AECOM

Final Drainage, Hydraulic and Stormwater Management (SWM) Report

Highway 400 - Highway 404 Link (The Bradford Bypass) (GWP 2008-21-00)
Town of Bradford West Gwillimbury, Township of King and Town of East Gwillimbury – Assignment # 2019-E-0048

Ministry of Transportation of Ontario

60636190

September 28, 2023

Delivering a better world

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("AECOM") for the benefit of the Client ("Client") in accordance with the agreement between AECOM and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

- is subject to the scope, schedule, and other constraints and limitations in the Agreement and the qualifications contained in the Report (the "Limitations");
- represents AECOM's professional judgement in light of the Limitations and industry standards for the preparation of similar reports;
- may be based on information provided to AECOM which has not been independently verified;
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued;
- must be read as a whole and sections thereof should not be read out of such context;
- was prepared for the specific purposes described in the Report and the Agreement; and
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time.

AECOM shall be entitled to rely upon the accuracy and completeness of information that was provided to it and has no obligation to update such information. AECOM accepts no responsibility for any events or circumstances that may have occurred since the date on which the Report was prepared and, in the case of subsurface, environmental or geotechnical conditions, is not responsible for any variability in such conditions, geographically or over time.

AECOM agrees that the Report represents its professional judgement as described above and that the Information has been prepared for the specific purpose and use described in the Report and the Agreement, but AECOM makes no other representations, or any guarantees or warranties whatsoever, whether express or implied, with respect to the Report, the Information or any part thereof.

Without in any way limiting the generality of the foregoing, any estimates or opinions regarding probable construction costs or construction schedule provided by AECOM represent AECOM's professional judgement in light of its experience and the knowledge and information available to it at the time of preparation. Since AECOM has no control over market or economic conditions, prices for construction labour, equipment or materials or bidding procedures, AECOM, its directors, officers and employees are not able to, nor do they, make any representations, warranties or guarantees whatsoever, whether express or implied, with respect to such estimates or opinions, or their variance from actual construction costs or schedules, and accept no responsibility for any loss or damage arising therefrom or in any way related thereto. Persons relying on such estimates or opinions do so at their own risk.

Except (1) as agreed to in writing by AECOM and Client; (2) as required by-law; or (3) to the extent used by governmental reviewing agencies for the purpose of obtaining permits or approvals, the Report and the Information may be used and relied upon only by Client.

AECOM accepts no responsibility, and denies any liability whatsoever, to parties other than Client who may obtain access to the Report or the Information for any injury, loss or damage suffered by such parties arising from their use of, reliance upon, or decisions or actions based on the Report or any of the Information ("improper use of the Report"), except to the extent those parties have obtained the prior written consent of AECOM to use and rely upon the Report and the Information. Any injury, loss or damages arising from improper use of the Report shall be borne by the party making such use.

This Statement of Qualifications and Limitations is attached to and forms part of the Report and any use of the Report is subject to the terms hereof.

AECOM: 2015-04-13

Quality Information

Prepared by

Andres Rodriguez, M.Sc.,P.Eng.
Senior Water Resources Engineer
(Hydraulic Assessment of Major Bridge Crossings)

Prepared by

Melanie Ego, B.Sc.(Eng.)
Water Resources, Water

Report Preparation - Reviewed and Verified by

, September 28, 2023

Jhalmar Maltez, M.Eng.,P.Eng.
Senior Water Resources Engineer, Project Manager

Revision History

Rev #	Revision Date	Revised By:	Revision Description
1	Dec. 23, 2022	AECOM	DRAFT Drainage, Hydraulic and Stormwater Management (SWM) Report
2	April 14, 2023	AECOM	DRAFT Drainage, Hydraulic and Stormwater Management (SWM) Report
3	May 8, 2023	AECOM	DRAFT Drainage, Hydraulic and Stormwater Management (SWM) Report
4	July 17, 2023	AECOM	DRAFT Drainage, Hydraulic and Stormwater Management (SWM) Report
5	Sept. 28, 2023	AECOM	Final Drainage, Hydraulic and Stormwater Management (SWM) Report

Distribution List

# Hard Copies	PDF Required	Association / Company Name
-	✓	Ministry of Transportation of Ontario
-	✓	AECOM Canada Ltd.

Table of Contents

Tables

Exhibits (provided at back of report except Exhibit 1.1)

Figures

Appendices

1. Introduction

The Ontario Ministry of Transportation (the Ministry) has retained AECOM Canada Ltd. (AECOM) to undertake a Preliminary Design and project-specific assessment of environmental impacts for the proposed Highway 400 – Highway 404 Link (Bradford Bypass). The Bradford Bypass (the project) is being assessed in accordance with Ontario Regulation 697/21 (the Regulation) (October 7, 2021).

The Bradford Bypass is part of Ontario's plan to expand highways and public transit across the Greater Golden Horseshoe to fight congestion, create jobs and prepare for the massive population growth expected in the next 30 years. Simcoe County's population is expected to increase to 416,000 by 2031, with the Regional Municipality of York growing to 1.79 million by 2041. The Bradford Bypass has been proposed as a response to this dramatic growth in population and travel demand in the area and the forecasted increase in congestion on key roadways linking Highway 400 to Highway 404.

The project is a new 16.3 kilometre, controlled-access freeway. The proposed highway will extend from Highway 400 between 8th Line and 9th Line in Bradford West Gwillimbury, will cross a small portion of King Township, and will connect to Highway 404 between Queensville Sideroad and Holborn Road in East Gwillimbury. There are proposed full and partial interchanges, as well as grade separated crossings at intersecting municipal roads and watercourses, including the Holland River and Holland River East Branch. This project also includes the design integration for the replacement of the 9th Line structure on Highway 400, which will accommodate the proposed future ramps north of the Bradford Bypass corridor. The Ministry is considering an interim four-lane configuration and an ultimate eight-lane design for the Bradford Bypass. The interim condition will include two general purpose lanes in each direction and the ultimate condition will include four lanes in each direction (one high-occupancy vehicle lane and three general purpose travel lanes in each direction). The interim and ultimate designs are being reviewed as the project progresses. Should the footprint change or be modified in any way, a review of the changes shall be undertaken, and an addendum to the Report will be prepared to reflect the changes, impacts, mitigation measures, and any commitments to future work.

This Drainage and Stormwater Management (SWM) Report (this Report) documents the hydrologic and hydraulic assessments of the existing and proposed drainage systems, including the conceptual stormwater management (SWM) strategy and a high-level Erosion and Sediment Control Plan (ESCP) associated with the Bradford Bypass improvements.

1.1 Drainage Objectives

The main purpose of this Report is as follows:

- Establish existing drainage patterns across the proposed alignment of the Bradford Bypass by reviewing contract drawings, previous drainage studies, background information from agencies, and topographic data,
- Complete site investigation to observe and document existing drainage infrastructure characteristics and conditions as well as any areas of concern (flooding issues, erosions and/or scour locations, etc.),
- Delineate drainage catchments and complete existing conditions hydrology analysis to determine peak flows for the hydrologic assessment of the drainage system,
- Complete the existing drainage conditions hydraulics assessment of culverts to establish if MTO's Design Criteria, and other applicable criteria are met,
- Identify locations of proposed culverts along the Bradford Bypass mainline, side roads, highway ramps and Metrolinx railway tracks,
- Identify locations of potential channel / watercourse realignment and new highway side ditches,

- Identify potential locations of SWM facilities, SWM Extended Detention ponds, Enhanced Grassed Swales and Flat Bottom Grassed Swales with flow check dams, including facilities to provide water quality treatment of runoff for the Holland River bridge deck areas,
- Complete the hydrology and hydraulics analyses and evaluation for the proposed drainage system to confirm adequacy of the new and modified structures, and to identify potential impacts in terms of increased peak flows, velocities, flooding and erosion potential,
- Complete a hydraulic assessment of the proposed Holland River bridge structures to identify the proposed bridge spans, and to complete a comparison between the existing and proposed floodplain and flow velocities. Identify overflow culvert requirements.,
- Maintain existing drainage pattern within the Study Area as feasible,
- Assess erosion potential across the site, and design mitigation measures as required, and
- Ensure positive drainage, under proposed drainage conditions, is provided for runoff generated within upstream lands – across the road - to receiving water bodies.
- Ensure the proposed drainage system will have sufficiency of outlet to avoid flooding issues at the upstream and downstream areas from the Bradford Bypass.
- Consultation with stakeholders to present the proposed drainage system and stormwater management strategy to obtain comments and feedback.

1.2 Policy Framework

The following design guidelines are referenced from MTO:

- MTO Drainage Management Manual, October 1997,
- MTO Highway Drainage Design Standards, January 2008,
- MTO Environmental Guide for Erosion and Sediment Control during Construction of Highway Projects, September 2015,
- MTO Environmental Reference for Highway Design, June 2013,
- MTO Contract Drawings, CONT No. 2021-2124,
- MTO Gravity Pipe Design Guidelines, April 2014,
- MTO Salt Management Plan, Dec. 2005,
- MTO Salt Management Plan Supplement, April 2017, and,
- MTO Navigable Waters Guidelines, March 2020.

Other guidelines:

- MECP Stormwater Management Planning and Design Manual, March 2003,
- MECP – Ontario Regulation 697/21 made under the Environmental Assessment Act for the Bradford Bypass Project, October 7, 2021,
- LSRCA Technical Guidelines for Stormwater Management Submissions, April 2022,
- NVCA Stormwater Technical Guidelines, December 2013,
- On. Reg. 172/06 (NVCA) – Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses,
- South Georgian Bay Lake Simcoe Source Protection Region, Source Protection Plan Jan. 26, 2015,
- Engineering Design Criteria Manual for the Town of Bradford West Gwillimbury, September 2015,
- Town of East Gwillimbury Engineering Standards and Design Criteria, September 2012, and,
- Township of King Design Criteria and Standard Detail Drawings, January 2019.

The hydrology and hydraulic assessments are completed in accordance with the MTO Highway Drainage Design Standards (HDDS, January 2008).

1.3 Review of Background Documents

The following information sources were reviewed in preparation of this Report:

- AECOM Fish and Fish Habitat Assessment Technical Memorandum, October 2021,
- Ontario Base Mapping (OBM),
- The latest topographic base map and survey (August 2021),
- LSRCA Holland River One Dimensional Dynamic Model Analysis Report, prepared by CCL, February 1990,
- Hydrologic and Hydraulic modeling for West Holland River, East Holland River and Maskinonge River Watersheds, prepared by CCL, July 2005,
- Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers, Black Ash, Silver and Sturgeon Creeks, prepared by MacLaren Plan search, May 1988,
- HEC-RAS Hydraulic modeling for Penville Creek and Innisfil Creek, provided by the NVCA, April 12, 2021,
- MTO Contract Drawings at Highway 400 and 404,
- Metrolinx Barrie Go Line Expansion SWM Report (2018),
- Environmental Assessment Report, Highway 400 – Highway 404 Extension Link (Bradford Bypass). W.P. 377-90-00, prepared by McCormick Rankin Corporation, December 1997,
- Lake Simcoe Region Conservation Authority (LSRCA) Innisfil Creek Subwatershed Study, April 2013, and,
- Nottawasaga Valley Watershed, Health Check 2018.

1.4 Study Area

As shown in **t**he Study Area is located in the Town of Bradford West Gwillimbury within the County of Simcoe, and the Town of East Gwillimbury and the Township of King within York Region. The west limits of the Study Area, including Highway 400, falls within the Penville Creek watershed (Innisfil Creek) and is under the jurisdiction of the Nottawasaga Valley Conservation Authority (NVCA). The rest of the Study Area falls within the Holland River watershed and Maskinonge River subwatershed and under the jurisdiction of Lake Simcoe Region Conservation Authority (LSRCA).

The limits of the Study Area are summarized below:

- West Limit is Highway 400 between Simcoe Road 8 and 9th Line, and
- East Limit is Highway 404 between Queensville Sideroad and south of Holborn Road.

The land use consists of agricultural lands with some rural residential and residential lands located along the west of the Holland River, south of the proposed Bradford Bypass. The topography of the site generally slopes towards the Holland River and Holland River East Branch, which ultimately convey flow north to Cook's Bay (Lake Simcoe).

Ontario AECOM

STUDY AREA

HIGHWAY 400-404 LINK - BRADFORD BYPASS (GWP 2008-21-00)

Exhibit 1.1

2. Design Criteria

2.1 Culverts

The design standards to assess the culverts are based on the "MTO Highway Drainage Design Standards" (HDDS) (February 2008)". The MTO standards were used since they incorporate most of the standards for watercourse crossings from the Canadian Highway Bridge Design Code (CHBDC). Performance standards include:

WC-1: Design Flows for Bridges and Culverts In accordance with the requirements of the MTO Highway Drainage Design Standard (HDDS), a structure with Total Span less than or equal to 6.0 m should be designed to convey a minimum of the 50-year design storm for the future Bradford Bypass, which is classified as a Freeway. The 50-year storm was used as the design storm for the culverts located along Highway 400, Highway 404 and the Bradford Bypass. For sideroads which are classified as rural arterial or collector roads, a 25-year design storm is applicable.

WC-7: Culvert Crossings on a Watercourse This standard identifies the freeboard and the maximum flood depth at the upstream face of a culvert crossing.

- **The desirable freeboard** is measured vertically from the Energy Grade Line (EGL) elevation for the 50-year Design Storm water level to the edge of the travelled lane at the lowest point on the road profile adjacent to the culvert (spill point). For example, for culverts located at or near a road sag, the spill elevation would be the lowest edge of travelled lane elevation at the sag. In cases where a culvert is not located at a highway sag, the spill point is considered to be the edge of travelled lane elevation at the point at which flows would spill to an adjacent culvert (highpoint along the road ditch).
- **The minimum freeboard** is measured vertically from the Hydraulic Grade Line (HGL) for the 50-year Design Storm water level to the edge of the travelled lane at the lowest point on the road profile.

Flood Depth at Culverts (WC-7) For culverts with a diameter or rise less than 3.0 m (non-structural) with a closed bottom or open footing culverts with a non-erodible bottom, this standard specifies that the ratio of headwater depth to culvert diameter or rise (HW/D) should be less than 1.5. For culverts with a diameter or rise between 3.0 m and 4.5 m, the HW/D ratio should be less than 4.5, and for culverts with a diameter or rise greater than 4.5 m the HW/D ratio should be less than 1.0.

WC-8: Minimum Culvert Size This standard identifies minimum culvert sizes for various road types. The minimum culvert size to be used under freeways and urban arterials is 800 mm diameter for circular culverts and 900 mm rise for box culverts.

SD-1: Design Flow for Surface Drainage Systems This standard identifies the minimum design flows that shall be used for the sizing of road surface drainage systems (minor and major drainage systems such as piped and surface systems). For a freeway, arterial (urban and rural), and collector (urban and rural) the minor system shall be designed for the 10-year design flow and the major system shall be designed for the 100-year design flow.

SD-13: Design Flow and Freeboards for Culverts not on a Watercourse This standard identifies the design flows and the required freeboard for culverts associated with runoff from roadways and local external catchment areas. Culverts under highways, ramps, and adjacent roadways shall be designed to convey the minor and major systems design flow.

In addition to the design standards provided above, the following criterion was also used in the hydraulic assessment of the culverts:

- **Overtopping Criterion:** This standard indicates that the Hydraulic Grade Line (HGL) generated by the 100-year design storm should not exceed the elevation of the spill point at the edge of the travel lane of the road.

WC-12: Fish Passage through Culverts the Ministry of Transportation (MTO) guidance on fish passage design criteria has been adopted for this Report. Section WC-12 of the MTO Drainage Design Standards requires to consider the 2-year flow for assessing fish passage and states the following:

- The velocity in the culvert for the fish passage design flow (i.e., the 2-year natural channel velocity) shall not exceed the natural channel velocity;
- The flow depth in the culvert shall be consistent with the average depth immediately upstream and downstream of the culvert; and
- There shall be no sudden drops in the water surface exceeding 0.15 m for the design flow (i.e., the 2-year flow) in or adjacent to the structure.

2.1.1 AREMA Criteria to Assess Metrolinx Culvert EX-CL-14

Culvert EX-CL-14 was evaluated using design criteria from the American Railway Engineering and Maintenance-of-Way Association (AREMA) Manual. The following design criteria was used to assess the hydraulic capacity of EX-CL-14.

- No Static Head (HW/D < 1) during the 25-year storm,
- A minimum freeboard of 2 feet (0.6 m) to the base of rail tracks during the 100-year storm, and
- A maximum headwater to depth (HW/D) ratio of 1.5 during the 100-year storm.

2.2 Side Ditches

MTO Standards SD-1 Design Flows for Surface Drainage Systems and SD-9 Roadside Ditches (Conveyance Only) outlines the minimum design requirements of Roadside Ditches for the conveyance of flow. It does not address the design of roadside ditches for enhancement of water quality. The following design standards should be applied for the design on roadside ditches:

- It shall be designed to convey both the minor (10-year) and the major (100-year) drainage systems design flow per Standard SD-1,
- The maximum flow depth in the roadside ditch associated with the minor system shall be 1.0 m,
- For the major system design flow, the design of the roadside ditch shall ensure that the flow will not spread onto either the shoulder or the travel lane,
- For the major system design flow, the desirable standard is that water will not extend beyond the Right-of-Way, and as a minimum standard any flow spread beyond the Right-of-Way shall not increase the existing extent of flooding,
- In no case, the maximum permissible velocity in the channel shall exceed 1.5 m/s unless protection for erosion potential techniques is to be used.
- The minimum freeboard to the top of sub-grade shall be 0.3 m for the minor design flow. There is no minimum freeboard associated with the major system design flow.

2.3 Stormwater Management (SWM) Plan

The design standards and criteria used in the design and assessment of temporary and permanent SWM facilities are based on the criteria outlined in the MECP *Stormwater Management Planning and Design Manual* (March 2003). The MTO *Highway Drainage Design Standards* (2008) provides additional recommendations that can be used for the design of roadside ditches intended to provide quality control of runoff. The LSRCA *Technical*

Guidelines for Stormwater Management Submissions, April 2022, and the NVCA *Stormwater Technical Guidelines*, December 2013, were consulted to identify additional SWM and Erosion Control requirements.

In the event that SWM treatment units are contemplated, the Canadian Environmental Technology Verification Program (ETV) provides support for the implementation of innovative environmental technologies in Canada. It is designed to provide objective and quality-assured performance data on environmental technologies. Only units verified through the Canadian ETV program will be allowed.

The specific design standards and criteria used for the design of the SWM plan for the Bradford Bypass are summarized below:

2.3.1 Flat Bottom Grassed Swales

Flat-bottom grassed swales are recommended where feasible to provide additional water quality treatment of runoff. The March 2003 MECP design manual identifies flat-bottom grassed swales as an acceptable stormwater management practice for water quality enhancement provided that certain Design Criteria are met. Flat-bottom grassed swales are most effective for water quality treatment and quality enhancement when the depth of flow and longitudinal slope are minimized, and the bottom width is maximized. As per the 2003 MECP design manual, the design criteria for flat-bottom grassed swales are:

- The flow from the 4-hour 25 mm design storm using the Chicago rainfall distribution should be ≤ 0.15 m3/s,
- The velocity from the 4-hour 25 mm Chicago design storm should be ≤ 0.50 m/s,
- Grassed swales are most effective when depth of flow is minimized. The flow depth for the 4-hour 25 mm Chicago design storm should be ≤ 0.25 m,
- The longitudinal slope of the swale should be less than 1.0%,
- The swale bottom width should be, at a minimum, 0.75 m,
- The velocity generated by the 100-year design storm should not exceed 1.5 m/s (at which point, rock protection should be provided along the swale to prevent erosion potential), and
- The contributing drainage area should be ≤ 2 ha (35% of imperviousness).

Typically, uncontrolled erosion can result in a loss of topsoil, a disruption of nearby watercourses due to sedimentation and high flow velocities (V_{100} > 1.5 m/s) resulting in a degradation of downstream water quality. An assessment of the flow velocities along the grassed swales during the 100-year design storm should be completed during the detail design stage to identify where rock protection is required to prevent erosion potential. In addition, the use of permanent rock flow check dams (i.e., OPSD 219.210) will reduce flow velocities, encourage runoff infiltration and will minimize erosion potential.

2.3.2 SWM Ponds

Stormwater management (SWM) ponds are proposed where applicable to provide additional water quality treatment of runoff and to provide quantity control of peak flows. SWM ponds will be designed as per the MECP design manual during the next design phase, assuming more information is available and appropriate. The design criteria for SWM ponds are summarized below:

- Minimum drainage area of 5 hectares.
- Permanent pool volume for wet ponds sized to provide Enhanced Level Quality Control (80% removal of Total Suspended Solids) as per Table 3.2 of the MECP design manual,
- Active storage detention for water quality and erosion control with a minimum drawdown time of 24 hours,

- Active storage sized to provide control of proposed condition peak flows to existing peak flows for storm events up to the 100-year design storm,
- A summary of design guidance for SWM Wet Ponds is provided in Table 4.6 Wet Ponds – Summary of Design Guidance in the MECP manual.

The LSRCA SWM Guidelines recommends the following standards:

- The post-development peak flow rates are not to exceed the corresponding pre-development peak flow rates for the 2-year and up to the 100-year design storm events (Unless specified otherwise by a subwatershed study or fluvial geomorphic analysis).
- Every effort must be made to maintain existing watershed boundaries and existing drainage patterns. As a rule, significant changes in drainage boundaries are not permitted. Pre-consultation is mandatory for any proposed change in drainage boundaries;
- Infiltration measures may be considered for peak flow control credits, subject to the conditions as described in Appendix B. Pre-consultation with the MECP, local municipality and the Authority is required;
- If a site is not accounted for within a downstream SWM facility than quantity control will be required as per this section. Additionally, this may require over-control such as controlling the flows to a minimum of the 2-year pre-development flow rate OR the specified municipal allowable flow rate OR an approved governing master drainage studies / document;
- Where there is an external drainage area flowing through a site, it is the developer's responsibility to demonstrate safe conveyance of the Regulatory Storm, through the development site to a sufficient outlet.
- For additional design requirements applicable to SWM ponds, see Section 6.4.2 in the LSRCA's Technical Guidelines for SWM Submissions (i.e., emergency overflow weir, outlet control structure, outlet headwall, safety features, maintenance access, warning signs, vegetative planting, freeboard, erosion protection, etc.).

2.4 LSRCA, NVCA, Town of Bradford West Gwillimbury, Town of East Gwillimbury and Township of King

The LSRCA and NVCA each have technical guidelines for stormwater management, which are outlined in the LSRCA Technical Guidelines for Stormwater Management (SWM) Submissions (April 2022) and the NVCA Stormwater Technical Guide (December 2013) respectively. The Town of Bradford West Gwillimbury, the Town of East Gwillimbury and the Township of King each have engineering design standards, which are outlined in the Engineering Design Criteria Manual for the Town of Bradford West Gwillimbury (September 2015), the Town of East Gwillimbury Engineering Standards and Design Criteria (September 2012), and the Township of King Design Criteria and Standard Detail Drawings (January 2019). The applicable stormwater design criteria from the LSRCA, NVCA and municipalities area summarized below.

2.4.1 Lake Simcoe Region Conservation Authority (LSRCA)

The LSRCA Technical Guidelines for SWM includes the following stormwater design criteria:

<u>Water Quantity- Peak Flow Control:</u> Required to provide control of post-development peak flow rates to pre-development peak flow rates for the 2 through 100 year storm events. In addition, every effort should be made to maintain existing watershed boundaries and drainage patterns.

<u>Water Quantity - Volume Control:</u> For linear development, the LSRCA has established a volume control target to capture and retain/treat on site the larger of the following:

- The direct runoff volume from the 12.5 mm of rainfall for the fully reconstructed or newly constructed impervious area; or
- The direct runoff volume from the 25 mm of rainfall from the net increase in impervious area on the site.

If this target cannot be achieved due to site constraints or restrictions, flexible alternatives have been established.

Water Quality: Suspended Solids MECP Enhanced Protection Level (80% removal of suspended solids) is to be provided as per MECP guidelines.

Water Quality: Winter Salt Design of roads is to minimize need for excess salt use. SWM pond design should include the use of submerged outlets located approximately at the midpoint of the permanent pool depth from SWM wet ponds to minimize potential salt concentrations and provide some thermal mitigation. The use of multi-draw or blended outlets, which consider both salt concentrations and temperature impacts, is preferred.

Stream Erosion Control Erosion control is to be provided as required by watershed and subwatershed studies, Master Drainage Plans and Master Environmental Servicing Plans, if applicable, or the MECP SWM manual. For sites greater than 2 hectares, runoff from a 25 mm 4-hr Chicago design storm is to be detained and released over a minimum 24 hour period.

Water Balance/Groundwater Recharge/WBRP Every feasible effort is to be made to maintain the pre-development infiltration rate and/or meet infiltration targets established in more comprehensive documents such as master plans, subwatershed plans and watershed plans, if applicable.

2.4.2 Nottawasaga Valley Conservation Authority (NVCA)

The NVCA Stormwater Technical Guide (December 2013) includes the following stormwater management criteria:

Water Quantity - Peak Flow Control: The post-development flows are to be controlled to pre-development levels for the 2-year through 100-year storm events. Drainage design must also provide safe conveyance of the Regulatory flow through the site.

Water Quality: MECP Enhanced Protection Level (80% removal of suspended solids) is to be provided as per MECP guidelines. Where applicable, SWM design should include mitigate potential thermal and bacteriological impacts using preventative measures (I.E., low impact development practices) and mitigation measures.

Erosion Control: At a minimum, stormwater management design must include retention of 5 mm on site where conditions do not warrant additional studies. If the site drains to a sensitive watercourse, a geomorphic assessment study must be completed to determine the site-appropriate erosion threshold. For site with SWM ponds, detention of the 25 mm design storm is required for a minimum of 48 hours, depending on the results of the geomorphic assessment study.

2.4.3 Town of Bradford West Gwillimbury

The Engineering Design Criteria Manual for the Town of Bradford West Gwillimbury (September 2015) states that stormwater and drainage design is to generally be in accordance with the applicable MECP, LSRCA and NVCA guidelines, policies and standards. In addition, Design Manual includes the following stormwater design criteria:

- Minor system designed to convey the 10-year design storm.
- Major system designed to convey the 100-year design storm.
- Culverts designed as per MTO Directive B-100.
- Stormwater management designed for the 100-year design storm.

2.4.4 Town of East Gwillimbury

The Town of East Gwillimbury Engineering Standards and Design Criteria (September 2012) states that stormwater and drainage design is to generally be in accordance with the applicable MECP and LSRCA guidelines, policies and standards. In addition, Design Manual includes the following stormwater design criteria:

- Minor system designed to convey the 5-year design storm.
- Major system designed to convey the 100-year design storm.
- Stormwater management designed for the 100-year design storm.
- Critical Infrastructure designed for the regional storm or greater.

2.4.5 Township of King

The Township of King Design Criteria and Standard Detail Drawings (January 2019) states that stormwater and drainage design is to generally be in accordance with the applicable MECP, TRCA and LSRCA guidelines, policies and standards. In addition, the Design Manual includes the following stormwater design criteria:

- Minor system designed to convey the 5-year design storm.
- Major system designed to convey the 100-year design storm.
- Culverts designed as per MTO Directive B-100.
- Stormwater management designed for control of the 100-year design storm and to safely pass the Regional storm.

2.5 Bridge Crossings

The design criteria for bridge structures are based on the “MTO Highway Drainage Design Standards” (HDDS) document (February 2008)”, these were applied to the two major bridge crossings that are required for the largest waterbodies within the alignment, which are the Holland River and Holland River East Branch. As mentioned previously, the functional road classification of the proposed Bradford Bypass is defined as a Freeway. For these two main bridges and any other bridge structures along the ROW the relevant design standards are summarized below and are based on the same criteria that is included for culverts.

Standard WC-1: Design Flows for Bridges and Culverts The design flow for a bridge structure with a span of more than 6 m on a Freeway is the 100-year flood event, while the check flow for scour is 130% of the 100-year flood event. As indicated in the standard, for Regulated Watercourses the Regulatory Flow shall be calculated where floodplain mapping is available, where a potential risk to public safety exists or where there is potential damage to adjacent properties. The analysis therefore included the design flow as the 100-year and the Regulatory Flow for verification purposes at the proposed Holland River and Holland River East Branch bridge structures.

Standard WC-2: Freeboard and Clearance at Bridge Crossings The design requirements indicate that for the design flow the desirable freeboard shall be measured vertically from the energy grade line elevation to the edge of the travelled lane, while the minimum freeboard is measured vertically from the high-water level to the edge of the travelled lane. The clearance is measured vertically from the high-water level to the lowest point in the bridge soffit.

For standard road classifications the freeboard and clearance at bridge crossings shall be greater than or equal to 1.0 m for Freeways. Additionally, navigation clearance is required for the main crossings and was assessed in accordance with MTO and federal guidelines.

Standard WC-3: Scour and Armouring Scour protection for structure foundations are to be designed on the basis of the design flow as per Standard WC-1. Rip-Rap Stones for protective aprons are designed for a velocity of 1.5

times the average velocity of the Design Flow. The thickness of the apron shall be not less than 1.5 times median stone size.

Standard WC-13: (Bridges and Culverts) Relief Flow Based on Section 3.2, the Regulatory Flow shall be used for defining the Relief Flow. The maximum depth of flow on the roadway shall not exceed 0.3 m, and the product of the velocity and depth on the roadway shall not exceed 0.8 m^2/s. However, given the size and height of the proposed bridges it is unlikely that this standard will be exceeded. Further details are provided in this Report.

Soffit Clearance The soffit clearance criterion relates to the clearance between the water surface elevation generated by the peak flow of the design storm (50-year return period) and the structure soffit. Clause 1-10.7.1 of the Canadian Highway Bridge Design Code (CHBDC) recommends that the minimum clearance shall be not less than 1.0 metre.

2.6 MECP – Ontario Regulation 697/21

Regulation 697/21 outlines requirements applicable to Stormwater Management, which includes actions to monitor and verify the effectiveness of the SWM measures and a plan to make the results of the monitoring and verification available on the Project website. The SWM plan includes flat bottom grassed swales with flow check dams. The team will provide recommendations to address the applicable operations and maintenance, and monitoring of the proposed SWM facilities. Below is a summary of the requirements for the *Bradford Bypass Stormwater Management Plan* included in Ontario Regulation 697/21 Section 22.

(1) The proponent shall prepare a Stormwater Management Plan for the early works in accordance with this section.

(2) The Stormwater Management Plan shall, at a minimum, include,

- (a) plans and descriptions showing the type of stormwater management to be provided for the early works, including the portions not being drained to a stormwater management wet pond;
- (b) a description of the receiving water features that would receive stormwater from the early works, including the characteristics, flow and ecological conditions and whether species protected under the *Endangered Species Act, 2007* are known to be present;
- (c) an operation and maintenance plan for the proposed stormwater management facilities; and
- (d) a monitoring plan to evaluate the performance of stormwater management facilities against the Design Criteria and objectives and to verify receiving surface waters are protected.

(3) The proponent shall develop the Stormwater Management Plan in accordance with,

- (a) the proponent's guidelines; and
- (b) the document entitled "Stormwater Management Planning and Design Manual", dated March 2003, published by the Ministry of the Environment, Conservation and Parks (MECP) and available on the Government of Ontario website.

(4) The proponent shall submit the Stormwater Management Plan to the following for review and comment:

1. The Ministry of Northern Development, Mines, Natural Resources and Forestry.
2. The Lake Simcoe Region Conservation Authority.
3. Fisheries and Oceans Canada.

4. The Ministry of the Environment, Conservation and Parks.

(5) The proponent shall consider any comments provided on the Stormwater Management Plan.

(6) The proponent shall provide the final Stormwater Management Plan to the Director of the Ministry's Environmental Assessment Branch.

(7) The proponent shall publish the final Stormwater Management Plan on the Project website.

3. Consultation with Agencies

3.1 Lake Simcoe Region Conservation Authority (LSRCA)

At the onset of the Bradford Bypass project, AECOM contacted LSRCA to obtain background information and to enquire about drainage issues that AECOM drainage staff should be aware of and to take them into consideration in the design. Additionally, LSRCA staff recommended to pre-consult with LSRCA's Acting Director of Engineering for any analysis being conducted within the West Holland River – Polder Area. The purpose of this pre-consultation was to discuss the additional technical details in the Polder Area which may need to be taken into account, prior to progressing into the analysis. AECOM contacted Mr. Kenneth Cheney (LSRCA) on July 5, 2021, to set up the pre-consultation meeting.

The pre-consultation meeting was conducted of February 17, 2022, which include a discussion about design requirements for flooding mitigation, the results from the Holland River hydraulic assessment and the technical issues associated with the Holland River - Polder Area. Discussion item were included about LSRCA expectations during the detail design, and the study process under the Ontario regulation 697/21.During the meeting, LSRCA stated not to be aware of any issues at the Polder Area.

LSRCA provided the following background information: East Holland River Engineered CCL 2005 VO2 hydrology models and PDF report; the West Holland River – Polder Area CCL 1990 report and model output (Holland River One Dimensional Dynamic Model Analysis).

In addition, Lake Simcoe Region Conservation Authority provided the Shoreline Flood Elevation Study for Lake Simcoe prepared by MMM in 1981.

3.2 Nottawasaga Valley Conservation Authority (NVCA)

NVCA provided on September 29, 2020, the Innisfil watershed boundary, flood hazard and regulated areas mapping (GIS format). In addition, NVCA provided on April 13, 2021, the following information: HEC-RAS models for the main Innisfil Creek and its tributary, and Penville Creek model which did not include the Penville Creek tributary located along the east side of Highway 400 and its associated peak flows. The Penville Creek model did not include the existing culverts under Highway 400 that are located within the Bradford Bypass Study Area. This model was deemed incomplete and was not used in the assessment of the existing culverts located under Highway 400. A meeting with NVCA was conducted on April 12, 2022, to discuss the following items: HEC-RAS model for the tributary of Penville Creek within the Bradford Bypass Study Area, NVCA's regulated areas, potential drainage modifications within the Penville Creek tributary watershed due to the proposed Bradford Bypass works, hydrologic and hydraulic information related to the MacLaren Hydrology Study (1988) provided by NVCA, and an overview of the Ontario Regulation 697/21 and remaining consultation opportunities.

The NVCA's Watershed Hydrology Study for Nottawasaga, Pretty and Batteaux Rivers Black Ash, Silver and Surgeon Creeks (MacLaren, May 1988) was provided in April 2021. The provided files included the watershed completed for the hydrology study (Appendix G - Design Flows for the Nottawasaga Basin), and the basin figure including the location of surveyed waterway cross-sections and representative stream reaches for the MacLaren Study.

3.3 Metrolinx

A meeting with Metrolinx (MX) staff was conducted on March 28, 2022, to discuss the Bradford Bypass and Metrolinx railway culvert crossings, existing conditions, the Barrie GO Expansion, and assumptions, structures and track clearances and access including drainage culvert crossings. AECOM enquire about drainage standards to be applied to culvert crossings and to confirm the construction timing for the Bradford Train Layover Facility.

Metrolinx (MX) responded to AECOM's requested information and enquires on August 19, 2022. MX provided a copy of the EA approved layout of the Bradford Layover confirming that there will be in the future a second track at this location including two mainline tracks and the installation of yard leads just to the north of the Bradford Bypass crossing of the corridor. Using a 14 inches (356 mm) track centre and the track will be on the west side of the existing track. The Bradford Bypass bridge span should also include appropriate clearances from the tracks to the abutments as per MX standards outlined in Pages 142 and 143 of the General Guidelines for Design of Railway Bridges and Structures (November 2018).

Metrolinx provided the Stormwater Management Report for the Barrie Rail Corridor Expansion Project (Hatch, Jan. 2018). This Report provides background information for the MX Culvert EX-CL-14 which will be impacted by the proposed Bradford Bypass works. MX identifies this culvert as Mileage 42.60 located in the MX Newmarket Subdivision. This culvert will need to be relocated to accommodate the proposed Bradford Bypass alignment.

3.4 Town of Bradford West Gwillimbury

The town' drainage superintendent confirmed that the drainage systems located at the areas adjacent to the 10th Sideroad Interchange are not municipal drains. They are private drainage systems that have been installed over the years by either the landowners or tenant farmers. The drainage superintendent directed to a layer that shows where systematic tile systems are located stating that there are some gaps in this information as it will only show the tile systems that are more recent and one which have been installed by licenced tile contractors. The superintendent expressed that the Town's only concern will be where these tile systems outlets and how they may impact municipal infrastructure.

3.4.1 Professor Day Drive Extension

An Official Plan Amendment No. 17 was adopted by the Town of Bradford West Gwillimbury Council on September 26, 2006, which included a new arterial road at Professor Day Drive north of 8th Line. The Town of Bradford West Gwillimbury completed a Municipal Class Environmental Assessment in 2012 for an extension of Professor Day Drive from 8th Line to the 2002 Technically Preferred Route of the Bradford Bypass. The design of Bradford Bypass will not preclude a Town of Bradford West Gwillimbury initiative for a potential future extension of Professor Day Drive, such that a future grade separate crossing (overpass) can be constructed at this location.

3.5 Town of East Gwillimbury

The Town provided an approved list of background information including stormwater management reports (Penny Lane Subdivision), groundwater monitoring program, hydrogeological report, and storm sewers design sheet. In addition, the town provided in a letter dated Dec. 5, 2022 (R.J. Burnside & Associates Limited). The letter outlines the Town's concerns about the potential drainage impacts, including municipal drains / private drainage systems caused by the proposed Bradford Bypass works.

3.6 Township of King

AECOM contacted the Township of King to request information related to topographic contours, existing culverts, municipal drains, wetlands and any other drainage information that could be relevant to the Bradford Bypass project. The Drainage Superintendent of the Township provided information including roadside ditches, dykes that surround the Township area. The private drainage system located in the Holland River area are shown in **Figure 1**.

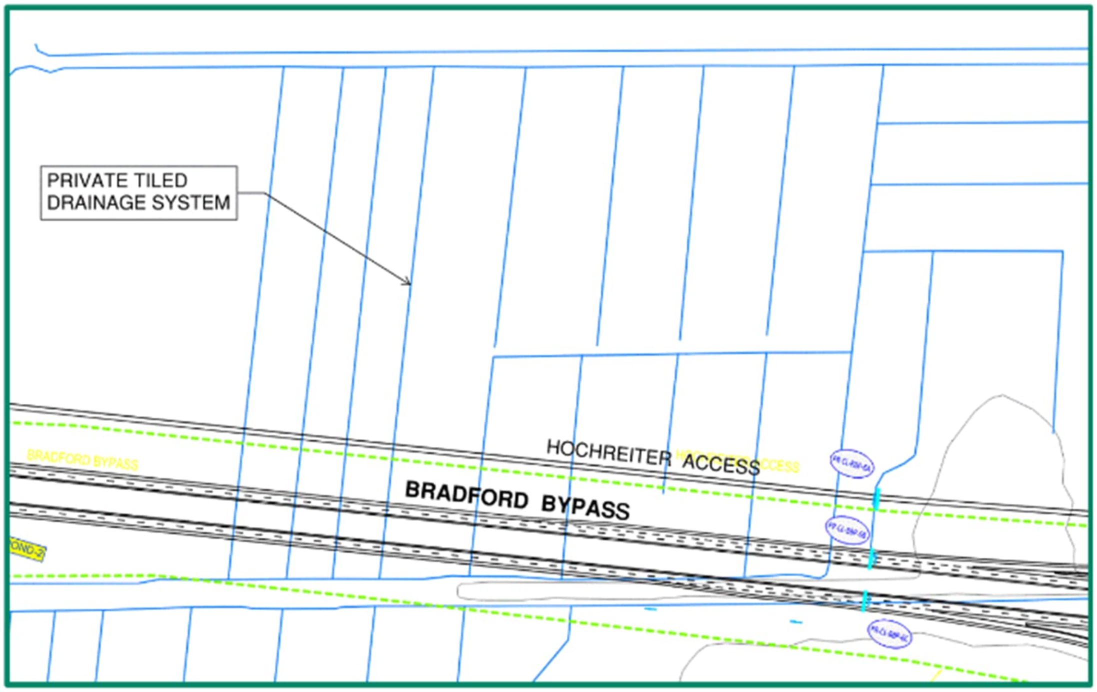


Figure 1: Private Drainage System along Bradford Bypass

4. Existing Drainage Conditions - Culverts

4.1 Overview

As illustrated in **Exhibits 3.1 to Figure 3.9** (provided at the back of this Report), the existing drainage system along Highway 400, Highway 404 and sideroads is accomplish by roadside ditches, transverse and sideroad culverts, catchbasins located along municipal roads and localized ditch inlets that collect water from the ditch inlets and roadside ditches.

As shown in **Figures 3.8 and 3.9**, runoff generated within the Study Area drains to the three main drainage features that cross the proposed alignment of the Bradford Bypass. Runoff from the western portion of the Study Area is conveyed westerly to Penville Creek by the existing culverts located under Highway 400 (EX-CL-400-1, EX-CL-400-2, and EX-CL-400-3). EX-CL-400-4 has been abandoned. These culverts discharge to a tributary of Penville Creek that runs southerly along the east side of Highway 400. Flows along the tributary drains westerly across the highway through Culvert EX-CL-400-5 5 to Penville Creek, which is withing the Innisfil Creek Watershed and in the jurisdiction of the Nottawasaga Valley Conservation Authority (NVCA). In addition, **Figure 3.9** shows the location of the existing culverts under Highway 400.

As depicted in **Figures 3.1, 3.2** and **3.9**, runoff generated within the center portion of the Study Area, which represents more than 90% of the project drainage areas, drains to Holland River and Holland River East Branch. These rivers run northerly through natural watercourses, roadside ditches and storm sewers located along municipal roads and ultimately discharge to Lake Simcoe.

Figure 3.8 shows that existing Culvert EX-CL-404-2 (4880 mm x 3050 mm structural concrete) drains an approximate area of 36.35 ha from a west area of Highway 404 to Maskinonge River, which drains northerly to Lake Simcoe. Holland River. Holland River East Branch and Maskinonge River are located within the jurisdiction of Lake Simcoe Region Conservation Authority (LSRCA).

4.2 Drainage Site Inspection

AECOM staff completed site inspection on October 13th, 2020, to inspect the existing drainage system along the Bradford Bypass. A second site inspection was conducted on September 15th, 2022, to review in more details the areas were the new 10th Sideroad and 2nd Concession Road interchanges are proposed. Existing drainage features were evaluated on site, and any drainage issues or concerns were documented.

The field reconnaissance was completed to clarify the following within the existing drainage system:

- Confirm the direction of surface flow;
- Confirm the location of culverts (sizes, material, physical conditions, outfalls etc.);
- Confirm drainage area dividers and natural flow paths;
- Characteristics and amount of sedimentation at culvert inlet and outlet ends;
- Inspect downstream conditions of the culverts to identify any obstructions to flows and to confirm tailwater conditions; and
- Identify erosion sites and drainage related deficiencies.

The existing culvert characteristics are summarized in **Table 1**. Culvert EX-CL-14 is a culvert located under the Metrolinx tracks which corresponds to Culvert at mileage 42.60 located within the Metrolinx Newmarket Subdivision.

Table 1: Existing Culvert Characteristics

	Total Drainage Area (ha)	Chainage (m)	Proposed Culvert Characteristics						Remarks
			Size (mm)	Material	Length (m)	Invert Elevations U/S	Invert Elevations D/S	Slope (%)	
Existing Highway 400 Culverts									
EX-CL-400-1	48.85	19+500	1220 x 910	Concrete Box	65.40	279.60	279.50	0.15	Highway 400
EX-CL-400-2	14.38	18+952	1220 x 910	Concrete Box	61.40	276.10	272.60	5.70	Highway 400
EX-CL-400-3	6.24	18+751	1220 x 910	Concrete Box	49.40	271.20	271.10	0.20	Highway 400
EX-CL-400-4	–	–	–	–	–	–	–	–	Highway 400. Culvert has been filled with grout (abandoned).
EX-CL-400-5	273.00	17+817	3600 x 1500	Concrete Box	57.0	252.90	252.36	0.95	Highway 400
EX-CL-400-6	26.70	17+335	1200 x 1200	Concrete Box	52.0	248.24	247.90	0.65	Highway 400
Existing Sideroad Culverts									
EX-CL-1	226.25	10+093	2440 x 1220	Concrete Box	15.82	269.20	269.20	0.4	
EX-CL-2	26.66	17+345	1500	CSP	22.0	247.80	247.60	0.90	McKinstry Road. Culvert is immediately downstream of EX-CL-400-6. Size of 1500 mm obtained from GIS data.
EX-CL-3	–	–	–	–	–	–	–	–	
EX-CL-4	–	–	–	–	–	–	–	–	
EX-CL-5	–	–	–	–	–	–	–	–	
EX-CL-6	–	–	–	–	–	–	–	–	
EX-CL-7	–	–	–	–	–	–	–	–	
EX-CL-8	18.78	10+144	1200 x 1200	Concrete Box	34.47	252.88	252.21	1.9%	
EX-CL-9	28.31	10+310	1220 x 910	Concrete Box	33.45	248.80	247.64	3.45%	
EX-CL-10	–	–	–	–	–	–	–	–	
EX-CL-11	2.10	9+990	825	CSP	17.02	224.10	224.10	0.0%	Artesian Industrial Parkway. Size as per site inspection report dated October 13, 2020. Length and inverts from GIS data.
EX-CL-12	20.80	–	–	–	18.20	225.0	224.70	1.7	Artesian Industrial Parkway. This culvert is outside the Study Area.
EX-CL-13	–	–	–	–	–	–	–	–	Size as per site inspection report dated October 13, 2020.
EX-CL-14	–	–	1830	CSP	9.70	221.07	220.69	1.0	CNR culvert crossing (Metrolinx). Metrolinx identifies this crossing as culvert at mileage 42.60 in the Metrolinx Newmarket Subdivision.
Existing Sideroad Culverts									
EX-CL-15	–	–	900	CSP	14.20	218.58	218.58	–	This culvert function as an equalizer culvert. It can be replaced with a like-for-like size.
EX-CL-16	–	–	–	–	–	–	–	–	
EX-CL-17	–	–	–	–	–	–	–	–	
EX-CL-18	–	–	–	–	–	–	–	–	
EX-CL-19	–	–	–	–	–	–	–	–	
EX-CL-20	24.34	10+097	1800	CSP	24.71	239.299	238.648	2.6%	Leslie Street. Size as per site inspection report dated October 13, 2020.
EX-CL-21	–	–	–	–	–	–	–	–	
EX-CL-22	–	–	–	–	–	–	–	–	

Table 1: Existing Culvert Characteristics

	Total Drainage Area (ha)	Chainage (m)	Proposed Culvert Characteristics						Remarks
			Size (mm)	Material	Length (m)	Invert Elevations U/S	Invert Elevations D/S	Slope (%)	
EX-CL-23	–	–	–	–	–	–	–	–	
EX-CL-24	–	–	–	–	–	–	–	–	
EX-CL-25	–	–	–	–	–	–	–	–	
EX-CL-26	–	–	–	–	–	–	–	–	
Existing Highway 404 Culverts									
EX-CL-404-1	–	–	–	–	–	–	–	–	
EX-CL-404-2	36.35	34+020	4880 x 3050	Structural Concrete	122.00	251.20	248.50	2.2	Highway 404. Information for this culvert (size, inverts, and length) were obtained from the Highway 404 Extension Contract Drawings (Contract No. 2010-2055, GWP 2005-07-00).

The culverts in **Table 1** that are shown in gray colour and italic text were included in the table for culvert numbering sequence purposes, but they were note evaluated for the following reasons:

- The culvert (s) is outside the areas of potential impact by the proposed Bradford Bypass works.
- Proposed highway works will not impact the watercourse where the culverts are located (EX-CL-26).
- Proposed Bradford Bypass works will not impact the following culvert location (culvert outside Study Area). EX-CL-3, EX-CL-4, EX-CL-5, EX-CL-6, EX-CL-7, EX-CL-10, EX-CL-12, EX-CL-13, EX-CL-17, EX-CL-18, EX-CL-19, EX-CL-21, EX-CL-22, EX-CL-23, EX-CL-24, EX-CL-25, EX-CL-26.
- Culvert EX-CL-404-1 was not found during the drainage site inspection.

Table 2 provides a summary of the findings from the drainage site inspection including the existing culverts. **Appendix A** provides the culvert inspection reports and culvert photograph inventory.

Table 2: Existing Culverts - Drainage Inspection Findings

Culvert I.D.	Chainage (m)	Culvert Size (mm)	Culvert Material	Site Inspection Findings
Existing Highway 400 Culverts				
EX-CL-400-1	Hwy 400	1220 x 910	Concrete Box	■ There is standing water at both the inlet and outlet ■ There is dense vegetation at the outlet
EX-CL-400-2	Hwy 400	1220 x 910	Concrete Box	■ There is no standing water at the inlet. There is standing water at the outlet ■ There is dense vegetation at the inlet and outlet ■ There is scour at the inlet
EX-CL-400-3	Hwy 400	1220 x 910	Concrete Box	■ There is standing water at the inlet. There is no standing water at the outlet ■ There is dense vegetation blocking the outlet ■ There is slumping on the embankment at the inlet
EX-CL-400-4	Hwy 400	450	HDPE	■ The culvert has been filled with grout and abandoned
EX-CL-400-5	Hwy 400	3600 x 1500	Concrete Box	■ The culvert is in excellent condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is dense vegetation at the inlet and outlet
EX-CL-400-6	Hwy 400	1200 x 1200	Concrete Box	■ The culvert is in poor condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is dense vegetation at the inlet and outlet ■ The highway embankment is slumped to the culvert
Existing Sideroad Culverts				
EX-CL-2	Hwy 400	1500	CSP	■ The culvert is located downstream of EX-CL-400-6 ■ The culvert is in excellent condition ■ There is no standing water at the inlet or outlet ■ There is overstorey vegetation at the inlet and understorey vegetation at the outlet
EX-CL-8	10+144	1200 x 1200	Open Bottom Concrete Box	■ The culvert is in excellent condition ■ There is standing water at the inlet, within the structure and at the outlet ■ At the inlet there is neither overstory nor understory vegetation, and at the outlet there is both ■ The downstream channel is does not appear to be well defined

Table 2: Existing Culverts - Drainage Inspection Findings

Culvert I.D.	Chainage (m)	Culvert Size (mm)	Culvert Material	Site Inspection Findings
EX-CL-9	10+310	1200 x 800	Open Bottom Concrete Box	■ The culvert is in excellent condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is overstory and understory vegetation at both the inlet and outlet ■ The downstream channel is covered in vegetation
EX-CL-11	Artesian Industrial Pkwy	825	CSP	■ The culvert is in good condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is overstorey vegetation at both the inlet and outlet
EX-CL-13	Artesian Industrial Pkwy	2400 x 1200	Concrete Box	■ The culvert is in excellent condition ■ There is standing water at the inlet, within the structure and at the outlet
EX-CL-19	Leslie St.	800	CSP	■ The culvert is in good condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is overstorey vegetation at both the inlet and outlet
EX-CL-20	Leslie St.	1800	CSP	■ The culvert is in good condition ■ There is standing water at the inlet, within the structure and at the outlet ■ There is overstorey and understorey vegetation at both the inlet and outlet ■ The downstream channel is does not appear to be well defined

4.3 Hydrologic Assessment

Hydrologic input parameters were estimated for each drainage area associated with the existing culvert based on:

- Subcatchment area,
- Land use distribution (estimated from topographic mapping and aerial photo),
- Soils distribution obtained from GIS database, and
- Slope and length of the overland and channel portions of the subcatchment to estimate the time to peak for catchment areas with an imperviousness percentage of less than 20%.

4.3.1 Rainfall parameters

With reference to MTO Drainage Management Manual 1995, Chicago, AES and SCS Type II rainfall distributions were developed to identify conservative storm events for the purpose of culvert assessment. Rainfall curves for the year 2021 have been obtained from the MTO's Intensity Duration Frequency (IDF) Curve Lookup Tool. The rainfall parameters A, B and C for the 2-year and up to the 100-year rainfall events are shown in **Table 3.**

Table 3: Rainfall IDF Parameters – MTO IDF Online Tool (2021)

Parameter	2-year	5-year	10-year	25-year	50-year	100-year
A	448.183	590.134	682.636	807.059	893.681	982.263
B	1.5	1.5	1.5	1.5	1.5	1.5
C	0.723	0.723	0.722	0.724	0.724	0.724

Appendix B includes the 2021 MTO IDF Curves that were used to obtain IDF parameters and rainfall data to generate the 12-hour and 24-hour SCS Type II, 12-hour AES and 12-hour and 24-hour Chicago rainfall distributions. **Appendix C** includes a comparison of peak flows between these rainfall distributions for all storm events (2-year and up to 100-year). The purpose of this comparison was conducted to identify the rainfall distribution that provided the highest peak flow values. It was determined that the 24-hour SCS Type II rainfall distribution generates the highest peak values and consequently was used in the hydraulic assessment of the drainage system within the project limits.

4.3.2 Hydrologic Assessment Results

To perform the hydrologic analysis, the catchment area delineation was completed based on Ontario Base Maps (OBM) mapping for the external areas, and topographic information from the latest survey and site investigation.

Table 4 summarizes the 2-year and up to the 100-year peak flows at the existing culvert locations.

Table 4: Existing Culverts - Peak Flows

Culvert I.D.	Total Area (ha)	Peak Flows (m^3/s) – 24-hour SCS Type II					
		2-year	5-year	10-year	25-year	50-year	100-year
Existing Highway 400 Culverts							
EX-CL-400-1	48.85	1.45	2.37	2.98	3.76	4.42	4.97
EX-CL-400-2	14.38	0.53	0.85	1.07	1.33	1.56	1.74
EX-CL-400-3	6.24	0.40	0.64	0.79	0.98	1.14	1.26
EX-CL-400-5	273.00	5.51	9.06	11.43	14.39	16.93	18.99
EX-CL-400-6	26.66	0.86	1.41	1.78	2.24	2.64	2.96
Existing Sideroad Culverts							
EX-CL-1	226.25	4.46	7.28	9.18	11.57	13.62	15.30
EX-CL-2	26.66	0.86	1.41	1.78	2.24	2.64	2.96
EX-CL-3	704.98	3.25	5.43	6.89	8.73	10.33	11.65
EX-CL-6	215.59	6.41	10.06	12.28	14.73	16.87	18.41
EX-CL-8	18.78	0.61	1.03	1.31	1.68	2.00	2.27
EX-CL-9	28.31	1.35	2.13	2.85	3.80	4.86	5.54
EX-CL-11	2.06	0.24	0.36	0.44	0.54	0.62	0.68
EX-CL-13	192.11	13.04	18.28	21.74	26.30	30.38	33.84
EX-CL-14	204.30	13.10	18.52	21.75	26.83	31.10	34.37
EX-CL-17	59.47	1.20	2.02	2.59	3.32	3.97	4.49
EX-CL-18	229.15	6.11	10.49	13.56	17.52	21.23	24.45
EX-CL-19	162.64	4.94	8.72	11.30	14.70	17.74	21.09
EX-CL-20	24.34	0.59	0.99	1.26	1.61	1.92	2.17
EX-CL-21	35.98	0.66	1.12	1.44	1.85	2.21	2.51
EX-CL-24	1,094.76	6.40	10.81	13.86	17.76	21.15	23.87
EX-CL-26	29.94	1.07	1.72	2.15	2.69	3.14	3.51
EX-CL-27	46.17	0.64	1.08	1.38	1.77	2.10	2.38

Table 4: Existing Culverts - Peak Flows

Culvert I.D.	Total Area (ha)	Peak Flows (m^3/s) – 24-hour SCS Type II					
		2-year	5-year	10-year	25-year	50-year	100-year
EX-CL-28	922.67	6.23	10.47	13.42	17.10	20.27	22.89
EX-CL-29	37.30	0.90	1.47	1.86	2.34	2.75	3.09
Existing Highway 404 Culvert							
EX-CL-404-2	36.35	0.66	1.13	1.46	1.88	2.26	2.57

Appendix D.1 includes the hydrologic modelling input parameters. **Appendix D.2**. provides the Visual Otthymo (VO) data and summary output files.

A comparison between existing peak flows and future Uncontrolled peak flows; and, between existing peak flows and future Controlled peak flows are provided in **Section 8.3**.

4.4 Hydraulic Assessment

A hydraulic assessment was undertaken for the existing culverts to determine whether the existing structures could satisfy the design criteria and to identify culvert replacement requirements. The hydraulic analyses were carried out using the hydraulic modelling tool CulvertMaster (CVM).

Peak flows used to assess the existing culverts are based on the 2021 IDF data. The results of the hydraulic assessment are summarized in **Table 5** and **Table 6.** The CVM outputs files are included in **Appendix E**.

After reviewing the results presented in these tables, the following is noted:

- Culverts EX-CL-400-3, EX-CL-400-6 and EX-CL-1 satisfy all three Design Criteria, Depth Criterion (HW/D ≤ 1.5), 50-year Freeboard Criterion (FB ≥ 1m), and the Overtopping Criterion (no road overtopping during the 100-year storm).
- Culverts EX-CL-400-1 and EX-CL-400-5 do not satisfy any of the three Design Criteria, Depth Criterion (HW/D ≤ 1.5), 50-year Freeboard Criterion (FB ≥ 1m), and the Overtopping Criterion (no road overtopping during the 100-year storm).
- Culvert EX-CL-2 satisfy the Depth Criterion (HW/D ≤ 1.5), and the Overtopping Criterion (no road overtopping during the 100-year storm). The 50-year Freeboard Criterion (FB ≥ 1m) is not satisfied. The provided value is 0.31 m.
- Culvert EX-CL-20 satisfy the Depth Criterion (HW/D ≤ 1.5), but not the Overtopping Criterion (no road overtopping during the 100-year storm) and the 50-year Freeboard Criterion (FB ≥ 1m).
- Assessment of EX-CL-12 was not performed as the culvert is outside the Study Area. EX-CL-15 can be replaced with a like-for-like size as this culvert functions as an equalizer culvert.
- Culvert EX-CL-404-2 is a structural culvert (4880 mm x 3050 mm) located along a regulated watercourse by Lake Simcoe Region Conservation Authority (LSRCA).
- Culverts EX-CL-8 and EX-CL-9 were evaluated as part of the County Road 4 advanced works for Bradford Bypass (GWP 2008-21-00).
- EX-CL-14 (Metrolinx Culvert) does not meet any of the standards with the exception of HW/D < 1.5 ratio under the 100-year storm. The provided 100-year HW/D < 1.5 value is 1.43.

Table 5: Hydraulic Assessment – Existing Culverts

Culvert I.D.	Exist. Culvert Data		Drainage Area (ha)	Spill Elevation at:		Headwater Elevation (m)		Energy Grade Line Calculations				Depth of Headwater / Height of Culv (H/D)	Freeboard from: Edge of Pavement (m)		Performance Criteria Satisfied? Yes / No		
				C/L of Travel Lanes (m)	Edge of Pavement (m)			Flow Velocity (m/s)		Velocity Head (m)	E.G.L.				Depth Criterion (HW/D < 1.5)	Freeboard Criterion (FB ≥ 1m)	Highway Overtopping Criterion
	Size (mm)	Type				50yr	100yr	50yr	100yr	50yr	50yr	50yr	50yr	100yr	50yr	50yr	100yr
Existing Highway 400 - Transverse Culverts																	
EX-CL-400-1	1220 x 910	Conc. Box	48.85	282.10	282.00	282.70	283.33	3.96	4.46	0.800	283.50	3.39	O/T	O/T	**No**	**No**	**No**
EX-CL-400-2	1220 x 910	Conc. Box	14.38	277.40	277.30	277.06	277.14	5.57	5.77	0.280	277.34	1.05	O/T	0.16	**Yes**	**No**	**Yes**
EX-CL-400-3	1220 x 910	Conc. Box	6.24	274.50	274.40	271.98	272.03	2.09	2.16	0.140	272.12	0.85	2.28	2.37	**Yes**	**Yes**	**Yes**
EX-CL-400-5	3600 x 1500	Conc. Box	273.0	255.50	255.40	255.50	255.88	3.14	3.52	0.500	256.00	1.73	O/T	O/T	**No**	**No**	**No**
EX-CL-400-6	1200 x 1200	Conc. Box	26.7	253.80	253.70	249.62	249.73	2.98	3.06	0.400	250.02	1.15	3.68	3.97	**Yes**	**Yes**	**Yes**
Side Road Culverts																	
EX-CL-1	2440 x 1220	Conc. Box	226.25	271.30	271.20	270.15	270.21	1.05	1.13	0.050	270.20	0.78	1.00	0.99	**Yes**	**Yes**	**Yes**
EX-CL-2	1500	CSP	26.7	249.90	249.80	249.23	249.33	2.58	2.68	0.260	249.49	0.94	0.31	0.47	**Yes**	**No**	**Yes**
EX-CL-8	1200 x 1200	Conc. Box	18.78	255.00	254.90	254.03	254.13	3.93	4.04	0.330	254.36	0.96	0.54	0.77	**Yes**	**No**	**Yes**
EX-CL-9	1220 x 910	Conc. Box	28.31	249.60	249.50	252.21	253.06	5.74	5.99	0.970	253.18	3.73	O/T	O/T	**No**	**No**	**No**
EX-CL-11	825	CSP	2.1	224.70	224.60	224.96	225.02	1.94	2.01	0.080	225.04	1.03	O/T	O/T	**Yes**	**No**	**No**
EX-CL-12	1800	CSP	20.8	225.60	225.50	–	–	–	–	–	–	–	–	–	–	–	–
EX-CL-14[1]	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
EX-CL-15	900	CSP	–	220.10	220.00	–	–	–	–	–	–	–	–	–	–	–	–
EX-CL-20	1800	CSP	24.34	240.30	240.20	240.44	240.52	3.05	3.16	0.250	240.69	0.62	O/T	O/T	**Yes**	**No**	**No**
Existing Highway 404 – Transverse Culverts																	
EX-CL-404-2	4880 x 3050	Structural	36.35	260.80	260.70	–	–	–	–	–	–	–	–	–	–	–	–

Notes: 1. See Table 6

Table 6: Hydraulic Assessment – Existing Culvert EX-CL-14 (Metrolinx Culvert Mileage 42.60 – Newmarket Subdivision)

Mile	Size (mm)	# Barrel	Hydraulic Assessment Results			AREMA DESIGN REQUIREMENTS		
			25-year	100-year		25-year	100-year	
			No Static Head (HW/D < 1.0)	HW/D < 1.5	Freeboard (m)	No Static Head (HW/D < 1.0)	HW/D < 1.5	Freeboard to Rail > 0.60 m
42.60	1830	1	1.12	1.43	0.41	**No**	**Yes**	**No**

5. Existing Drainage Conditions – Holland River and Holland River East Branch Bridges

The Bradford Bypass is a proposed new highway alignment and therefore the Holland River and Holland River East Branch do not currently have bridge structures spanning them within the highway Right-of-Way (ROW). As indicated previously, the proposed highway alignment falls under the functional road classification of Freeway, and the design flow is the 100-yr event based on Section 1.1 of Standard WC-1 (MTO, 2008). Given the significance and size of the proposed bridge crossings, the Regulatory Event was also included in this preliminary assessment.

The Holland River and Holland River East Branch are located within a smaller portion of the highway alignment and are separated by a distance of 3 km. The area where these two major bridge crossings are proposed is mainly comprised of agricultural land and contains the Holland Marsh. Other land cover types at or near the highway bridge crossings include forested areas, wetlands and low-density urban development.

A preliminary hydraulic assessment of both crossings was completed using the software HEC-RAS to determine potential impacts within the highway ROW and nearby properties. The assessment included the evaluation of changes to floodplain boundaries, water velocities, and applicable MTO design criteria at both crossings. Further details of this assessment are included herein.

5.1 Hydrologic Assessment at Bridge Crossings

For the major bridge crossings at the Holland River and Holland River East Branch the hydrologic inputs were obtained in the form of flow hydrographs from an updated Visual Otthymo (VO) model provided by the Lake Simcoe Region Conservation Authority (LSRCA). The flow hydrographs for the 2, 5, 10, 25, 50, 100-year and Regional events were extracted from the model at the nearest nodes to the crossing locations, these are nodes 8234 and 8184 for the Holland River and Holland River East Branch, respectively.

The flow hydrographs were generated using the 12-hour SCS Type II rainfall distribution and are shown in **Figure 2** and **Figure 3**, these flow hydrographs were applied to a HEC-RAS hydraulic model that was developed as part of this preliminary assessment.

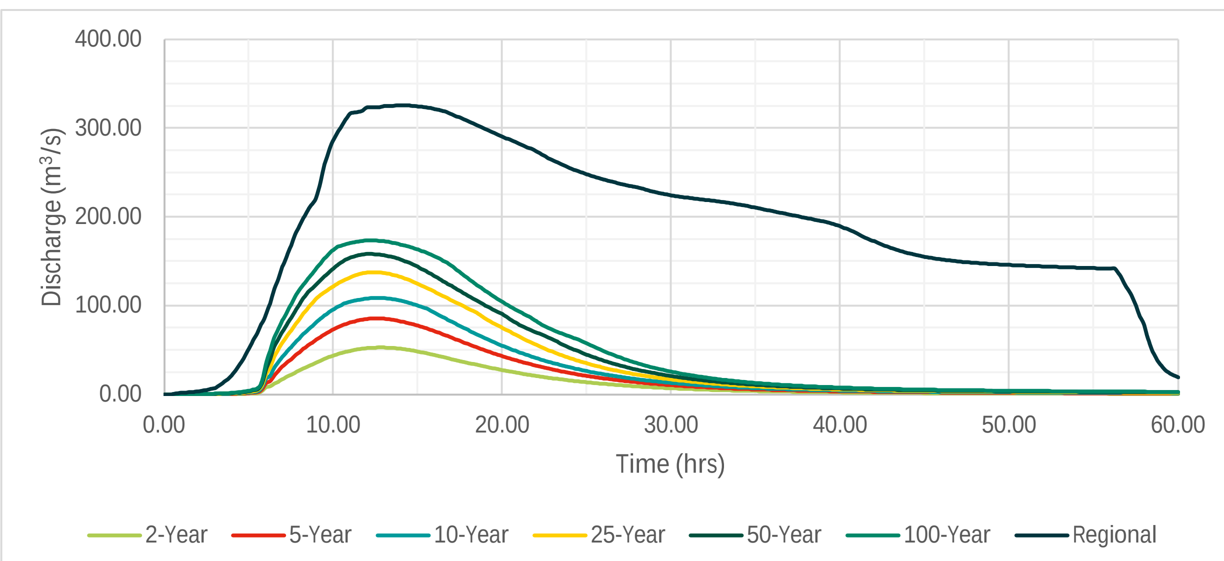


Figure 2: Flow Hydrographs at the Holland River Highway Crossing

The Holland River and Holland River East Branch have catchment surface areas with values of 305 km^2 and 194 km^2, respectively. Both rivers join at a confluence point located 3 km north (downstream) of the proposed highway ROW, from this confluence point the Holland River continues north for another 4 km to its discharge location at Lake Simcoe.

Even when the Holland River catchment is larger, the Holland River East Branch contains a higher percentage of urban land cover (including the Towns of Newmarket and Aurora). Therefore, land cover types and times of concentration within the catchments affect the total runoff and peak discharge at each river, which explains the higher flows and faster catchment response at the Holland River East Branch during the Regional event.

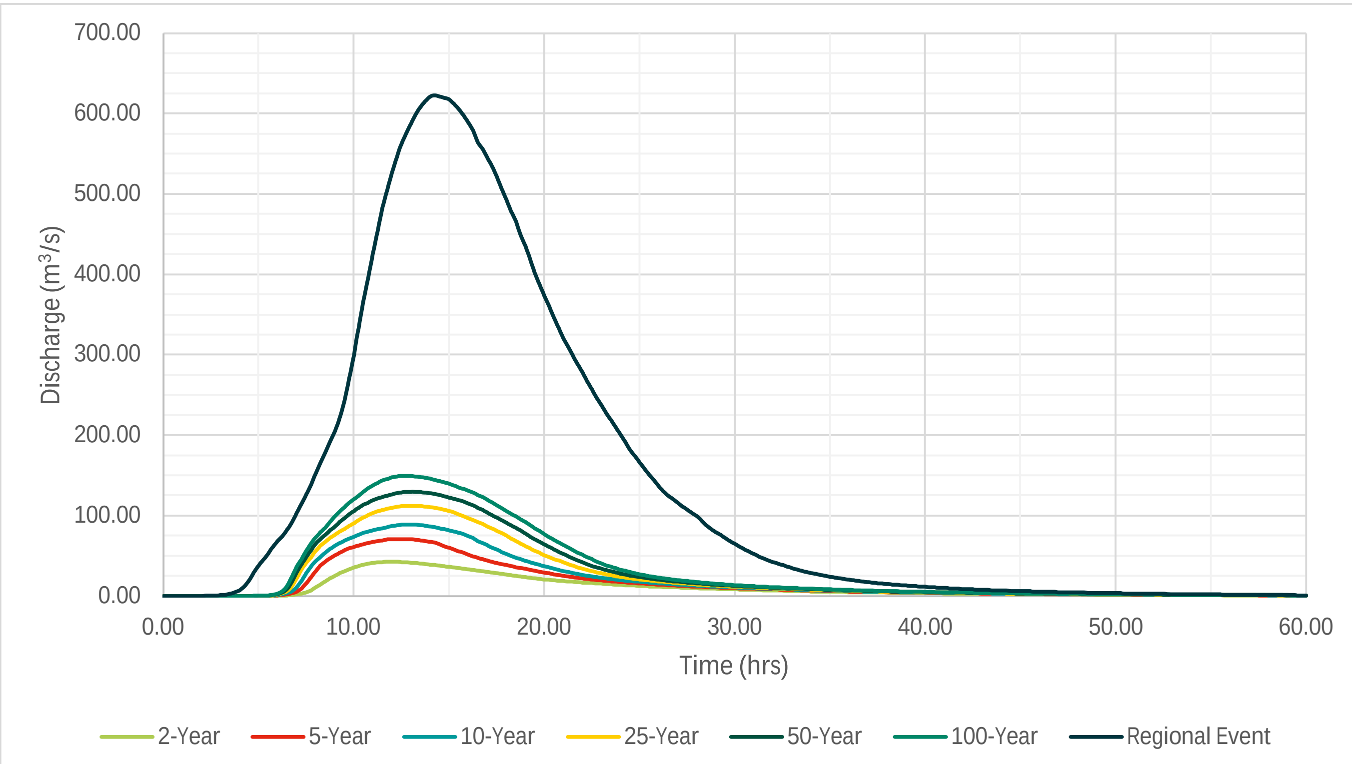


Figure 3: Flow Hydrographs at the Holland River East Branch Highway Crossing

Furthermore, the peak flows for each storm event at the Holland River and Holland River East Branch are summarized in **Table 7**.

Table 7: Peak Flows from Visual Otthymo for the Holland River and Holland River East Branch

Location	Area (km^2)	Peak Flows (m^3/s) – 12-hour SCS Type II						
		2-year	5-year	10-year	25-year	50-year	100-year	Regional
Holland River	305	53	86	109	138	158	174	326
Holland River East Branch	194	43	71	89	112	130	150	623

The flow hydrographs shown in **Figure 2** and **Figure 3** were combined at the intersection of both rivers in the hydraulic model. Additionally, Lake Simcoe elevations were added to complete the boundary conditions that controls water levels downstream of the proposed highway alignment.

5.2 Hydraulic Assessment at Bridge Crossings

The hydraulic assessment of these two major bridge crossings included the calculation of baseline conditions at the proposed bridge locations (existing condition) for the following flood events: 2, 5, 10, 25, 50, 100-yr and the Regional Event including the following tasks:

- Delineation of floodplain boundaries within the ROW and nearby areas to assess potential flooding impacts of the bridge crossings.
- Assessment of MTO design requirements for both structures including freeboard, clearance, scour protection, navigation, and relief flow.
- Calculation of water velocities and applied shear stress to support the geomorphological assessment of the Holland River and Holland River East Branch crossings.
- Calculation of water elevations and depths for the existing condition to develop baseline scenarios to determine impacts due to the proposed bridge crossings.

The location of bridge abutments and span magnitudes required the analysis of constraints provided by other disciplines such as structural (i.e., maximum bridge span allowance), environmental (i.e., wetland areas), archeology, and geomorphology (i.e., buffer distances from the riverbanks and the definition of the meander belt boundaries). The locations of the proposed bridge crossings are shown in **Figure 4** along with the highway ROW.

The channel widths at the proposed bridge crossings for the Holland River and Holland River East Branch are 100 m and 80 m, respectively. There are also wetland areas within the ROW, of which some are designated as Provincially Significant Wetlands (PSW), these are identified based on the Ontario Wetland Evaluation System (OWES). Previous project requirements define that the location of bridge abutments and piers will be located to the extent possible outside of these sensitive areas.

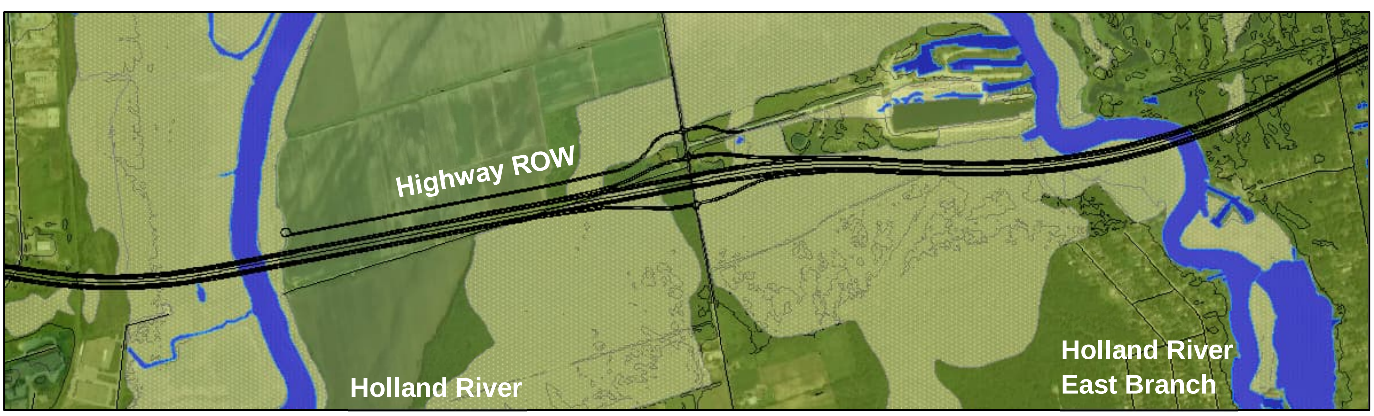


Figure 4: Holland River and Holland River East Branch

The hydraulic analysis included the development of a two-dimensional (2D) hydraulic model using the software HEC-RAS (version 6.1 later updated to 6.3.1). Details of the HEC-RAS model are included in the following sections.

5.2.1 Hydraulic Model Selection

A review of background information and the available hydraulic models from LSRCA indicated that the Holland Marsh has very flat terrain with a complex drainage system. It was also noticed from available floodplain maps that during larger flood events these major rivers have lateral hydraulic connectivity (i.e., their individual floodplains connect to form one larger floodplain). Based on the characteristics of the area and the scope of work for the proposed highway alignment it was decided to develop a new hydraulic model in two dimensions (2-D) with the software HEC-RAS. The simulation capabilities of a 2-D model are better suited to reflect the complex hydraulic connections within the Holland Marsh, and even when one-dimensional (1-D) models already exist for the Holland Marsh, these were developed for regional floodplain mapping purposes and therefore were not considered to meet the requirements of this assessment (hydraulic assessment at highway bridge crossings). The 1-D models are also fragmented and only cover one channel each, with clear challenges to solve both models separately over a wide floodplain. These 1-D models were instead used for reference purposes and to extract relevant information that was applied to the 2-D model (i.e., channel bathymetry and roughness coefficients).

5.2.2 Hydraulic Model Domain

The extent of the hydraulic model is shown in **Figure 5** which covers the Holland River and Holland River East Branch and other minor tributaries and drainage ditches.

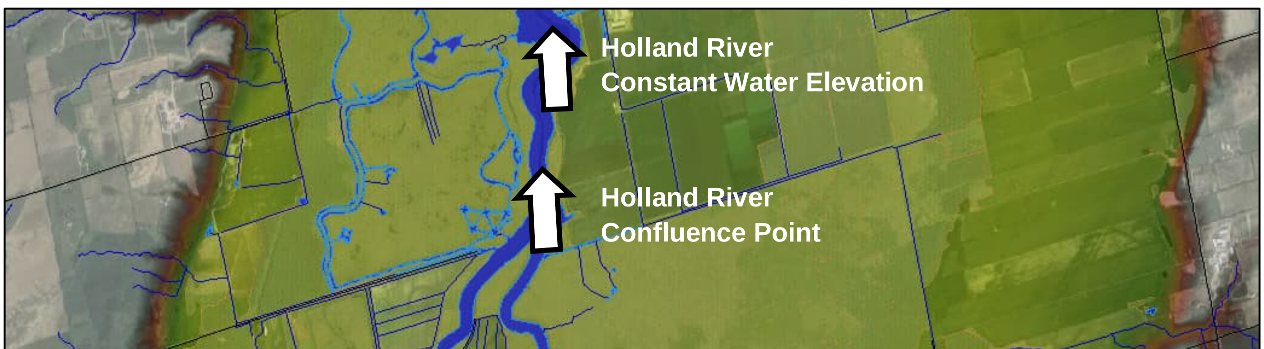


Figure 5: HEC-RAS Model Domain

For the purposes of this preliminary assessment attention was given to the major crossings within the ROW and included minor crossings that provide hydraulic connectivity between the proposed alignment. The model domain was further extended 2 km to the south (upstream) and 4.5 km to the north (downstream) to provide a buffer distance to allow hydraulic calculations to stabilize and also to assess potential flooding and erosion impacts at areas near the highway ROW.

A model computational mesh with a horizontal resolution of 25 m by 25 m containing 75,381 cells was created in the geometry editor of HEC-RAS. This computational mesh is the basis of the hydraulic model as it integrates terrain characteristics such as topography and land roughness with flow inputs, hydraulic structures and the conveyance capacity of the channels. The computational mesh is used to solve hydraulic parameters such as water depths, elevations, velocity, and shear stress.

5.2.3 Digital Elevation Model and Boundary Conditions

A digital elevation model (DEM) was developed using different sources which are listed below. All sources were integrated into GIS software to create a composite DEM layer to represent terrain characteristics. The DEM was then imported into HEC-RAS and was used as the base terrain for the hydraulic assessment. The terrain DEM was developed using the horizontal coordinate system NAD1983 -CSRS98 MTM Zone10, with the vertical coordinate System Canadian Geodetic Vertical Datum (CGVD) 28:78.

It is noted that the composite terrain layer contains data from different sources and with different levels of accuracy, the most recent layers with the highest accuracy were applied first while layers with lower resolutions were used to fill in data gaps. The resultant composite terrain layer is shown in **Figure 6**.

- The terrain data is listed below in the order that was used to generate the terrain raster for HEC-RAS.
- The highway ROW terrain was extracted from AutoCAD Civil-3D design surfaces for the east and west segments.
- The channel bathymetry was approximated with data from the existing LSRCA HEC-Ras model and integrated into the terrain for the Holland River East Branch, the Holland River bathymetry was added with assumptions based on water depths on the east branch channel.
- Terrain details for the rest of the model domain were added from Lidar datasets which included York-Lake Simcoe Package B (2019) and GTA Lidar (2002).

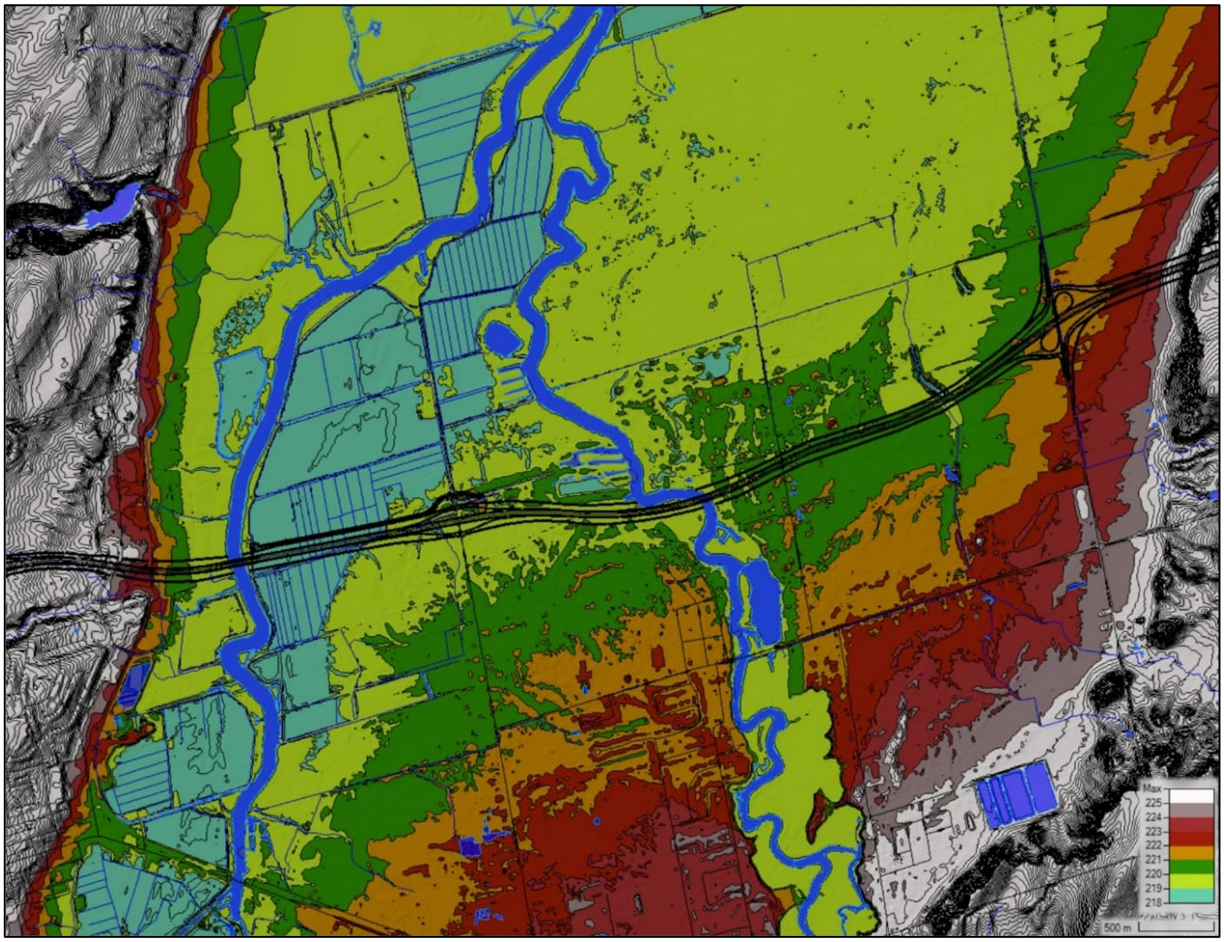


Figure 6: HEC-RAS Model Terrain

Additionally, boundary conditions were added at four locations within the model domain, the flow hydrographs obtained from the Visual Otthymo model were applied to each river channel and a constant water elevation was applied at the exit of the model domain to represent the water levels near Lake Simcoe.

An additional flow hydrograph was added at the confluence of the Holland River and Holland River East Branch which represents the sum of both river flows plus the contribution of the catchment area that is covered within the model domain. The locations of boundary conditions within the HEC-RAS model are shown in **Figure 5**.

Lake Simcoe is the receiving waterbody and the discharge location for the Holland River. Given the very flat slopes of the terrain in this area, Lake Simcoe provides hydraulic control at the Holland River and its backwater effect can propagate upstream towards the highway ROW.

An analysis of water elevations at Lake Simcoe shows that the lake is part of the Trent-Severn Waterway, which is an interconnected series of lakes, improved river channels and artificial canals stretching for 386 km in southern Ontario. The water in the system comes from the Trent and Severn watersheds. Lake Simcoe is located within the Severn watershed and is one of the largest lakes in Southern Ontario.

Lake Simcoe is regulated by Parks Canada by following a defined rule curve which is shown in **Figure 7**. Historical maximum and minimum water elevations are also shown, with values ranging between 219.5 m and 218.5 m. The rule curve also shows seasonal trends where the lake is lowered during the fall and winter to allow for water elevations to rise during the spring.

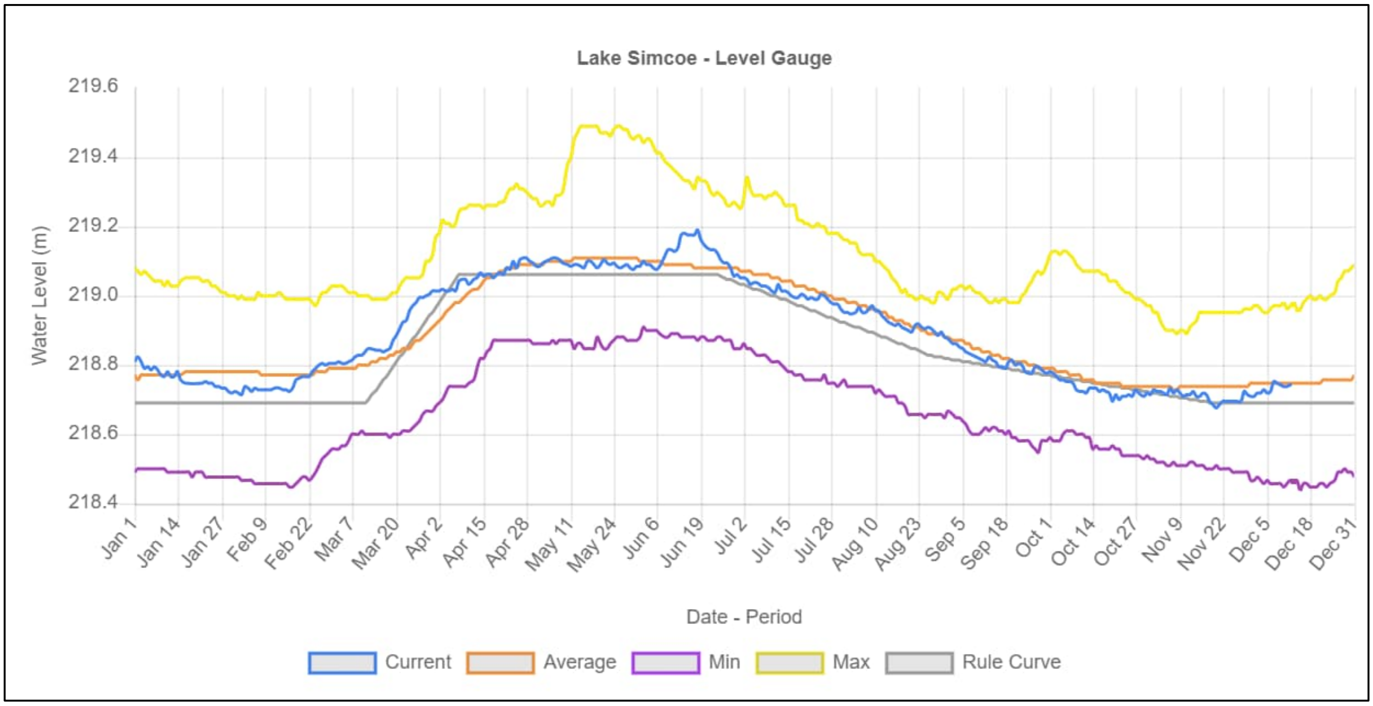


Figure 7: Lake Simcoe Annual Water Elevations

Two water elevations at Lake Simcoe were used for hydraulic simulations, these include an average water elevation of 219.05 m and a higher water elevation of 219.52 m. These water elevations were applied to the 2, 5, 10, 25, 50, 100-year and Regional events in the hydraulic model.

5.2.4 Manning's Roughness Conditions

Manning's Roughness coefficients are used by the hydraulic model to simulate friction forces exerted by the terrain on the flow, and they are part of the application of the Manning's Equation, which is an empirical relationship that relates this coefficient to water velocity, energy slope, and the hydraulic radius of the channel or conduit.

The value of the Manning's Coefficient is a function of the land cover type (or material type) and other hydraulic parameters such as water depth and velocity. It is accepted that materials with smoother surfaces have lower coefficients, while land cover types that have obstructions to the flow (such as vegetation) have higher values.

The selected roughness coefficients that were applied to the HEC-RAS model are based on the Ontario Land Cover Composite layer (OLCC version 2, 2014). Land cover types were assigned a Manning's Roughness value based on published values for similar surfaces. If warranted, these values can be revised in future model iterations, however, a sensitivity analysis of Manning's coefficients was not completed for this preliminary analysis. A list of selected coefficients for different land uses are included in **Table 8**.

Table 8: Applied Manning's Roughness Coefficients to HEC-RAS Model

Land Cover Type	Manning's Coefficient (n)	Land Cover Type	Manning's Coefficient (n)
Open Water	0.03	**Marsh**	0.045
Treed Upland	0.05	**Tallgrass**	0.04
Deciduous Treed	0.05	**Woodland**	0.05
Mixed Treed	0.05	**Infrastructure**	0.085
Coniferous Treed	0.05	**Agriculture**	0.05
Plantations	0.04	**Fen**	0.045
Hedge Rows	0.04	**Fen/Bog**	0.045

5.2.5 Water Elevations and Floodplain Boundaries

The water elevations and floodplain boundaries for the existing condition were calculated with the HEC-RAS model at the proposed locations of the bridge crossings for the Holland River and Holland River East Branch. The results of the hydraulic model for the 100-year and Regional Events are shown in **Figure 8**.

For the existing condition, the model shows water depths and floodplain boundaries which extend between both rivers. A hydraulic connection exists for the majority of the Holland Marsh and within the proposed highway ROW. As expected, the Regional Event creates a larger floodplain extent when compared to the 100-year event.

The water elevations at the proposed highway ROW for the existing condition are included in **Table 9** and includes the boundary condition set as the historical high-water elevation at Lake Simcoe of 219.52 m. This is considered to be a conservative assumption to maximize floodplain boundaries.

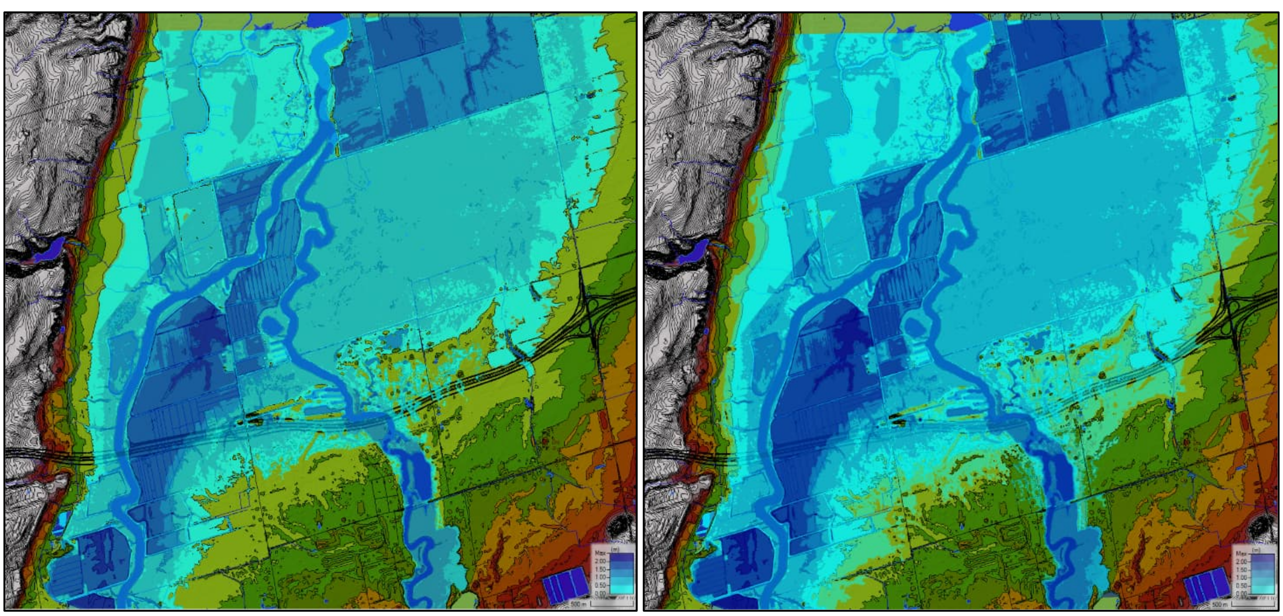


Figure 8: Floodplain Boundaries - Existing Condition during the 100-year and Regional events

A summary of water elevations at the proposed bridge crossings is also included in **Table 9** for the 2, 5, 10, 25, 50, 100-yr and Regional Events.

5.2.6 Water Velocities

Water velocities for the 100-year and Regional events at the Holland River and Holland River East Branch are shown in **Figure 9**. The water velocity values calculated by the model at bridge crossing locations are also included in **Table 9**, based on the average water level at Lake Simcoe of 219.05 m which maximizes velocities.

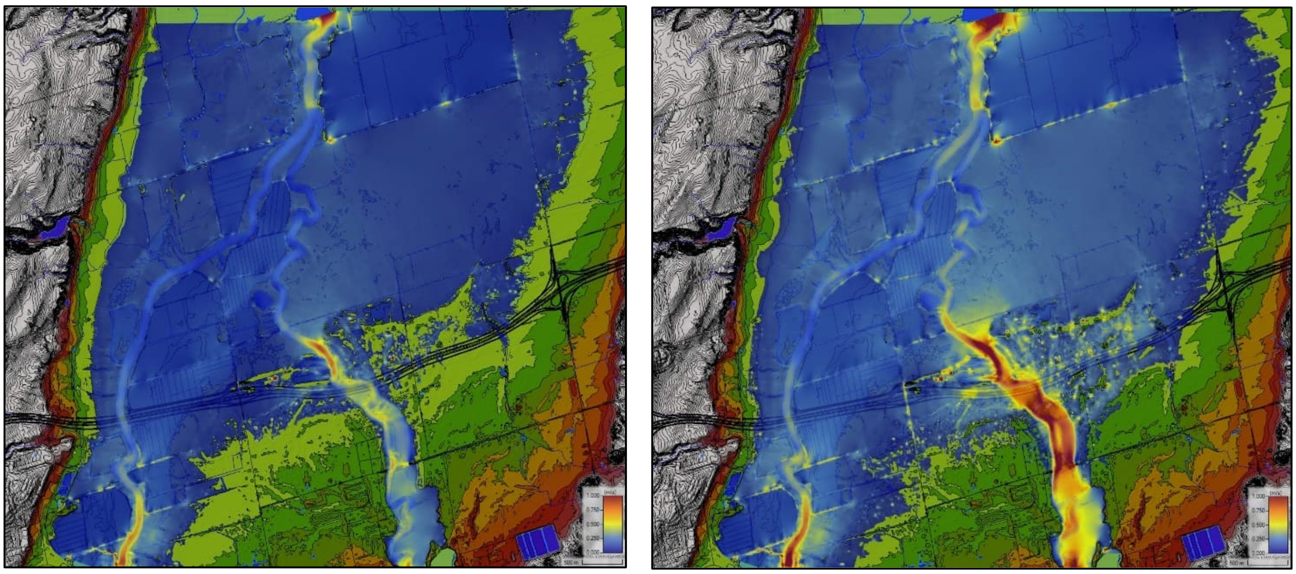


Figure 9: Water Velocities for the Existing Condition during the 100-year and Regional Events

Table 9: Summary of Water Elevations and Velocities - Existing Condition at the BBP ROW

Flood Event	Location			
	Holland River		Holland River East Branch	
2-year	219.65 m	0.27 m/s	219.76 m	0.25 m/s
10-year	219.79 m	0.41 m/s	220.01 m	0.34 m/s
25-year	219.86 m	0.44 m/s	220.10 m	0.38 m/s
50-year	219.91 m	0.46 m/s	220.17 m	0.41 m/s
100-year	219.95 m	0.48 m/s	220.23 m	0.44 m/s
Regional Event	220.50 m	0.52 m/s	220.90 m	0.84 m/s

6. Proposed Drainage Conditions - Culverts

6.1 Overview

The purpose of the Bradford Bypass project is to undertake a Preliminary Design project-specific assessment of environmental impacts for the proposed Highway 400 – Highway 404 Link (Bradford Bypass) in accordance with Ontario Regulation 697/21.

The project is a new 16.3 kilometre, controlled-access freeway. The proposed highway will extend from Highway 400 between 8th Line and 9th Line in Bradford West Gwillimbury, will cross a small portion of King Township, and will connect to Highway 404 between Queensville Sideroad and Holborn Road in East Gwillimbury. There are proposed full and partial interchanges, as well as grade separated crossings at intersecting municipal roads and watercourses, including the Holland River and Holland River East Branch. This project also includes the design integration for the replacement of the 9th Line structure on Highway 400, which will accommodate the proposed future ramps north of the Bradford Bypass corridor. The Ministry is considering an interim four-lane configuration and an ultimate eight-lane design for the Bradford Bypass. The interim condition will include two general purpose lanes in each direction and the ultimate condition will include four lanes in each direction (one high-occupancy vehicle lane and three general purpose travel lanes in each direction). The interim and ultimate designs are being reviewed as the project progresses. Should the footprint change or be modified in any way, a review of the changes shall be undertaken, and an addendum to the Report will be prepared to reflect the changes, impacts, mitigation measures, and any commitments to future work.

The Study Area encompasses nineteen (19) bridges, thirteen (13) new structural culverts, 63 non-structural culverts and two (2) culvert extensions. One (1) existing culvert (EX-CL-14) is located under Metrolinx tracks, which will require relocation to accommodate the proposed Bradford Bypass alignment. Metrolinx staff is aware of the required relocation of this culvert.

As part of the project-specific assessment of environmental impacts as identified in Ontario Regulation 697/21, an Environmental Impact Assessment Report (EIAR) will also be prepared to document the:

- description of environmental conditions within the Bradford Bypass corridor,
- description of all studies undertaken,
- assessment and evaluation of preliminary design alternatives,
- description of any measures proposed to mitigate any negative impacts that the preliminary design alternatives may have on the environment and the criteria for assessment and evaluation of those impacts,
- description of the methods to monitor the effectiveness of the mitigation measures proposed,
- description of any municipal, provincial, federal or other approvals or permits that may be required; and,
- consultation record with Indigenous communities, regulatory agencies and interested stakeholders etc.

Drainage and Hydrology modelling and assessments in consultation with the MTO and external agencies will provide:

- preliminary layout and design of the roadside ditches, other minor flow channels, and any other ancillary flow elements to convey the highway runoff to a sufficient outlet,
- accommodation of major overland flow requirements on the road surface and other major flow paths,
- preliminary layout and design of culvert opening, erosion protection and associated structures that are part of the surface drainage system,

- identify the location of the outlet and preliminary design of outfall, connections to outlets and outfall protection,
- preliminary selection, layout and design of storm water management (SWM) control facility,

The Overall Proposed Conditions Drainage Mosaic are shown on **Exhibits 5.1** and **5.2** (provided at the back of this Report), shows the location of the proposed culverts and the extend of the drainage areas to each proposed culverts.

6.2 Proposed Culverts Characteristics

Table 11 provides the characteristics of the proposed transverse, highway ramps and sideroad culverts**.** Table 11 includes preliminary information for the structural culverts and overflow culverts to be located within the floodplain of Holland River to provide flood relief and water level reduction during the 100-year and Regional storms.

6.3 Hydrologic Assessment - Culverts

The design storms were generated using the Rainfall Intensity-Duration-Frequency (IDF) parameters obtained from the MTO Rainfall IDF On-line Tool based on two points located along Bradford Bypass and at the Holland River and Holland River East Branch. The IDF curves were projected to the year 2097 (75-year service life) to account for the climate effect of rainfall intensities and peak flows.

The proposed Drainage Mosaic (**Exhibits 5.1** and **5.2**) shows the drainage areas for proposed culverts. The hydrologic assessment of these culverts was completed using the MTO 2097 IDF Curves corresponding to the 75 years service life of the Bradford Bypass proposed drainage structure included the new culverts. **Table 10** summarizes the IDF parameters that were input into the hydrologic model to generate the 50-year and 100-year design peak flows based on the 24-hour SCS Rainfall distribution.

Table 10: Rainfall IDF Parameters – MTO IDF Online Tool (2097)

Parameter	2-year	5-year	10-year	25-year	50-year	100-year
A	388.05	511.48	592.99	694.44	773.49	844.22
B	0.043	0.052	0.051	0.051	0.053	0.052
C	0.676	0.682	0.685	0.686	0.688	0.688

The peak flows for the 2-year and up to the 100-year design storms are depicted in **Table 12**.

Table 12 shows that the 50-year and 100-year peak flows used in the assessment of the proposed culverts.

Appendix F provides the MTO IDF Curves corresponding to 2097.

Appendix G.1 includes the hydrologic input parameters, and **Appendix G.2** provides the SWMHYMO data and summary output files.

Table 11: Proposed Culverts Characteristics

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Proposed Culvert Characteristics						Notes / Culvert Under:
			Size (mm) (Span x Rise)	Material	Length (m)	Invert Elevations		Slope (%)	
						U/S	D/S		
Proposed Highway 400 Culverts									
PR-CL-400-1	3.90	18+595	900	Conc.	101.8	268.60	264.60	3.93	Highway 400
PR-CL-400-2	279.7	17+800	5000 x 1200	Con Span	99.8	253.00	252.36	0.64	Highway 400. Structural Culvert. Span recommended by Fluvial.
Bradford Bypass & Highway 400 Interchange – Proposed Ramp Culverts									
PR-R-BBP-1A	8.6	10+096	Twin 750	Conc. Box	24.6	276.10	275.90	0.81	Ramp N-E.
PR-R-BBP-1B	11.2	10+950	1200	Conc.	43.6	271.55	269.30	5.16	Ramp E-N.
PR-R-BBP-2	11.1	10+357	1200	Conc.	48.0	273.50	272.53	2.02	Ramp N-E.
PR-R-BBP-3	2.4	10+471	900	Conc.	42.6	276.65	274.20	5.75	Ramp N-E
PR-R-BBP-4	226.5	10+700	4920 x 2400	Con Span	47.8	267.00	265.25	3.66	Ramp E-N. Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-5	2.2	11+171	900	Conc.	25.2	260.25	260.15	0.40	Ramp E-S
PR-R-BBP-6A	544.4	10+077 / 11+068	12000 x 2400	Con Span	60.0	258.45	257.65	1.33	Ramp E-N / Ramp E-S. Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-6B	550.1	10+774	12000 x 2400	Con Span	73.0	256.35	255.60	1.03	Bradford Bypass. Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-7	1.8	11+000	900	Conc.	60.5	261.65	261.00	1.07	Bradford Bypass
PR-R-BBP-8	85.4	10+346	12000 x 2400	Con Span	103.0	263.70	262.65	1.02	Ramp E-S. Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-9A	5.4	11+619	900	Conc.	62.6	258.75	258.45	0.48	Ramp N-E & Bradford Bypass
PR-R-BBP-9B	12.2	11+040	900	Conc.	76.9	258.15	257.30	1.10	Ramp N-E & Bradford Bypass
PR-R-BBP-10	270.2	10+206	5000 x 1200	Con Span	33.5	253.29	253.24	0.15	Ramp S-E. Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-11	295.0	12+190	5500 x 2400	Con Span	46.0	252.35	252.00	0.76	Ramp E-S. Structural Culvert. Span recommended by Fluvial.
Proposed Bradford Bypass Transverse Culverts									
PR-CL-BBP-1	4.9	12+340	1050	Conc.	82.6	282.10	281.76	0.41	
PR-CL-BBP-2	78.6	13+663	1800 x 1200	Conc. Box	98.7	266.15	265.35	0.81	
PR-CL-BBP-3	20.5	14+190	1800 x 900	Conc. Box	100.7	263.75	263.15	0.60	
PR-CL-BBP-4	20.5	15+514	900	Conc.	92.6	250.68	250.44	0.26	Upstream of proposed Pond P-SWM P-4
PR-CL-BBP-5	26.9	16+337	2400 x 1200	Conc. Box	84.3	232.40	230.45	2.31	
PR-CL-BBP-6A	–	18+448			20.1	218.20	218.00		Along private drainage tile system
PR-CL-BBP-6B	–	18+448			56.5	218.00	218.00		Along private drainage tile system
PR-CL-BBP-6C	–	18+448			54.7	218.00	218.00		Along private drainage tile system
PR-CL-BBP-7	4.2	18+807	1200	Conc.	18+807	18+807	18+807	18+807	
PR-CL-BBP-8	5.7	19+103	1200	Conc.	18+807	18+807	18+807	18+807	
PR-CL-BBP-9	–	21+483	20000 x 3000	Con Span	104.0	219.60	219.50		Overflow Culvert. Located between Yonge Street and 2nd Concession Road
PR-CL-BBP-10	–	21+877	20000 x 3000	Con Span	101.0	219.50	219.50		Overflow Culvert. Located between Yonge Street and 2nd Concession Road
PR-CL-BBP-11	–	22+294	–	–	–	–	–	–	Proposed bridge structure at the existing pond. Located approx. 902 m west of 2nd Concession Road.

Table 11: Proposed Culverts Characteristics

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Proposed Culvert Characteristics						Notes / Culvert Under:
			Size (mm) (Span x Rise)	Material	Length (m)	Invert Elevations		Slope (%)	
						U/S	D/S		
PR-CL-BBP-12	4.6	23+142	1200	Conc.	105.7	220.40	220.25	0.14	
PR-CL-BBP-13	30.8	23+272	1800 x 900	Conc. Box	114.3	220.90	220.85	0.04	
PR-CL-BBP-14	32.7	24+636	1350	Conc.	93.4	243.60	242.20	1.50	
PR-CL-BBP-15	45.6	25+071	1050	Conc.	111.4	241.23	239.25	1.78	
PR-CL-BBP-16	10.0	25+202	900	Conc.	106.4	241.00	238.90	1.97	
PR-CL-BBP-17	22.0	25+328	1050	Conc.	111.0	241.55	240.30	1.13	
Proposed Sideroad Culverts – 9th Line									
PR-CL-1	5.2	9+912	Twin 750	Conc.	18.7	270.45	270.45	0.00	
PR-CL-2	221.5	10+110	5000 x 1200	Con Span	22.3	268.95	268.95	0.00	Located under 9th Line. Structural Culvert. Span recommended by Fluvial.
Bradford Bypass & 10th Sideroad Interchange - Proposed Ramp Culverts									
PR-R-10IC-1	3.6	9+540	900	Conc.	20.0	282.50	282.45	0.25	Ramp N-W.
PR-R-10IC-2	4.5	10+250	900	Conc.	52.2	281.40	281.30	0.19	Ramp E-N/S. Upstream of proposed Pond R-Ex-Pond-2
PR-R-10IC-3	1.4	9+883	900	Conc.	42.3	281.45	281.40	0.12	Ramp S-W
PR-R-10IC-4	6.2	9+894	900	Conc.	45.2	279.60	279.30	0.66	Ramp N-E. Upstream of proposed Pond P-SWM P-3
PR-R-10IC-5	8.9	10+130	900	Conc.	33.4	279.10	279.00	0.30	Ramp W-N/S
PR-R-10IC-6	4.9	9+730	900	Conc.	32.7	280.70	280.65	0.15	Ramp S-E
PR-R-10IC-7	1.3	9+711	825	Conc.	28.7	280.35	280.05	1.04	Ramp N-W.
PR-R-10IC-8	0.4	9+290	825	Conc.	26.2	283.00	282.10	3.44	Ramp S-E
Bradford Bypass & County Road 4 Interchange - Proposed Ramp Culverts									
PR-R-C4IC-1	17.5	9+691	1050	Conc.	34.4	252.88	251.67	3.52	Ramp N-W
PR-R-C4IC-2A	0.6	9+860	900	Conc.	19.8	254.60	254.50	0.50	Ramp N-E. Upstream of proposed Pond P-SWM P-4
PR-R-C4IC-2B	1.7	9+954	900	Conc.	34.1	253.80	253.00	2.35	Ramp N-E. Upstream of proposed Pond P-SWM P-4
PR-R-C4IC-3	24.4	9+773	1200	Conc.	46.4	249.88	249.50	0.82	Ramp N-E. Upstream of Culvert PR-CL-CTY4-1. Culvert inverts and length from County Road 4 design
PR-R-C4IC-4	2.5	9+820	900	Conc.	42.8	244.30	243.80	1.17	Ramp S-E
PR-R-C4IC-5	0.4	9+788	750	Conc.	36.9	259.70	258.00	4.63	Ramp S-W
PR-R-C4IC-6	1.7	9+940	750	Conc.	31.0	250.55	247.00	11.45	Ramp S-W. Upstream of proposed Pond P-SWM P-5
PR-R-C4IC-7	4.8	10+160	1050	Conc.	42.0	246.00	245.60	0.95	Ramp E-N/S
Bradford Bypass & Bathurst Street Interchange - Proposed Ramp Culverts									
PR-R-BST-1	2.2	9+818	1200	Conc.	35.3	218.95	218.94	0.03	Ramp N-S/W
PR-R-BST-2	6.2	10+230	1200	Conc.	29.4	218.83	218.80	0.01	Ramp W-N/S
PR-R-BST-3	3.6	10+163	1200	Conc.	35.3	220.20	219.86	0.95	Ramp E-N/S
PR-R-BST-4	7.7	9+863	1200	Conc.	33.7	219.07	218.75	0.95	Ramp N/S-E

Table 11: Proposed Culverts Characteristics

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Proposed Culvert Characteristics			Invert Elevations			Notes / Culvert Under:
			Size (mm) (Span x Rise)	Material	Length (m)	U/S	D/S	Slope (%)	
Bradford Bypass & 2nd Concession Road Interchange - Proposed Ramp Culverts									
PR-R-2CON-1	9.2	9+680	2400 x 1200	Conc. Box	32.1	220.15	220.10	0.16	Ramp N-W. Upstream of proposed Pond P-SWM P-6
PR-R-2CON-2	3.0	9+920	900	Conc.	56.7	220.55	220.50	0.09	Ramp N-E
PR-R-2CON-3	243.6	9+732	2500 x 1000	Conc. Box	28.6	221.30	221.05	0.87	2nd Concession Road
PR-R-2CON-4	27.8	9+657	1800 x 900	Conc. Box	29.0	221.00	220.90	0.34	Ramp S-E
PR-R-2CON-5	32.3	9+893	1800 x 900	Conc. Box	49.0	220.80	220.75	0.10	Ramp S-W. Upstream of proposed Pond P-SWM P-7
PR-R-2CON-6	35.3	10+206	Twin 2400 x 1200	Conc. Box	40.8	220.67	220.60	0.17	Ramp E-N/S. Downstream of proposed Pond P-SWM P-7
Bradford Bypass & Leslie Street Interchange - Proposed Ramp Culverts									
PR-R-LST-1	43.4	10+084	1050	Conc.	34.8	241.85	241.23	1.78	Ramp W-N/S
PR-R-LST-2	8.8	10+228	900	Conc.	29.5	241.65	241.00	2.20	Ramp W-N/S
PR-R-LST-3	11.1	9+714	900	Conc.	26.9	238.70	238.10	2.23	Ramp N/S-W
Bradford Bypass & Highway 404 Interchange – Proposed Ramp Culverts									
PR-R-404-1	121.2	11+445	5360 x 2400	Conc. Box	92	242.30	240.75	1.70	Ramp S-W. Structural Culvert.
PR-R-404-2	119.4	25+636 / 10+14625+628 / 10+153	5360 x 2400	Conc. Box	40	243.00	242.35	1.70	Bradford Bypass / Ramp W/N. Structural Culvert. Span recommended by Fluvial. Chapman Pond.
PR-R-404-3	118.5	10+130	5360 x 2400	Conc. Box	43	243.75	243.05	1.70	Ramp W-S.
PR-R-404-4	3.6	10+318	900	Conc.	43.2	248.55	248.05	1.16	Ramp W-S
PR-R-404-5	8.3	10+333	900	Conc.	61.4	247.45	246.55	1.47	Ramp W-N
PR-R-404-6	12.0	11+208	900	Conc.	48.5	246.50	246.10	0.82	Ramp S-W
PR-R-404-7	7.2	10+567	900	Conc.	62.3	249.75	247.15	4.17	Ramp N-W
PR-R-404-8A	1.7	10+250	750	Conc.	33.9	251.15	249.40	5.16	Ramp N-W
PR-R-404-8B	2.9	11+420	900	Conc.	35.7	250.80	250.75	0.14	Ramp W-N
PR-R-404-9	1.8	10+400	750	Conc.	63.7	247.00	244.65	3.69	Ramp S-W
PR-R-404-10	39.6	10+293	4880 x 3050	Con Span	59.8	247.60	246.55	1.76	Ramp S-W. This culvert size will match the upstream existing culvert size of 4880 x 3050mm.
PR-R-404-11	30.2	10+960	4880 x 3050	Con Span	63.0	252.85	251.85	1.59	Ramp W-S. This culvert size will match the downstream existing culvert size of 4880 x 3050mm.

Notes:

PR-R-404-11 – Denotes *Proposed Structural Culvert*

PR-R-404-5 – Denotes *Proposed Non-structural Culvert*

PR-CL-BBP-11 – Denotes *Designed as a bridge structure*

Table 12: Proposed Culverts – Peak Flows

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Total Peak Flows (m^3/s) 24-hour SCS Type II						Remarks
			2-year	5-year	10-year	25-year	50-year	100-year	
Proposed Highway 400 Culverts									
PR-CL-400-1	3.9	18+595	0.18	0.32	0.41	0.53	0.64	0.73	
PR-CL-400-2	279.7	17+800	2.149	3.792	4.955	6.394	7.402	8.523	Structural Culvert. Span recommended by Fluvial.
Bradford Bypass & Highway 400 Interchange – Proposed Ramp Culverts									
PR-R-BBP-1A	8.6	10+096	0.169	0.304	0.400	0.523	0.631	0.720	
PR-R-BBP-1B	11.2	10+950	0.232	0.403	0.523	0.676	0.809	0.920	
PR-R-BBP-2	11.1	10+357	0.267	0.479	0.628	0.818	0.986	1.124	
PR-R-BBP-3	2.4	10+471	0.086	0.156	0.205	0.268	0.324	0.370	
PR-R-BBP-4	226.5	10+700	1.622	2.773	3.582	4.619	5.418	6.264	Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-5	2.2	11+171	0.055	0.099	0.130	0.169	0.204	0.233	
PR-R-BBP-6A	554.4	10+077 / 11+068	0.839	1.784	2.508	3.493	4.397	5.166	Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-6B	550.1	10+774	0.850	1.803	2.533	3.524	4.433	5.207	Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-7	1.8	11+000	0.081	0.145	0.190	0.248	0.299	0.341	
PR-R-BBP-8	85.4	10+346	0.18	0.40	0.56	0.80	1.05	1.20	Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-9A	5.4	11+619	0.14	0.27	0.34	0.46	0.56	0.64	
PR-R-BBP-9B	12.2	11+040	0.16	0.30	0.39	0.52	0.62	0.70	
PR-R-BBP-10	270.2	10+206	2.009	3.525	4.597	5.933	6.865	7.913	Structural Culvert. Span recommended by Fluvial.
PR-R-BBP-11	295.0	12+190	2.394	4.244	5.559	7.168	8.306	9.539	Structural Culvert. Span recommended by Fluvial.
Proposed Bradford Bypass Transverse Culverts									
PR-CL-BBP-1	4.9	12+340	0.13	0.20	0.27	0.35	0.43	0.50	
PR-CL-BBP-2	78.6	13+663	0.654	1.227	1.638	2.174	2.652	3.052	
PR-CL-BBP-3	20.5	14+190	0.34	0.61	0.80	1.05	1.26	1.44	
PR-CL-BBP-4	20.5	15+514	0.34	0.61	0.80	1.05	1.26	1.44	
PR-CL-BBP-5	26.9	16+337	0.277	0.532	0.722	0.973	1.198	1.385	
PR-CL-BBP-6A	–	18+448	–	–	–	–	–	–	Culverts PR-CL-BBP-6A, PR-CL-BBP-6B and PR-CL-BBP-6C are located along a private drainage systems. Design requirements of these drains to be confirmed in future design stages and in consultation with the town's drainage superintendent.
PR-CL-BBP-6B	–	18+448	–	–	–	–	–	–	
PR-CL-BBP-6C	–	18+448	–	–	–	–	–	–	
PR-CL-BBP-7	4.2	18+807	0.253	0.398	0.497	0.620	0.728	0.811	
PR-CL-BBP-8	5.7	19+103	0.236	0.358	0.444	0.548	0.646	0.714	
PR-CL-BBP-9	–	21+483	–	–	–	–	–	–	Overflow Culvert. Located between Yonge Street and 2nd Concession Road
PR-CL-BBP-10	–	21+877	–	–	–	–	–	–	Overflow Culvert. Located between Yonge Street and 2nd Concession Road
PR-CL-BBP-11	–	–	–	–	–	–	–	–	Proposed bridge structure at the existing pond. Located approx. 902 m west of 2nd Concession Road.

Table 12: Proposed Culverts – Peak Flows

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Total Peak Flows (m^3/s) 24-hour SCS Type II						Remarks
			2-year	5-year	10-year	25-year	50-year	100-year	
PR-CL-BBP-12	4.6	23+142	0.455	0.691	0.858	1.070	1.243	1.394	
PR-CL-BBP-13	30.8	23+272	0.328	0.493	0.616	0.765	0.911	1.020	
PR-CL-BBP-14	32.7	24+636	0.25	0.51	0.71	0.97	1.21	1.40	
PR-CL-BBP-15	45.6	25+071	0.24	0.49	0.69	0.95	1.18	1.38	
PR-CL-BBP-16	10.0	25+200	0.109	0.175	0.229	0.316	0.394	0.461	
PR-CL-BBP-17	22.0	25+328	0.230	0.461	0.631	0.854	1.054	1.222	
Proposed Sideroad Culverts – 9th Line									
PR-CL-1	5.2	9+912	0.14	0.24	0.31	0.40	0.48	0.55	
PR-CL-2	221.5	10+110	1.560	2.650	3.412	4.389	5.244	6.075	
Bradford Bypass & 10th Sideroad Interchange - Proposed Ramp Culverts									
PR-R-10IC-1	3.6	9+540	0.05	0.122	0.17	0.24	0.31	0.36	
PR-R-10IC-2	4.50	10+250	0.238	0.363	0.454	0.577	0.687	0.775	
PR-R-10IC-3	1.40	9+883	0.030	0.059	0.079	0.106	0.129	0.149	
PR-R-10IC-4	6.2	9+894	0.14	0.24	0.32	0.42	0.51	0.60	
PR-R-10IC-5	8.9	10+130	0.28	0.44	0.58	0.75	0.91	1.05	
PR-R-10IC-6	4.9	9+730	0.44	0.64	0.77	0.94	1.08	1.22	
PR-R-10IC-7	1.3	9+711	0.02	0.05	0.06	0.09	0.10	0.12	
PR-R-10IC-8	0.4	9+290	0.01	0.02	0.025	0.03	0.04	0.05	
Bradford Bypass & Bradford Bypass Interchange - Proposed Ramp Culverts									
PR-R-C4IC-1	17.5	9+691	0.16	0.35	0.50	0.69	1.01	0.778	
PR-R-C4IC-2A	0.6	9+860	0.04	0.06	0.07	0.09	0.11	0.12	
PR-R-C4IC-2B	1.7	9+954	0.11	0.16	0.20	0.25	0.30	0.33	
PR-R-C4IC-3	24.4	9+773	0.69	1.06	1.34	1.70	2.02	2.29	
PR-R-C4IC-4	2.50	9+820	0.268	0.382	0.458	0.554	0.640	0.708	
PR-R-C4IC-5	0.40	9+788	0.014	0.027	0.037	0.049	0.060	0.069	
PR-R-C4IC-6	1.7	9+940	0.029	0.060	0.083	0.114	0.142	0.165	
PR-R-C4IC-7	4.8	10+160	0.243	0.373	0.467	0.592	0.709	0.799	
Bradford Bypass & Bathurst Street Interchange - Proposed Ramp Culverts									
PR-R-BST-1	2.20	9+818	0.085	0.150	0.194	0.251	0.301	0.341	
PR-R-BST-2	6.2	10+230	0.428	0.661	0.822	1.020	1.206	1.326	
PR-R-BST-3	3.60	10+163	0.070	0.126	0.166	0.217	0.262	0.299	
PR-R-BST-4	7.7	9+863	0.418	0.634	0.788	0.970	1.147	1.270	

Table 12: Proposed Culverts – Peak Flows

Culvert I.D.	Total Drainage Area (ha)	Chainage (m)	Total Peak Flows (m^3/s) 24-hour SCS Type II						Remarks
			2-year	5-year	10-year	25-year	50-year	100-year	
Bradford Bypass & 2nd Concession Road Interchange - Proposed Ramp Culverts									
PR-R-2CON-1	9.2	9+680	0.97	1.45	1.78	2.21	2.56	2.85	
PR-R-2CON-2	3.0	9+920	0.27	0.42	0.52	0.66	0.77	0.88	
PR-R-2CON-3	243.60	9+732	1.061	2.054	2.780	3.736	4.593	5.310	
PR-R-2CON-4	27.8	9+657	0.124	0.264	0.370	0.512	0.641	0.750	
PR-R-2CON-5	32.3	9+893	0.461	0.705	0.887	1.093	1.303	1.459	
PR-R-2CON-6	35.3	10+206	0.770	1.165	1.460	1.796	2.134	2.383	
Bradford Bypass & Leslie Street Interchange - Proposed Ramp Culverts									
PR-R-LST-1	43.4	10+084	0.24	0.52	0.73	1.01	1.26	1.48	
PR-R-LST-2	8.8	10+228	0.066	0.147	0.208	0.291	0.366	0.429	
PR-R-LST-3	11.1	9+718	0.200	0.305	0.381	0.485	0.578	0.657	
Bradford Bypass & Highway 404 Interchange – Proposed Ramp Culverts									
PR-R-404-1	121.2	11+445	0.437	0.901	1.250	1.717	2.140	2.498	
PR-R-404-2	119.4	25+636 / 10+146	0.433	0.894	1.241	1.705	2.126	2.481	Structural Culvert. Span recommended by Fluvial. Chapman Pond (Irrigation Pond)
PR-R-404-3	118.5	10+130	0.432	0.891	1.237	1.699	2.119	2.474	
PR-R-404-4	3.6	10+318	0.04	0.085	0.12	0.17	0.21	0.24	
PR-R-404-5	8.3	10+333	0.06	0.14	0.20	0.27	0.34	0.40	
PR-R-404-6	12.0	11+208	0.11	0.23	0.33	0.45	0.57	0.66	
PR-R-404-7	7.2	10+567	0.06	0.12	0.17	0.23	0.29	0.34	
PR-R-404-8A	1.7	10+250	0.02	0.04	0.06	0.08	0.10	0.12	
PR-R-404-8B	2.9	11+420	0.034	0.07	0.10	0.13	0.16	0.19	
PR-R-404-9	1.8	10+400	0.029	0.062	0.086	0.118	0.148	0.172	
PR-R-404-10	39.6	10+293	0.23	0.51	0.72	1.00	1.26	1.50	NEW CULVERT. The culvert size will match the existing upstream culvert size of 4880 x 3050mm Con-Span.
PR-R-404-11	30.2	10+960	0.163	0.357	0.506	0.706	0.889	1.043	NEW CULVERT. The culvert size will match the existing downstream culvert size of 4880 x 3050mm Con-Span.

Notes:

PR-R-404-11 – Denotes Proposed "Structural" Culvert

PR-R-404-5 – Denotes Proposed Non-structural Culvert

6.4 Hydraulic Assessment – Proposed Culverts

The 50-year and 100-year peak flows estimated based on the MTO IDF Curves corresponding to 2097 were input into the CulvertMaster compute program to obtain data obtained from the hydraulic performance of the proposed culverts; such as, headwater and tailwater elevations, headwater depth / culvert height ratio, upstream velocity head, and to identify if the culverts performance is under inlet or outlet control.

Culvert inverts elevations were obtained from the proposed preliminary grading, culvert lengths were obtained from design drawings. Some of the culvert sizes were obtained from discussions with the highway grading, fluvial geomorphology and fisheries teams to incorporate the culvert design requirements from these disciplines. Tailwater elevations were obtained from typical section of the watercourses located downstream of the culverts where this information was applicable and available. Otherwise, the cross section and slope of the proposed side ditches where outflows from the culverts will discharge to were used.

For culverts not associated with fish habitat or fluvial processes, the size that was suitable to the site conditions where the culvert will be installed was confirmed iteratively until the design standards are satisfied. CSP pipe was not used at locations with high fills. It should be noted that MTO Gravity Pipe Assessment was not performed in the assessment of the culverts to identify suitable pipe material based on environmental site conditions. However, it is recommended to complete this assessment in future design stages.

Table 13 and **Table 14** summarize the hydraulic assessment of the proposed culverts. The CulvertMaster output files are provided in **Appendix H.1**. The rating curves for the proposed structural culverts are included in **Appendix H.2**.

After reviewing the results presented in **Table 13,** the following is noted:

- All the proposed culverts satisfy the three Design Criteria, Depth Criterion (HW/D ≤ 1.5), 50-year Freeboard Criterion (FB ≥ 1m), and the Overtopping Criterion (no road overtopping during the 100-year storm) with the exception of Culvert PR-CL-1 (located under 9th Line), and Culvert PR-R-2CON-3 (located under 2nd Concession Road). This culvert is pending further assessment design in coordination with the structural team and other applicable disciplines.
- Culvert PR-CL-1 satisfies two Design Criteria, Depth Criterion (HW/D ≤ 1.5) and the Overtopping Criterion (no road overtopping during the 100-year storm). The culvert does not satisfy the required 50-year freeboard of 1 m. The outlet point of this culvert will be revised to confirm if its conveyance capacity is improved. The alternative of reviewing the culvert size will also investigated.
- Culvert PR-R-2CON-3 satisfies two Design Criteria, Depth Criterion (HW/D ≤ 1.5) and the Overtopping Criterion (no road overtopping during the 100-year storm). The culvert does not satisfy the required 50-year freeboard of 1 m. However, as was aforementioned, the design of this culvert is pending further assessment in coordination with the structural team.

After reviewing the results presented in **Table 14,** the following is noted:

- Proposed EX-CL-14 (Metrolinx Culvert at Mileage 42.60) meets all the three AREMA design criteria.

Table 13: Hydraulic Assessment – Proposed Culverts

Culvert I.D.	Proposed Culvert Data		Drainage Area (ha)	Spill Elevation at :		Headwater Elevation (m)		Energy Grade Line Calculations				Depth of Headwater / Height of Culv (H/D)	Freeboard from: Edge of Pavement (m)		Performance Criteria Satisfied? Yes / No			Notes
				C/L of Travel Lanes (m)	Edge of Pavement (m)			Flow Velocity (m/s)		Velocity Head (m)	E.G.L.				Depth Criterion (HW/D < 1.5)	Freeboard Criterion (FB ≥ 1m)	Highway Overtopping Criterion	
	Size (mm)	Type				50yr	100yr	50yr	100yr	50yr	50yr	50yr	50yr	100yr	50yr	50yr	100yr	
Highway 400 - Proposed Transverse Culverts																		
PR-CL-400-1	900	Conc.	3.9	270.7	270.55	269.29	269.34	4.26	4.42	0.180	269.47	0.75	1.08	1.21	**Yes**	**Yes**	**Yes**	
PR-CL-400-2	5000 x 1200	Conc. Span	279.7	255.3	255.15	253.97	254.07	1.23	1.42	0.300	254.27	0.81	1.18	1.08	**Yes**	**Yes**	**Yes**	Minimum freeboard (without EGL) criteria used.
Bradford Bypass & Highway 400 Interchange - Proposed Ramp Culverts																		
PR-R-BBP-1A	Twin 750	Conc.	8.6	278	277.85	276.60	276.64	1.16	1.23	0.130	276.73	0.65	1.12	1.21	**Yes**	**Yes**	**Yes**	
PR-R-BBP-1B	1200	Conc.	11.2	276	275.85	272.25	272.30	4.87	5.02	0.180	272.43	0.57	3.42	3.55	**Yes**	**Yes**	**Yes**	
PR-R-BBP-2	1200	Conc.	11.1	278.4	278.25	274.28	274.34	3.65	3.76	0.140	274.42	0.65	3.83	3.91	**Yes**	**Yes**	**Yes**	
PR-R-BBP-3	900	Conc.	2.4	278.7	278.55	277.12	277.16	4.00	4.16	0.120	277.24	0.52	1.31	1.39	**Yes**	**Yes**	**Yes**	
PR-R-BBP-4	4920 x 2400	Conc. Span	226.5	269.35	269.20	267.92	267.88	1.00	1.09	0.250	268.17	0.38	1.03	1.32	**Yes**	**Yes**	**Yes**	
PR-R-BBP-5	900	Conc.	2.2	262.15	262.00	260.62	260.65	1.35	1.41	0.090	260.71	0.40	1.29	1.35	**Yes**	**Yes**	**Yes**	
PR-R-BBP-6A	12000 x 2400	Conc. Span	544.4	262.15	262.00	258.89	258.94	0.68	0.74	0.120	259.01	0.18	2.99	3.06	**Yes**	**Yes**	**Yes**	
PR-R-BBP-6B	12000 x 2400	Conc. Span	550.1	263.6	263.45	256.79	256.85	0.68	0.74	0.120	256.91	0.19	6.54	6.60	**Yes**	**Yes**	**Yes**	
PR-R-BBP-7	900	Conc.	1.8	265.4	265.25	262.10	262.13	2.16	2.24	0.110	262.21	0.49	3.04	3.12	**Yes**	**Yes**	**Yes**	
PR-R-BBP-8	12000 x 2400	Conc. Span	85.4	274	273.85	263.87	263.89	0.14	0.15	0.050	263.92	0.07	9.93	9.96	**Yes**	**Yes**	**Yes**	
PR-R-BBP-9A	900	Conc.	5.4	266	265.85	259.39	259.44	1.91	1.98	0.170	259.56	0.70	6.29	6.41	**Yes**	**Yes**	**Yes**	
PR-R-BBP-9B	900	Conc.	12.2	264	263.85	258.79	258.87	2.67	2.76	0.180	258.97	0.74	4.88	4.98	**Yes**	**Yes**	**Yes**	
PR-R-BBP-10	5000 x 1200	Conc. Span	270.2	255.4	255.25	254.33	254.42	1.47	1.59	0.120	254.45	0.87	0.92	0.83	**Yes**	**No**	**Yes**	The peak flow control by the proposed pond P-SWM P-2 will improve freeboard conditions as this culvert.
PR-R-BBP-11	5500 x 2400	Conc. Span	295.0	255.2	255.05	253.49	253.60	1.48	1.61	0.310	253.80	0.47	1.25	1.45	**Yes**	**Yes**	**Yes**	
Bradford Bypass - Proposed Transverse Culverts																		
PR-CL-BBP-1	1050	Conc.	4.9	284	283.85	282.62	282.66	1.67	1.74	0.130	282.75	0.49	1.10	1.19	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-2	1800 x 1200	Conc. Box	78.6	269.85	269.70	267.26	267.34	3.15	3.28	0.300	267.56	0.91	2.14	2.36	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-3	1800 x 900	Conc. Box	20.5	267.75	267.60	264.42	264.49	1.66	1.78	0.180	264.60	0.74	3.00	3.11	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-4	900	Conc.	20.5	253.45	253.30	251.84	252.07	2.47	2.64	0.190	252.03	1.27	1.27	1.23	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-5	2400 x 1200	Conc. Box	26.9	234.25	234.10	232.88	232.92	3.14	3.31	0.150	233.03	0.39	1.08	1.18	**Yes**	**Yes**	**Yes**	

Table 13: Hydraulic Assessment – Proposed Culverts

Culvert I.D.	Proposed Culvert Data		Drainage Area (ha)	Spill Elevation at :		Headwater Elevation (m)		Energy Grade Line Calculations				Depth of Headwater / Height of Culv (H/D)	Freeboard from: Edge of Pavement (m)		Performance Criteria Satisfied? Yes / No			Notes
				C/L of Travel Lanes (m)	Edge of Pavement (m)			Flow Velocity (m/s)		Velocity Head (m)	E.G.L.				Depth Criterion (HW/D < 1.5)	Freeboard Criterion (FB ≥ 1m)	Highway Overtopping Criterion	
	Size (mm)	Type				50yr	100yr	50yr	100yr	50yr	50yr	50yr	50yr	100yr	50yr	50yr	100yr	
PR-CL-BBP-6A																		Along private drainage system. Assessment requirements to be confirmed in detailed design.
PR-CL-BBP-6B																		
PR-CL-BBP-6C																		
PR-CL-BBP-7	1200	Conc.	4.2	223.85	223.70	219.70	219.75	1.42	1.49	0.060	219.76	0.62	3.94	3.95	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-8	1200	Conc.	5.7	226.00	225.85	220.45	220.48	1.36	1.41	0.160	220.61	0.51	5.24	5.37	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-9	20000 x 3000	Conc. Span																Overflow culvert.
PR-CL-BBP-10	20000 x 3000	Conc. Span																Overflow culvert.
PR-CL-BBP-11																		Bridge Structure.
PR-CL-BBP-12	1200	Conc.	4.6	225	224.85	221.34	221.41	1.79	1.89	0.120	221.46	0.77	3.39	3.44	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-13	1800 x 900	Conc. Box	30.8	225.1	224.95	221.56	221.60	0.82	0.87	0.030	221.59	0.72	3.36	3.35	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-14	1350	Conc.	32.7	247.15	247.00	244.43	244.51	3.48	3.63	0.220	244.65	0.61	2.35	2.49	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-15	1050	Conc.	45.6	246.75	246.60	242.14	242.23	3.75	3.91	0.250	242.39	0.86	4.21	4.37	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-16	900	Conc.	10.0	248.8	248.65	241.52	241.57	2.90	3.03	0.140	241.66	0.57	6.99	7.08	**Yes**	**Yes**	**Yes**	
PR-CL-BBP-17	1050	Conc.	22.0	248.8	248.65	242.41	242.48	3.08	3.20	0.230	242.64	0.80	6.01	6.17	**Yes**	**Yes**	**Yes**	
Proposed Sideroad Culverts - 9th Line																		
PR-CL-1	Twin 750	Conc.	5.2	272	271.85	270.87	270.94	1.39	1.53		270.87	0.55	0.98	0.91	**Yes**	**No**	**Yes**	Note: Rural arterial road. Design storm is 25yr storm. Minimum freeboard (without EGL) criteria used.
PR-CL-2	5000 x 1200	Conc. Span	221.5	270.54	270.39	269.70	269.85	1.46	1.75	0.100	269.80	0.62	0.70	0.54	**Yes**	**No**	**Yes**	Note: Rural arterial road. Design storm is 25yr storm. Culvert under low road profile.
Bradford Bypass & 10th Sideroad Interchange - Proposed Ramp Culverts																		
PR-R-10IC-1	900	Conc.	3.6	286.11	286.00	282.96	283.00	1.52	1.59	0.090	283.05	0.50	2.95	3.00	**Yes**	**Yes**	**Yes**	
PR-R-10IC-2	900	Conc.	4.5	284.75	284.60	282.14	282.20	1.95	2.03	0.110	282.25	0.81	2.35	2.40	**Yes**	**Yes**	**Yes**	
PR-R-10IC-3	900	Conc.	1.4	284.25	284.10	281.76	281.78	0.95	0.99	0.030	281.79	0.34	2.31	2.32	**Yes**	**Yes**	**Yes**	
PR-R-10IC-4	900	Conc.	6.2	283.26	283.11	280.20	280.26	2.10	2.20	0.160	280.36	0.66	2.75	2.85	**Yes**	**Yes**	**Yes**	
PR-R-10IC-5	900	Conc.	8.9	281.7	281.55	279.95	280.04	2.16	2.28	0.170	280.12	0.93	1.43	1.51	**Yes**	**Yes**	**Yes**	
PR-R-10IC-6	900	Conc.	4.9	286.35	286.20	281.68	281.77	2.31	2.44	0.170	281.85	1.08	4.35	4.43	**Yes**	**Yes**	**Yes**	
PR-R-10IC-7	825	Conc.	1.3	281.8	281.65	280.61	280.64	1.57	1.65	0.000	280.61	0.31	1.04	1.01	**Yes**	**Yes**	**Yes**	
PR-R-10IC-8	825	Conc.	0.4	284.5	284.35	283.16	283.18	1.80	1.93	0.040	283.20	0.19	1.15	1.17	**Yes**	**Yes**	**Yes**	

Table 13: Hydraulic Assessment – Proposed Culverts

Culvert I.D.	Proposed Culvert Data		Drainage Area (ha)	Spill Elevation at :		Headwater Elevation (m)		Energy Grade Line Calculations				Depth of Headwater / Height of Culv (H/D)	Freeboard from: Edge of Pavement (m)		Performance Criteria Satisfied? Yes / No			Notes
				C/L of Travel Lanes (m)	Edge of Pavement (m)			Flow Velocity (m/s)		Velocity Head (m)	E.G.L.				Depth Criterion (HW/D < 1.5)	Freeboard Criterion (FB ≥ 1m)	Highway Overtopping Criterion	
	Size (mm)	Type				50yr	100yr	50yr	100yr	50yr	50yr	50yr	50yr	100yr	50yr	50yr	100yr	
Bradford Bypass & County Road 4 Interchange - Proposed Ramp Culverts																		
PR-R-C4IC-1	1050	Conc.	17.5	255.5	255.35	253.64	253.72	4.21	4.35	0.200	253.84	0.71	1.51	1.63	**Yes**	**Yes**	**Yes**	
PR-R-C4IC-2A	900	Conc.	0.6	256	255.85	254.87	254.88	1.23	1.26	0.000	254.87	0.29	1.0	0.97	**Yes**	**Yes**	**Yes**	Minimum freeboard (without EGL) criteria used.
PR-R-C4IC-2B	900	Conc.	1.7	255.5	255.35	254.25	254.28	2.85	2.93	0.120	254.37	0.49	0.98	1.07	**Yes**	**No**	**Yes**	Minimum freeboard (without EGL) criteria used.
PR-R-C4IC-3	1200	Conc.	24.4	256	255.85	251.06	251.16	3.18	3.28	0.340	251.40	0.97	4.45	4.69	**Yes**	**Yes**	**Yes**	
PR-R-C4IC-4	900	Conc.	2.5	252.65	252.50	244.99	245.03	2.75	2.82	0.180	245.17	0.75	7.33	7.47	**Yes**	**Yes**	**Yes**	
PR-R-C4IC-5	750	Conc.	0.4	262.35	262.20	259.91	259.92	2.29	2.39	0.050	259.96	0.27	2.24	2.28	**Yes**	**Yes**	**Yes**	
PR-R-C4IC-6	750	Conc.	1.7	253	252.85	250.87	250.90	4.08	4.26	0.080	250.95	0.42	1.90	1.95	**Yes**	**Yes**	**Yes**	
PR-R-C4IC-7	1050	Conc.	4.8	248	247.85	246.68	246.73	2.60	2.68	0.180	246.86	0.64	1.0	1.12	**Yes**	**No**	**Yes**	Minimum freeboard (without EGL) criteria used.
Bradford Bypass & Bathurst Street Interchange - Proposed Ramp Culverts																		
PR-R-BST-1	1200	Conc.	2.2	220.65	220.50	219.41	219.44	1.03	1.07	0.040	219.45	0.37	1.05	1.06	**Yes**	**Yes**	**Yes**	
PR-R-BST-2	1200	Conc.	6.2	221	220.85	219.74	219.79	1.77	1.85	0.130	219.87	0.74	0.98	1.06	**Yes**	**No**	**Yes**	Minimum freeboard (without EGL) criteria used.
PR-R-BST-3	1200	Conc.	3.6	223	222.85	220.58	220.61	0.99	1.03	0.090	220.67	0.31	2.18	2.24	**Yes**	**Yes**	**Yes**	
PR-R-BST-4	1200	Conc.	7.7	222	221.85	219.92	219.97	1.73	1.81	0.220	220.14	0.70	1.71	1.88	**Yes**	**Yes**	**Yes**	
Bradford Bypass & 2nd Concession Road Interchange - Proposed Ramp Culverts																		
PR-R-2CON-1	2400 x 1200	Conc. Box	9.2	222.3	222.15	221.00	221.06	1.55	1.65	0.130	221.13	0.70	1.02	1.09	**Yes**	**Yes**	**Yes**	
PR-R-2CON-2	900	Conc.	3.0	222.5	222.35	221.38	221.46	1.81	1.93	0.000	221.38	0.91	0.97	0.89	**Yes**	**No**	**Yes**	Minimum freeboard (without EGL) criteria used.
PR-R-2CON-3	2500 x 1000	Conc. Box	243.6	223.3	223.25	222.45	222.63	3.41	3.55	0.000	222.45	1.15	0.80	0.62	**Yes**	**No**	**Yes**	Minimum freeboard (without EGL) criteria used. Options to improve freeboard conditions to be investigated during detail design phase
PR-R-2CON-4	1800 x 900	Conc. Box	27.8	223	222.85	221.43	221.47	1.17	1.27	0.110	221.54	0.47	1.31	1.38	**Yes**	**Yes**	**Yes**	
PR-R-2CON-5	1800 x 900	Conc. Box	32.3	223	222.85	221.47	221.52	1.43	1.52	0.090	221.56	0.73	1.29	1.33	**Yes**	**Yes**	**Yes**	
PR-R-2CON-6	Twin 2400 x 1200	Conc. Box	35.3	222.45	222.30	221.27	221.30	0.70	0.75	0.030	221.30	0.49	1.01	1.01	**Yes**	**Yes**	**Yes**	Actual freeboard for the 50-year storm will be greater than 1.0m as the flows to this culvert will be reduced by the flow control provided by pond P-SWM P-7.
Bradford Bypass & Leslie Street Interchange - Proposed Ramp Culverts																		
PR-R-LST-1	1050	Conc.	43.4	244.7	244.55	242.80	242.90	2.01	2.18	0.260	243.06	0.89	1.49	1.65	**Yes**	**Yes**	**Yes**	
PR-R-LST-2	900	Conc.	8.8	243.45	243.30	242.15	242.20	1.33	1.41	0.130	242.28	0.55	1.02	1.10	**Yes**	**Yes**	**Yes**	
PR-R-LST-3	900	Conc.	11.1	240.7	240.55	239.35	239.40	3.24	3.33	0.170	239.52	0.71	1.05	1.15	**Yes**	**Yes**	**Yes**	

Table 13: Hydraulic Assessment – Proposed Culverts

Culvert I.D.	Proposed Culvert Data		Drainage Area (ha)	Spill Elevation at :		Headwater Elevation (m)		Energy Grade Line Calculations				Depth of Headwater / Height of Culv (H/D)	Freeboard from: Edge of Pavement (m)		Performance Criteria Satisfied? Yes / No			Notes
				C/L of Travel Lanes (m)	Edge of Pavement (m)			Flow Velocity (m/s)		Velocity Head (m)	E.G.L.				Depth Criterion (HW/D < 1.5)	Freeboard Criterion (FB ≥ 1m)	Highway Overtopping Criterion	
	Size (mm)	Type				50yr	100yr	50yr	100yr	50yr	50yr	50yr	50yr	100yr	50yr	50yr	100yr	
Bradford Bypass & Highway 404 Interchange - Proposed Ramp Culverts																		
PR-R-404-1	5360 x 2400	Conc. Box	121.2	248.5	248.35	242.74	242.79	0.99	1.07	0.130	242.87	0.18	5.48	5.56	**Yes**	**Yes**	**Yes**	
PR-R-404-2	5360 x 2400	Conc. Box	119.4	249.8	249.65	243.47	243.52	0.45	0.49	0.130	243.60	0.19	6.05	6.13	**Yes**	**Yes**	**Yes**	
PR-R-404-3	5360 x 2400	Conc. Box	118.5	250	249.85	244.19	244.24	0.45	0.49	0.130	244.32	0.18	5.53	5.61	**Yes**	**Yes**	**Yes**	
PR-R-404-4	900	Conc.	3.6	250.2	250.05	248.92	248.95	2.00	2.08	0.090	249.01	0.41	1.04	1.10	**Yes**	**Yes**	**Yes**	
PR-R-404-5	900	Conc.	8.3	249.75	249.60	247.93	247.98	1.29	1.37	0.120	248.05	0.53	1.55	1.62	**Yes**	**Yes**	**Yes**	
PR-R-404-6	900	Conc.	12.0	249	248.85	247.14	247.20	2.35	2.44	0.170	247.31	0.70	1.54	1.65	**Yes**	**Yes**	**Yes**	
PR-R-404-7	900	Conc.	7.2	252	251.85	250.19	250.23	3.45	3.62	0.110	250.30	0.49	1.55	1.62	**Yes**	**Yes**	**Yes**	
PR-R-404-8A	750	Conc.	1.7	252.7	252.55	251.42	251.44	2.78	2.93	0.070	251.49	0.35	1.06	1.11	**Yes**	**Yes**	**Yes**	
PR-R-404-8B	900	Conc.	2.9	252.35	252.20	251.14	251.17	1.26	1.32	0.040	251.18	0.37	1.02	1.03	**Yes**	**Yes**	**Yes**	
PR-R-404-9	750	Conc.	1.8	255.7	255.55	247.33	247.36	2.77	2.15	0.080	247.41	0.43	8.14	8.19	**Yes**	**Yes**	**Yes**	
PR-R-404-10	4880 x 3050	Conc. Span	39.6	255.7	255.55	247.93	247.97	0.53	0.58	0.090	248.02	0.11	7.53	7.58	**Yes**	**Yes**	**Yes**	
PR-R-404-11	4880 x 3050	Conc. Span	30.2	256.9	256.75	253.11	253.14	0.67	0.72	0.080	253.19	0.09	3.56	3.61	**Yes**	**Yes**	**Yes**	

Table 14: Hydraulic Assessment – Proposed Metrolinx Culvert EX-CL-14

Mile	Preliminary Size (mm)	# Barrel	Hydraulic Assessment Results			AREMA DESIGN REQUIREMENTS		
			25-year	100-year		25-year	100-year	
			No Static Head (HW/D < 1.0)	HW/D < 1.5	Freeboard (m)	No Static Head (HW/D < 1.0)	HW/D < 1.5	Freeboard to Rail > 0.60 m
42.60	1400	4	0.95	1.16	0.8	**Yes**	**Yes**	**Yes**

7. Proposed Drainage Condition – Holland River and Holland River East Branch Bridges

The major bridge crossings for the Holland River and Holland River East Branch were included in the HEC-RAS model geometry based on the proposed highway alignment shown below.

7.1.1.1 Land Constraints and Proposed Bridge Geometry

The span of the major river crossings within the proposed Bradford Bypass alignment is based on different engineering parameters and land constraints. A summary of the main requirements is provided below, however, this is not an exhaustive list and is included to provide a basic understanding of the design process, which is based on the requirements of this preliminary analysis.

The structural requirements of the crossing and the maximum design span is limited by available bridge options and their associated cost, it was therefore necessary to find a balance between structural and hydrodynamic parameters to define potential bridge spans and the location of bridge piers.

The bridge span and location of bridge piers requires minimum disruption to existing wetland areas (including Provincially Designated Wetlands) as well as areas of archeological significance. For these reasons, the proposed bridge spans were placed outside these designated areas to the extend possible.

The geomorphological requirements of the river crossings were also considered to include setback distances between the piers and the channel banks as well as other parameters such as channel velocities and applied shear stress.

The selection of bridge pier locations and bridge span also included the consideration of the navigational requirements of both the Holland River and Holland River East Branch. It is noted that there is an active boating community and marinas within this area.

Based on these parameters, the minimum bridge span for the Holland River and Holland River East Branch were selected at 550 m and 750 m respectively, as shown in **Figure 10**.

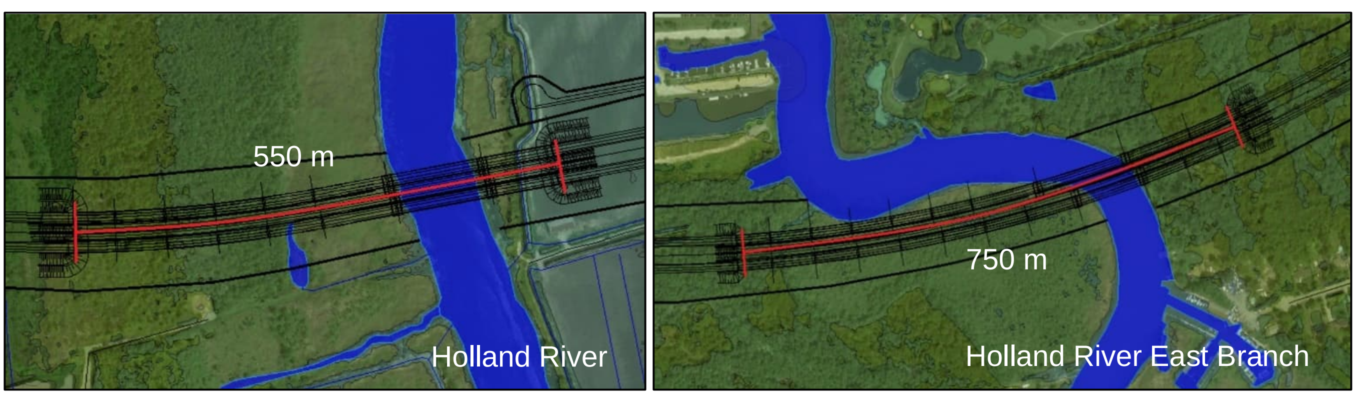


Figure 10: Proposed Bridge Crossings within the Highway ROW

The bridge geometry was added to the model terrain as three separate embankments, with internal structures to account for proposed highway bridge structures to maintain existing road and stream crossings. The distance between openings for the major bridges (500 m and 750 m) were simulated with bridge abutments instead of bridge structures, this was a required assumption based on the capabilities of the 2-D model.

7.1.1.2 Water Elevations and Floodplain Boundaries

The floodplain boundaries for the 100-year and Regional events are shown in **Figure 11** with the proposed bridge crossings at the Holland River and Holland River East Branch, while the results of the hydraulic simulations are summarized in **Table 15**.

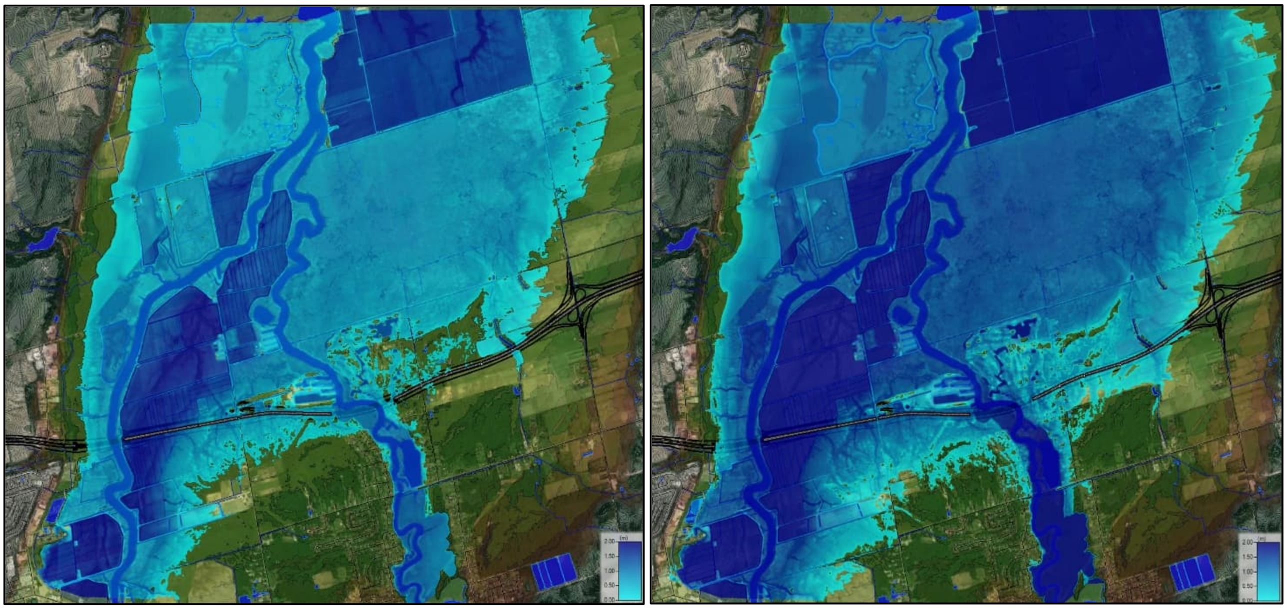


Figure 11: Floodplain Boundaries for Proposed Condition during the 100-year and Regional Events

7.1.2 Water Velocities

The maximum water velocities for the 100-year and Regional events at the Holland River and Holland River East Branch are shown in **Figure 12** within the proposed bridge crossings. The water velocity values calculated by the model at bridge crossing locations are also summarized in **Table 15**, including the difference between the proposed and existing conditions shown in **Table 9**.

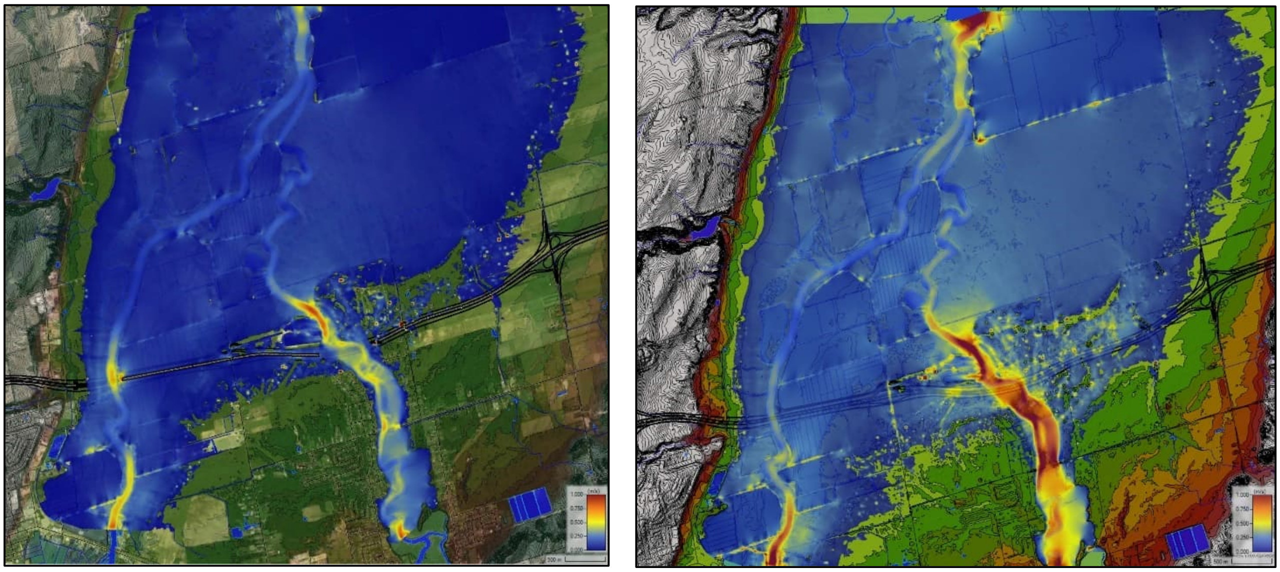


Figure 12: Water Velocities the Existing Condition - 100-year and Regional events

Table 15: Summary of Water Elevations and Velocities for Proposed Condition at the BBP ROW

Location	100-year Event		Regional Event	
	Holland River		Holland River East Branch	
2-year	219.65 m (0.00)	0.29 m/s (+0.02)	219.76 m (0.00)	0.25 m/s (0.00)
10-year	219.80 m (+0.01)	0.52 m/s (+0.11)	220.00 m (+0.01)	0.34 m/s (0.00)
25-year	219.88 m (+0.02)	0.59 m/s (+0.15)	220.10 m (0.00)	0.38 m/s (0.00)
50-year	219.94 m (+0.03)	0.65 m/s (+0.19)	220.16 m (+0.01)	0.41 m/s (0.00)
100-year	219.99 m (+0.04)	0.59 m/s (+0.11)	220.22 m (+0.01)	0.42 m/s (-0.02)
Regional Event	220.52 m (+0.02)	0.86 m/s (+0.36)	220.91 m (-0.01)	0.88 m/s (+0.04)

As shown in the hydraulic model results, water elevations and velocities at the Holland River East Branch remain similar between the existing and proposed conditions, with marginal increases in water velocity for the 100-year and Regional events. Furthermore, the Holland River presents larger increases in water elevations and velocities as the floodplain is constrained within the bridge abutments with a smaller opening (500 m).

Given that the floodplain is approximately 5 km wide, most areas present minimal changes in water elevations, as shown in **Table 15**. The largest increase in water elevations of 0.04 m which corresponds to the 100-year and Regional Event are localized at the Holland River and Holland River East Branch, respectively. These are localized observations that could be refined during subsequent design phases.

7.1.2.1 Scour Assessment

A preliminary scour assessment was completed for the bridge piers that will span the Holland River and Holland River East Branch. The total number of piers for each crossing are 7 (Holland River) and 10 for the Holland River East Branch Westbound bridge and 11 for the Holland River East Branch Eastbound bridge. The maximum distance between piers is defined by the river width and is 115 m for the Holland River bridge crossing and varies between 100 m and 120 m for the eastbound and westbound bridges of the Holland River East crossing, respectively.

Local scour estimations were completed with the Transportation Association of Canada (TAC) *Guide to Bridge Hydraulics* method included in the MTO Drainage Management Manual (1997). For a rectangular pier shape with a width of 2.5 m the adjustment factor is 2, which means that the local scour is 5 m.

8. Stormwater Management Strategy

As shown on **Exhibits 7.1** to **7.4** (provided at the back of this Report) The overall objective of the drainage SWM plan is to minimize impacts in terms of water quality and erosion potential to the existing drainage system and natural environment along the Bradford Bypass (BBP) due to the proposed road widening and proposed highway works. It must be noted that SWM measures do not exist under existing drainage conditions along the BBP.

MTO *Highway Drainage Design Standards (HDDS, Feb. 2008)*, and the Ministry of the Environment, Conservation and Parks (MECP) *Stormwater Management Planning and Design Manual (March 2003)* provided the design standards for the selection and design of the SWM measures required to mitigate the impacts of the proposed roadway works. Additionally, LSRCA SWM Guidelines provided standards and recommendations applied to the proposed SWM facilities.

The SWM strategy for this Bradford Bypass Project includes flat-bottom grassed swales, enhanced grassed swales particularly at the upstream of wetlands, marshes, and fish sensitive areas to prevent untreated runoff from discharging directly to these areas.

MECP guidelines includes provision of grassed swales for slopes up to 4%, despite the flat bottom swales not meeting the required longitudinal slope of “less that 1.0%”. However, the MECP guidelines state that *“Grassed swales with a slope up to 4% can be used for water quality purposes, but effectiveness diminishes as velocity increases”.* A summary of the proposed stormwater measures is provided below.

8.1 MECP Flat Bottom Grassed Swales

As shown in **Table 16,** flat bottom grassed swales are proposed along the Braford Bypass north and south side ditch and along the highway ramps to improve water quality of runoff, reduced flow velocities and promote sedimentation. They are particularly ideal for roadway applications due to their linear nature. However, specific Design Criteria must be achieved. Proposed flowrates will be determined along the swales to ensure that velocity criteria are met.

To maintain the swale within the highway ROW, the bottom widths will be sized based on the available land, road slope and grading constraints. Based on findings from the geotechnical investigations, in areas where the groundwater is high, the swale will be designed as shallow as possible to minimize adverse impacts to ground water levels and quality.

Permanent flow check dams are proposed along swales where longitudinal swale profile allows. The flow check dams will further slow down flow velocities, provide to some extent measure of flood attenuation and to some extent quality control of runoff and infiltration.

For illustrative purposes, **Figure 13** shows a typical grassed swale with rock check dams, and **Figure 14** presents a concept of the flow check dams spacing.

Appendix L provides the calculations for the Water Quality Analysis during the 4 hour 25mm Chicago Storm, and the Erosion Potential Analysis during the 100 year Design Storm. The calculations document the hydraulic performance of the proposed flat-bottom grassed swales and their compliance with the water quality and erosion potential design criteria from MECP.

Figure 13: Location of the Flow Check Dams along a Flat Bottom Grassed Swale

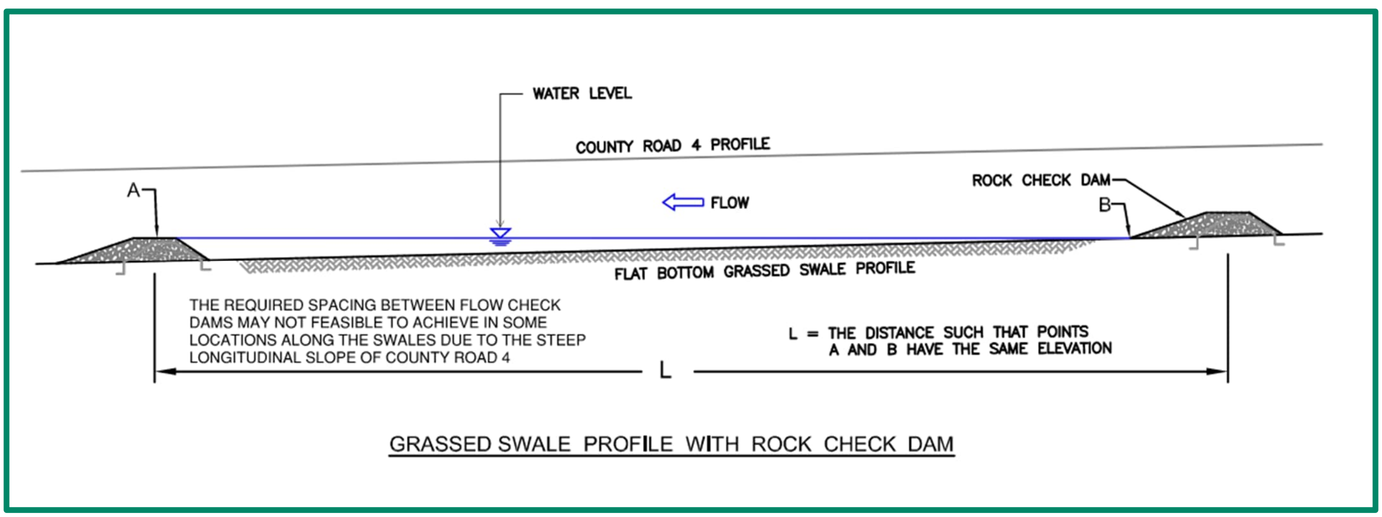


Figure 14: Conceptual Locations of Flow Check Dams Along Flat Bottom Grassed Swale

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
Proposed Bradford Bypass – West of Holland River							
Right Ditch	11+760	11+720	40	0.35	1.2	3:1	
Left Ditch	12+015	12+000	15	0.84	1.2	3:1	10th Sideroad interchange
Right Ditch	12+100	12+120	20	0.92	1.2	3:1	10th Sideroad interchange
Right Ditch	12+300	12+260	40	0.90	1.2	3:1	10th Sideroad interchange
Left Ditch	12+390	12+260	130	0.80	1.2	3:1	10th Sideroad interchange
Right Ditch	12+440	12+540	100	0.60	1.2	3:1	10th Sideroad interchange
Right Ditch	12+560	12+740	180	0.60	1.2	3:1	10th Sideroad interchange
Right Ditch	12+740	13+080	340	0.60	1.2	3:1	10th Sideroad interchange
Left Ditch	12+440	12+480	40	0.60	1.2	3:1	10th Sideroad interchange
Left Ditch	12+550	12+720	170	0.70	1.2	3:1	10th Sideroad interchange
Left Ditch	12+820	12+880	60	0.80	1.2	3:1	10th Sideroad interchange
Left Ditch	12+980	13+100	120	0.85	1.2	3:1	
Right Ditch	13+340	13+380	40	0.50	1.2	3:1	
Left Ditch	13+400	13+420	20	0.64	1.2	3:1	
Right Ditch	13+460	13+500	40	0.30	1.2	3:1	
Right Ditch	13+710	13+670	40	0.40	1.2	3:1	
Left Ditch	13+660	13+710	50	0.65	1.2	3:1	
Left Ditch	13+740	13+720	20	0.60	1.2	3:1	
Right Ditch	13+760	13+740	20	0.40	1.2	3:1	
Right Ditch	13+780	14+020	240	0.50	1.2	3:1	
Left Ditch	13+820	13+780	40	0.74	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
Left Ditch	13+820	13+920	100	0.50	1.2	3:1	
Left Ditch	13+960	14+060	100	0.45	1.2	3:1	
Left Ditch	14+100	14+140	40	0.60	1.2	3:1	
Right Ditch	14+320	14+220	100	0.45	1.2	3:1	
Left Ditch	14+200	14+260	60	0.60	1.2	3:1	
Left Ditch	14+280	14+260	20	0.68	1.2	3:1	
Right Ditch	14+350	14+600	250	0.60	1.2	3:1	
Left Ditch	14+350	14+600	250	0.60	1.2	3:1	
Left Ditch	14+700	14+720	20	0.96	1.2	3:1	
Right Ditch	14+880	14+980	100	0.40	1.2	3:1	
Right Ditch	15+100	15+260	160	0.35	1.2	3:1	County Road 4 Interchange
Left Ditch	15+135	15+165	30	0.30	1.2	3:1	County Road 4 Interchange
Left Ditch	15+660	15+680	20	0.90	1.2	3:1	County Road 4 Interchange
Left Ditch	15+840	15+880	40	0.60	1.2	3:1	County Road 4 Interchange
Right Ditch	16+320	16+340	20	0.97	1.2	3:1	
Left Ditch	16+320	16+340	20	0.56	1.2	3:1	
Right Ditch	16+380	16+550	170	0.36	1.2	3:1	
Left Ditch	16+440	16+500	60	0.75	1.2	3:1	
Right Ditch	16+760	16+875	115	0.34	1.2	3:1	
Left Ditch	16+740	16+840	100	0.30	1.2	3:1	
Right Ditch	16+980	17+025	45	0.45	1.2	3:1	
Left Ditch	16+940	17+025	85	0.33	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
Proposed Bradford Bypass – East of Yonge Street							
Right Ditch	21+280	21+140	140	0.20	1.2	3:1	
Left Ditch	21+295	21+160	135	0.16	1.2	3:1	
Right Ditch	21+280	21+480	200	0.15	1.2	3:1	
Left Ditch	21+300	21+480	180	0.16	1.2	3:1	
Right Ditch	21+660	21+480	180	0.35	1.2	3:1	
Left Ditch	21+600	21+480	120	0.50	1.2	3:1	
Left Ditch	21+680	21+600	80	0.30	1.2	3:1	
Right Ditch	21+800	21+660	140	0.20	1.2	3:1	
Left Ditch	21+820	21+680	140	0.20	1.2	3:1	
Right Ditch	21+800	21+880	80	0.25	1.2	3:1	
Right Ditch	21+880	21+940	60	0.25	1.2	3:1	
Left Ditch	21+820	22+020	200	0.25	1.2	3:1	
Right Ditch	22+020	21+940	80	0.60	1.2	3:1	
Right Ditch	22+080	22+265	185	0.30	1.2	3:1	
Left Ditch	22+020	22+280	260	0.22	1.2	3:1	
Right Ditch	22+445	22+285	160	0.35	1.2	3:1	
Right Ditch	22+880	22+485	395	0.15	1.2	3:1	2nd Concession Interchange
Right Ditch	22+920	22+990	70	0.15	1.2	3:1	2nd Concession Interchange
Left Ditch	23+160	22+305	855	0.20	1.2	3:1	2nd Concession Interchange
Right Ditch	23+900	23+3 45	555	0.30	1.2	3:1	2nd Concession Interchange
Left Ditch	23+860	23+250	610	0.25	1.2	3:1	2nd Concession Interchange

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
Right Ditch	24+380	24+560	180	0.45	1.2	3:1	
Left Ditch	24+380	24+575	195	0.45	1.2	3:1	
Right Ditch	24+620	24+700	80	0.40	1.2	3:1	
Right Ditch	24+770	24+880	110	0.40	1.2	3:1	
Left Ditch	24+755	24+840	85	0.35	1.2	3:1	
Left Ditch	24+840	24+915	75	0.50	1.2	3:1	
Right Ditch	24+895	24+965	70	0.55	1.2	3:1	
Right Ditch	25+090	25+155	65	0.25	1.2	3:1	
Left Ditch	25+125	25+155	30	0.35	1.2	3:1	
Right Ditch	25+260	25+200	60	0.30	1.2	3:1	
Left Ditch	25+255	25+210	45	0.70	1.2	3:1	
Right Ditch	25+315	25+295	20	0.45	1.2	3:1	
Left Ditch	25+355	25+335	6020	0.45	1.2	3:1	
Left Ditch	25+305	25+335	30	0.45	1.2	3:1	
Proposed Bradford Bypass & Highway 400 Interchange							
E-N Ramp, Right Ditch	10+400	10+120	280	1.00	1.2	3:1	
E-N Ramp, Left Ditch	10+400	10+140	260	1.00	1.2	3:1	
E-N Ramp, Right Ditch	10+660	10+580	80	0.30	1.2	3:1	
E-N Ramp, Right Ditch	10+680	10+700	20	0.70	1.2	3:1	
E-N Ramp, Left Ditch	10+680	10+700	20	0.64	1.2	3:1	
E-N Ramp, Right Ditch	10+820	10+740	80	0.36	1.2	3:1	
E-N Ramp, Right Ditch	10+910	10+840	70	0.40	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
E-N Ramp, Left Ditch	10+860	10+880	20	0.90	1.2	3:1	
E-N Ramp, Right Ditch	11+080	11+000	80	0.80	1.2	3:1	
E-S Ramp, Left Ditch	10+360	10+345	15	0.76	1.2	3:1	
E-S Ramp, Right Ditch	10+420	10+380	40	0.50	1.2	3:1	
E-S Ramp, Left Ditch	10+400	10+380	20	1.01	1.2	3:1	
E-S Ramp, Left Ditch	10+400	10+420	20	0.32	1.2	3:1	
E-S Ramp, Right Ditch	10+540	11+000	460	0.75	1.2	3:1	
E-S Ramp, Left Ditch	10+540	10+710	170	0.75	1.2	3:1	
E-S Ramp, Left Ditch	10+810	10+715	95	0.75	1.2	3:1	
E-S Ramp, Left Ditch	10+820	10+900	80	0.75	1.2	3:1	
E-S Ramp, Left Ditch	10+960	10+980	20	0.68	1.2	3:1	
E-S Ramp, Right Ditch	11+260	11+120	140	0.40	1.2	3:1	
E-S Ramp, Left Ditch	11+320	11+160	160	0.50	1.2	3:1	
E-S Ramp, Right Ditch	11+420	11+440	20	0.36	1.2	3:1	
E-S Ramp, Left Ditch	11+440	11+420	20	1.00	1.2	3:1	
E-S Ramp, Right Ditch	12+120	12+140	20	0.77	1.2	3:1	
E-S Ramp, Right Ditch	12+320	12+190	130	0.31	1.2	3:1	
E-S Ramp, Left Ditch	12+265	12+245	20	0.36	1.2	3:1	
E-S Ramp, Right Ditch	12+390	12+415	25	0.75	1.2	3:1	
E-S Ramp, Right Ditch	12+475	12+490	15	0.75	1.2	3:1	
N-E Ramp, Right Ditch	10+000	10+190	190	0.35	1.2	3:1	
N-E Ramp, Left Ditch	10+260	10+355	95	0.70	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
N-E Ramp, Right Ditch	10+300	10+320	20	0.61	1.2	3:1	
N-E Ramp, Right Ditch	10+440	10+420	20	0.50	1.2	3:1	
N-E Ramp, Right Ditch	10+540	10+520	20	0.14	1.2	3:1	
N-E Ramp, Right Ditch	10+540	10+640	100	0.35	1.2	3:1	
N-E Ramp, Left Ditch	10+540	10+580	40	0.12	1.2	3:1	
N-E Ramp, Left Ditch	11+020	10+990	30	0.65	1.2	3:1	
N-E Ramp, Left Ditch	11+460	11+235	225	0.40	1.2	3:1	
S-E Ramp, Right Ditch	10+060	10+020	40	0.40	1.2	3:1	
S-E Ramp, Right Ditch	10+060	10+100	40	0.40	1.2	3:1	
S-E Ramp, Right Ditch	10+140	10+100	40	0.40	1.2	3:1	
S-E Ramp, Right Ditch	10+220	10+200	20	0.90	1.2	3:1	
S-E Ramp, Right Ditch	10+380	10+360	20	0.81	1.2	3:1	
S-E Ramp, Left Ditch	10+380	10+340	40	0.80	1.2	3:1	
S-E Ramp, Left Ditch	10+510	10+480	30	0.35	1.2	3:1	
S-E Ramp, Right Ditch	10+520	10+500	20	0.77	1.2	3:1	
S-E Ramp, Right Ditch	10+560	10+540	20	0.89	1.2	3:1	
S-E Ramp, Right Ditch	10+720	10+580	140	0.40	1.2	3:1	
S-E Ramp, Right Ditch	10+760	10+740	20	0.70	1.2	3:1	
S-E Ramp, Right Ditch	10+760	10+780	20	0.30	1.2	3:1	
S-E Ramp, Right Ditch	10+820	10+785	35	0.30	1.2	3:1	
S-E Ramp, Right Ditch	10+980	10+860	120	0.30	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
Proposed Bradford Bypass & Highway 404 Interchange							
N-W Ramp, Right Ditch	10+080	10+100	20	0.27	1.2	3:1	
N-W Ramp, Right Ditch	10+120	10+180	60	0.40	1.2	3:1	
N-W Ramp, Right Ditch	10+180	10+220	40	0.45	1.2	3:1	
N-W Ramp, Right Ditch	10+240	10+260	20	0.45	1.2	3:1	
N-W Ramp, Right Ditch	10+620	10+700	80	0.80	1.2	3:1	
N-W Ramp, Right Ditch	10+700	10+765	65	0.05	1.2	3:1	
W-N Ramp, Right Ditch	10+320	10+295	25	0.35	1.2	3:1	
W-N Ramp, Left Ditch	10+260	10+340	80	0.50	1.2	3:1	
W-N Ramp, Left Ditch	10+380	10+340	40	0.50	1.2	3:1	
W-N Ramp, Left Ditch	11+120	11+170	50	0.70	1.2	3:1	
W-N Ramp, Right Ditch	11+180	11+160	20	0.20	1.2	3:1	
W-N Ramp, Right Ditch	11+280	11+340	60	0.35	1.2	3:1	
W-N Ramp, Left Ditch	11+360	11+425	65	0.30	1.2	3:1	
W-N Ramp, Left Ditch	11+425	11+500	75	0.30	1.2	3:1	
W-N Ramp, Right Ditch	11+400	11+500	100	0.55	1.2	3:1	
S-W Ramp, Right Ditch	10+000	10+040	40	0.53	1.2	3:1	
S-W Ramp, Right Ditch	10+140	10+220	80	0.63	1.2	3:1	
S-W Ramp, Right Ditch	10+355	10+400	45	0.10	1.2	3:1	
S-W Ramp, Right Ditch	10+440	10+400	40	0.20	1.2	3:1	
S-W Ramp, Left Ditch	10+480	10+440	40	0.75	1.2	3:1	
S-W Ramp, Right Ditch	10+520	10+500	20	0.70	1.2	3:1	

Table 16: Proposed Flat-Bottom Grassed Swales – Preliminary Location

Swale Location	Chainage (m)		Swale Length (m)	Average Longitudinal Slope (%)	Swale Bottom Width (m)	Swale Side Slopes	Remarks
	From	To					
S-W Ramp, Right Ditch	10+800	10+830	30	0.40	1.2	3:1	
S-W Ramp, Left Ditch	10+840	10+800	40	0.03	1.2	3:1	
S-W Ramp, Left Ditch	11+140	11+210	70	0.40	1.2	3:1	
S-W Ramp, Left Ditch	11+210	11+300	90	0.40	1.2	3:1	
W-S Ramp, Right Ditch	10+040	10+000	40	0.75	1.2	3:1	
W-S Ramp, Right Ditch	10+100	10+120	20	0.82	1.2	3:1	
W-S Ramp, Right Ditch	10+270	10+320	50	0.34	1.2	3:1	
W-S Ramp, Left Ditch	10+280	10+320	40	0.40	1.2	3:1	
W-S Ramp, Right Ditch	10+360	10+340	20	0.55	1.2	3:1	
W-S Ramp, Right Ditch	10+680	10+580	100	0.50	1.2	3:1	
W-S Ramp, Left Ditch	10+630	10+580	50	0.50	1.2	3:1	
W-S Ramp, Right Ditch	10+680	10+780	100	0.55	1.2	3:1	
W-S Ramp, Left Ditch	10+635	10+780	145	0.55	1.2	3:1	
W-S Ramp, Left Ditch	10+800	10+820	20	0.67	1.2	3:1	
W-S Ramp, Left Ditch	10+840	10+860	20	0.10	1.2	3:1	
W-S Ramp, Right Ditch	10+860	10+900	40	0.80	1.2	3:1	
W-S Ramp, Right Ditch	10+960	10+980	20	0.42	1.2	3:1	
TOTAL LENGTH (m)			**15,225**				

8.2 MECP Stormwater Management (SWM) Ponds

Exhibits 7.1 to **7.4** (provided at the back of this Report), show the location of the proposed nine (9) SWM ponds that will provide quantity and quality control of runoff for an area of 130.0 hectares that drains toward the Bradford Bypass. The ponds will provide an enhanced protection levels (80% long-term S.S. removal) or greater. The ponds will not provide water quality treatment for flows generated within external drainage areas. **Table 17** provides the characteristics of the SWM ponds, including their drainage area, pond dimensions, elevations for the different zones within the ponds (top and bottom elevations, and the permanent pool elevation).

Additionally, the required storage capacity based on the runoff volume from the 100-year design storm and the provided storge capacity based on the available land area, preliminary grading and outlet point elevation are provided accounting for the requirement of matching proposed outflows from the ponds to existing flow rates downstream of the ponds at selected hydrologic points of interest.

The pond characteristics are based on the MECP *Stormwater Management Planning and Design Manual* (March 2003), and the LSRCA *Technical Guidelines for Stormwater Management Submissions* (Sept. 1, 2016).

The MECP's Table 3.2 (Water Quality Storage Requirements based on Receiving Waters), provide storage requirements for drainage areas with a minimum percentage of imperviousness of 35%, which was adopted for drainage areas with less than this minimum threshold.

Proposed pond P-SWM P-1, will provide water quality and quantity control of runoff for a drainage area of 14.50 ha with a percentage of imperviousness of 35% (actual 11% imperviousness). This pond will discharge to the upstream end of proposed Culvert PR-R-BBP-11.

Proposed pond P-SWM P-2, will provide water quality and quantity control of runoff for a drainage area of 242.50 ha with a percentage of imperviousness of 35% (actual 10% imperviousness). This pond will discharge to the upstream end of proposed Culvert PR-R-BBP-10. It is recommended during future design stages to investigate the feasibility of bypassing flows from the undeveloped area of 161.70 (PR-CL-2).

Proposed pond P-SWM P-3, will provide water quality and quantity control of runoff for a drainage area of 11.0 ha with a percentage of imperviousness of 35%. This pond will discharge to the upstream end of proposed Culvert PR-R-10IC-4 located at the Bradford Bypass and 10th Sideroad interchange.

Proposed pond P-SWM P-4, will provide water quality and quantity control of runoff for a drainage area of 20.80 ha with a percentage of imperviousness of 38%. This pond will discharge to the upstream end of proposed Culvert PR-R-C4IC-3 located at the Bradford Bypass and County Road 4 interchange. To create this pond, a berm should be constructed at the downstream end of the pond to provide positive drainage to PR-R-C4IC-3.

Proposed pond P-SWM P-5, will provide water quality and quantity control of runoff for a drainage area of 4.80 ha with a percentage of imperviousness of 40%. This pond will discharge to the upstream end of proposed Culvert PR-R-10IC-7 located at the Bradford Bypass and County Road 4 interchange.

Proposed pond P-SWM P-6, will provide water quality and quantity control of runoff for a drainage area of 7.60 ha with a percentage of imperviousness of 37%. This pond will discharge to a channel with an approximate bottom elevation of 220.0 (to be confirmed in future design stages). A berm will be required to provide the required positive drainage for outflows from the pond to the downstream channel. The pond is located at the Bradford Bypass and 2nd Concession Road interchange.

Table 17: BBP – Proposed SWM Ponds – Preliminary Characteristics

SWM Pond ID [1]	Pond Drainage Area (ha)	Pond Dimension at Top of Pond (m)			Side Slopes (5:1) [3]	Pond Elevations (m)			100-year Storage Volume (m^3)		Surface Area (m^2) [5]	Based on Table 3.2 (MECP Guideline) [6]		Pond Discharges to:
		Length	Width	Depth [2]		Approximate Ground	Pond Bottom	Permanent Pool	Required [4]	Provided		Imperviousness (%)	Required Volume (m^3)	
Bradford Bypass & Highway 400 Interchange														
P-SWM P-1	14.50	66.0	35.0	2.50	5:1	254.0	251.50	252.50	2875	3141	2310	35	2030	Upstream end (Inv=252.35) of proposed Culvert PR-R-BBP-11
P-SWM P-2	15.90	75.0	45.0	2.50	5.1	256.10	253.60	254.60	5200	5211	3375	35	2226	Upstream end (Inv=253.30) of proposed Culvert PR-R-BBP-10
Bradford Bypass & 10th Sideroad Interchange														
P-SWM P-3	8.90	41.0	33.0	2.40	5:1	283.50	281.0	282.0	1542	1578	1353	35	1246	Upstream end (Inv=279.60) of proposed Culvert PR-R-10IC-4
Bradford Bypass & County Road 4 Interchange														
P-SWM P-4	24.40	41.50	35.0	2.50	5:1	252.0	249.50	250.50	1738	1762	1423	38	2440	Upstream end (Inv=249.88) of proposed Culvert PR-R-C4IC-3. Flows from an external area to the pond will be redirected so that its flows will bypass the pond to reduce the pond's storage volume requirements
P-SWM P-5	4.80	36.0	30.0	2.50	5:1	248.0	245.50	246.50	1127	1159	1080	40	732	Upstream end (Inv=246.0) of proposed Culvert PR-R-C4IC-7
Bradford Bypass & 2nd Concession Road Interchange														
P-SWM P-6	9.20	43.0	38.0	2.50	5:1	221.85	219.35	220.35	2000	2006	1594	37	1334	Upstream end (Inv=220.15) of proposed Culvert PR-R-2CON-1
P-SWM P-7	35.30	43.0	31.0	2.50	5:1	222.15	219.65	220.65	1400	1453	1333	43	4236	Upstream end (Inv=220.60) of proposed Culvert PR-R-2CON-6. Flows from an external area to the pond will be redirected so that its flows will bypass the pond to reduce the pond's storage volume requirements
Bradford Bypass & Highway 404 Interchange														
P-SWM P-8	13.10	37.0	32.0	2.50	5:1	246.20	243.70	244.70	1300	1325	1184	38	1932	Downstream watercourse. Approximate bottom elevation 244.50
P-SWM P-9	7.20	36.0	30.0	2.50	5:1	252.0	249.50	250.50	1112	1159	1080	35	1008	Upstream end (Inv=249.75) of proposed Culvert PR-R-404-7

Notes: A total area of approximately 130.0 ha will be treated by the proposed SWM ponds (excluding the existing ponds to be relocated and the proposed ponds to treat bridge deck areas). The treated areas excludes eternal drainage areas.

1. *SWM Ponds will provide an Enhanced Level of water quality treatment (80% TSS Removal) based on MECP requirements. P-SWM P-1 denotes: Proposed SWM Pond number 1*
2. *Depth from bottom of weir elevation to pond bottom. Bottom of weir set at the 100-yr Water Level in the pond. Top of berm elevation equals bottom of weir plus 0.30m freeboard.*
3. *Berm side slopes (5:1) based on MECP standards.*
4. *Required 100-year storage volume from SWMHYMO output file.*
5. *Based on dimensions of the pond. No safety factor has been included.*
6. *Based on Enhanced Protection Level (80% Long Term S.S. Removal)*

Proposed pond P-SWM P-7, will provide water quality and quantity control of runoff for a drainage area of 35.50 ha with an imperviousness of 43%. This pond will discharge to the upstream end of proposed Culvert PR-R-2CON-6 located at the Bradford Bypass and 2nd Concession Road interchange. A berm will be required to create this pond and to provide positive drainage to the proposed culvert.

Proposed pond P-SWM P-8, will provide water quality and quantity control of runoff for a drainage area of 13.10 ha with an imperviousness of 38%. This pond will discharge to a watercourse located approximately 14 meters from the pond. The pond will be located just north of Ramp N-W of the Bradford Bypass and Highway 404 interchange.

Proposed pond P-SWM P-9, will provide water quality and quantity control of runoff for a drainage area of 6.50 ha with an imperviousness of 35% (actual 12% imperviousness). This pond will discharge to the upstream end of proposed Culvert PR-R-404-7 located at the Bradford Bypass and Highway 404 interchange.

In addition to the proposed ponds, existing ponds (R-EX Pond 1 and R-EX Pond 2) will be relocated and will provide quality and quantity control of runoff for an area of 1.40 ha and 4.5 ha respectively. These two ponds are located at the Bradford Bypass and 10th Sideroad interchange.

The highway areas that will not be feasible to be treated by SWM ponds will be treated by flat-bottom grassed swales and enhanced grassed swales to be designed according to MECP design standards and requirements.

In addition, **Table 17** provides the storage volume for each pond based on Table 3.2 of the MECP Guidelines. Table 3.2 provides the storage volume (m^3/ha) based on the impervious level within the drainage area to the pond. The storage volume values are based on the Enhanced Protection Level (80% Long Term S.S. Removal).

8.3 Flow Comparison - Controlled vs. Uncontrolled

This section documents the results from comparing the existing peak flows and proposed peak flows at point of interest locations (pour points) that were selected during the assessment of the existing drainage system, which did not account for the locations of proposed culverts and SWM facilities, since by then, the proposed drainage system was not defined. As a result, some pour point locations are not associated with the location of some proposed SWM facilities and the drainage areas between existing and proposed drainage conditions do not correspond to each other due to the locations of new ramps at the proposed interchanges. In these cases, the comparison between existing peak flows and proposed peak flows (uncontrolled / controlled) is not practical and have been excluded from the comparison of peak flows assessment.

However, the locations of the point of interest (pour points) will be revised to make them more suitable with the locations of the proposed SWM facilities. The results from the revised assessment will be documented in the next submission of this Drainage and Hydrology report.

Exhibit 7.5 (provided at the back of the report), shows the locations of the hydrologic points of interest that are associated with the proposed SWM facilities. This exhibit will be revised and it will be included in the next submission of this Drainage and Hydrology report.

Table 18 will provide a summary of the comparison between the existing and proposed uncontrolled peak flows at the locations where a new SWM pond has been proposed; where as **Table 19** will provide the comparison between the existing and proposed controlled peak flows.

Appendix I provides the SWMHYMO data and summary file for the comparison between existing and proposed uncontrolled peak flows; whereas **Appendix J** includes the comparison between existing and proposed controlled peak flows. **Appendix K** provides the SWMHYMO schematic for the proposed conditions controlled peak flows.

Table 18: Comparison of Existing and Proposed Uncontrolled Peak Flows

Pour Point (Hydraulic Point of Interest)		Peak Flows Comparison (m^3/s) 24-hr SCS Type II																	
Existing	Proposed	2 -year			5 -year			10 -year			25 -year			50 -year			100 -year		
		Existing	Proposed Uncontrolled	Difference	Existing	Proposed Uncontrolled	Difference	Existing	Proposed Uncontrolled	Difference	Existing	Proposed Uncontrolled	Difference	Existing	Proposed Uncontrolled	Difference	Existing	Proposed Uncontrolled	Difference
C10-A-5	P-SWM P-1	0.17	0.28	+0.11	0.38	0.51	+.0.13	0.53	0.67	+0.14	0.73	0.87	+0.14	0.73	1.05	+0.13	1.08	1.20	+0.12
EX-CL-400-5	P-SWM P-2	0.32	0.40	+0.08	0.58	0.71	+0.13	0.77	0.93	+0.16	1.01	1.21	+0.20	1.01	1.50	+0.28	1.40	1.66	+0.26
C11-B-1	P-SWM P-3	0.25	0.34	+0.09	0.45	0.54	+0.09	0.60	0.70	+0.10	0.78	0.92	+0.14	0.78	1.11	+0.16	1.08	1.28	+0.20
C11-B-2	R-Ex Pond-2 (PR-R-10IC-2)	0.15	0.24	+0.09	0.31	0.36	+0.05	0.42	0.45	+0.03	0.57	0.58	+0.01	0.70	0.69	-0.01	0.81	0.78	-0.03
C-15-A-1	P-SWM P-4	0.40	0.60	+0.20	0.69	0.91	+0.22	0.90	1.14	+0.24	1.18	1.45	+0.27	1.18	1.73	+0.31	1.63	1.96	+0.33
C15-B-1	P-SWM P-5	0.18	0.24	+0.06	0.31	0.37	+0.06	0.39	0.47	+0.08	0.50	0.60	+0.10	0.50	0.71	+0.11	0.68	0.80	+0.12
C23-B-1	P-SWM P-6	0.42	0.55	+0.13	0.70	0.87	+0.17	0.90	1.08	+0.18	1.15	1.36	+0.21	1.15	1.62	+0.25	1.55	1.83	+0.28
C23-B-2	P-SWM P-7	0.51	0.77	+0.26	0.87	1.17	+0.30	1.13	1.46	+0.33	1.45	1.80	+0.35	1.45	2.13	+0.39	2.0	2.38	+0.38
C25-B-1	P-SWM P-8	0.09	0.12	+0.03	0.19	0.25	+0.06	0.26	0.36	+0.10	0.36	0.50	+0.14	0.36	0.62	+0.16	0.53	0.72	+0.19
C25-B-2	P-SWM P-9	0.046	0.05	+0.01	0.09	0.11	+0.02	0.13	0.15	+0.02	0.19	0.21	+0.02	0.19	0.27	+0.03	0.28	0.31	+0.03

Table 19: Comparison of Existing and Proposed Controlled Peak Flows

Pour Point (Hydraulic Point of Interest)		Peak Flows Comparison (m^3/s) 24-hr SCS Type II																	
Existing	Proposed	2 -year			5 -year			10 -year			25 -year			50 -year			100 -year		
		Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?	Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?	Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?	Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?	Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?	Existing	Controlled Proposed	Proposed Exceeds Exist. Flow Rate?
C10-A-5	P-SWM P-1	0.17	-	-	0.38	0.31	No	0.53	0.32	No	0.73	0.33	No	0.73	0.34	No	1.08	0.34	No
EX-CL-400-5	P-SWM P-2	0.32	0.09	No	0.58	0.10	No	0.77	0.11	No	1.01	0.12	No	1.01	0.13	No	1.40	0.13	No
C11-B-1	P-SWM P-3	0.25	0.25	No	0.45	0.26	No	0.60	0.26	No	0.78	0.27	No	0.78	0.27	No	1.08	0.28	No
C11-B-2	R-Ex Pond-2 (PR-R-10IC-2)	0.15	0.11	No	0.31	0.11	No	0.42	0.11	No	0.57	0.12	No	0.57	0.12	No	0.81	0.14	No
C-15-A-1	P-SWM P-4	0.40	0.32	No	0.69	0.34	No	0.90	0.36	No	1.18	0.38	No	1.18	0.40	No	1.63	0.42	No
C15-B-1	P-SWM P-5	0.18	0.08	No	0.31	0.08	No	0.39	0.08	No	0.50	0.09	No	0.50	0.08	No	0.68	0.08	No
C23-B-1	P-SWM P-6	0.42	0.41	No	0.70	0.42	No	0.90	0.43	No	1.15	0.45	No	1.15	0.46	No	1.55	0.47	No
C23-B-2	P-SWM P-7	0.51	0.51	No	0.87	0.53	No	1.13	0.55	No	1.45	0.56	No	1.45	0.60	No	2.0	0.60	No
C25-B-1	P-SWM P-8	0.09	0.10	No	0.19	0.12	No	0.26	0.13	No	0.36	0.14	No	0.36	0.14	No	0.53	0.14	No
C25-B-2	P-SWM P-9	0.046	0.05	No	0.09	0.07	No	0.13	0.07	No	0.19	0.08	No	0.19	0.07	No	0.28	0.08	No

9. Erosion and Sediment Control

9.1 Overview

Construction will require clearing of vegetation, topsoil stripping and earth grading that leaves exposed soils vulnerable to wind and water erosion. Stringent sediment and erosion control measures will need to be implemented to ensure that the receiving storm drainage system or watercourse is not negatively impacted by construction practices. Sediment release due to construction activities is not only detrimental to the health of the receiving system but will also result in costly future maintenance work of the existing downstream drainage infrastructure.

Prior to construction, the objectives of the ESCP are to protect the environmental features, water resources and receiving water bodies located within the Study Area, such as the Holland River and Holland River East Branch where runoff from the Bradford Bypass drainage areas discharge into.

During construction, erosion and sedimentation control measures should be implemented to prevent the migration of soils from the site. The following recommendations should be considered when developing the detailed Erosion and Sedimentation Control Plan:

- Minimize erosion potential by implementing effective measures, procedural Best Management Practices (BMPs), and SWM BMPs; and
- Apply sediment control measures (BMPs) to prevent off-site sediment release in the event of sediment mobilization.

The following OPSSs and MTO SPs are recommended for inclusion in the contract documents.

- Environmental Protection During Work in Watercourses and on Watercourse Banks in accordance with OPSS 182;
- Construction Specifications for Temporary Erosion Control (OPSS 804, April 2021);
- Temporary Erosion and Sediment Control Measures in accordance with OPSS 805 and Erosion and Sediment Control in accordance with MTO NSSP (SP805F01);
- Environmental Incident Management Under Legislation Protecting the Environment and Natural Resources in accordance with OPSS 100;
- Management of Excess Materials in accordance with OPSS 180;
- General Environmental Protection in accordance with MTO NSSP;
- Maintenance of Existing Drainage in accordance with MTO NSSP;
- Spill Prevention and Response Contingency Plan in accordance with MTO NSSP;
- Timing of in-water Work in accordance with SSP101F23;
- Construction Specification for Dewatering in accordance with OPSS 517;
- Placement of Aggregates in Waterbodies in accordance with OPSS.PROV 825; and
- Material Specification for Aggregates – Streambed Material with OPSS.PROV 1005.

Vegetative:

- All areas not subject to active construction 30 days after area grading should be top soiled and seeded as per Special Provision 572S01 Oct. 2002 immediately after completion of such grading; and

- Immediately following seed application, a straw erosion control blanket (or equivalent) should be installed on any exposed slopes adjacent to sensitive features, as per OPSS 572.05.07, 572.05.08 and 572.07.04.05.

Structural:

- As construction proceeds, diversion swales should be graded where needed along the right-of-way boundaries to intercept drainage from external areas and direct it away from exposed surfaces;
- Temporary sedimentation traps should be sized based on 125 m^3 per hectare of drainage area;
- All culvert work should be conducted "in the dry";
- All dewatering for culvert installation should be directed to a sediment/dewatering trap;
- The locations of sediment/dewatering traps should be confirmed in the field by the on-site inspector and environmental inspector;
- Temporary silt fencing should be installed around sensitive vegetative features and approximately 2 m from the final toe-of-slope for the roadway embankment widening areas;
- Rock checks dams should be provided in roadside ditches. Rock check dams detain runoff and promote sedimentation, and reduce channel flow velocities thereby reducing potential for channel erosion;
- Runoff from excavated areas or unvegetated soil will not be permitted to discharge off site or directly into active or temporary watercourses or any natural areas; and
- The contractor should abide by the requirements set out in the Greater Golden Horseshoe Area Conservation Authorities Erosion and Sediment Guideline for Urban Construction (December 2006).

9.2 Supervision, Inspection and Maintenance

To ensure that the intent of the ESCP is maintained, and that erosion and sedimentation potential is minimized until the development areas have been stabilized, the following is recommended:

- The construction of the erosion control works should be carefully supervised;
- Inspection of proposed measures should be completed after periods of excessive precipitation (i.e., rainfall depths exceed 15 mm);
- Bi-weekly inspection reports prepared by the engineer responsible for the Project should be submitted to the contract administrator during construction until the development area has been stabilized;
- Control features that fail should be repaired and an evaluation should be completed to determine whether additional measures are required; and
- Prior to removal of controls, the contractor, and the engineer responsible for the Project should conduct a joint inspection of the development area.

10. Summary and Conclusions

This Drainage and Stormwater Management (SWM) report has been prepared to document the existing and proposed drainage systems for the Bradford Bypass, including hydrologic and hydraulic assessments of existing and proposed culverts and proposed bridges, the conceptual stormwater management (SWM) strategy and a high-level Erosion and Sediment Control Plan (ESCP).

The assessments of the existing and proposed drainage systems can be summarized as follows:

An evaluation was completed for the existing culverts along Highway 400, Highway 404 and Sideroad culverts within the Study Area. A hydrologic and hydraulic assessment are provided in Sections 3.4 and 3.5 of this Report. The hydrologic assessment was done using the 2021 IDF curves from the MTO online tool. The hydraulic assessment found that:

- Culverts EX-CL-400-3, EX-CL-400-6 and EX-CL-1 satisfy the Design Criteria (Depth Criterion (HW/D ≤ 1.5), 50-year Freeboard Criterion (FB ≥ 1m), and the Overtopping Criterion (no road overtopping during the 100-year storm)).
- Culverts EX-CL-400-1, EX-CL-400-5, EX-CL-2 and EX-CL-20 do not satisfy all of the Design Criteria
- Assessment of EX-CL-12 was not performed as the culvert is located outside the Study Area. EX-CL-15 can be replaced with a like-for-like size as this culvert acts as an equalizer culvert.
- Culvert EX-CL-404-2 is a structural culvert (4880 mm x 3050 mm) located along a regulated watercourse by Lake Simcoe Region Conservation Authority (LSRCA).
- EX-CL-14 (Metrolinx Culvert) does not meet any of the standards with the exception of HW/D < 1.5 ratio under the 100-year storm.
- Culverts EX-CL-8 and EX-CL-9 were evaluated as part of the early works (County Road 4) for Bradford Bypass (GWP 2008-21-00).

Several new culverts are proposed as part of the Bradford Bypass, the highway ramps at interchanges as well as impacted sideroads. A hydrologic and hydraulic assessment are provided in Sections 5.3 and 5.4 of this Report. The hydrologic assessment was done using the 2097 IDF curves from the MTO online tool. An evaluation of the proposed transverse, highway ramps and sideroad culverts found that:

- All proposed culverts satisfy the Design Criteria (Depth Criterion (HW/D ≤ 1.5), 50-year Freeboard Criterion (FB ≥ 1m), and the Overtopping Criterion (no road overtopping during the 100-year storm).
- The major bridge crossings for the Holland River and Holland River East Branch were included in the HEC-RAS model as discussed in Sections 4 and 6 of this Report.

A preliminary SWM strategy was developed to minimize impacts in terms of water quality and erosion potential to the existing drainage system and natural environment along the Bradford Bypass (BBP) due to the proposed road widening and proposed highway works. It must be noted that SWM measures do not exist under existing drainage conditions along the BBP. The SWM strategy for this Bradford Bypass Project is provided in Section 8 of this Report and includes:

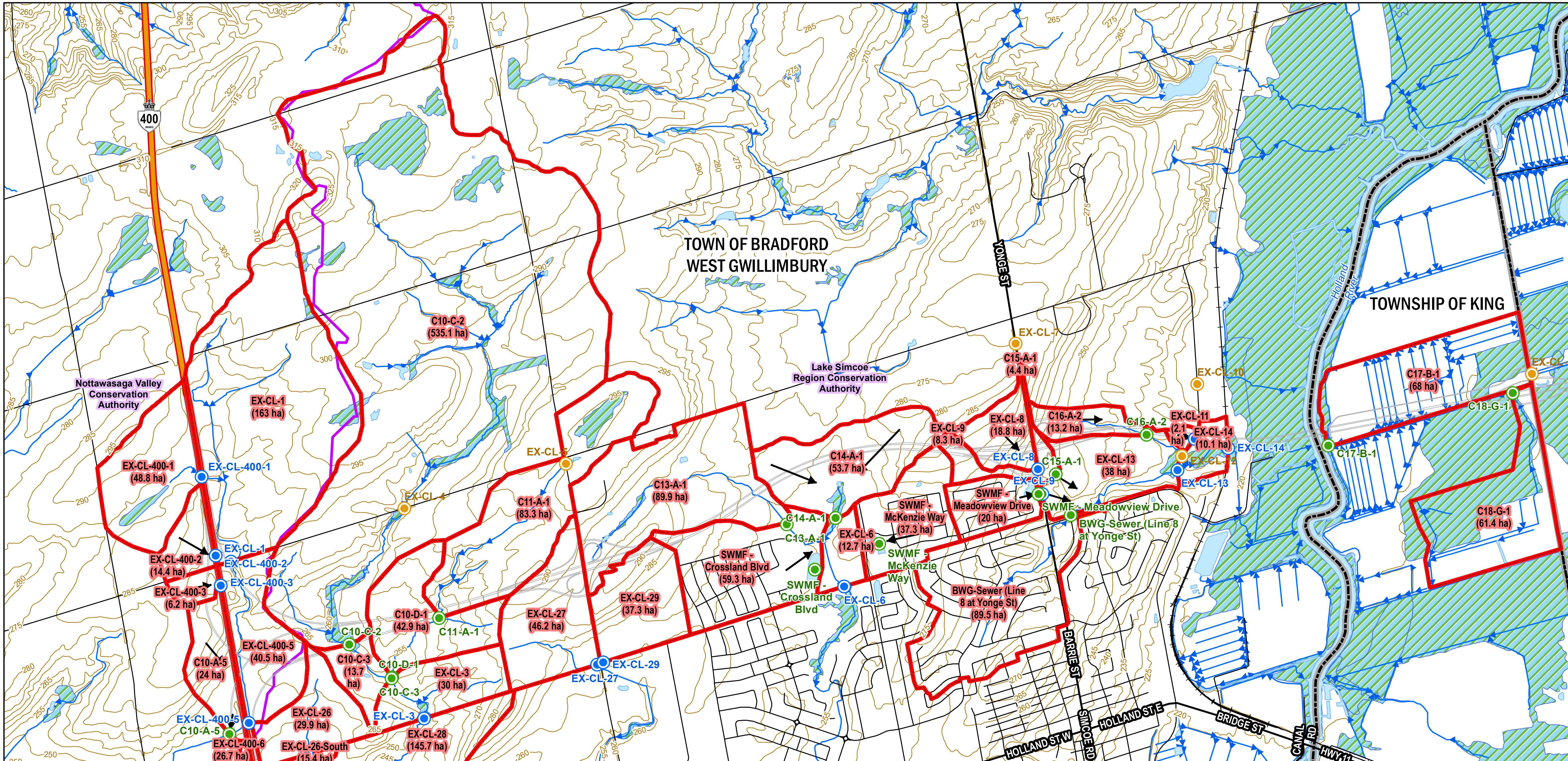
- 15,225 m of flat-bottom grassed swales are proposed along the north and south side of the Bradford Bypass where MECP standards are satisfied. In addition, enhanced grassed swales particularly at the upstream area to wetlands, marshes, and fish sensitive areas will be provided to prevent untreated runoff from discharging directly to these areas.
- Nine (9) SWM ponds that will provide quantity and quality control of runoff, located at highway interchanges where required.

  - Relocation of existing ponds (R-EX Pond-1 and R-EX-Pond 2) located at the Bradford Bypass and 10th Sideroad Interchange.
  - The highway areas that will not be feasible to be treated by SWM ponds will be treated by flat bottom grassed swales and enhanced grassed swales to be designed according to MECP design standards and requirements.
- Stringent sediment and erosion control measures will need to be implemented to ensure that the receiving storm drainage system or watercourse is not negatively impacted by construction practices. Recommendations for erosion and sediment control, including supervision, inspection and maintenance, are provided in Section 8 of this Report.

Section 9 documents the preliminary Erosion and Sediment Control Plan (ESCP). The main objectives of the preliminary ESCP are to minimize erosion potential by implementing effective measures, procedural Best Management Practices (BMPs), and SWM BMPs, and apply sediment control measures (BMPs) to prevent off-site sediment release in the event of sediment mobilization and to protect environmental sensitive areas from the uncontrolled discharge of sediment laden runoff.

Exhibits

- Exhibits 3.1 to 3.7: Existing Drainage Mosaic
- Exhibit 3.8: Study Area 3 Watersheds
- Exhibit 3.9: Penville Creek Tributary Location
- Exhibits 5.1 to 5.2: Proposed Drainage Mosaic
- Exhibits 7.1 to 7.4: Stormwater Management (SWM) Plan



Proposed Bradford Bypass (shown for illustration purposes)
Direction of Flow
Subcatchment Pour Point - Existing Culvert
Subcatchment Pour Point - Point of Interest
Existing Culverts Outside Study Area (Not Evaluated)
Subcatchment Boundary
Contours (5 m)
Existing Watercourse
Waterbody
Wetland
Existing Freeway
Existing Major Road
Existing Local Road
Railway
Conservation Authority Boundary
Municipal Boundary

EX-CL-1 (164 ha) Subcatchment ID Area

Note: Points of interest and proposed highway alignment are shown for information purposes only.

Keymap

AECOM

Ontario
Ministry of Transportation

N W E S

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

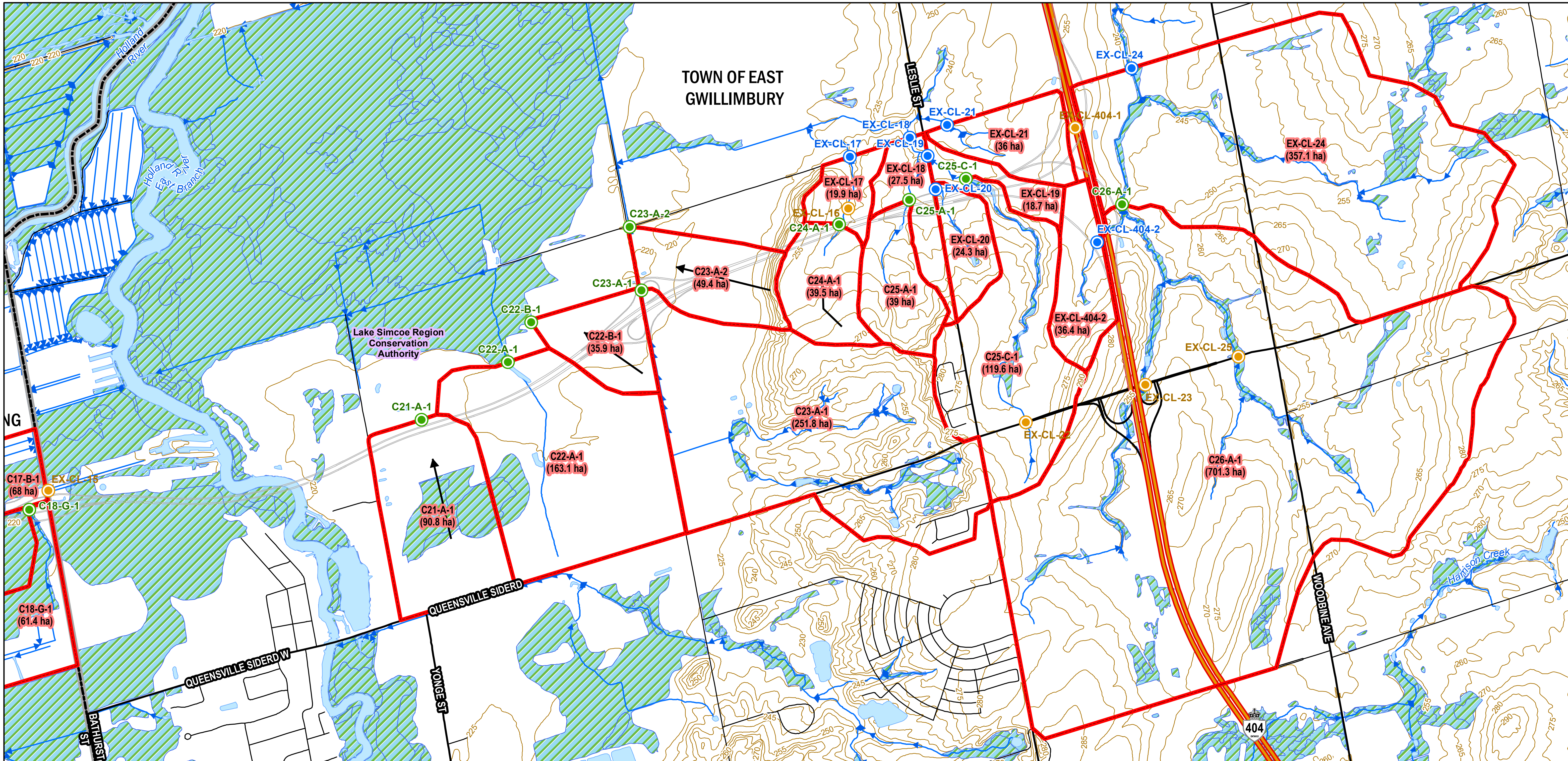
Scale: 1:25,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.1



- Proposed Bradford Bypass (shown for illustration purposes)
- Direction of Flow
- Subcatchment Pour Point - Existing Culvert
- Subcatchment Pour Point - Point of Interest
- Existing Culverts Outside Study Area (Not Evaluated)
- Subcatchment Boundary
- Contours (5 m)
- Existing Watercourse
- Waterbody
- Wetland
- Existing Freeway
- Existing Major Road
- Existing Local Road
- Railway
- Conservation Authority Boundary
- Municipal Boundary

EX-CL-1 Subcatchment ID
(164 ha) Area

Note: Points of interest and proposed highway alignment are shown for information purposes only.

Keymap

AECOM

Ontario
Ministry of Transportation

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

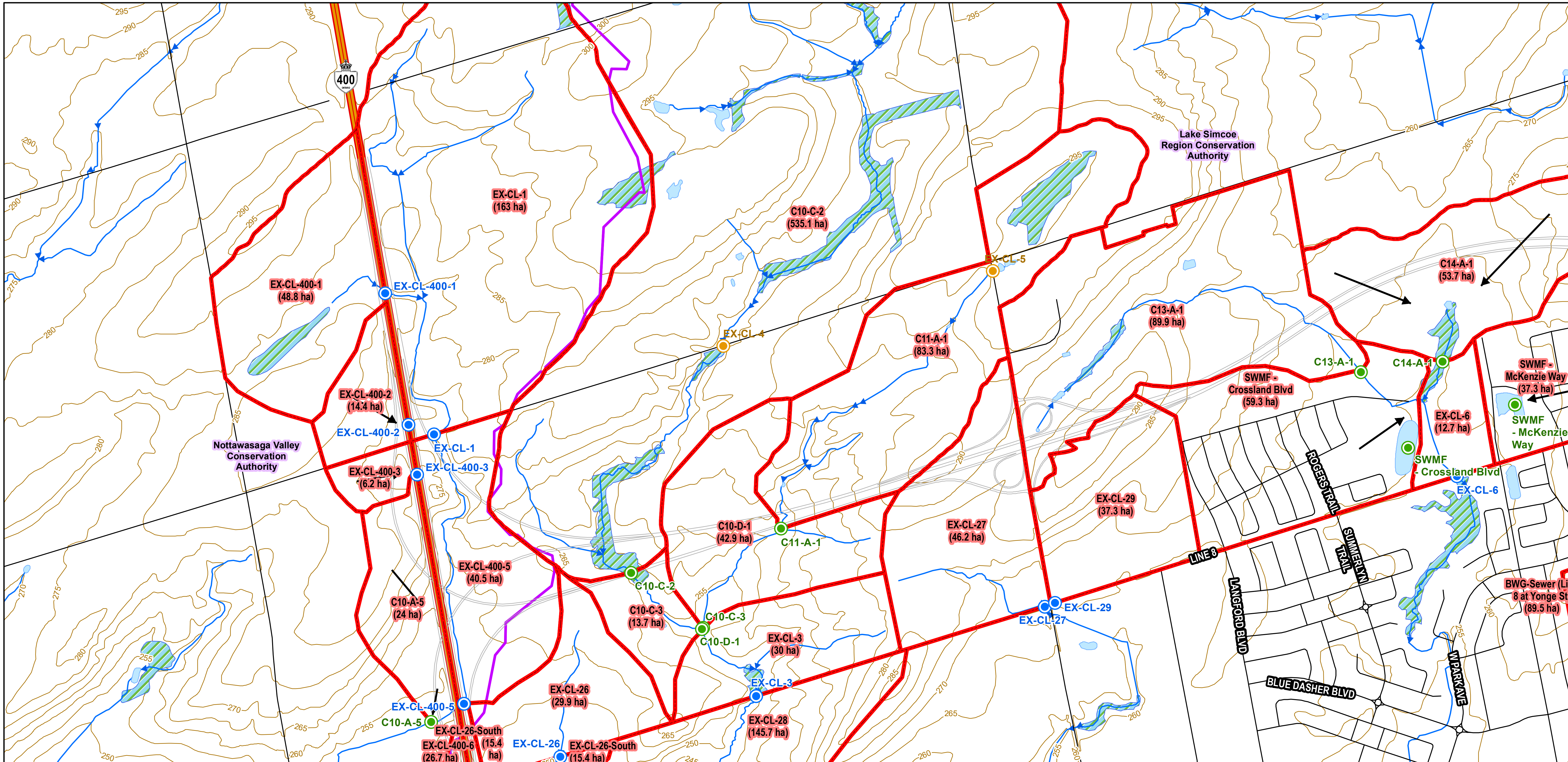
Scale: 1:25,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.2



Proposed Bradford Bypass (shown for illustration purposes)
Direction of Flow
Subcatchment Pour Point - Existing Culvert
Subcatchment Pour Point - Point of Interest
Existing Culverts Outside Study Area (Not Evaluated)
Subcatchment Boundary
Contours (5 m)
Existing Watercourse
Waterbody
Wetland

Existing Freeway
Existing Local Road
Railway
Conservation Authority Boundary
Municipal Boundary

EX-CL-1 Subcatchment ID
(164 ha) Area

Note: Points of interest and proposed highway alignment are shown for information purposes only.

AECOM

Ontario Ministry of Transportation

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

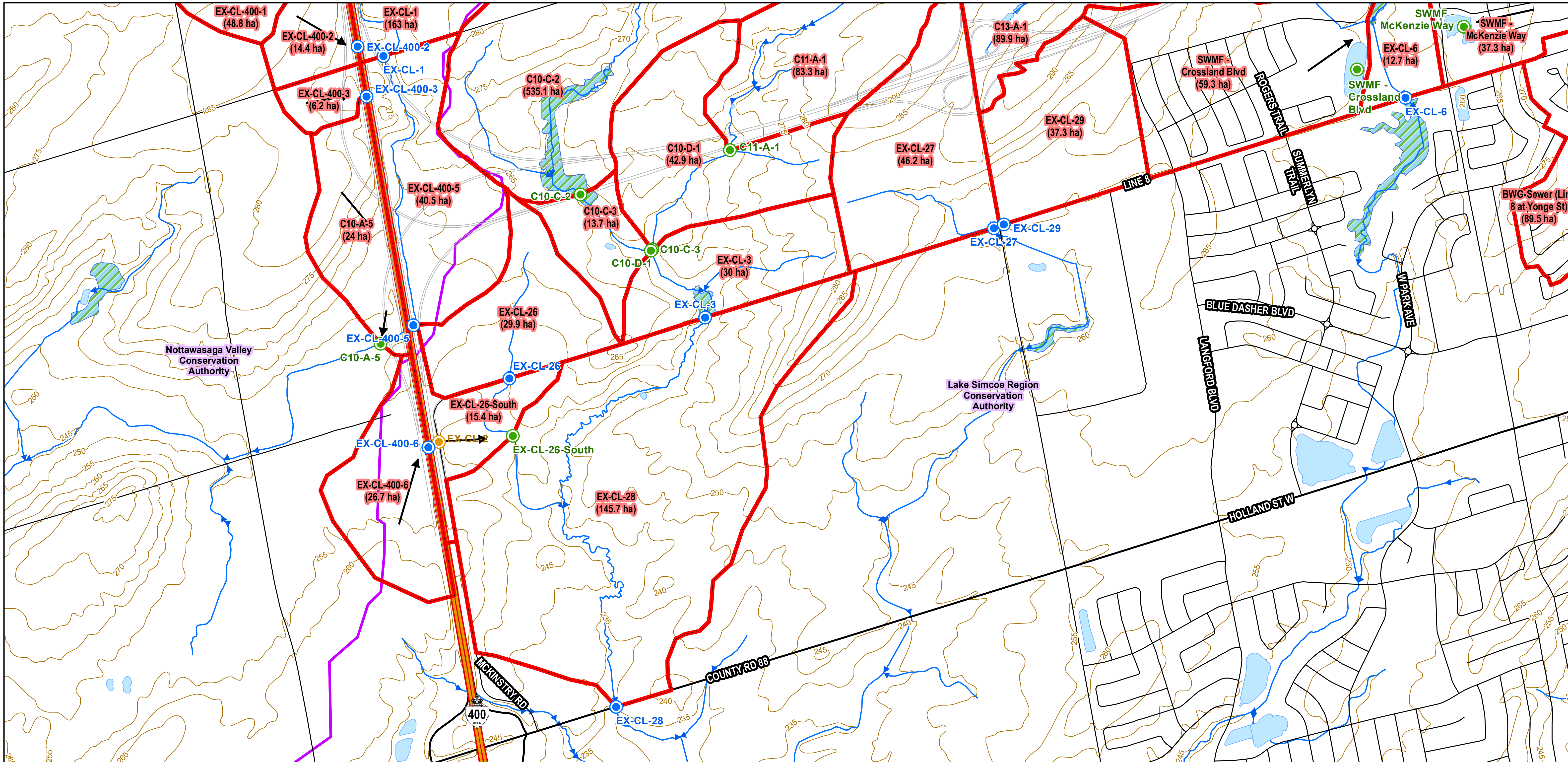
Scale: 1:15,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.3



Proposed Bradford Bypass (shown for illustration purposes)
Direction of Flow
Subcatchment Pour Point - Existing Culvert
Subcatchment Pour Point - Point of Interest
Existing Culverts Outside Study Area (Not Evaluated)
Subcatchment Boundary
Contours (5 m)
Existing Watercourse
Waterbody
Wetland

Existing Freeway
Existing Major Road
Existing Local Road
Railway
Conservation Authority Boundary
Municipal Boundary

EX-CL-1 Subcatchment ID
(164 ha) Area

Note: Points of interest and proposed highway alignment are shown for information purposes only.

Keymap

AECOM

Ontario
Ministry of Transportation

N
W E
S

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

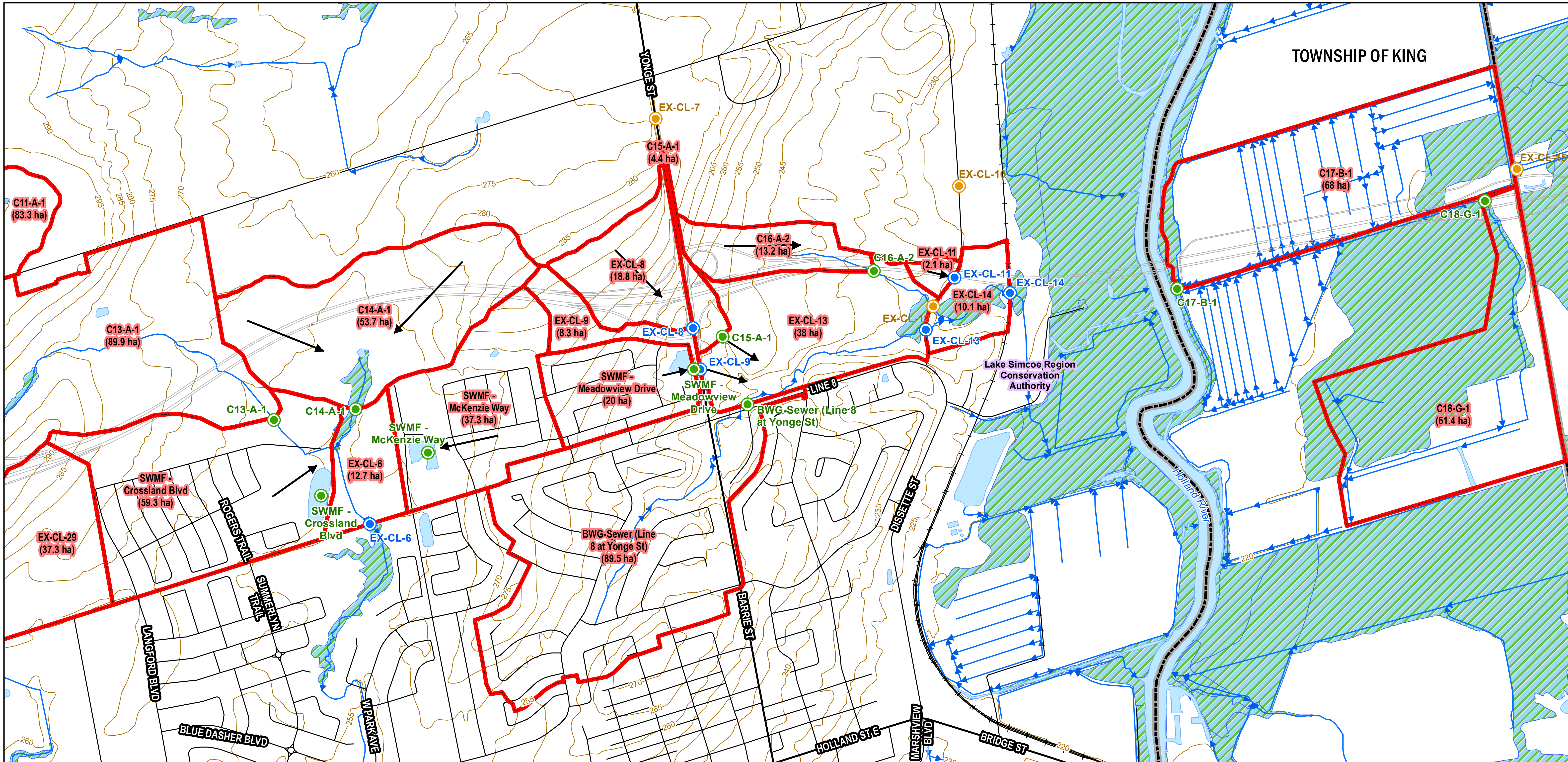
Scale: 1:15,000

**Ontario Ministry of Transportation
Central Region**

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

**DRAFT
Overall Existing Conditions
Drainage Mosaic**

Exhibit 3.4



- Proposed Bradford Bypass (shown for illustration purposes)
- Direction of Flow
- Subcatchment Pour Point - Existing Culvert
- Subcatchment Pour Point - Point of Interest
- Existing Culverts Outside Study Area (Not Evaluated)
- Subcatchment Boundary
- Contours (5 m)
- Existing Watercourse
- Waterbody
- Wetland
- Existing Major Road
- Existing Local Road
- Railway
- Conservation Authority Boundary
- Municipal Boundary

EX-CL-1 (164 ha) Subcatchment ID Area

Note: Points of interest and proposed highway alignment are shown for information purposed only.

Keymap

AECOM

Ontario Ministry of Transportation

N W E S

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000 Meters

July 2023

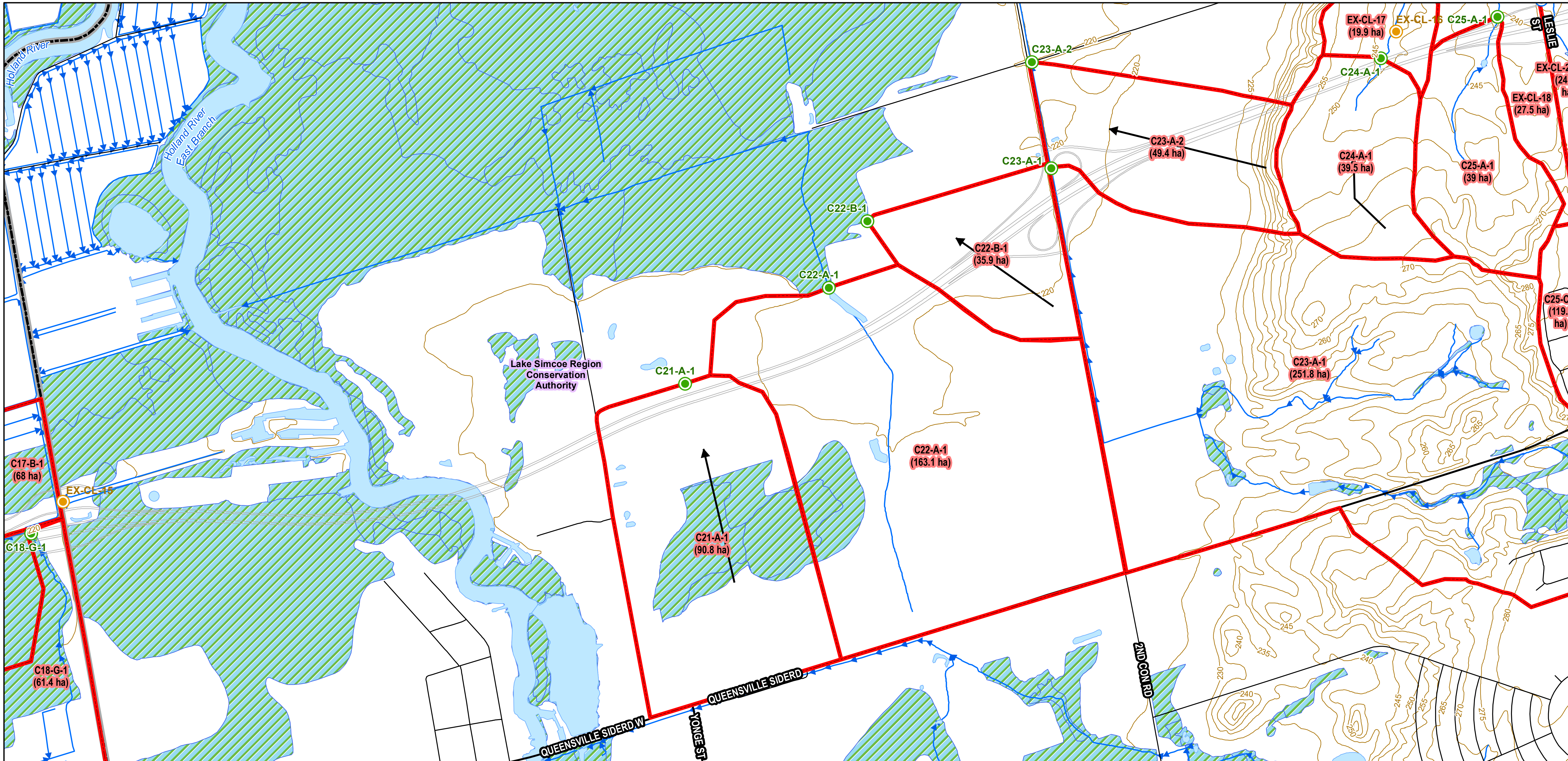
Scale: 1:15,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.5



- Proposed Bradford Bypass (shown for illustration purposes)
- Direction of Flow
- Subcatchment Pour Point - Existing Culvert
- Subcatchment Pour Point - Point of Interest
- Existing Culverts Outside Study Area (Not Evaluated)
- Subcatchment Boundary
- Contours (5 m)
- Existing Watercourse
- Waterbody
- Wetland
- Existing Major Road
- Existing Local Road
- Railway
- Conservation Authority Boundary
- Municipal Boundary

EX-CL-1 Subcatchment ID
(164 ha) Area

Note: Points of interest and proposed highway alignment are shown for information purposes only.

Keymap

AECOM

Ontario
Ministry of Transportation

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

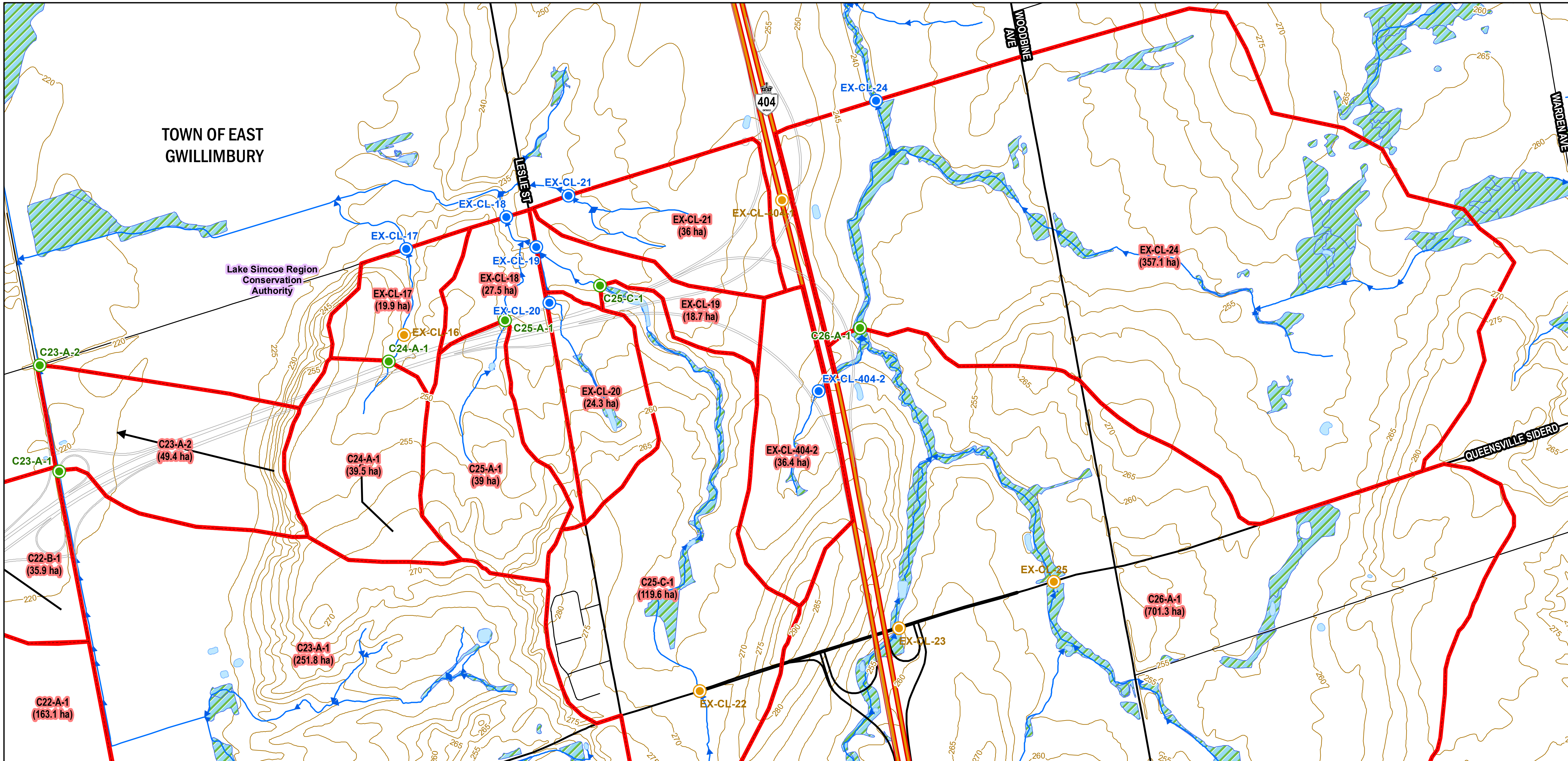
Scale: 1:15,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.6



- Proposed Bradford Bypass (shown for illustration purposes)
- Direction of Flow
- Subcatchment Pour Point - Existing Culvert
- Subcatchment Pour Point - Point of Interest
- Existing Culverts Outside Study Area (Not Evaluated)
- Subcatchment Boundary
- Contours (5 m)
- Existing Watercourse
- Waterbody
- Wetland
- Existing Freeway
- Existing Major Road
- Existing Local Road
- Railway
- Conservation Authority Boundary
- Municipal Boundary

EX-CL-1 Subcatchment ID
(164 ha) Area

Note: Points of interest and proposed highway alignment are shown for information purposed only.

Keymap

AECOM

Ontario
Ministry of Transportation

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 250 500 1,000
Meters

July 2023

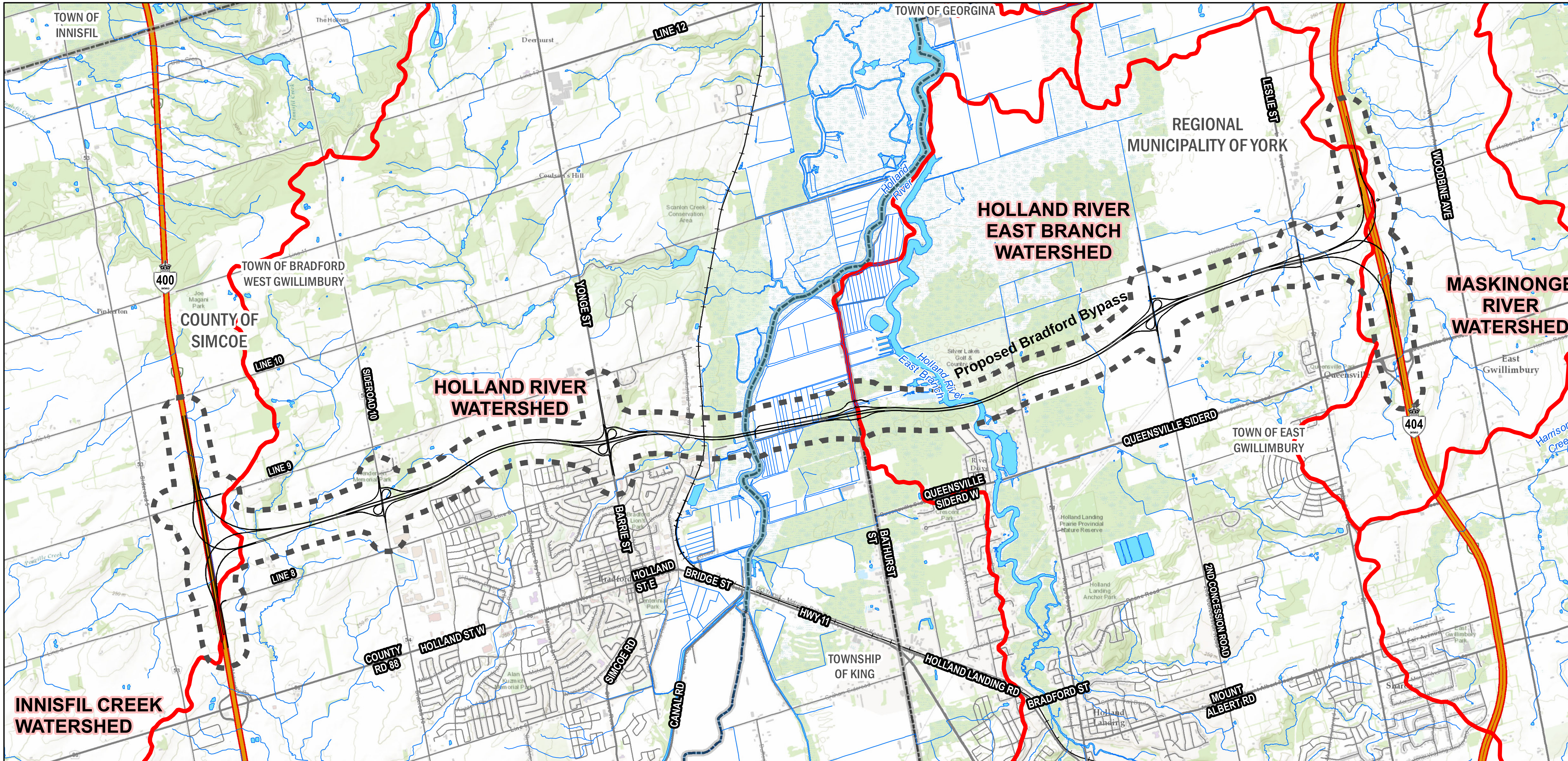
Scale: 1:15,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

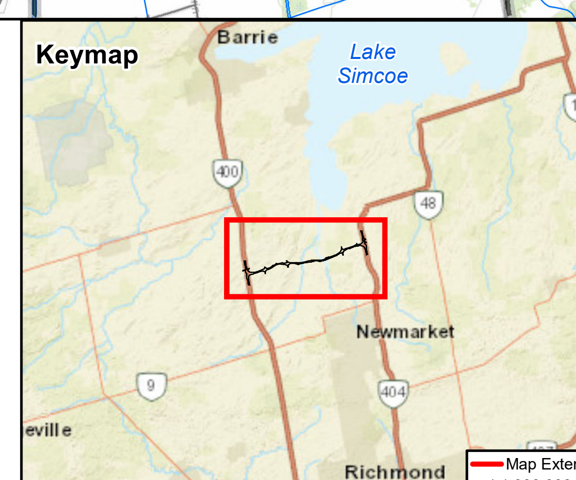
DRAFT
Overall Existing Conditions Drainage Mosaic

Exhibit 3.7



Legend

- Proposed Bradford Bypass
- Study Area Limits
- Watershed Boundary
- Existing Freeway
- Existing Major Road
- Existing Local Road
- Railway (Metrolinx)
- Municipal Boundary



AECOM

Ontario
Ministry of Transportation

N
W E
S

Datum: NAD 1983 CSRS MTM 10

Source: Contains information licensed under the Open Government Licence Ontario. Base map provided by ESRI.

0 0.5 1 2 3
Kilometers

July 2023

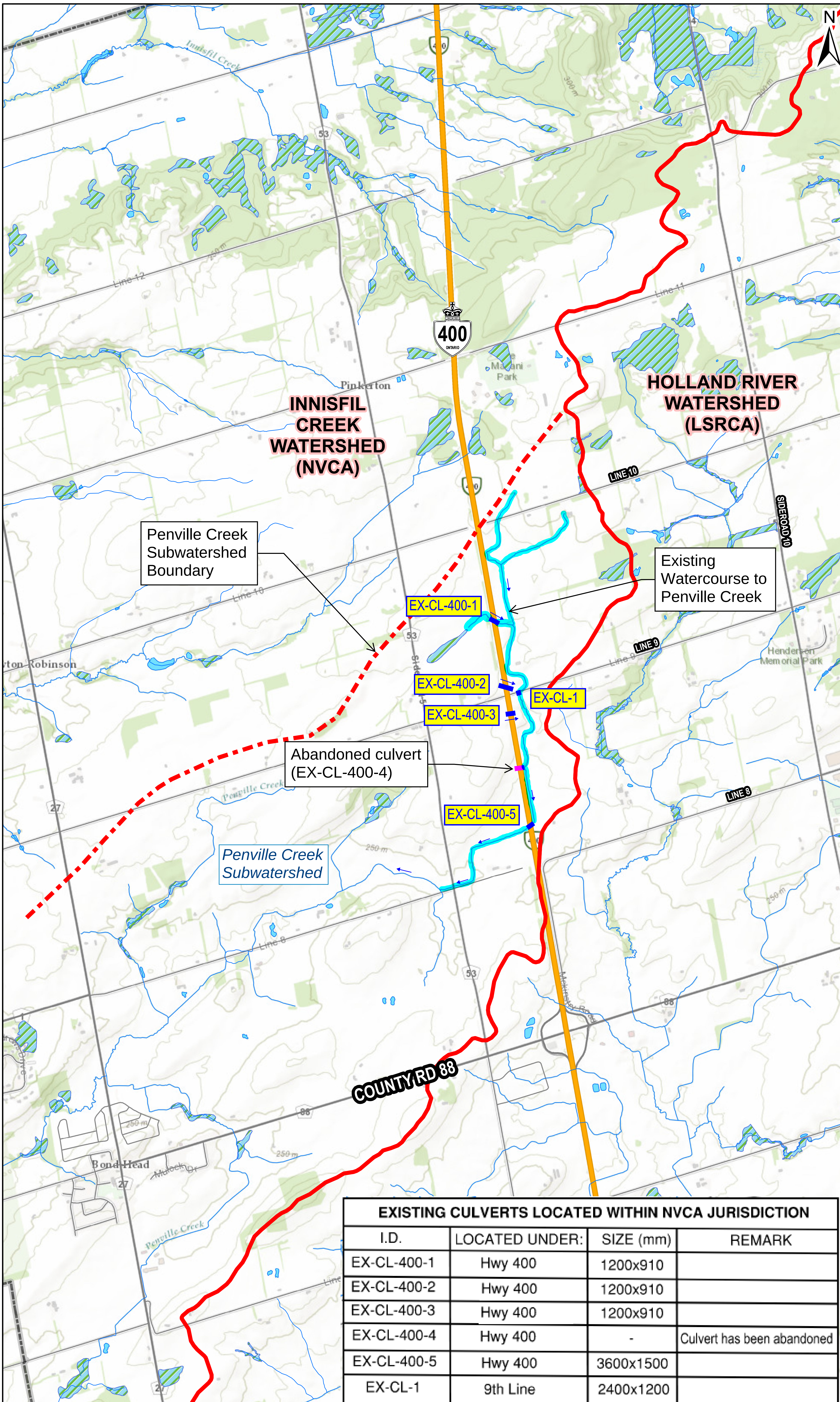
Scale: 1:50,000

Ontario Ministry of Transportation Central Region

60636190
Highway 400 - Highway 404 Link (The Bradford Bypass)
WO # 19-2001
Assignment Number: 2019-E-0048

River Watersheds within the Study Area

Exhibit 3.8



EXISTING CULVERTS LOCATED WITHIN NVCA JURISDICTION			
I.D.	LOCATED UNDER:	SIZE (mm)	REMARK
EX-CL-400-1	Hwy 400	1200x910	
EX-CL-400-2	Hwy 400	1200x910	
EX-CL-400-3	Hwy 400	1200x910	
EX-CL-400-4	Hwy 400	-	Culvert has been abandoned
EX-CL-400-5	Hwy 400	3600x1500	
EX-CL-1	9th Line	2400x1200	

Exhibit 3.9

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES WILL BE EVALUATED TO ENSURE THEIR HYDRAULIC PERFORMANCE MEETS MINISTRY DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES WILL BE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE AN AVERAGE CROSS SECTION OF 2.0 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF LESS THAN 1%.
PERMANENT FLOW CHECK DAMS WILL BE PROVIDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOEN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date | Reviewer
Date | Reviewer
Date | Reviewer

LEGEND

- CATCHMENT BOUNDARY
- PR-R-BBP-3 / 2.4ha: CATCHMENT I.D. / CATCHMENT AREA
- PROPOSED CULVERT
- PROPOSED STRUCTURAL CULVERT
- PROPOSED OVERFLOW CULVERT
- PR-R-BBP-4: PROPOSED CULVERT I.D.
- PROPOSED SIDE DITCH
- PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY
- EXISTING SWM FACILITY TO BE RELOCATED
- PROPOSED ROW
- LIMITS OF GRADING
- EXISTING WATERCOURSE

SCALE

BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PROPOSED DRAINAGE MOSAIC

EXHIBIT
5.1

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES WILL BE EVALUATED TO ENSURE THEIR HYDRAULIC PERFORMANCE MEETS MINISTRY DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES WILL BE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE AN AVERAGE CROSS SECTION OF 2.0 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF LESS THAN 1%.
PERMANENT FLOW CHECK DAMS WILL BE PROVIDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOEN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date | Reviewer
Date | Reviewer
Date | Reviewer

LEGEND

- CATCHMENT BOUNDARY
- PR-R-BBP-3 2.4ha — CATCHMENT I.D. / CATCHMENT AREA
- PROPOSED CULVERT
- PROPOSED STRUCTURAL CULVERT
- PROPOSED OVERFLOW CULVERT
- PR-R-BBP-4 — PROPOSED CULVERT I.D.
- PROPOSED SIDE DITCH
- PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY
- EXISTING SWM FACILITY TO BE RELOCATED
- PROPOSED ROW
- LIMITS OF GRADING
- EXISTING WATERCOURSE

SCALE

0 100 200 METERS

BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PROPOSED DRAINAGE MOSAIC

EXHIBIT 5.2

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES SHOULD BE CONFIRMED DURING THE DETAIL DESIGN PHASE TO ASSURE THEIR HYDRAULIC PERFORMANCE MEET MTO DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES ARE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE AN AVERAGE CROSS SECTION OF 2.0 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF 1% OR LESS.
PERMANENT FLOW CHECK DAMS ARE RECOMMENDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOWN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date | Reviewer

Date | Reviewer

Date | Reviewer

LEGEND

AREA TO BE TREATED BY SWM PONDS	PROPOSED MECP FLAT BOTTOM GRASSED SWALE FOR WATER QUALITY OF RUNOFF
PROPOSED CULVERT	PROPOSED CULVERT I.D. (PR-R-BBP-4)
PROPOSED STRUCTURAL CULVERT	PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY WITH OUTFLOW DIRECTION
PROPOSED OVERFLOW CULVERT	EXISTING SWM FACILITY TO BE RELOCATED WITH OUTFLOW DIRECTION
PROPOSED SIDE DITCH	
PROPOSED ROW	EXISTING WATERCOURSE

SCALE

0 50 100 200 METERS

BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PROPOSED STORMWATER MANAGEMENT PLAN

EXHIBIT 7.1

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES SHOULD BE CONFIRMED DURING THE DETAIL DESIGN PHASE TO ASSURE THEIR HYDRAULIC PERFORMANCE MEET MTO DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES ARE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE AN AVERAGE CROSS SECTION OF 2.0 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF 1% OR LESS.
PERMANENT FLOW CHECK DAMS ARE RECOMMENDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOWN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date | Reviewer

Date | Reviewer

Date | Reviewer

LEGEND

- AREA TO BE TREATED BY SWM PONDS
- PROPOSED CULVERT
- PROPOSED STRUCTURAL CULVERT
- PROPOSED OVERFLOW CULVERT
- PROPOSED SIDE DITCH
- PROPOSED MECP FLAT BOTTOM GRASSED SWALE FOR WATER QUALITY OF RUNOFF
- PR-R-BBP-4 PROPOSED CULVERT I.D.
- PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY WITH OUTFLOW DIRECTION
- EXISTING SWM FACILITY TO BE RELOCATED WITH OUTFLOW DIRECTION
- PROPOSED ROW
- EXISTING WATERCOURSE

SCALE

0 50 100 200 METERS

BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PROPOSED STORMWATER MANAGEMENT PLAN

EXHIBIT 7.2

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES SHOULD BE CONFIRMED DURING THE DETAIL DESIGN PHASE TO ASSURE THEIR HYDRAULIC PERFORMANCE MEET MTO DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES ARE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE AN AVERAGE CROSS SECTION OF 2.0 m BOTTOM WIDTH, 2.5:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF 1% OR LESS.
PERMANENT FLOW CHECK DAMS ARE RECOMMENDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOWN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date — Reviewer

Date — Reviewer

Date — Reviewer

LEGEND

AREA TO BE TREATED BY SWM PONDS

PROPOSED CULVERT

PROPOSED STRUCTURAL CULVERT

PROPOSED OVERFLOW CULVERT

PROPOSED SIDE DITCH

PROPOSED MECP FLAT BOTTOM GRASSED SWALE FOR WATER QUALITY OF RUNOFF

PR-R-BBP-4 PROPOSED CULVERT I.D.

PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY WITH OUTFLOW DIRECTION

EXISTING SWM FACILITY TO BE RELOCATED WITH OUTFLOW DIRECTION

PROPOSED ROW

EXISTING WATERCOURSE

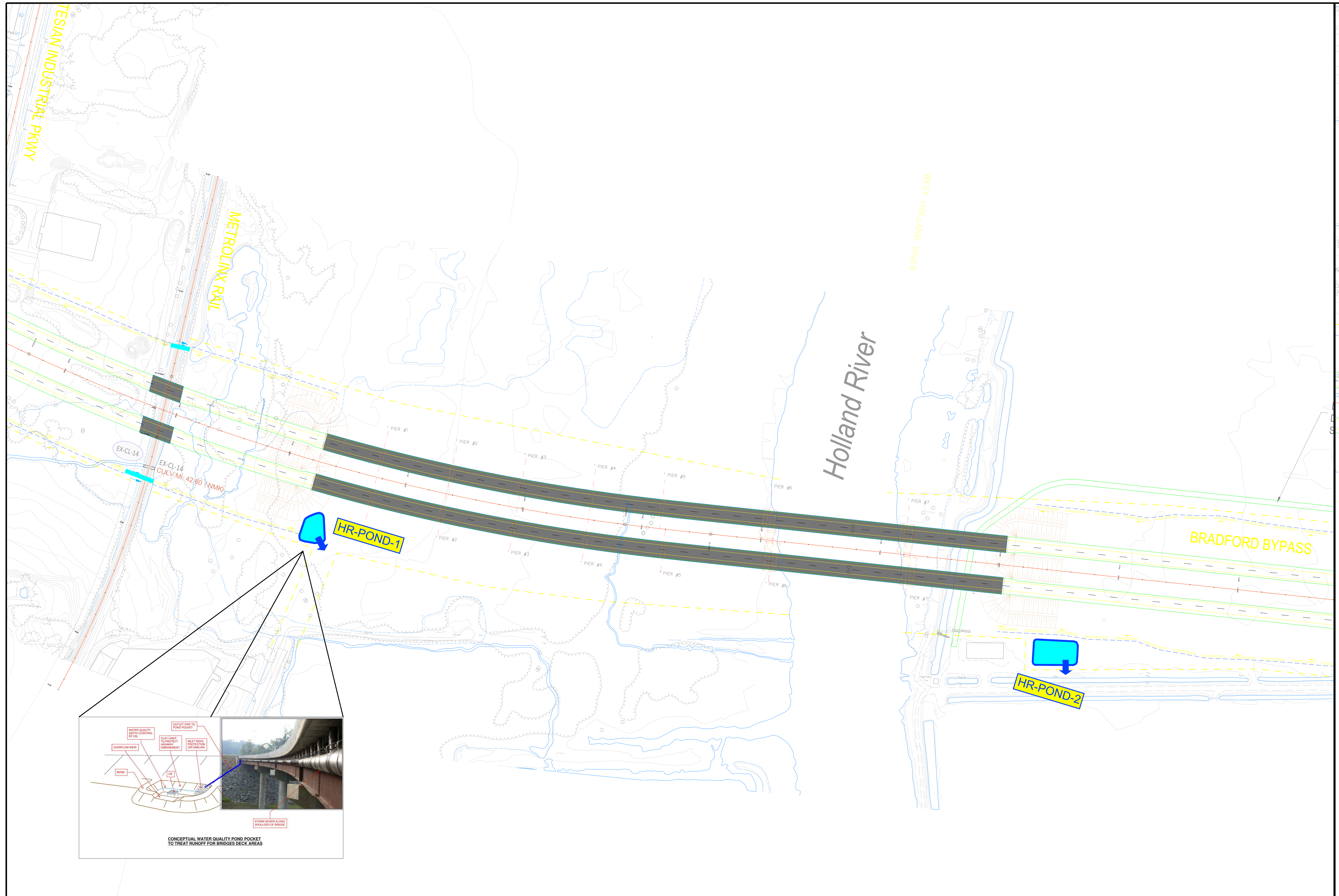
SCALE

0 50 100 200 METERS

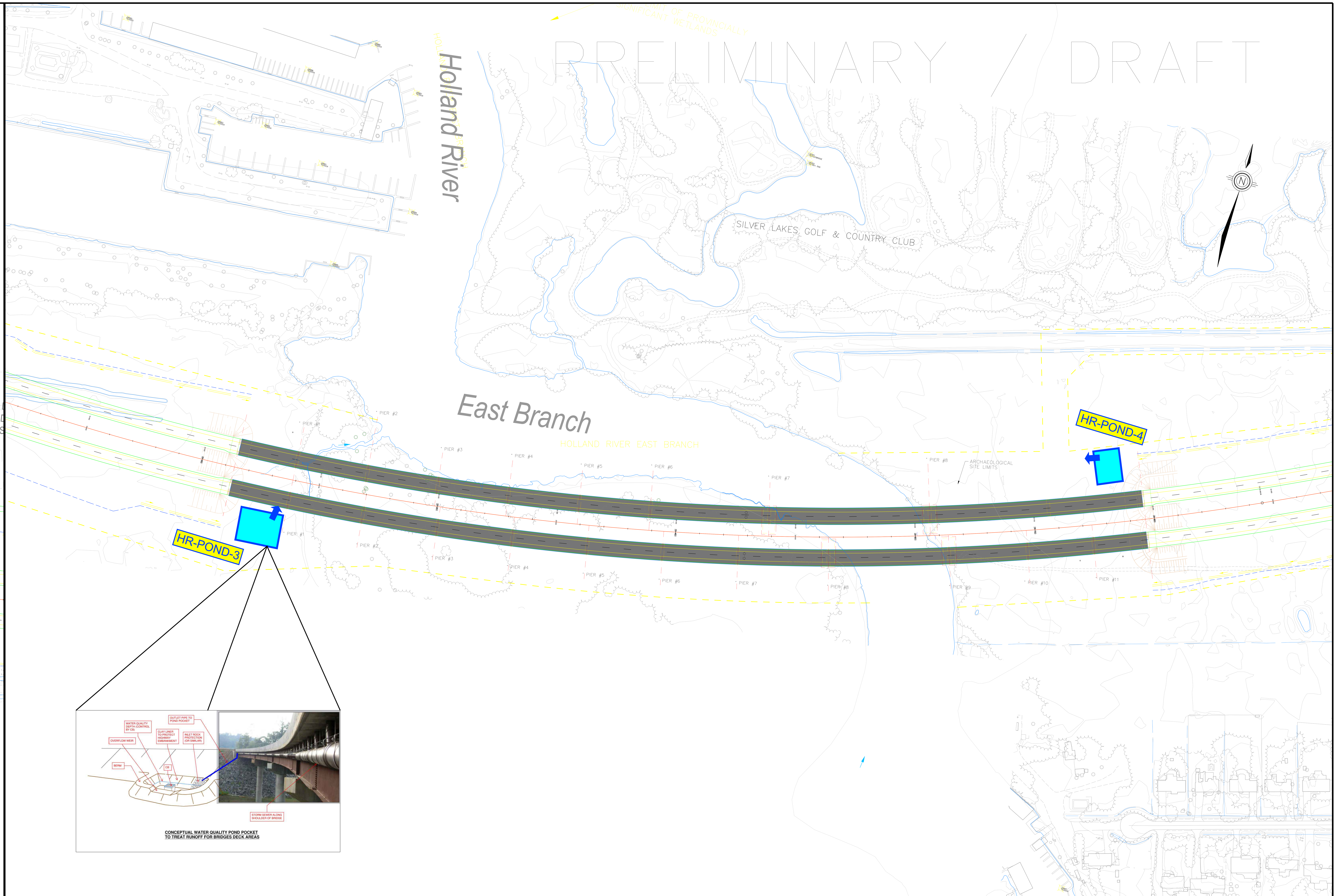
BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PROPOSED STORMWATER MANAGEMENT PLAN

EXHIBIT 7.3



PRELIMINARY STORMWATER MANAGEMENT POND - HOLLAND RIVER BRIDGE AND MARSH AREAS



PRELIMINARY STORMWATER MANAGEMENT POND - HOLLAND RIVER EAST BRANCH BRIDGE AND MARSH AREAS

Ontario

AECOM

NOTES:

SIDE DITCHES FOR RUNOFF CONVEYANCE:

SIDE DITCHES ALONG BRADFORD BYPASS WILL BE PROVIDED WITH A SECTION OF 1.2 m BOTTOM WIDTH, 3:1 SIDE SLOPES, AND A MINIMUM OF 0.5 m DEPTH.
THE SIDE DITCHES WILL BE EVALUATED TO ENSURE THEIR HYDRAULIC PERFORMANCE MEETS MINISTRY DESIGN STANDARDS.

FLAT BOTTOM GRASSED SWALES FOR WATER QUALITY TREATMENT OF RUNOFF:

GRASSED SWALES WILL BE PROVIDED WHERE MINISTRY OF ENVIRONMENT, CONSERVATION AND PARKS (MECP) REQUIREMENTS ARE MET.
THE SWALES WILL HAVE A CROSS SECTION OF 1.2 TO 3.0 m BOTTOM WIDTH, 3:1 SIDE SLOPES, A MINIMUM 0.5 m DEPTH AND A LONGITUDINAL SLOPE OF LESS THAN 1%.
PERMANENT FLOW CHECK DAMS WILL BE PROVIDED IN THE SWALES TO PROVIDE RUNOFF STORAGE FOR LOW RAINFALL EVENTS AND TO SLOW DOWN FLOW VELOCITIES.

REVISIONS

REVIEWED BY:

Date	Reviewer
Date	Reviewer
Date	Reviewer

LEGEND

CATCHMENT BOUNDARY

PR-R-BBP-3 / 2.4ha — CATCHMENT I.D. / CATCHMENT AREA

PROPOSED CULVERT

PROPOSED STRUCTURAL CULVERT

PROPOSED OVERFLOW CULVERT

PR-R-BBP-4 — PROPOSED CULVERT I.D.

PROPOSED SIDE DITCH

PROPOSED STORMWATER MANAGEMENT (SWM) FACILITY

EXISTING SWM FACILITY TO BE RELOCATED

PROPOSED ROW

LIMITS OF GRADING

EXISTING WATERCOURSE

SCALE

0 50 100 METERS

BRADFORD BYPASS
HIGHWAY 400-404 LINK (GWP 2008-21-00)

PRELIMINARY DRAINAGE AND STORMWATER MANAGEMENT PLAN

EXHIBIT 7.4

AECOM Canada Ltd.
50 Sportsworld Crossing Road, Suite 290
Kitchener, ON
N2P 0A4

Tel: 519.650.5313
Fax:519.650.3424
Aecocm.com