materials for construction of the berm and temporary access road. All excess and unsuitable materials generated during construction will be managed appropriately. The materials may be reused as a construction material or transported from the site. Materials may also be temporarily stockpiled in preparation for these uses or temporarily removed from the site if required. Any soil stockpiles will be stabilized in accordance with the Erosion and Sediment Control Guideline for Urban Construction (TRCA, 2019).

All excess fill and any contaminated waste encountered naturally or through the Contractor’s efforts (e.g., diesel spill) should be managed in accordance with the

'On-Site and Excess Soil Management' (MECP, 2019) and Ontario Regulation 406/19.

In addition, a comprehensive ESC plan will be prepared in the detailed design stage.

6.6 Property Impacts

Construction of the flood protection berm requires excavation and fill placement near but outside the existing residential lots to the north, with limited grading within the Highway 401 right-of-way. As such, no property impacts are anticipated for construction of the flood protection berm.

It may be necessary for construction equipment to access the work area for the storm sewer backflow prevention devices via easements over private properties. The existing easement agreements should be reviewed to confirm the Town's responsibilities for notification and use of the existing easements to access the storm sewer outfalls, for both installation of the devices and future inspection and maintenance of the devices.

The Contractor will minimize impacts on adjacent private properties by confining all construction activities to the working area and not entering upon or occupying any private property outside of the working area for any purpose unless written permission from the landowner has been obtained in advance (by the Contractor or the Town) and proof of which is provided to the Town before entering the property. Should access to private property be granted, the property will be restored to its original condition or better following the completion of construction operations.

The Flood Proofing and Education Program may also result in works on private property to improve the resiliency of homes to flooding. However, any works on private property would be completed by the homeowner, in compliance with all relevant by-laws and regulations.

6.7 Air Quality, Noise and Vibration

The Contractor's activities, specifically the operation of construction equipment, will result in a temporary increase in noise, vibration and dust in the project area during the construction period. It is anticipated that these effects will be short in duration and limited to periods of construction machinery operation, and can be effectively mitigated by providing advance notice of construction to the adjacent residences, by limiting construction activities to normal working hours, and applying best management practices. If warranted, only non-chloride dust suppressants are to be

applied during construction. A comprehensive list of dust prevention and control measures can be found in Environment Canada's "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" (Cheminfo, 2005).

6.8 Traffic and Transportation

Traffic on Michael Boulevard may be temporarily impacted during construction as materials are transported to and from the working area for the flood protection berm. A traffic management plan will be developed in accordance with Ontario Health and Safety Book 7 to ensure the least possible impact, and standard traffic control measures will be implemented to safely co-ordinate traffic flow. Signage and flagmen will be posted if necessary during these events.

6.9 Post-Construction Impacts and Mitigation

Few impacts are anticipated following construction of the berm and backflow prevention devices. There may be occasional impact to residents for Town staff to inspect and maintain the backflow prevention devices, but the Town has existing easements over these properties to allow access to the storm sewer. Inspection of the backflow prevention devices by Town staff would be considered routine storm sewer maintenance and should be allowed under the existing easement agreements. No additional mitigation is warranted for inspection of the backflow prevention devices.

As noted in **Section 3.4**, the storm sewer backflow prevention devices have the potential to block local storm drainage from the residential areas east of Lynde Creek when water levels in the creek exceed the lowest elevations in the residential area. Given the differences in timing of peak water levels in Lynde Creek versus local runoff discharging to Lynde Creek, the risk of localized flooding from storm sewer backup is very low. Furthermore, these areas would be flooded regardless through storm sewer backup from Lynde Creek if the backflow prevention devices were not in place. As such, no additional mitigation is warranted.

Post construction impacts associated with the Flood Proofing and Education program would be limited to potential follow-up consultations with Town staff to ensure previously installed flood proofing measures are maintained, to encourage homeowners to adopt recommendations to reduce flood damages, and to educate new homeowners moving into the area after the initial roll-out of the program. However, Town staff would not access properties for consultations and inspections without the prior consent of the homeowner. No additional mitigation is warranted.

7 Public Consultation

7.1 Consultation Approach

The Municipal Class Environmental Assessment (EA) requires contact with the public at certain points during the EA study. The study involves 'works undertaken in a watercourse for the purposes of flood and erosion control,' and therefore the study was completed as a Schedule 'B' project under the Municipal Class EA. The points of public contact for this project are summarized in **Table 7-1**.

Table 7-1 Public Consultation Summary

Point of Contact	Date
Notice of Commencement	December 12, 2019
Community Open House #1	May 23, 2019
Community Open House #2	October 10, 2019
Notice of Completion	December 24, 2020

7.2 Notice of Commencement

A Notice of Commencement was prepared and circulated on December 12, 2018, on behalf of the Town of Whitby. A copy of the Notice is provided in **Appendix A**. The Notice was mailed directly to relevant agencies, First Nations organizations, utility providers and property owners within the study area. The Notice of Commencement was also advertised for two consecutive weeks in Whitby This Week and posted on the Town's website. The Notice summarized the purpose and scope of the study and invited interested parties to provide comments. All response forms received are included in **Appendix A**.

7.3 Community Open House # 1

The first Community Open House (COH) was held on May 23, 2019 from 6 pm to 8 pm. The COH was hosted at the Town of Whitby's Centennial Building, located a short distance from the study area at 416 Centre Street South. The Notice for COH #

1 was advertised in Whitby This Week on May 16 and May 23, posted on the Town's website and mailed to property owners in the study area and all stakeholders who indicated in interest in the study in their response to the Notice of Commencement. A copy of the Notice of COH # 1 is included in **Appendix A**.

The purpose of the first COH was to inform the public of the current flood risk in the study area, provide relevant information from previous studies of flooding from Lynde Creek, describe the existing social and natural environments present in the study area, and present some potential alternative concept solutions to mitigate the existing flood risk. The COH followed an informal open house format with display boards presenting the project information. The COH provided participants with an opportunity to review and comment on the project information and correspond directly with the project team. A copy of the display boards is included in **Appendix A**. Attendees were encouraged to provide contact information on the sign-in sheet and complete a comment form.

Twenty-two (22) people provided their contact information on the sign-in sheet, and 12 comment forms were received. Copies of the comment forms are included in **Appendix A**, and the feedback provided on the comment forms is summarized below.

Regarding the Existing Conditions information presented:

- Flooding has extended into private property abutting Lynde Creek several times over the last 5 years
- Ice jams occur frequently in Lynde Creek and cause flooding
- There is erosion along the bank of Lynde Creek north of Highway 401
- Concerns about the recent / planned improvements to Jeffrey Park given that it is within the flood plain and has been flooded in the past

Regarding the previously identified Metrolinx / CNR Relief Culverts alternative:

- General support for this alternative
- Concerns about project delays due to the significant cost and approvals needed from MTO, Metrolinx and CNR
- A desire to integrate a pedestrian and cycling trail into the relief culverts

Regarding the previously identified Flood Protection Berm alternative:

- Concerns that the berm could increase flood levels in Lynde Creek
- Concerns regarding blocked drainage behind the berm
- Concerns about impacts to properties abutting the berm

Regarding the Flood Protection and Education Program and the Emergency Management and Flood Response Plan alternatives:

- General support for these alternatives to complement physical flood reduction works
- A desire for risk and mitigation assessments for individual properties

The feedback received at COH # 1 was taken into consideration during the development and evaluation of alternative solutions to reduce flooding and flood damages from Lynde Creek, as documented in **Section 3** and **Section 4** of this PFR.

7.4 Community Open House # 2

The second COH was held on October 10, 2019 from 6 pm to 8 pm at the Town of Whitby Centennial Building.

The Notice for COH # 2 was advertised in Whitby This Week on September 26 and October 3, posted on the Town's website and mailed to property owners in the study area and all stakeholders who indicated in interest in the study in their response to the Notice of Commencement and through COH # 1. A copy of the Notice of COH # 2 is included in **Appendix A**.

The purpose of COH # 2 was to present and seek feedback regarding the alternative solutions considered to reduce flooding and flood damages from Lynde Creek, the evaluation of alternatives and preliminary preferred solution. Similar to COH # 1, COH# 2 followed an informal open house format with display boards presenting the project information. Representatives from the Town of Whitby, CLOCA and TMIG were in attendance to interact with attendees, guide them through the display boards and answer any questions.

Fourteen (14) people provided their contact information on the sign-in sheet, and 3 comment forms were received. Copies of the comment forms are included in **Appendix A**. Feedback received from the comment forms included information regarding beavers blocking the outlet from one of the storm sewers where backflow prevention devices are proposed. In response to this comment, **Section 5.1.1** includes a recommendation to remove any beaver dams and prevent future beaver activity at the outfall when the backflow prevention devices are installed.

Another attendee recommended minor re-grading within Central Park to prevent floodwater from flowing through the residential areas to the south. However, this was based on CLOCA's current approved regulatory flood plain for Lynde Creek. Recall

from **Section 2.4.2** that the updates to the CNR and Metrolinx rail embankments in the HEC-RAS hydraulic model resulted in a significant increase in Regional storm flood levels relative to the levels currently used by CLOCA to regulate Lynde Creek. While it is unlikely that grading refinements could contain the higher Regional flood plain within the park, this could be explored in a future study once CLOCA has reviewed and updated their regulatory flood plain mapping, if warranted, based on the more accurate representation of the rail embankments (refer to **Section 5.2.6**).

7.5 Notice of Completion

The Notice of Completion was advertised in Whitby This Week on December 24, and December 31, 2020, posted on the Town's website and issued directly to relevant agencies, First Nations organizations, utilities, surrounding property owners, and all other stakeholders who indicated an interest in the study through previous project consultations. A copy of the Notice of Completion is included in **Appendix A**, and includes the locations where the Project File Report could be viewed and instructions on how to provide comments and request a Part II Order.

Note that as of July 1, 2018, a Part II Order Request Form must be used to request a Part II Order. The Part II Order Request Form is available online on the Forms Repository website (http://www.forms.ssb.gov.on.ca/) by searching "Part II Order" or "012-2206E" (the form ID number).

Copies of the Draft Final Project File Report were sent to the MECP, CLOCA, MTO and Durham Region in April 2020. Comments were received from MECP on May 20, 2020. The letter from MECP and follow-up correspondence indicating how the concerns have been addressed in this Final Project File Report are included in **Appendix A**.

7.6 Other Agency and Stakeholder Consultation

7.6.1 MTO

Staff at MTO were provided information on the preferred solution in October 2019, including the limited grading that would be required in the Highway 401 right-of-way for the flood protection berm. MTO did not raise any concerns with the proposed works, and noted that an encroachment permit would be required from MTO prior to undertaking the work.

7.6.2 Durham Region

Staff at Durham Region were contacted by e-mail in October 2019 to solicit feedback on the proposed flood protection berm and potential impacts to the Region's overflow sewer connecting the Michael Boulevard SPS to Lynde Creek. A reply from Aaron Christie, Manager, Engineering Planning & Studies, stated that the Region did not foresee any problems associated with an additional 0.5 m of fill on top of the sanitary sewer, but indicated that the Region will want to review construction plans during detailed design to ensure that there will be minimal vehicle traffic over the sewer. He also indicated that the Region may require a CCTV inspection of the sewer before and after construction.

Durham Region staff were provided a draft copy of the Final Project File Report in April 2020, and replied confirming that they had no additional concerns. Copies of the correspondence with the Region is included in **Appendix A**.

7.6.3 Indigenous Communities

Pre-consultation with MECP identified the following indigenous communities with a potential interest in the study

- Curve Lake First Nation
- Mississaugas of Scugog Island First Nation
- Alderville First Nation
- Hiawatha First Nation
- Huron-Wendat Nation

Only one of the communities replied to the Notice of Commencement that was sent by mail at the beginning of the study. The remaining communities were contacted by e-mail prior to the first COH, and additional efforts were made to contact these communities ahead of the second COH. To date, responses have been received from the Alderville First Nation, Curve Lake First Nation and the Huron-Wendat Nation.

A summary of the contact with the identified indigenous communities is summarized in **Table 7-2** and additional details are provided in **Appendix A**.

Table 7-2 Summary of Indigenous Community Consultation

Community	Date and Form of Initial Contact	Date(s) and Form of Follow-up Contact	Date Response Received	Comments
Alderville First Nation	2018-12-12 (L)	2019-05-15(E) 2019-10-03 (E)	2019-10-03	No concerns, but they requested to remain on the project mailing list
Curve Lake First Nation	2018-12-12 (L)	2019-05-15(E) 2019-10-03 (E)	2019-10-04	Requested additional information to determine applicable consultation framework The Town responded with a letter on December 5, 2019 providing the requested information and demonstrating that the works would have no impacts on the identified areas of interest.
Hiawatha First Nation (Mississaugi of Rice Lake)	2018-12-12 (L)	2019-05-15(E) 2019-10-03 (E)		
Huron-Wendat Nation	2018-12-12 (L)	-	2019-01-11	No concerns, but they have requested that they be contacted if an archaeological investigation is initiated

Community	Date and Form of Initial Contact	Date(s) and Form of Follow-up Contact	Date Response Received	Comments
Mississaugas of Scugog Island First Nation	2018-12-12 (L)	2019-05-15(E) 2019-10-03 (E)		

(L) – Letter (T) – Telephone (E) – E-mail

8 Summary

Previous studies have determined that a large number of residential properties to the east of Lynde Creek, north of Highway 401 are potentially at risk of flooding during severe storm events. To date there have been no reports of homes damaged by flooding from Lynde Creek, but there is evidence that floodwater has extended up to and even into private properties during recent severe storm events.

This Municipal Class Environmental Assessment study has been undertaken to more accurately assess the current flood risk from Lynde Creek in the Michael Boulevard area, and to determine the most appropriate means of reducing flooding and flood damages from Lynde Creek.

Land use within the study area is primarily residential, with some commercial development along Dundas Street, schools adjacent Annes Street and several parks. The majority of the study area was developed in the 1970's, prior to the adoption of modern strategies for stormwater management and flood protection. The Town of Whitby Official Plan also designates a portion of the undeveloped lands west of Lynde Creek for industrial uses, and identifies a future extension of Burns Street West from its existing limit west of Annes Street along the north side of Highway 401, crossing Lynde Creek before turning north to intersect with Dundas Street east of Highway 412.

A natural heritage investigation was completed, which confirmed that Lynde Creek serves as a migratory route for a range of species including trout and salmon, and confirmed that the Provincially Significant Lynde Creek Coastal Wetland Complex (Lynde Creek Marsh) extends north of Highway 401 into the study area. The investigation determined that the study area potentially contains habitat for a number of Species at Risk, though none were identified in the field investigations.

The Lynde Creek Master Drainage Plan Update (MDPU) (AECOM, currently under study) included refinements to the Lynde Creek watershed hydrology model. This model is used to estimate the peak flow rates throughout Lynde Creek in response to storm events ranging from a 2 year return period event to a 100 year return period event as well as Hurricane Hazel. The model was prepared in accordance with the Technical Guide - River & Stream Systems: Flooding Hazard Limit (MNRF, 2002), which includes a number of very conservative assumptions to develop a 'worst-case' scenario for the purposes of establishing the extent of the Regulatory flood plain. This includes not accounting for any man-made storage in formal stormwater management facilities as well as ignoring the storage and attenuation of flows behind undersized roadway and rail culverts and embankments. For this study, the

hydrology model from the Lynde Creek MDPU was further refined to relax some of these conservative assumptions and account for the most significant storage areas behind road and rail culverts in order to provide a better estimate of the actual flows and flood risk in Lynde Creek under current watershed conditions.

The Lynde Creek MDPU also included refinements to the HEC-RAS hydraulic model used to estimate the depth and extent of flooding in Lynde Creek for different storm events. The HEC-RAS hydraulic model was updated based on more detailed topographic information for the study area, and was further refined to more accurately represent flow conditions through the road and rail bridges in the study area. The flows from the refined hydrology model were then input to the model to determine the depth and extent of flooding for different storm events.

The modelling confirmed that the existing bridges under the CN and Metrolinx rail embankments south of Highway 401 represent the most significant restrictions along Lynde Creek that contribute to the high flood levels upstream of Highway 401. The updated flood plain mapping determined that 24 homes are potentially at risk of flooding in a 50 year return storm event, 45 homes are potentially at risk of flooding in a 100 year return period storm event, and over 500 homes are potentially at risk of flooding if Hurricane Hazel were to reoccur over the Lynde Creek watershed. Flood damages are estimated to be approximately $2.3 Million in a 100 year storm event, and $64,000 per year on an average annualized basis.

A range of alternative solutions were developed to mitigate the potential for flooding from Lynde Creek. These are briefly summarized below:

Status Quo (Do Nothing): This solution does not propose any measures to reduce flooding or flood damages. However, flood risk will continue to be managed through the Central Lake Ontario Conservation Authority's (CLOCA) jurisdiction-wide flood forecasting and warning and the Town's and Region's current emergency management plans.

CNR and Metrolinx Relief Culverts: Previous investigations have recommended installing additional culverts under the CNR and Metrolinx rail embankments to pass more flow and reduce upstream flood levels for up to the 100 year return period storm event. Building on the most recent study, this alternative involves installing 8 – 1.8 m diameter pipes under the two railway embankments using trenchless methods. This would reduce upstream flood levels sufficient to prevent flood damages in a 100 year return period storm event, but would not reduce the depth of flooding in the Regional (Hurricane Hazel) storm event.

Flood Protection Berm with Storm Sewer Backflow Prevention Devices: The refined flood plain mapping determined that under existing conditions, floodwater

from Lynde Creek initially reaches the residential areas to the east by backing up and out of the storm sewer systems discharging to Lynde Creek, and by floodwater flowing east through the open area between Highway 401 and the residential lots to the north, and then flowing into the residential area through a low area in the vicinity of Michael Boulevard and Flemington Court. This alternative includes the construction of a low berm in the Town-owned open area north of Highway 401 to prevent water from Lynde Creek from flowing eastward and northward into the residential area, and backflow prevention devices on 4 storm sewer outfalls to prevent floodwater from Lynde Creek from backing up through the storm sewer systems and into the study area. The combination of the berm and backflow prevention devices would protect 44 of the 45 homes currently at risk of flooding in a 100 year storm, but would not reduce flooding or flood damages from larger storms including the Regional storm event.

Flood Proofing and Education Program: This alternative would reduce flood damages through physical works completed by homeowners to reduce the risk of floodwater from entering their homes, and through practices implemented by residents to minimize damages when floodwater enters a home. At a minimum, the program would include the preparation and distribution of an information package to residents informing them of the current flood risks in the study area, and descriptions of a range of best practices for works inside and outside flood vulnerable homes to minimize the risk of water entering the structure and to minimize damages in the event of flooding. It could be augmented by inspections by Town staff, who would then prepare a list of recommendations tailored to each property, and could be further enhanced through a program that would provide a rebate or other financial incentive to homeowners to cover a portion of the cost of physical improvements to a home to reduce flood risk and damages. The cost and effectiveness of this solution would depend on how many homeowners voluntarily implement works to reduce flood damages on their property. These works would not be completed by or mandated by the Town.

Emergency Management Planning: The final alternative considered is an enhancement to the existing flood forecasting and warning systems and emergency management plans, tailored specifically to Lynde Creek north of Highway 401. It would include a forecasting system developed based on local streamflow characteristics, and a warning system that would send messages to local residents alerting them to potential and actual flooding conditions. It would also involve the development of a site specific plan to evacuate residents from the flood plain before flooding renders the roads in the study area impassable. The program would not reduce flood levels or flood damages from Lynde Creek.

The above alternative solutions were evaluated against a number of criteria considering the natural environment, social and cultural impacts, technical effectiveness, construction challenges, costs and benefits. The preferred solution to reduce flood damages from Lynde Creek is the **Flood Protection Berm with Storm Sewer Backflow Prevention Devices**. It is further recommended that this solution be augmented with elements of a **Flood Proofing and Education Program**. The evaluation of alternatives is summarized in **Table 8-1**.

The flood protection berm solution was selected because it can be implemented relatively quickly on Town owned lands with few challenges or approvals, and can protect almost all of the homes currently at risk of flooding in a 100 year return period storm event. It is also much less expensive than the CNR and Metrolinx Relief Culverts alternative, resulting in a much higher benefit:cost ratio and much shorter payback period for nearly the same level of flood protection. The Flood Proofing and Education Program may be sufficient to protect the remaining vulnerable home from flooding in a 100 year storm event, and could reduce flood impacts and flood damages from larger storm events.

Table 8-1 Evaluation Summary

Alternative	Capital Cost	Number of At-Risk Homes Protected in a 100 Year Flood	Benefit: Cost Ratio	Evaluation Notes
Status Quo	$0	None	n/a	Not recommended as it does not reduce flooding or flood damages
CNR and Metrolinx Relief Culverts	$8.4 Million	45 of 45	0.8:1	Not recommended due to the high risks and costs for implementation of the relief culverts (challenges to secure approvals from CN and Metrolinx and to install the culverts without disturbing the

Alternative	Capital Cost	Number of At-Risk Homes Protected in a 100 Year Flood	Benefit: Cost Ratio	Evaluation Notes
				active rail lines, challenges and environmental impacts to access the construction area)
Flood Protection Berm with Storm Sewer Backflow Prevention Devices	$500 Thousand	44 of 45	6:1	**Recommended**: Protects all but one home from flooding in a 100 year storm event, and can be implemented relatively quickly and economically on Town-owned land
Flood Proofing and Education Program	Up to $500 Thousand, depending on program elements and uptake by residents	Depends on the degree of uptake by residents	n/a	Not recommended as a standalone solution due to challenges to ensure implementation of flood proofing measures by homeowners, **but elements of this program could complement other flood reduction solutions**
Emergency Management Planning	Up to $130,000 per year, depending on staffing	None	n/a	Not recommended due to challenges to maintain a resident contact database and additional staff

Alternative	Capital Cost	Number of At-Risk Homes Protected in a 100 Year Flood	Benefit: Cost Ratio	Evaluation Notes
	requirements to administer the program			needed on a permanent basis for a relatively low risk of flooding

A number of additional studies are recommended to facilitate implementation of the preferred solution, including detailed topographic surveys, a geotechnical investigation to inform the design of the flood protection berm, a vegetation inventory for areas potentially disturbed for construction of the berm, and a video inspection of the Region's sanitary overflow sewer that is aligned in the open area north of Highway 401 between the Michael Boulevard sanitary pumping station and emergency outlet to Lynde Creek.

A drainage investigation is also recommended to improve drainage of the area north of Highway 401 between the high point east of Lynde Creek and a concrete box culvert under Highway 401 near the west limit of Burns Street. It is also recommended that a preliminary design be advanced for the future Burns Street extension, which will be aligned within the Town-owned lands on the north side of Highway 401. The preliminary design can avoid potential conflicts and ensure that the future roadway can be configured to continue to contain flooding from Lynde Creek.

The Michael Boulevard Flood Mitigation Strategy has been completed in accordance with the Municipal Class Environmental Assessment process, as is required for the planning of all major municipal projects or activities. Considerable consultation with the public, agencies and other stakeholders has taken place throughout the project, including two Community Open Houses to provide opportunities for the public to provide input to the characterization of existing conditions and the development and evaluation of alternative solutions.

All concerns raised by the public and agency staff, including Indigenous Communities, have been considered in the evaluation of alternative solutions and have been addressed in this final Project File Report.

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