

Appendix C

Fluvial Geomorphological Assessment Memorandum



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Project #: 60683946
Project Name: Greenhouse Road Reconstruction and Extension
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Greenhouse Road Reconstruction and Extension Project Memorandum

Subject: Fluvial Geomorphological Assessment

1. Introduction

AECOM Canada Ltd. (AECOM) has been retained by the Woolwich Township to complete the Municipal Class Environmental Assessment study for the reconstruction of Greenhouse Road from Highway 7 (Victoria Street North) to the Metrolinx Rail Corridor, in Breslau, Ontario. This includes the extension of Greenhouse Road south of Kramp Road to the Metrolinx Corridor, with a turnaround area at the southerly end of the Greenhouse Road extension. The study is evaluating various alternatives for the cross section of the road extension. The intent of the project is to fully urbanize Greenhouse Road in this area to service existing and future development within the Breslau Settlement Area.

The study is being conducted in accordance with Schedule 'B' requirements of the Municipal Engineers Association "Municipal Class Environmental Assessment" manual (as recently amended in 2015) which is approved under the *Ontario Environmental Assessment Act*.

The current Fluvial Geomorphological Assessment memorandum is a high-level study of the fluvial features present in the area of the proposed Greenhouse Road reconstruction and extension. The results of the fluvial geomorphological assessment will support the evaluation of the Greenhouse Road reconstruction and extension alternatives, including the recommended water crossing design in support of the preferred cross section alternative. The results of the fluvial geomorphological assessment will also inform the Environmental Impact Study (EIS), which is being completed by AECOM under a separate cover. The three Greenhouse Road alternatives being evaluated for the proposed road extension are presented in **Table 1-1** and also includes the road reconstruction component. Alternative 1 is the preferred solution.

Table 1-1: Greenhouse Road Cross Section Alternatives

Alternative 1	Alternative 2	Alternative 3
Road Extension: Two-lane urbanized cross-section with sidewalks on both sides of the road, including culvert upgrade south of Kramp Road.	Road Extension: Two-lane urbanized cross-section with - Multi-use pathway on one side of the road, including culvert upgrade south of Kramp Road.	Road Extension: Two-lane urbanized cross-section with sidewalks on both sides of the road and bike lanes within the roadway width, including culvert upgrade south of Kramp Road.
Road Reconstruction: same cross section as the road extension	Road Reconstruction: same cross section as the road extension	Road Reconstruction: same cross section as the road extension

1.1 Study Area

The Project occurs along Greenhouse Road in Breslau, Ontario which is a road located in the Breslau Settlement Area in the Township of Woolwich. The Study Area, located within the Township's Ward 3 boundary, extends from Highway 7 (Victoria Street North) to the Canadian National Railway – Metrolinx Rail Corridor. The existing segment of Greenhouse Road currently terminates at an existing cul-de-sac approximately 75 m south of Kramp Road in the south. The right-of-way for this road extends an additional 320 m further to the south to the existing rail corridor, where there is currently no road infrastructure in place. This project proposes the reconstruction of the existing Greenhouse Road and its southerly extension to the existing rail corridor. **Figure 1-1** shows the fluvial geomorphic assessment Study Area, including the proposed road reconstruction and extension components for the Project.

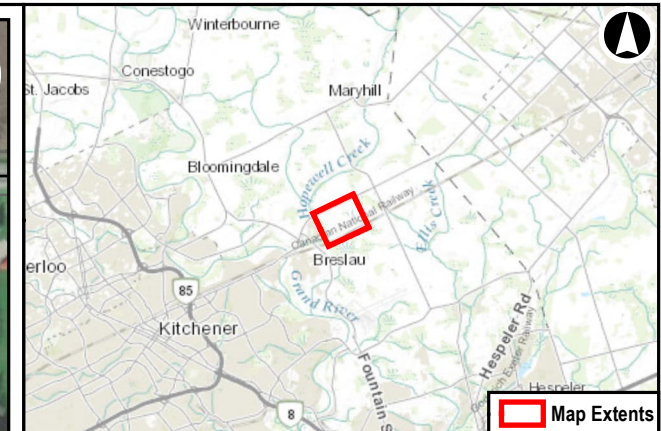
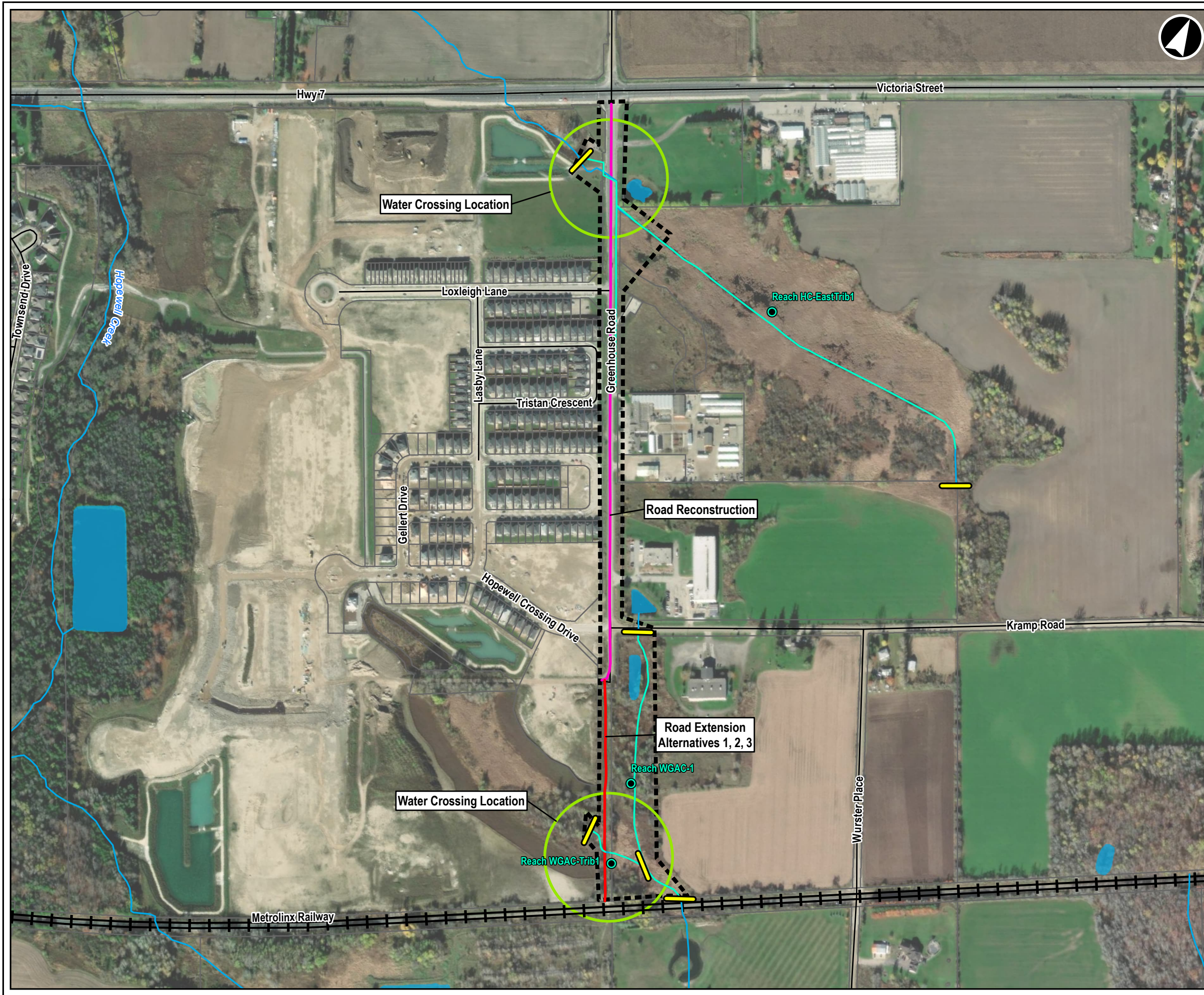
The Study Area extends for 1.2 km along Greenhouse Road between Highway 7 (Victoria Street) and the Canadian National Railway – Metrolinx Rail Corridor. The frontage along this section of roadway is comprised of residential, commercial, industrial, institutional, Breslau Wetland Provincially Significant Wetland (PSW) Complex and green space areas. It includes driveway access to Belgian Nursery (#2615 Victoria Street North), Grobe Nursery (#1787 Greenhouse Road), and National Engineered Fasteners (#1747 Greenhouse Road), maintenance access to the stormwater management pond at the northeast corner of the Hopewell Crossing subdivision as well as to a Union Gas inspection station, and intersections with Loxleigh Lane and Kramp Road/Hopewell Crossing Drive.

1.2 Scope of Work

As part of the scope of work, this high-level fluvial geomorphic assessment was prepared to characterize the geomorphological baseline conditions in the Study Area to inform and support the evaluation of Greenhouse Road alternatives and the Environmental Impact Study (EIS) Report as well as recommended water crossing design (south of Kramp Road).

The following was completed as part of the fluvial geomorphic assessment:

- A desktop assessment summarizing the background information related to the watercourses.
- A field reconnaissance survey completed in November 2022.
- A crossing assessment of the existing watercourse crossings to ensure that the proposed crossing structure has considered the fluvial characteristics of the existing watercourse.



- Legend**
- Road Reconstruction
 - Road Extension - Alternatives 1, 2, 3
 - Fluvial Geomorphic Assessment Study Area
 - Fluvial Geomorphic Assessment Reach Breaks
 - Fluvial Geomorphic Assessment Reaches
 - Fluvial Geomorphic Assessment Watercourse
 - Watercourse
 - Waterbody
 - Railway
 - Parcel
 - Water Crossing Location

GREENHOUSE ROAD RECONSTRUCTION AND EXTENSION PROJECT

FLUVIAL GEOMORPHIC ASSESSMENT

0 50 100 150 200 250 300
Metres

Datum: NAD 1983 UTM Zone 17N

Mar, 2023	PN#: 60683946	1:5,500 * when printed 11"x17"
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Figure 1-1

AECOM

Data Sources: LID
Service Layer Credits: Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), (c) OpenStreetMap contributors, and the GIS User Community
Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community

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2. Background

The fluvial geomorphic assessment included a review of relevant background reports to better inform and understand the watershed characteristics in the context of physiography, surficial geology, topography, and land use/land cover. The following reports were used to support the scope and goals this current fluvial geomorphological assessment. Refer to **Section 2.1.4** for a summary of the reports with relevant fluvial geomorphology information.

- East Side Lands - Stage 2 Master Environmental Servicing Plan and Secondary Plan Study. Prepared by WSP and MMM Group for the Regional Municipality of Waterloo
- Comprehensive Environmental Impact Study for Proposed Mixed Use Development – Ariss Glen Developments & Thomasfield Homes - Woolwich Township (Breslau) DRAF. Prepared for Thomasfield Homes by Natural Resource Solutions Inc., March 2011
- Stormwater Management Facility Design Report – Proposed Hopewell Crossing Development Township of Woolwich (Breslau) Draft Plan of Subdivision 30T-11701 Final Submission. Prepared for Ariss Glen Development by AECOM Canada Ltd., June 2018
- Intersection Improvements at Victoria Steet North (Highway 7) & Greenhouse Road, Breslau – Class Environmental Assessment and Preliminary Design Study – Environmental Screening Document Class EA (Group “C”) – DRAFT. Prepared for Ariss Glen Development by AECOM Canada Ltd., February 2019
- Natural Environment Impact Analysis Greenhouse Road – Highway 7 Intersection, MTO EA. Prepared by Natural Resource Solutions Inc. (NRSI) for AECOM Canada Ltd., October 2019
- Environmental Impact Study Terms of Reference for Greenhouse Road Reconstruction Project – Breslau (Memorandum). Prepared by AECOM Canada Ltd. for Grand River Conservation Authority, November 30, 2022
- Greenhouse Road Reconstruction and Extension Project Municipal Class Environmental Assessment – Phase 1: Problem or Opportunity Statement. Prepared by AECOM Canada Ltd. The Township of Woolwich, December 2022

2.1 Watershed Characteristics

The Study Area is located within the Hopewell Creek subwatershed. It has an area of approximately 77.2 km² (GRCA, 2022), and is part of the larger Grand River watershed under the jurisdiction of the Grand River Conservation Authority. Surface drainage in the vicinity of the Study Area is generally from southeast to northwest.

There are two sites of interest located within the Study Area. The first site (The Hopewell Creek Tributary) is located at the corner of Greenhouse Road and Victoria Street North where a provincially significant wetland was mapped and evaluated in 1993 and included as part of the provincially significant Breslau Wetland Complex. Due to changes in drainage in the local area through road and culvert improvements and maintenance, weather patterns and subsequent agricultural activities, this wetland has fluctuated in size over the years. It is currently mapped as 0.47 ha in size. The wetland is within a mixed-use development site, which was under construction as of 2019 (AECOM, 2019). The second site is located to the south, past the southern limit of Greenhouse Road, between Kramp Road and the Metrolinx Corridor where a second wetland has been delineated.

2.1.1 Physiography and Surficial Geology

The Study Area is located within the Guelph Drumlin Fields physiographic region of Southern Ontario (Chapman and Putnam, 1984). It has a surficial geology consisting of stone-poor, sandy silt to silty sand-textured till on to of Paleozoic terrain (Ontario Geological Survey, 2010). The surficial geology is relatively permeable but more easily erodible than clay-rich till.

Based on the hydrogeological site assessment conducted by PML (2010), the bedrock is anticipated to be at elevations ranging from 297.0 (approx. 25 m below ground surface) in the Study Area. The bedrock is comprised of grey limestone with green shale interbedding.

2.1.2 Topography

The land in the Study Area is relatively flat, with a local plateau along Greenhouse Road (at elevation 325 m) and a large wetland to the east (elevation approximately 321 m) within a localized low area. The elevation at the Canadian National Railway (CNR) – Metrolinx Rail Corridor is 321.5 m. Overall, this is a low change in elevation across the Study Area. Areas of low relief/flat topography are expected to experience low rates of erosion and remain relatively stable.

2.1.3 Land Use/ Land Cover

The Study Area is bound west of Greenhouse Road by a residential subdivision and is bound in the east by wetlands (immediately south of Highway 7), commercial land use, and agricultural land use. The residential subdivision is relatively new, with Phase 1 completed and Phase 2 currently under construction.

The increased urbanization in the area results in an increase in impervious area, which directly results in increased runoff and decreased infiltration (Ontario Ministry of the Environment, 2003). To mitigate the flooding and erosion hazards in the surrounding area, a number of stormwater ponds were created as part of the residential development in the area. The intended purpose of the storm ponds is to manage flow volumes to preserve the natural or pre-development conditions (i.e., surface runoff, infiltration, and evapotranspiration (AECOM, 2018). A Stormwater Impact Assessment and Conceptual Stormwater Management Design Memorandum has been completed under a separate cover for this MCEA. Furthermore, a separate stormwater management report will be completed by AECOM during the detailed design phase for this project.

2.1.4 Previous Studies

The following summarizes the previous studies completed with relevant fluvial geomorphology information pertaining to this project.

Stormwater Management Facility Design Report – Proposed Hopewell Crossing Development Township of Woolwich (Breslau) Draft Plan of Subdivision 30T-11701 Final Submission. Prepared for Ariss Glen Development by AECOM Canada Ltd., June 2018

AECOM was retained by Ariss Glen Developments to provide a final stormwater management facility design for a proposed subdivision plan within the Township of Woolwich. Pertaining to the current fluvial geomorphic assessment, the report identifies a larger wetland (15.29 ha - Breslau Wetland Complex, MAS3-1), southeast of the intersection of Greenhouse Road and Highway 7, which is drained northwesterly by a tributary of the Hopewell Creek (Reach HC-EastTrib1).

A second wetland (2.26 ha) of interest to the current fluvial geomorphic assessment was identified west of the area of the Greenhouse Road proposed extension, north of the CNR – Metrolinx Corridor. The wetland discharges southeasterly under the proposed road extension by a tributary of the Waterloo-Guelph Airport Creek (Reach WGAC-Trib1), connects to the main stem of the Waterloo-Guelph Airport Creek (Reach WGAC-1) and then flows south under the CNR.

Understanding of the drainage patterns and awareness of water features in the area is relevant to the fluvial assessment, as the Greenhouse Road Reconstruction and Extension Project provides an opportunity to improve connectivity, prevent ecological degradation, and reduce or eliminate flooding risks and damage to adjacent infrastructure.

Intersection Improvements at Victoria Street North (Highway 7) and Greenhouse Road, Breslau – Class Environmental Assessment and Preliminary Design Study – Environmental Screening

Document Class EA (Group “C”) – DRAFT. Prepared for Ariss Glen Development by AECOM Canada Ltd., February 2019

Retained by Ariss Glen Developments Limited, AECOM completed a Class Environmental Assessment and Preliminary Design Study (Group ‘C’ project). The report identified a wetland (MAM2-2) at the southwest corner of Greenhouse Road and Victoria Street North was mapped and evaluated in 1993 and was included as part of the provincially significant Breslau Wetland Complex. This wetland was also previously identified as part of the NRSI 2019 Natural Environment Impact Analysis. Due to changes in drainage in the local area through road and culvert improvements and maintenance, weather patterns and subsequent agricultural activities, this wetland has fluctuated in size over the years. It is currently mapped as 0.47ha in size.

The wetland is within a mixed-use development site that is currently (back in 2019) under construction. A 10m buffer was provided to the wetland and delineated with protective fencing. A stormwater management facility has been constructed adjacent to the buffer and the wetland is the receiver of water from this facility.

The report also identified the local drainage and hydrology as generally flowing from the southeast to the northwest within the Hopewell Creek subwatershed. The larger wetland (MAS3-1 – 15.29 ha) located to the southeast of the intersection, and also part of the Breslau Complex, is identified as discharging northwest under Greenhouse Road into a catchbasin on the west side of the road via a tributary of the Hopewell Creek (Reach HC-EastTrib1). This wetland was identified as connecting to MAM2-2 through a series of roadside ditches and culverts.

Pertinent to the current fluvial assessment and the Greenhouse Road Reconstruction and Extension Project is the connection between the wetlands located to the east and west of Greenhouse Road through a series of poorly connected roadside ditches and CSP culverts. A smooth connection between features is important to maintain a healthy flow and transport of water and sediments to maintain a dynamic equilibrium.

3. Desktop Assessment

3.1 Reach Delineation

Reaches are generally defined as a length or segment of a watercourse that displays similar physical characteristics and have a setting that remains nearly constant along their length (OMNR, 2002). A selected reach displays relative homogeneity in channel form, functions and process, and are influenced by similar controlling (discharge, slope) and modifying factors (vegetation) to which the channel has become or is becoming adjusted. Reach breaks within the Study Area were delineated through desk-based assessment of tributary locations, channel gradient, surficial geology, valley setting, sinuosity, and riparian vegetation using GIS layers, and considering previously identified features from previous studies and reports (see **Section 2.1.4**). A summary of the reach breaks and justifications are available in **Table 3-1**. Reach breaks are also shown in **Figure 1-1**.

Table 3-1: Reach Delineation

Reach	Upstream Reach Break	Downstream Reach Break	Justification
Hopewell Creek East Tributary (HC-EastTrib1)	549201.25 m E; 4815743.85 m N	548500.00 m E; 4815946.00 m N	– Feature appears bounded by a wetland and was delineated based on GRCA GIS Platform. Watercourse does not appear very defined. – Upstream Reach Break; Based on hydro lines on GRCA GIS tool. – Downstream Reach Break: Connects to roadside ditch.

Reach	Upstream Reach Break	Downstream Reach Break	Justification
Waterloo-Guelph Airport Creek – Main Stem (WGAC-1)	548873.00 m E; 4815354.00 m N	549096.36 m E; 4815025.89 m N	– Not very defined. Delineated based on GRCA GIS Platform. – Upstream Reach Break: Pond outlet (flows south-southeast) discharge point south of Kramp Rd. – Downstream Reach Break: Feature appears to flow under CNR – Metrolinx Corridor train tracks and discharges into online pond south of the tracks.
Waterloo-Guelph Airport Creek – Tributary (WGAC-Trib1)	548930.00 m E; 4815053.00 m N	549025.77 m E; 4815036.99 m N	– Delineated based on GRCA GIS Platform. – Upstream Reach Break: Start of the watercourse as per GRCA GIS platform. – Downstream Reach Break: Confluence with WGAC-1.

4. Field Reconnaissance

The field assessment was completed November 17, 2022, to verify the reach breaks and identify local geomorphological form and function of the Hopewell Creek East Tributaries in the vicinity of the proposed road reconstruction and extension. The following components were also part of the field-based assessment:

- Identification of the hydraulic regime of each feature
- Floodplain access characteristics
- Rapid Geomorphic Assessment (RGA)
- Identification of stability and dominant channel process
- Photographic Record

During the field reconnaissance, basic geomorphological data were collected, including the hydraulic regime of each feature, bed materials, surrounding land use, riparian vegetation, degree of channel-floodplain connectivity, and the location of erosion and channel modification. An overview of site observations and interpretations are provided below, and the following sections also describe the conditions encountered during the field-based assessments. A photographic record of the assessed sites can be found in **Appendix A**.

4.1 Geomorphological Reach Characterization

4.1.1 Reach HC-EastTrib1

The feature is located close to the intersection between Greenhouse Road and Highway 7, and it is a tributary of the Hopewell Creek. It consists of an undefined and unconfined ephemeral-type feature with no visual channel form (bankfull width or depth). The feature follows a low gradient and resides within a topographic low point. Bed substrate consists of fines (clay, silt, sand) and the feature has a relatively straight planform. No flow was present on the day of the assessment.

The feature flows towards the northwest conveying flow from a wetland (MAS3-1), part of the Breslau Wetland Complex, to the east of Greenhouse Road towards a roadside drainage ditch parallel to Greenhouse Road. The feature crosses Greenhouse Road through a pair of twin 40 cm wide circular corrugated steel pipe (CSP) culverts that are aligned perpendicular to Greenhouse Road, as described in detail in **Section 5**. After the feature exits the Greenhouse Road twin culverts, the feature accepts flow from roadside drainage, and immediately enters another pair of (perched) 40 cm wide circular CSP twin culverts aligned parallel to Greenhouse Road to cross under a small access road. There is a drain present at their intersection as well, which is covered by a grate. Where the feature exits this set of culverts, it then enters a third and final set of twin culverts that are 45 cm wide and are again perpendicular to Greenhouse Road. After this set of culverts flow discharges into a small wetland (MAM2-2) before continuing north, under Victoria Street North. From this point,

it appears that the drainage channel is tiled, but eventually outlets to Hopewell Creek, approximately 725 m north of Victoria Street North (AECOM, 2019).

The feature was surrounded by herbaceous vegetation and grassy vegetation, including cattails, and the feature had abundant in-channel vegetation. Near the Greenhouse Road crossing the channel had placed armour stone around the culvert opening. No evidence of erosion was noted during the assessment.

4.1.2 Reach WGAC-Trib1

This feature is located approximately 250 m south of the end of Greenhouse Road along a trail, and approximately 80 m north of the CNR – Metrolinx Corridor crossing. It consists of an undefined and unconfined ephemeral-type feature with no visual channel form (bankfull width or depth). The feature follows a low gradient and resides within a topographic low. Bed substrate consists of fines (clay, silt, sand) and the feature has a sinuous planform. No flow was present on the day of the assessment.

No crossing under the trail (proposed Greenhouse Road extension location) was identified on the day of the assessment. It appears that recently placed soil on both sides of the trail, which may have covered a culvert, if one was present, was observed at the time of the field assessment. According to the reviewed background material, the feature flows southeast into Reach WGAD-1, however no discernable flow path or channel could be identified.

The location of the feature was surrounded by tall grassy vegetation and shrubs with dense in-channel vegetation. No evidence of bank armouring or erosion was noted during the assessment.

4.1.3 Reach WGAC-1

WGAC-1 is an undefined and unconfined ephemeral-type feature and is the upper portion of the main stem of the Waterloo-Guelph Airport Creek. The feature measures approximately 3.3 m wide and 0.35 m deep. No flow was present on the day of the assessment. The feature follows a low gradient, with flow concentrating along a topographic low. Bed substrate consists of fines (clay, silt, sand) and organics and the feature had a slightly sinuous planform.

The feature flows to the south under the CNR – Metrolinx Rail Corridor through a closed bottom culvert measuring approximately 2.4 m wide and 1.2 m high. The culvert appeared to have been recently built and no clear connection had been made yet between the feature and the culvert (i.e., no definable flow path).

The feature was surrounded by tall grassy vegetation and shrubs, and it had abundant in-channel vegetation. No evidence of bank armouring or erosion was noted during the assessment.

4.2 Rapid Geomorphic Assessment (RGA)

The Rapid Geomorphic Assessment (RGA) was designed by the Ontario Ministry of the Environment, Conservation and Parks (MECP;1999) to assess reaches in urban channels. This technique uses visual indicators to document evidence of channel instability using presence/ absence methodology. Stability is determined by adjustment in slope, either an increase (aggradation) due to sediment deposition or a decrease (degradation) due to bed erosion. It also considers an increase in the bank-to-bank width (widening) and by any evidence indicating adjustment in the planimetric form regime. Each of the geomorphic indicators is documented throughout the reach and upon completion, is tallied by category. These data are then used to calculate an overall reach stability index which classifies the reach as 'stable', 'transitional', or 'in-adjustment' corresponding to their relative sensitivity to altered sediment and flow regimes. The classification and interpretation as defined by the factor value (total score) are identified in **Table 4-1** (taken from Ontario Ministry of the Environment, 2003). Results of the RGA are presented in **Table 4-2**.

Table 4-1: Rapid Geomorphic Classification

Factor Value	Classification	Interpretation
≤ 0.20	In Regime or Stable (Least Sensitive)	Channel morphology is within a range of variance for streams of similar hydrographic characteristics – evidence of instability is isolated or associated with normal river propagation processes.
0.21 – 0.40	Transitional or Stressed (Moderately Sensitive)	Channel morphology is within the range of variance for streams of similar hydrographic characteristics, but the evidence of instability is frequent.
≥ 0.41	In Adjustment (Most Sensitive)	Channel morphology is not within a range of variance and evidence of instability is widespread.

Table 4-2: RGA Results

Reach	Factor Value Aggradation	Factor Value Widening	Factor Value Planimetric Form Adjustment	Factor Value Degradation	Stability Index	Condition
HC-EastTrib1	0.00	0.00	0.00	0.14	0.04	In Regime
WGAC-Trib	0.00	0.00	0.00	0.14	0.04	In Regime
WGAC-1	0.00	0.00	0.00	0.14	0.04	In Regime

All three reaches assessed in the field were ephemeral-type features that received an “In Regime” rating. An ephemeral features position in the landscape and channel form is typically determined by vegetation, groundwater, topography, and/or agricultural practices, as opposed to channel-forming flows. Flow for ephemeral features is seasonal, with the highest flow typically occurring during the spring thaw season. Flows that produce ephemeral features are typically not strong enough to form defined channel boundaries and rarely cause erosion except on steep slopes (Irwin, K., B. Bergmann and J. Boos, 2013) and therefore, a RGA rating of “In Regime” is expected and is acceptable for the features.

5. Watercourse Crossing Assessment

5.1 Reach HC-EastTrib1

Only one crossing structure was identified under Greenhouse Road. The crossing conveys flows for Reach HC-EastTrib1 to the northwest. The first crossing consists of twin CSP culverts which begin east of Greenhouse Road and convey flow to the West. The East-West culverts discharge into a roadside ditch on the west side of Greenhouse Road, after which the flow is forced in to turn 90 degrees to be oriented North-South. Flow enters a second set of perched twin CSP culverts that convey flow northwards under an access roadway. A drain is also present at the intersection of the two sets of twin culverts which is covered with metal grating. Once flow exits the second set of twin culverts it then must make another 90 degree turn to resumes its East-West orientation, before flowing into a third set of twin CSP culverts. Flow exits the third set of culverts and discharges into a small wetland south of Highway 7 (Victoria Street North) before continuing north, under Highway 7 (Victoria Street North). **Table 5-1** contains a summary of key issues identified during the watercourse crossing assessment of HC-EastTrib1.

Table 5-1: Summary of Key Issues with Watercourse Crossing HC-EastTrib1

Observation	Fluvial Geomorphic Issue	Comments on Crossing Structure
No Defined Channel Boundaries were Observed / No Evidence of Erosion	The ability of a channel to create its own channel form and to actively migrate across the floodplain presumes a shear dominated watercourse. This is in contrast to a watercourse whose position in the landscape, and channel form, is determined by other factors such as vegetation, topography, and groundwater. The feature present is an undefined ephemeral-type watercourse, which lacks energy to erode distinct channel boundaries.	A meander belt assessment is not applicable for this location.
No Evidence of Erosion Around Crossing Structures	From a fluvial geomorphological perspective, there were no erosion concerns identified during the field assessment.	Lack of erosion and excessive deposition indicates the crossing structure is likely not impacted by fluvial processes at this time.
Perched Culvert	Receiving perched culverts can generate backwater effects as the water elevation required to flow through the culvert will need to be higher. Additionally, perched culverts present a barrier to fish movement.	Additional discipline input required to determine significance of barrier to fish movement.
90-degree turn	The 90 degrees turns that the channel has to make when it exits the culverts can increase the possibility of erosion on the banks of the receiving features.	Current configuration may introduce risk of erosion and therefore indicators of sediment deposition and erosion should be monitored for.
Twin Culvert	Flow separation occurs with multi-span crossings, as a result, sedimentation and blockages can occur within the culvert that is less preferred by the flow.	No indication of sediment deposition or blockage at this time.
Closed Bottom Culvert	Closed bottom culverts constrain the channel profile. Closed bottom culverts can cause significant disruption to the riverbed profile which can lead to channel adjustments and pose a barrier to fish migration.	No indication of channel adjustment at this time.

5.2 Reach WGAC-Trib1

Based on GIS mapping WGAC-Trib1 crosses the access trail south of Greenhouse Road. This watercourse flows to the east before joining WGAC-1. No defined channel or crossing structure were observed in the field during the fluvial geomorphic field reconnaissance. Newly placed soil was observed lining the access trail, which may have buried the culvert. **Table 5-2** contains a summary of key issues identified during the watercourse crossing assessment of WGAC-Trib1.

Table 5-2: Summary of Key Issues with Watercourse Crossing WGAC-Trib1

Observation	Fluvial Geomorphic Issue	Comments on Crossing Structure
No Defined Channel Boundaries were Observed / No evidence of erosion	The ability of a channel to create its own channel form and to actively migrate across the floodplain presumes a shear dominated watercourse. This is in contrast to a watercourse whose position in the landscape, and channel form, is determined by other factors such as vegetation, topography, and groundwater. The feature present is an undefined ephemeral-type watercourse, which lacks energy to erode distinct channel boundaries.	Due to lack of channel boundaries, a meander belt assessment is not applicable.
Lack of Visible Culvert / No Evidence of Erosion Around Crossing Structures	It is unclear how flow crosses the access trail at this time. No erosion concerns identified during the field assessment on the area of the supposed location of the culvert.	Culvert was not visible on day of assessment. Fresh soil on either side of the crossing may have buried culvert. The lack of erosion and excessive deposition at the crossing site indicates the crossing structure is likely not impacted by fluvial

Observation	Fluvial Geomorphic Issue	Comments on Crossing Structure
		processes at this time. If crossing has become blocked by the soil, it should be removed to allow for flow to resume.

6. Applicable Policies

Wetlands are important natural features that help moderate water by absorbing surface runoff and slowly releasing it. The GRCA has a comprehensive policy (Policy 8.4 – *Policies for Wetlands and Areas of Interference*) that outlines specific cases where development/ interference within a wetland is permitted (GRCA, 2015).

A detailed Environmental Impact Study (EIS) is currently being prepared by AECOM, (available under a separate cover) which will demonstrate how the proposed works complies with the GRCA's Wetland Policy by addressing opportunities for wetland protection and/ or enhancement, impacts that can be avoided or mitigated, detailed description of the proposed avoidance, protection and/or mitigation measures and development setbacks, wetland buffer zones (if possible), and other development constraints as well as environmental protection opportunities including enhancement opportunities among elements of the Greenlands Network. Compliance and Effectiveness Monitoring requirements will also be identified in the EIS to ensure mitigation measures are properly implemented and the efficacy of protection or mitigation measures are adequate. This EIS will be prepared in support of the EA. The EIS report will also be reviewed and updated during the detailed design, if required, once the construction footprint, staging areas and access roads are known in order to update the impact assessment and refine the mitigation measures recommended.

The large wetland (HC-EastTrib1) drains through a culvert under Greenhouse Road to a catch basin on the west side of the road. The feature then flows north, under Highway 7 (Victoria Street North). From this point, it appears that the drainage is tiled, but eventually outlets to Hopewell Creek, approximately 725 m north of Victoria Street North (AECOM, 2019). It is assumed that the crossing under Greenhouse Road was designed in accordance with GRCA watercourse crossing guidelines (Guideline 9.1.2) and that it will not be replaced at this time. No erosion was noted in the field indicating the culvert is likely an adequate size to convey flow from the wetland east of the road from a fluvial geomorphic perspective. However, the perched nature of the culverts, the 90 degree turns, and the twin nature of the crossings are not recommended from a fluvial geomorphic perspective.

7. Conclusions and Recommendations

The fluvial geomorphological assessment completed along Greenhouse Road concluded the following based on the field investigation and the review of background material:

- None of the investigated features (reaches HC-EastTrib1, WGAC-1, and WGAC-Trib1) had defined bankfull width or depth, suggesting that they are ephemeral-type features or low energy flows
- No evidence of erosion was visible during the field assessment, indicating that the size and location of the twin culverts are not affected by fluvial processes
- Even though the culvert on the section where the Greenhouse Road extension is proposed could not be located, there was no evidence of erosion in the area indicating that the size and location of the culvert is not affected by fluvial processes

The following is a list of recommendations for both crossings:

- From a fluvial geomorphic perspective, it is key that sediment be able to move downstream. For crossing HC-East-Trib1, the perched nature of the culverts, the 90 degree turns, and the twin nature of the crossings are not recommended due to impacts to fluvial processes. These issues may pose a barrier to sediment travelling downstream and increase erosion at the locations where the culverts discharge perpendicular to the roadside ditch banks
- It is recommended that open bottom culverts be used. Closed bottom culverts introduce grade separation in the longitudinal profile of a fluvial feature, can become perched, and affect sediment transport over time
- New crossings should be sized accordingly to maintain flow and sediment transport downstream. The anticipated migration of the channel (i.e., meander belt) does not need to be considered for culvert sizing as the investigated features are undefined channels.

Flow in ephemeral-type features is seasonal and typically lacks the stream power to form a defined channel with a meandering planform. Therefore, a meander belt assessment is not applicable for the investigated features. Generally, a meander belt can only be delineated when defined banks are present and/or when the planform of a watercourse can be tracked over time to determine its possible extent within the floodplain. The GRCA “Policies and Procedures for Compliance with the Development, Interference with Wetlands and Alterations to Shorelines and Watercourses Regulation Ontario Regulation 150/06” is not applicable in this situation. However, restrictions on watercourse and wetland alteration exist within the GRCA 150/60 Ontario Regulation and should be considered if crossing replacements are proposed.

As introduced in **Section 1**, there are three proposed alternatives being evaluated through the Municipal Class Environmental Assessment process. All alternatives also include the Greenhouse Road reconstruction component as part of the preferred solution.

- Alternative 1: Two-lane urbanized cross-section with sidewalks on both sides of the road, including culvert upgrade south of Kramp Road
- Alternative 2: Two-lane urbanized cross-section with multi-use pathway on one side of the road, including culvert upgrade south of Kramp Road
- Alternative 3: Two-lane urbanized cross-section with sidewalks on both sides of the road and bike lanes within the roadway width, including culvert upgrade south of Kramp Road

Alternative 1 is the preliminary preferred solution for the road extension along with the road reconstruction component. The preferred cross-section will include sidewalks on both sides of the right-of-way, with the east boulevard being demolished and widened in the future when warranted due to traffic levels. The proposed design will involve upgrading the existing cross-section from a rural local road to an urbanized local road. Laneways will be widened slightly from approximately 3.5 m to a proposed width of 4.5 m to conform with the urbanized cross section. The cross section will also use a blend of 20 m urban local road and a 26 m urban collector road to account for potential widening in the future to support the potential future Breslau GO station. If there are any alterations to the watercourse due to the proposed design, it is recommended that a fluvial geomorphologist be involved.

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HC-EastTrib1



Photograph 1. ↑

Cattail-dominated eastern extent of feature. Looking east from roadway.



Photograph 2. ↑

N-S trending roadside drainage ditch that the feature flows into. Looking to the southeast.

HC-EastTrib1



Photograph 3. ↑

Twin culverts (Set # 1) each measuring approximately 0.40 m wide. Culverts cross east-west under Greenhouse Road.



Photograph 4. ↑

Twin culverts (Set # 1) measuring approximately 0.40 m wide crossing east-west under Greenhouse Road. Looking to the West.

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Photograph 5. ↑

Image with mark-up showing the location of the three sets of twin culverts. Looking to the west across Greenhouse Road.



Photograph 6. ↑

Outlet of Twin Culvert Set #1 (right) and inlet of Twin Culvert Set #2 (left). To the far left of the figure there is a man-made drain covered in a metal grate.

HC-EastTrib1



Photograph 7. ↑

Man made drain located beside the inlet of Twin Culvert Set #2. Drain is covered by wire and is overgrown with tall grasses. There is water in the drain approximately 1-2 m from metal grating.



Photograph 8. ↑

Outlet of Twin Culvert Set #2 (left) and inlet of Twin Culvert Set #3 (right). Looking to the south. Each twin culvert for Set #2 measures 0.40 m wide, while each twin culvert for Set #3 measures 0.45 m wide.

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Photograph 9. ↑

Outlet of Twin Culvert Set #3. Each culvert is 0.45 m wide.



Photograph 10. ↑

Outlet of Twin Culvert Set #3 looking to the west.

WGAC-Trib1



Photograph 11. ↑

Ephemeral feature as viewed from access trail looking to the northeast.



Photograph 12. ↑

Gravel access trail. No culvert could be located crossing the access road. Soils have been dumped on both sides of the access trail. Looking to the southwest

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WGAC-Trib1



Photograph 13. ↑

Looking from the ephemeral feature to the access trail (looking southwest). There was freshly dumped soil on both sides of the gravel access trail which may have buried a culvert if there was one previously.



Photograph 14. ↑

Feature weaves through the grassy scrubland field before joining feature WGAC-1. There is no visible defined connection between the two features.

WGAC-1



Photograph 15. ↑

WGAC-1 occupies a topographic low in the grassy field. Looking to the south. Approximately 100 m upstream of the rail crossing.



Photograph 16. ↑

WGAC-1 occupies a topographic low in the grassy field. Looking to the south. Approximately 20 m upstream of the rail crossing.

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WGAC-1



Photograph 17. ↑

New culvert that crosses under the train tracks (photo taken north of train tracks). Culvert measures 2.4 m wide and 1.2 m high. Looking to the southeast



Photograph 18. ↑

New culvert that crosses under the train tracks (photo taken north of train tracks). Culvert measures 2.4 m wide and 1.2 m high. Looking to the southeast