MISSISSAUGA ROAD ENVIRONMENTAL ASSESSMENT
FLUVIAL GEOMORPHIC ASSESSMENT

144162-22380-522

Report Prepared for:
AMEC FOSTER WHEELER

Prepared by:
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October, 2017
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1 INTRODUCTION

A Schedule "C" Class Environmental Assessment (EA) Study is being completed for Mississauga Road from Financial Drive to Queen Street West (Regional Road 6), referred to as **Location 1**. In conjunction with the EA, an update to previously completed technical studies is required to update the 2006 EA, prepared by Trow Associates Inc. (2006a), completed for Mississauga Road from Queen Street West to Bovaird Drive, referred to as **Location 2**.

Matrix Solutions Inc. has been retained by AMEC Foster Wheeler to provide fluvial geomorphic input into both the Location 1 Class EA as well as the technical study update for Location 2. This report includes detailed assessments for all watercourse crossings within the study area (encompassing both Location 1 and Location 2), following the standard methods for Meander Belt Assessment and Crossing Assessment, and taking into consideration regulatory guidelines of the Credit Valley Conservation Authority (CVC); Fluvial Geomorphic Guidelines (Fact Sheet I) regarding hazards to confined and unconfined watercourses and (Fact Sheet III) checklist regarding crossing design (CVC 2015). The study area is presented in **Figure 1.1** below.

1.1 Work Plan

Scope of work for the Class EA includes consideration of fluvial geomorphology within the study area, with particular focus on the stream Meander Belt Assessment in order to determine trends, channel reaches, meander belt width, meander amplitude, erosion and scouring characteristics and identify potential setbacks, buffers or mitigation measures for work taking place around these features. The Meander Belt Assessment will also be used to provide input into the sizing of replacement culvert structures and ensuring watercourse structures are sized at minimum, based on the local erosion within the watercourse.

This report documents the findings of the fluvial geomorphic assessment within the study area, the objectives of which were to:

- use digital ortho-imagery and available GIS data for the study area to identify channel reaches within the vicinity of all existing road crossings
- on a reach basis, establish a preliminary meander belt width following the orientation of the valley
- based on historical aerial photography, complete a 100-year erosion analysis to identify the necessary setbacks or belt width allowance
- complete rapid field assessments for all existing road crossings to confirm physical setting of each channel reach and appropriateness of meander belt results
- provide comments on crossing structures and crossing configuration based on channel processes

Prior to undertaking the fluvial geomorphological assessment, a background review was undertaken in order to highlight other studies and previous work of relevance to fluvial geomorphology within the study area.

In September 2016, field reconnaissance was completed for reach crossings within the study area which included: Rapid Geomorphic Assessments (RGAs), documenting channel stability; Rapid Stream Assessment Technique (RSAT), documenting channel dimensions and degree of watercourse health, and Stream Crossing Assessment Forms, which record information regarding the condition of crossing structures and the watercourse upstream and downstream of the crossing. A detailed historical assessment was completed, using available mappings, aerial photos from 1974 and 1989, and digital ortho-imagery from 2016, to quantify changes in channel location and migration tendencies.

The detailed assessment of watercourse conditions and crossing structure recommendations provided in the current report take into account the degree of stability (see **Table 5.2** for RGA results) and channel dynamics (see **Section 4** for historic assessment and **Section 6** for meander belt width assessment) upstream and downstream of Mississauga Road. Where appropriate, additional factors of safety are provided to ensure the long-term protection of crossing structures from channel migration and geomorphic processes.

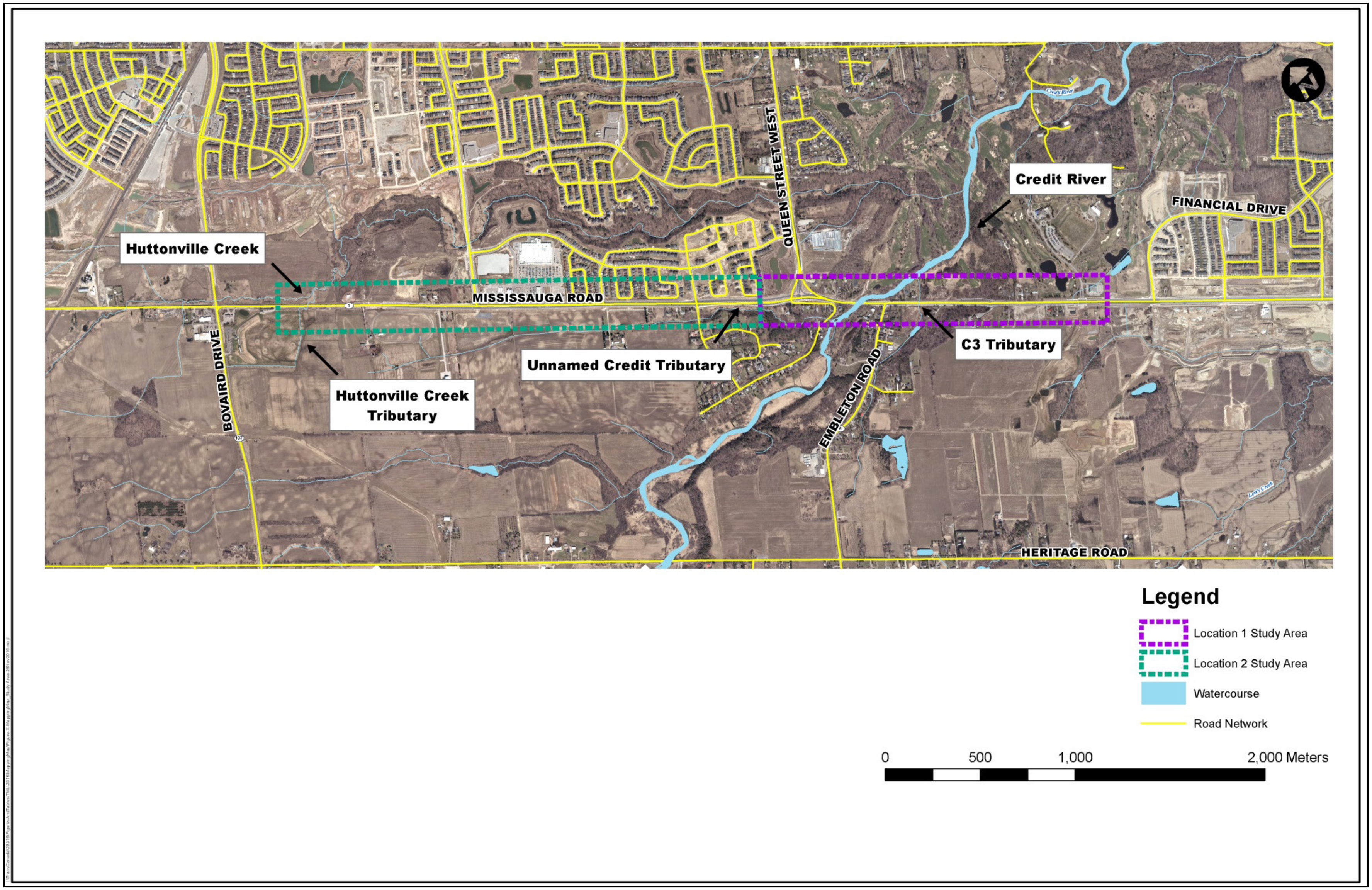


FIGURE 1.1 Mississauga Road EA Location 1 and Location 2 Study Areas.

2 BACKGROUND REVIEW

A background review was undertaken in order to build on the current understanding of the study area and site-specific characteristics that may influence the subject waterways.

2.1 Study Area

The study area covers a buffered area around Mississauga Road between Bovaird Drive and Financial Drive (**Figure 1.1**). Major drainage systems within the area are Credit River, two tributaries to Credit River, Huttonville Creek, and an unnamed tributary to Huttonville Creek. Land use in the study area east of Mississauga Road are designated as 'residential,' with the exception of the land surrounding Huttonville Creek which is designated as 'open space/valleylands/natural hazards.' West of Mississauga Road is designated as either 'village residential,' 'estate residential' or 'agricultural.' The study area is located within the Peel Plain physiographic region, which is gradually sloped towards Lake Ontario. The soils within this area are classified as Oneida clay loam, Fox sandy loam, Chinguacousy clay loam and Bottom Lands (Hoffman and Richards 1953). Borehole studies have revealed that the soil profile under most of Mississauga Road consists of clayey silt till. Based on the 2006 Mississauga Road Class EA, the surrounding agricultural lands were planted with field corn or used for hay production. An Ecological Land Classification for Southern Ontario was completed and determined vegetation communities were common to Ontario with no plant species considered rare, threatened or endangered.

Fish species observed in Huttonville Creek are considered common or very common, however uncommon and exotic species, including Redside Dace and rainbow trout respectively, have been observed prior to 2002. Both tributaries to Huttonville Creek and the Credit River have been designated as "small warmwater community" management zones by the MNR and CVC in the Credit River fisheries management plan report (MNR and CVC 2002). The report divided Huttonville Creek into three fish communities: small warmwater (upstream from Bovaird Drive to approximately 900 m upstream of Queen Street); mixed warm/cool (Queen Street approximately 900 m upstream); and coldwater (downstream of Queen Street to confluence with Credit River). Credit River

Credit River is nearly 90 km long and meanders through southeastern Ontario, flowing from Orangeville through Erin, Mono and Mississauga to eventually converge with Lake Ontario at Port Credit. The study area is within the lower Credit River watershed and generally flows east. Here, the river is approximately 20 to 26 m wide with moderate sinuosity. Substrate within the watercourse is composed of cobble with some boulders. The MNR and CVC have designated the watercourse as a "small warmwater community" management zone within the Credit River fisheries management plan (MNR and CVC 2002). Within the study area, there is one major crossing of the Credit River at Mississauga Road. The crossing spans approximately 50 m and contains two piers spaced 16 m apart (see **Photo Appendix**).

2.1.1 Unnamed Tributary to Credit River

An unnamed tributary to Credit River runs parallel to Mississauga Road between Ostrander Boulevard and River Road. The tributary converges with the Credit River's north bank approximately 100 m upstream from the Mississauga Road crossing.

2.1.2 C3 Tributary to Credit River

The C3 Tributary crosses Mississauga Road just south of the main Credit River crossings. Channel definition is varied throughout the reach walked during site assessments, with several man-made bridges and culverts providing disturbance upstream from Mississauga Road. Both upstream and downstream from the road substrate is composed of sands, silts, pebbles and gravels with poorly formed pools and riffles. The channel was dry downstream from Mississauga Road and the corridor is overgrown with riparian vegetation and debris.

2.1.3 Huttonville Creek

The upstream portion of Huttonville Creek runs along the west side of Mississauga Road and crosses the road just north of the Mississauga Road and Bovaird Drive intersection. From here, the creek runs parallel to the east side of Mississauga Road until it confluences with Credit River approximately 900 m downstream from the Mississauga Road crossing. The creek is moderately sinuous with a low gradient and riparian vegetation consisting of scrub, tall grasses, sparse trees and scrub cover. The channel's substrate is composed of clay, silt and fine sand with a defined bed and bank.

2.1.4 Huttonville Creek Tributary

A tributary to Huttonville Creek runs along the southwest and southeast property line of the Old Pro Driving Range west of Mississauga Road. Based on the general shape of the ephemeral tributary, the watercourse was likely previously realigned. Approximately 400 m south of Bovaird Drive, the creek crosses Mississauga Road and confluences with Huttonville Creek approximately 50 m east of the road. Currently, the Mississauga Road crossing of the unnamed tributary is under construction.

2.2 Previous Reports

The Class EA Study for Mississauga Road (Trow 2006a) was completed to develop and evaluate design alternatives to deal with the increased traffic volumes anticipated in the area. The assessment found that a combination of road widening, intersection improvements, horizontal and vertical realignment, rehabilitation and replacement of various culvert structures were the best approach to mitigate the impacts due to increased traffic volume. The results of the approach will minimize impacts to the natural environment and avoid potential impacts on ornamental vegetation. Although it will be necessary to remove some trees during the construction process, the road alignment will be designed to avoid as many trees as possible. Significant impacts to either Huttonville Creek or Credit River tributary are not expected as they are both located beyond the area of influence of this project. The hydrologic changes resulting from the widening are not expected to have significant impacts on the watersheds within the study area. Further, with no significant increase in surface water elevation, no stormwater quantity controls are required. The stormwater management plan consists of a storm sewer system that will drain the urbanized east side of Mississauga Road and a swale drainage system for the more rural west side of the road.

As part of the Class EA, a meander belt width assessment of Huttonville Creek was completed by Trow Associates (2006a). The assessment pertained to the section of Huttonville Creek that flows adjacent to the east side of Mississauga Road, immediately downstream of Bovaird Drive. A meander belt width is typically used to establish a buffer as it represents the horizontal extent that the channel currently and could potentially occupy. The final meander belt width of approximately 32.8 m was estimated for the reach which includes a factor of safety of 1.2.

3 METHODOLOGY

This section describes the methodology used to characterize the fluvial form and function of the watercourses within the study area.

3.1 Historical Assessment

A historical assessment of the study area was undertaken on available historical aerial imagery from 1974 and 1984 and compared with recent ortho-imagery from 2004 to 2016. A review of past conditions is typically carried out in order to document changes in land use and channel form over time.

3.2 Reach Delineation

Reaches are lengths of channel (typically 200 m to 2 km) that display similarity with respect to degree of valley confinement, sinuosity, riparian vegetation, and land use. Reach length will vary with channel scale since the morphology of low-order watercourses will vary over a smaller distance than those of higher-order watercourses. At the reach scale, characteristics of the river corridor exert a direct influence on channel form, function and processes (Parish 2004). In a reach, the controlling and modifying influences on the channel are similar, and are reflected in similar geomorphological form, function and processes within the reach.

Reaches were defined and verified for all streams within the Location 1 and Location 2 study areas. Reaches were defined within the study area based on desktop assessment of characteristics including sinuosity, valley setting, gradient and tributary using aerial photography, drainage network and topographic mapping.

3.3 Identification of Watercourse Crossings

Existing water crossings were initially identified using current aerial photography and topographic mapping resources. Crossing locations were verified based on field reconnaissance.

3.4 Meander Belt Assessment

Streams and rivers are dynamic features that change their configuration and position within a floodplain by means of meander evolution, development, and migration processes. When meanders change shape and position, the associated erosion and deposition that enable these changes to occur can cause loss or damage to private property and infrastructure. For this reason, when development or other activities are contemplated near a watercourse, it is desirable to designate a corridor that is intended to contain all of the natural meander and migration tendencies of the channel. Outside of this corridor, it is assumed that private property and structures will be safe from the erosion potential of the watercourse. The space that a meandering watercourse occupies on its floodplain, within which all associated natural channel processes occur, is commonly referred to as the meander belt.

The Belt Width Delineation Procedure is applicable to confined and unconfined systems and follows a process-based methodology for determining the meander belt width based on background information, historic data (including aerial photography), degree of valley confinement and channel planform (Parish 2004).

3.5 Field Reconnaissance

Following the desk-based assessment, field reconnaissance was undertaken at each of the stream crossing locations. At each location, the following assessments were undertaken:

- Stream Crossing Assessment
- Rapid Assessments: RGA and RSAT
- Detailed Channel Characterization

The Stream Crossing Assessment was undertaken in order to collect data relating specifically to the crossing in question. Information recorded included crossing type, material, shape and dimensions, structural condition and assessment of potential issues relating to the crossing (e.g. bank erosion, bed scour, debris trapping and fish passage).

The RGA was designed by the Ontario Ministry of Environment (2003) to assess reaches in urban channels. This qualitative technique is purely a presence/absence methodology designed to document evidence of channel instability. The various indicators are grouped into four categories indicating a specific geomorphic process: Aggradation, Degradation, Channel Widening and Planimetric Form Adjustment. Over the course of the survey, the existing geomorphic conditions of each reach are noted and individual geomorphic indicators are documented. Upon completion of the field inspection, these indicators are tallied by category and used to calculate an overall reach stability index, which corresponds to one of three stability classes which correspond to their relative sensitivity to altered sediment and flow regimes (Table 3.1).

TABLE 3.1 RGA Classification

Factor Value	Classification	Interpretation
≤0.20	In Regime or Stable (Least Sensitive)	The channel morphology is within a range of variance for streams of similar hydrographic characteristics - evidence of instability is isolated or associated with normal river meander 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 the range of variance and evidence of instability is wide spread

(Source: Ontario Ministry of Environment, 2003 - App. C3)

The RSAT was developed by John Galli at the Metropolitan Washington Council of Governments (Galli 1996). The RSAT provides a more qualitative assessment of the overall health and functions of a reach in order to provide a quick assessment of stream conditions and the identification of restoration needs on a watershed scale. This system integrates visual estimates of channel conditions and numerical scoring of stream parameters using six categories:

- Channel Stability
- Erosion and Deposition
- Instream Habitat
- Water Quality
- Riparian Conditions
- Biological Indicators

Once a condition has been assigned a score, these scores are totaled to produce an overall rating that is based on a 50 point scoring system, divided into three classes:

- <20 Low
- 20-35 Moderate
- >35 High

While the RSAT does score streams from a more biological and water quality perspective than the RGA, this information is also of relevance within a geomorphic context. This is based on the fundamental notion that, in general, the types of physical features that generate good fish habitat tend to represent good geomorphology as well (i.e., fish prefer a variety of physical conditions - pools provide resting areas while riffles provide feeding areas and contribute oxygen to the water - good riparian conditions provide shade and food - woody debris and overhanging banks provide shade).

Photographs of each crossing taken during the course of the field reconnaissance are contained in **Appendix A**.

4 HISTORICAL ASSESSMENT

A review of past conditions is typically carried out to document changes in land use and channel form over time, therefore historical aerial imagery was obtained for the study area for the years 1974, 1989, 2004 - 2007, 2009, 2013, 2015, and compared to recent imagery from 2016. Within the study area, the planforms of all four watercourses are identifiable throughout the historical record. The historical images reveal changes to the land use within and surrounding the study area. Over the past 40 years, the east side of Mississauga Road has remained in large part agricultural, while the east side of Mississauga Road has been developed and is largely dominated by residential developments.

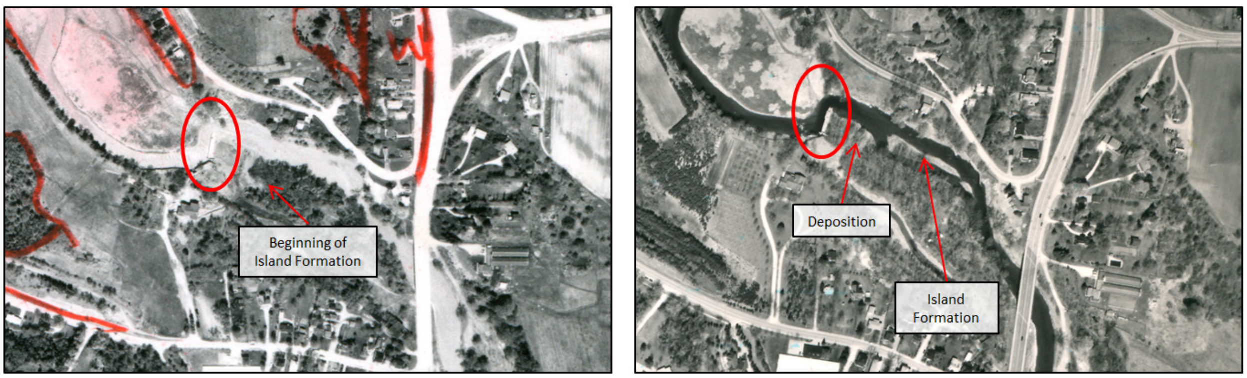
Historical imagery shows the section of Huttonville Creek that flows parallel to Mississauga Road south of Bovaird Drive West approximately 400 m remained relatively unchanged between 1974 and 1989. Between 1989 and 2016 the surrounding development remained largely agricultural with the exception of a driving range and gas station which were constructed prior to 2004 and two updated box culverts at Bovaird Drive West and Mississauga Road (**Figure 4.1**). Approximately 200 m east of the creek, development of the Jean Augustine Secondary School and residential development were underway as of 2015. The secondary school is currently in use. With no significant changes to the land use surrounding Huttonville Creek and its unnamed tributary, the two watercourses have remained relatively unchanged with the exception of minor alternations to sinuosity over the past 40 years.

1989 ***2016***

FIGURE 4.1 Two culvert replacements occurred between 1989 and 2016 along Bovaird Dr. W. and Mississauga Rd. Land use changes and increased creek sinuosity are visible. (1989 vs. 2016)

Historical imagery of the Mississauga Road crossing of Credit River reveals some upstream channel adjustments between 1974 and 2016. The major channel adjustments appear to be the result of an upstream dam structure (circled feature shown in **Figure 4.2**). Between 1974 and 1989, significant deposition has occurred just downstream of the dam structure with an island feature forming further downstream. Recent imagery shows the island has remained relatively unchanged since 1989.

Aerial imagery taken between 1974 and 1989 shows the land use surrounding the tributary to Credit River changed from agricultural to light residential. The residential area has remained relatively unchanged since 1989 with the exception of an increase in vegetation, predominantly trees and shrubs, buffering the watercourse. As such, the sinuosity and form of the watercourse has remained stable.



1974 ***1989***

FIGURE 4.2 Deposition and island formation downstream of dam structure (circled) on Credit River. (1974 vs. 1989)

5 REACH DELINEATION AND CROSSING LOCATIONS

A study reach was delineated along the Credit River, corresponding to 350 m upstream and 200 m downstream from Mississauga Road. Within this reach, confining valley walls are located in close proximity to the watercourse with an average valley width of approximately 125 m. Outside of this reach, the valley form broadens and the channel becomes less confined.

The study reach identified for the unnamed Credit River tributary extends upstream from River Road, (70 m west of Mississauga Road), until 60 m north of Ostrander Boulevard. This reach has a characteristically steep gradient and flows through a thickly vegetated riparian corridor. The current channel planform comes within 8 m of the valley toe which supports the Mississauga Road embankment.

Huttonville Creek was assessed for approximately 600 m downstream (south) of Bovaird Drive.

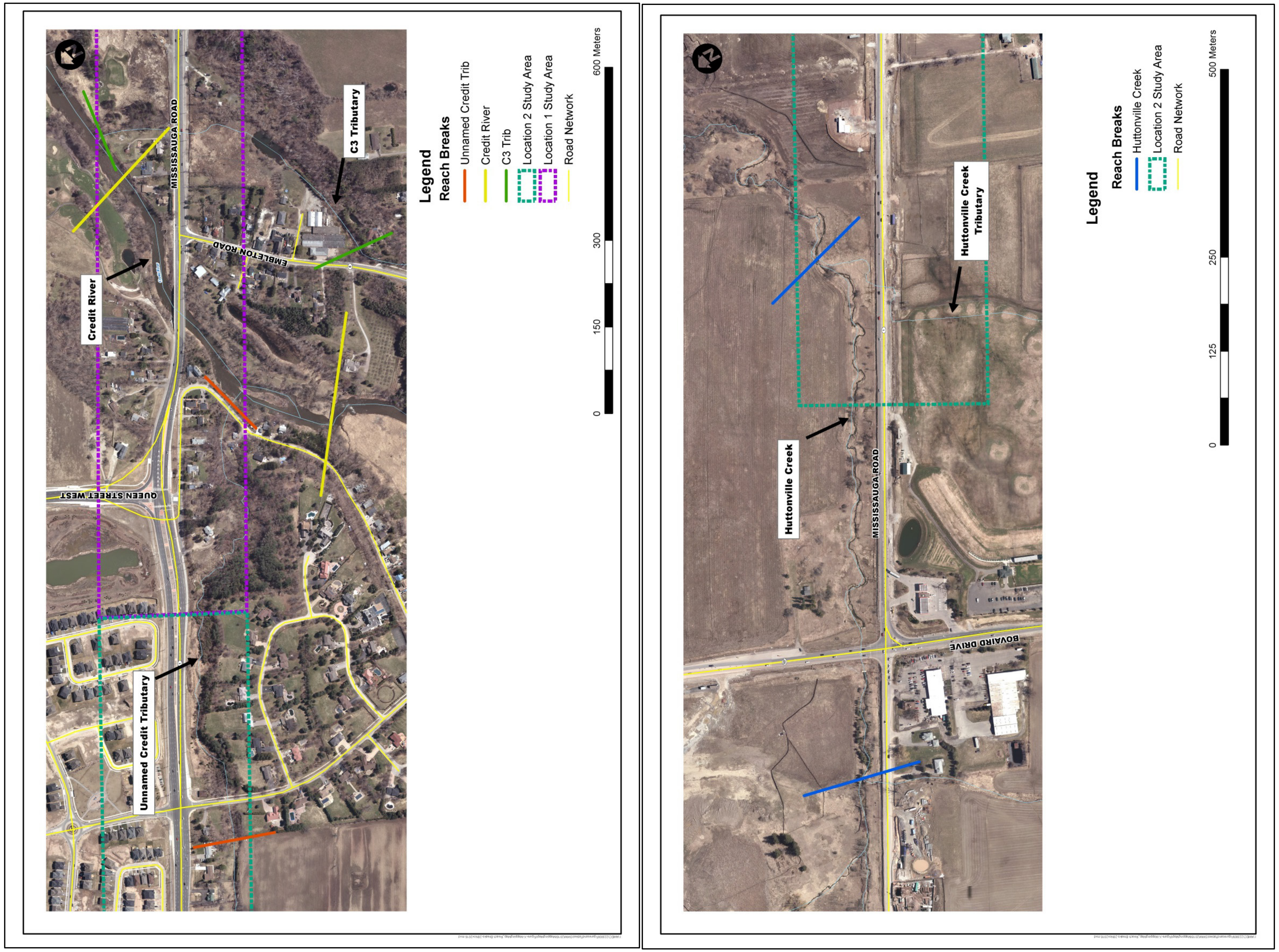


FIGURE 5.1 Reach Breaks along Study Watercourses.

6 EXISTING GEOMORPHIC CONDITIONS

Documentation of existing fluvial geomorphic conditions for the Credit River, Huttonville Creek and an unnamed tributary to the Credit River were collected within the vicinity of Mississauga Road right-of-way. The field assessments identify existing channel form and function to provide insight on channel stability and erosion migration potential that could result in negative affects to the Mississauga Road corridor. This data was used to guide restoration opportunities associated with road widening. At the time of the field assessments, construction was being completed on the culvert crossing of the Huttonville Creek tributary so detailed measurements of the channel were not able to be collected.

6.1 Rapid Assessment Results

The following section provides the results of the rapid assessments for the watercourse reaches within the study area. A summary of channel characteristics describing each reach is provided below.

TABLE 5.1 Summary of RSAT scores for Mississauga Road Study Area.

Reach	Factor Value						Overall Score	Condition
	Channel Stability	Scour / Deposition	Instream Habitat	Water Quality	Riparian Condition	Biological Indicators		
Max Score	**11**	**8**	**8**	**8**	**7**	**8**	**50**	
Tributary to Credit River	5	5	4	5	6	4	29	Moderate
Credit River	8	6	7	5	3	5	34	Moderate
Huttonville Creek	5	6	6	4	4	4	29	Moderate

TABLE 5.2 Summary of RGA scores for Mississauga Road Study Area.

Reach	Factor Value				Stability Index	Condition
	Aggradation	Degradation	Widening	Planimetric Adjustment		
Tributary to Credit River	0.33	0.29	0.25	0.14	0.25	Transitional
Credit River	0.11	0.14	0.25	0.14	0.16	In Regime
Huttonville Creek	0.22	0.14	0.38	0.14	0.22	Transitional

The unnamed tributary to Credit River showed minor evidence of aggradation, degradation and widening. Within the watercourse there were multiple occurrences of woody debris jams, fallen trees and exposed roots. As a result, small island formations were observed. Upstream of the debris jams cause pooling and localize erosion along the channel bank, contributing to the channel widening.

The channel 200 to 300 m upstream of the Credit River confluence was steeply sloped and straight with a moderate level of entrenchment. Near the confluence with Credit River, several large (0.35 to 0.65 m) nick points were observed with exposed bedrock present downstream. Further upstream, flows were controlled by debris jams and heavy vegetation, this area also had a relatively low slope. The upstream culvert at Ostrander Road is buffered by gabion baskets and scour pad. A 1 m drop carries the water to a 400 m section of the watercourse that flows approximately 20 m west of Mississauga Road, coming as close as 8 m to the toe of slope. A Stability Index Value (0.25) of the reach indicated that it is “transitional” in nature. This indicates that the channel morphology is within the expected range of variance but is experiencing a stress to the system that brings it out of a “stable” regime state. Based on the increased factor values for both widening and aggradation it can be interpreted that the prevailing hydrological regime is “flashy” in nature where high intensity, short duration storms produce a significant increase in erosion and sediment delivery into the channel. If the flow event is short, a drop in discharge will deposit entrained sediment along the bed before it can be transported out of the reach, leading to aggradation of the system. Bankfull widths along the watercourse ranged from 2 m wide in entrenched sections, to 4 m wide adjacent to Mississauga Road and downstream from Ostrander Blvd. Average Bankfull width is 3.5 m. Bankfull depths range from 0.4 m to 0.6 m.

Additional to the Unnamed Tributary to the north, the C3 Tributary (refer to Figure 1.1) was assessed from River Road to the confluence with the Credit River. Water was not observed downstream from Mississauga Road and the feature did not appear to have a morphology dictated by fluvial processes. The presence of a wetland feature mid-way through the study reach, upstream from Mississauga Road, appears to retain much of the surface runoff which would limit the channel to an ephemeral or intermittent flow regime. As such, rapid assessments were not performed on this feature.

Credit River was examined 200 m upstream and 600 m downstream of the Mississauga Road crossing. The majority of the bank network was observed to be stable with infrequent signs of slumping. Bank heights were generally 0.75 to 1.0 m above the bed and exposed tree roots were presented mainly from older trees. Exposed bank material was predominately clay. Deposition was uncommon along the reach with the exception of under the bridge crossing near both banks. Minor deposition was noted along the inner meander bends and point bars were minimal. Some deep pools were noted downstream of large boulders. Upstream of the Mississauga Road bridge crossing showed an increase in point bar formation and houses along the river had constructed retaining walls. The Stability Index Value (0.16) of the reach indicated that it was “in regime” with minimal evidence of widening. Bankfull widths were measured ranging from 23 m (upstream) to 27 m (downstream); throughout the reach average bankfull width is 25 m. Bankfull depth ranges from 1 m to 1.2 m.

A 600 m reach of Huttonville Creek was examined downstream of the Bovaird Drive West culvert. The reach was sinuous with undercut banks and slumping. Long grasses were present alongside the reach which helps reduce erosion of the channel. A moderate number of deep pools were present with poorly formed riffles and minimal sand deposits. The wetted perimeter was found to be approximately 90% of the bed with water moving at a slow velocity. Turbidity was moderate but increases significantly with bed disturbance. The bank material was predominately clay soils with some sand and silt in pools and cobble, gravel and pebbles in riffles. The reach was given a stability index of "transitional" (0.22) with moderate evidence of widening. Measured bankfull widths remain consistent with measurements in the Trow, 2006b report, with an average width of 3.5 m. Bankfull depths range from 0.6 m to 0.7 m.

7 MEANDER BELT WIDTH

A meander belt width has previously been assigned to Huttonville Creek within the Location 2 study area as part of the Class EA Study for Mississauga Road (Trow 2006a). Results of this study identified a final meander belt width of approximately 32.8 m was estimated for the reach which includes a factor of safety of 1.2. As part of the Location 2 technical study updates, the Huttonville Creek meander belt width will be reviewed and updated as necessary based on review of current ortho-imagery. In addition to the Huttonville Creek meander belt review, meander belt assessments are carried out for the Credit River and its unnamed tributary. An assessment was not completed for the unnamed Huttonville Creek tributary due to the lack of geomorphic characteristics observed on aerial imagery indicating that this feature is more of a headwater feature or swale in which case a meander belt is not appropriate assessment to establish hazard limits.

7.1 Belt Width Delineation

Preliminary meander belt delineations for the Credit River and Huttonville Creek were undertaken as recommended by Leopold and Wolman (1960) and is outlined in the Belt Width Delineation Procedures (Parish 2004). Their method prescribes drawing tangential lines along the outside bends of laterally extreme meanders within a study reach, parallel to the meander axis (i.e., valley axis). The distance, perpendicularly, between these two lines represents the preliminary meander belt width. The assessment is conducted using digital images, topographic maps, and historic channel positions in a Geographic Information System (ArcGIS). Using this same approach, the existing preliminary meander belt was verified (location and width) and was extended to encompass the entire study area. For these channels a 100-year erosion rate was calculated based on historical aerial imagery and added as an erosion setback to determine the final meander belt width where appropriate.

Results from this analysis, including preliminary corridor width, erosion setback, and final meander belt width are presented in **Table 7.1 and Figure 7.1**. The preliminary meander belt width for FC-3 was determined to be 100 m. The preliminary meander belt width for FC-4 was determined to be 105 m.

TABLE 7.1 Preliminary and Final Belt Widths.

Study Reach	Preliminary Belt Width (m)	Factor of Safety Setback (m)	Final MBW (m)
Credit River	140	**28**	**168**
Credit Tributary	36	**7.2**	**43.2**
Huttonville Creek	30.5	**6.1**	**36.6**

7.1.1 Credit River Meander Belt

A final meander belt width of approximately **168 m** was estimated for the study reach. A preliminary belt width of 140 m was measured representing the width of the controlling meander bends which define the meander belt boundary. This width also takes into consideration historical planform alignments of the river.

An erosion rate was difficult to determine due to multiple local alterations and river bank stabilizations that have occurred within the reach over the timeframe of historical imagery. Bank stabilizations limit the ability of the watercourse to horizontally migrate across the floodplain. Additionally, the partially confined nature of the watercourse, particularly upstream from the bridge crossing, additionally limits horizontal migration. An erosion rate of 0.12 m/yr was estimated for meander bends upstream from the study reach. However, as the preliminary belt width is greater than 50 m, the adoption of a 20% factor of safety in lieu of a 100 year erosion rate is acceptable. Using the 20% factor of safety in this case allows for a more conservative meander belt delineation.

7.1.2 Unnamed Credit River Tributary Meander Belt

A final meander belt width of approximately **43.2 m** was established for the unnamed Credit River tributary that generally parallel along the west side of Mississauga Road, crossing through both the Location 1 and Location 2 study corridors. The preliminary belt width of 32 m was established based on the meander belt (valley axis) and using the valley toe as the belt boundaries and adding the average bankfull width of 3.5 m.

When the preliminary meander belt is less than 50 m, it is customary to add an additional factory of safety that represents the 100 year erosion rate. However, due to the high degree of vegetative cover along the unnamed Credit River tributary, the existing planform along the study reach was difficult to distinguish using aerial photographs. When applying a final meander belt width to an obscure watercourse, such as the subject channel, a factor of safety representing 20% of the preliminary meander belt width is established and projected to either side of the channel (10% each side).

Prior to this assessment, restoration and toe-of-slope works have taken place within the tributary valley adjacent to Mississauga Road. As a result, future channel migration has been mitigated and is unlikely to pose a risk to infrastructure.

7.1.3 Huttonville Creek Meander Belt

For Huttonville Creek, the final meander belt width was estimates at **36.6 m**. This belt width is larger than the 32.8 m originally identified by Trow (2006b). The preliminary belt width of 30.5 m was established by measuring the width of the controlling meander bends which define the meander belt boundary and takes into consideration historical planform alignments of the watercourse and the average bankfull width.

Huttonville Creek, within the study reach, is clearly visible on historical aerial imagery allowing for the quantification of an appropriate erosion rate. An erosion rate was calculated based on measuring the distance between two known (stationary) points in the vicinity of the watercourse and calculating the difference between subsequent years (1974, 1989, 2016). An erosion rate of 0.2 m/yr was determined for the study reach based on the migration of dominant meander bends throughout the reach. While this erosion rate is more than double what was calculated by Trow in 2006b (0.089 m/yr) additional comparison of 2006 to 2016 aerial imagery indicated continued movement in the form of down-valley meander extension migration contributed to observed movement in primary beds throughout the reach. Comparison of 1974 to 1989 imagery with 1974 to 2016 imagery indicates an increase in erosion tendencies in recent years. Since the erosion rate calculated correlates to down-valley migration and not across-valley migration which would threaten the extent of the defined meander belt, using the erosion rate to determine final belt width extents would result in an overly conservative belt width. Instead, a 20% factory of safety (6.1 m) was applied to the preliminary belt width.

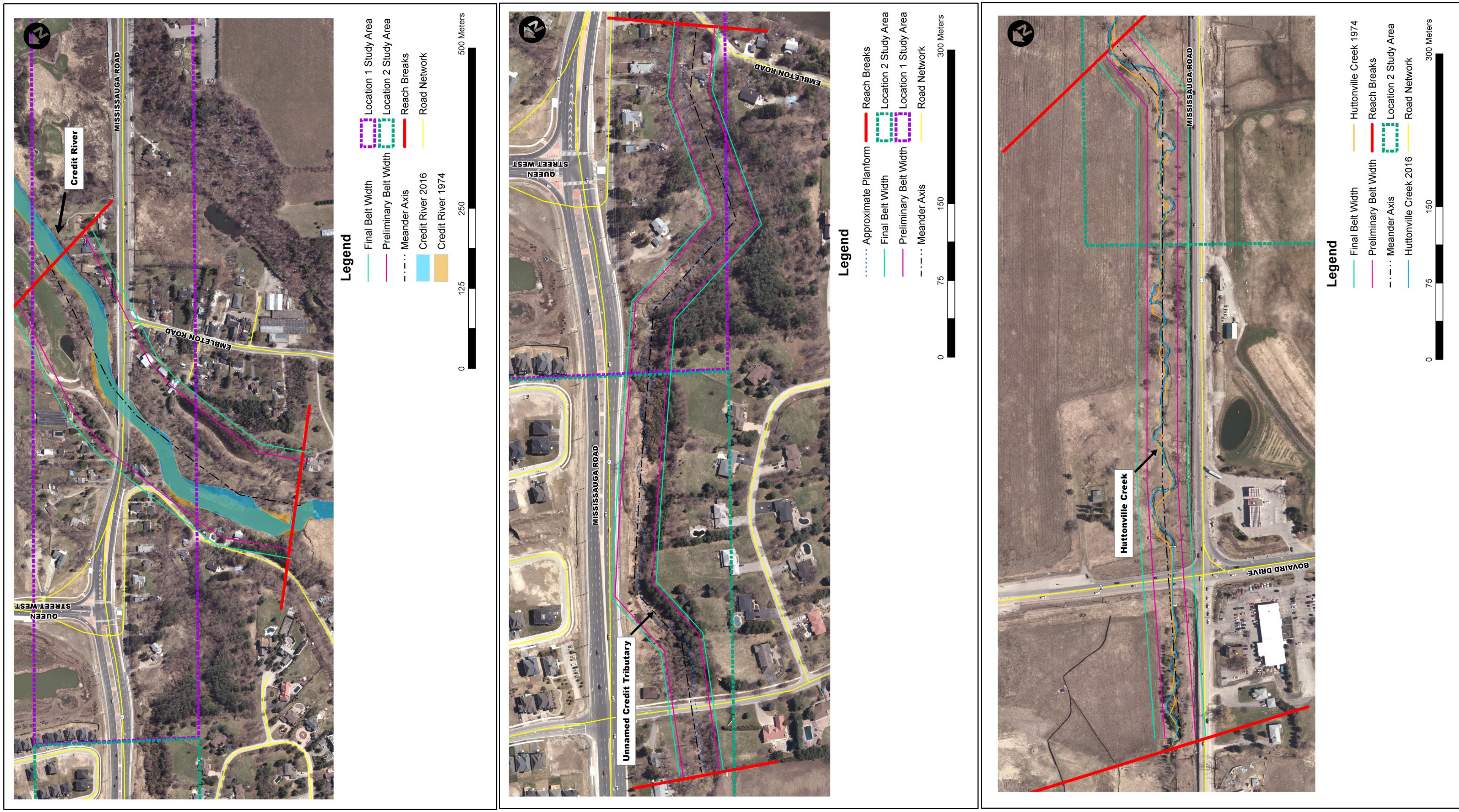


FIGURE 7.1 Meander Belt Width Delineation along Study Watercourses.

8 CROSSING ASSESSMENTS

The risk-based approach was applied to the Credit River crossing within the Location 1 study corridor as its structure will be impacted by the widening of Mississauga Road. In the development of a recommended structure size, it is not always realistic to span the entire belt width. Consideration of a number of factors, including crossing location setting and constraints, were taken to develop preliminary recommendations based on CVC guidelines for the size of the proposed crossing. The recommendations made below consider only fluvial geomorphologic factors. Further considerations of other important factors such as constructability and cost will be completed by the Class EA team to determine the overall recommendation for each crossing.

The purpose of this section is to provide more detailed recommendations in relation to sizing of the bridge crossing from a geomorphic perspective at the Credit River. This work is to support the alternative assessment process for this site.

8.1 Risk-Based Approach

In order to provide recommendations with respect to structure size and configuration from a geomorphic perspective, a risk-based assessment protocol is typically implemented on a site-specific basis to evaluate and determine the appropriate crossing structure size from a geomorphic perspective. The risk assessment process involves the following parameters:

- Channel Size: The potential for lateral channel movement and erosion tends to increase with stream size. Headwater streams tend to exhibit low rates of lateral migration due to the stabilizing influence of vegetation on the channel bed and banks. Erosive forces in larger watercourses tend to exceed the stabilizing properties of vegetation and result in higher migration rates.

- Valley Setting: Watercourses with wide, flat floodplains and with low valley and channel slopes tend to migrate laterally across the floodplain over time. Watercourses that are confined in narrow, well defined valleys are less likely to erode laterally but are more susceptible to downcutting and channel widening, particularly where there are changes to upstream land use. Typically the classification of the valley will fall into one of three categories: confined; partially confined; and, unconfined.

- Meander Belt Width: The meander belt width represents the maximum expression of the meander pattern within a channel reach. Therefore, this width/corridor, covers the lateral area where the channel could potentially occupy over time. This value has been used by regulatory agencies for corridor delineation associated with natural hazards and the meander belt width is typically of a similar dimension to the regulatory floodplain. The use of the meander belt width for structure sizing has been a criteria from some of the agencies and certainly represents a very conservative approach.

- Meander Amplitude: The meander amplitude and wavelength are important parameters to ensure that channel processes and functions can be maintained within the crossing. For the purposes of this study, the meander amplitude of the watercourse was measured in vicinity of the crossing and used as a guide to determine the preliminary crossing structure span.

- Rapid Geomorphic Assessment Score: An RGA score is essentially a measure of the stability of the channel. Channels that are unstable tend to be actively adjusting and thus more sensitive to the possible effects of the proposed crossing. Accordingly, there is more risk associated with unstable channels. While the actual RGA score will be reported, there are three levels of stability: 0 to 0.20 is stable; 0.21 to 0.40 is moderately stable; >0.40 is unstable.

- 100-year Migration Rates: Using historical aerial photographs, migration rates were previously quantified for reaches upstream and downstream of the crossing. A higher migration rate indicates a more unstable system and higher geomorphic risk.

All of these parameters feed into the risk assessment process which is outlined in **Figure 8.1**. It is key to recognize the spatial context when completing this assessment and providing the interpretation. Essentially, it is a risk assessment where, based on the condition of the channel, migration rates and trends, existing planform and valley configuration, an appropriate opening size from a geomorphic perspective can be developed.

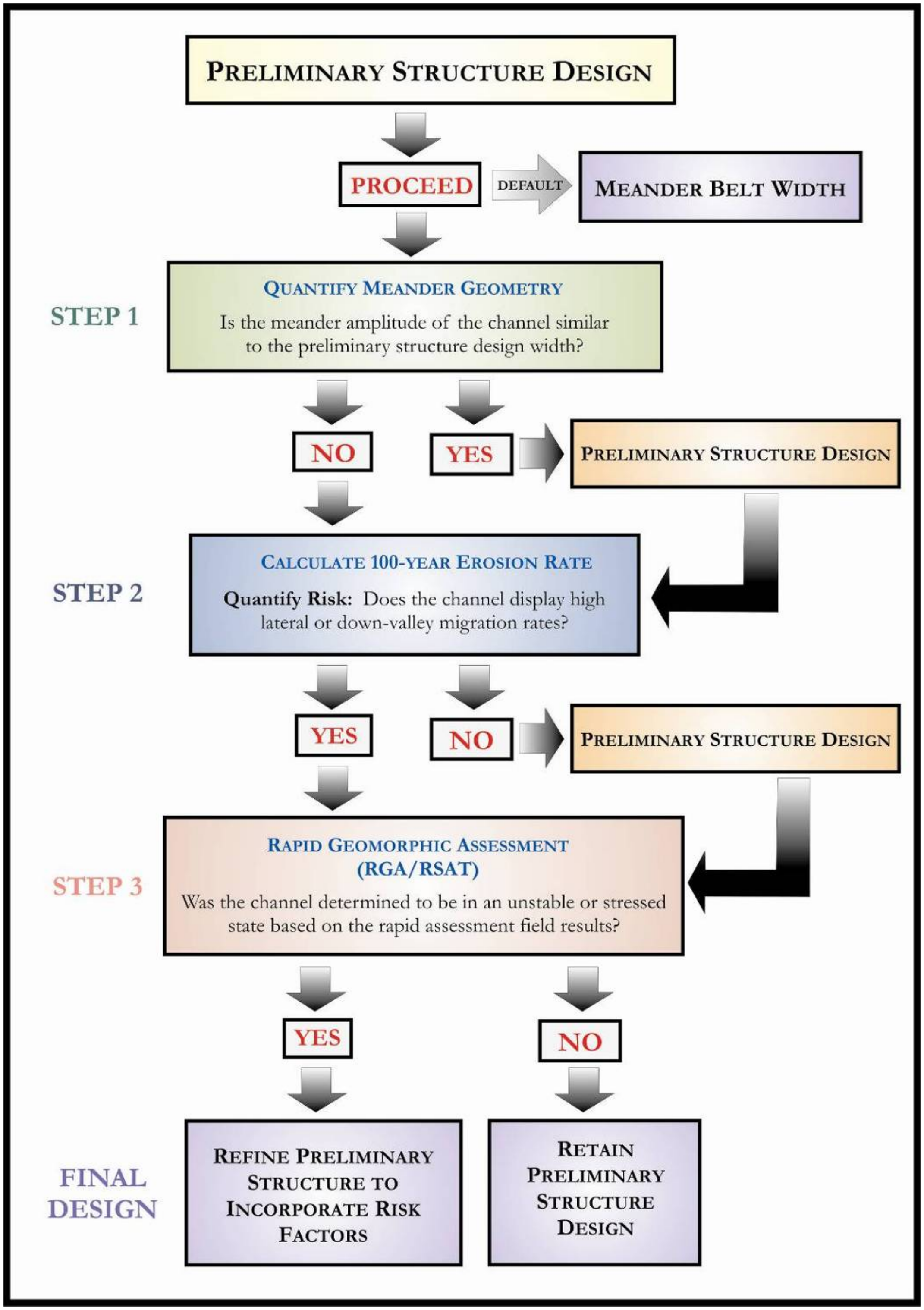


FIGURE 8.1 Geomorphic risk-based assessment protocol for crossing recommendations.

8.1.1 Characteristics of Credit River at the Crossing

The Credit River crossing of Mississauga Road is located along a generally straight section of the river; with a slight south easterly curve. The current bridge structure is constructed with two piers spaced approximately 16 m apart. The slight curve in the reach has caused scour along the length of the right abutment (looking downstream). There is no flow through either side of the piers, but stagnant water is present. The Credit River ranges from approximately 23 to 27 m wide at bankfull in the vicinity of the bridge crossing. To compensate for the flow constricted through the 16 m space between the piers, the flow over-widens on the downstream, eastern edge of the bridge. At the downstream end of the crossing, the river meanders south easterly to run almost parallel to Mississauga Road for 150 m. The initial portion of the meander puts the right bank of the Credit River less than 10 m from Mississauga Road.

The current crossing span is restricting flow of the channel. To reduce the possibility of increased channel widening on the downstream end of the crossing as well as limit additional bed scour, it is recommended the pier structures be removed and the crossing spans the width of the channel plus a factor of safety for future migration of the river.

- Channel Size: The channel upstream and downstream of the crossing has a bankfull width of approximately 23 to 27 m based on conservative field estimation. The channel is slightly narrower upstream of the crossing due to confinement of valley walls - the channel width was thus recorded as larger than the existing span between bridge piers (16 m) at the Mississauga Road crossing.

- Valley Setting: the Credit River flows within a generally broad well defined valley that narrows at the Mississauga Road crossing confining the flow path.

- Meander Belt Width: The meander belt width delineated in the above assessment is 168 m.

- Meander Amplitude: Meander amplitudes in the vicinity of the existing bridge crossing is 75 m. Dominant meander form upstream from the crossing is a result of island formation pushing the dominant flow path towards River Road.

- RGA Score: The RGA score recorded for the Credit River within the study reach was 0.16 indicating that the channel is “In regime” or stable. Channel widening was the dominant geomorphological process occurring as indicated by exposed tree roots, steep bank angles and basal scour.

- 100-year Migration Rate*:* 100-year migration rates calculated upstream from the current study reach it 12 m.

8.1.2 Recommendations for Credit River Crossing

The existing bridge crossing at Mississauga Road constricts active flow to a 16 m wide corridor. This width is than the reach average bankfull channel width of 25 m. At the crossing, backwater and ponding are located to either side of the bridge piers away from active flow. This indicates a lack of crossing capacity and it is therefore recommended that the replacement structure be wider to minimize any potential impacts on stream morphology.

Applying the risk-based approach (**Figure 8.1**):

- By default, in order to accommodate the full meander belt width of the reach, the crossing would need to be 168 m wide. From a geomorphic perspective, however, it is more critical that the structure accommodate the localized meander geometry in vicinity of the crossing.

- Based on conservative measurements taken from digital aerial photography of the study area, the governing meander amplitude immediately upstream of the crossing measures 70 m. As such, this represents the minimum required structure size from a geomorphic perspective in order to ensure that the crossing can accommodate the existing meander geometry of the channel.

- Based on the combined consideration of 100-year migration rates and field observations of existing conditions made through the rapid assessment phase, this site was deemed low risk from an erosion/horizontal channel migration perspective. However, evidence of channel widening was noted at the time of survey and the current planning context does anticipate continued suburban residential development of lands to the north. With this in mind, an additional factor of safety would benefit the channel and minimize future risk to the structure.

Using a risk-based approach, the recommended structure size for the Mississauga crossing of the Credit River was evaluated from a geomorphic perspective. Based on the governing meander amplitude in vicinity of the structure, a preliminary crossing size of 70 m was identified. While 100-year migration rate calculated upstream is in the range of 12 m (moderate risk), rapid assessment results indicated the channel is currently stable, although it does show evidence of widening. With this in mind a span of 75 m is recommended for the Credit River bridge crossing. This span is equivalent to three times the average bankfull channel width and is sufficient to support the long-term form and function of the channel. Specifically, this span refers to a clear-span bridge structure that is set at an optimal skew (90 degrees) to the meander axis and is applicable to the current channel alignment.

The above recommendations take into consideration fluvial geomorphic risk factors as well as conform to CVC guidelines for watercourse crossings. As per CVC guidelines, a well-designed crossing: spans the watercourse and banks, does not change water velocity, has natural substrate, and creates no noticeable change to river form.

TABLE 8.1 Geomorphic Parameters and Recommended Structure Size for Credit River.

Preliminary Meander Belt Width (m)	100-Year Migration Rates (Risk)	Meander Amplitude (m)	Bankfull Width (m)	Valley Setting	RGA Score (Risk)	Recommended Structure Size (m)
140	12 (Moderate)	70	23 -27 Average (25 m)	Semi-Confined	0.16 (Stable - low)	75

* Governing meander amplitude in vicinity of the crossing

8.1.3 Recommendations For Huttonville Creek and Unnamed Tributaries

The meander belt delineated for the unnamed Credit River tributary is 43.2 m wide, and crosses over the current road alignment. While there is no crossing of the watercourse, the widening of Mississauga Road has already resulted in the consideration for slope stability and watercourse restoration (i.e., additional bank protection or realignments away from the roadway) in order to mitigate potential hazards or watercourse erosion alongside the roadway. As a result of these works, it is not anticipated that channel migration will impact infrastructure.

The meander belt width delineated for Huttonville Creek is 36.6 m. While larger than the Trow, 2006b belt width, the delineated belt width does not cross or contact the existing Mississauga Road extent. The widening of Mississauga Road adjacent to Huttonville Creek within Location 2 study corridor is not expected to encroach upon the preliminary belt width and the widening will occur to the west. This will also help to mitigate disturbance to Redside Dace habitat.

The unnamed tributary to Huttonville box culvert crossing was under construction during the time of the field visit. As such a full field investigation of the crossing could not be completed. However, the box culvert under construction has been updated from a corrugated steel pipe. Based on the previous Mississauga Road ESR report, the culvert at this location is for an ephemeral tributary which does not support fish habitat (direct or indirect) and does not contribute to the maintenance of fish downstream. A confluence with Huttonville Creek was not identified during the field assessments and flow was not observed. Based on these observations, structure sizing is deferred to hydraulic flow requirements.

Based on observations made of the C3 Tributary, structure sizing is deferred to hydraulic flow requirements.

9 CONCLUSIONS

A fluvial geomorphological assessment has been conducted involving:

- broad scale historical assessment
- reach delineation
- identification of stream crossing locations
- meander belt width assessment
- field reconnaissance

The streams and the crossings along Mississauga Road have been characterized and key management considerations highlighted within the preceding report. Watercourses within the two study corridors warrant specific consideration as they have a well-defined channel and morphology, are actively adjusting, and are of greater habitat value.

The following summarizes the key findings:

- The recommended span of the Credit River crossing is 75 m. This is equivalent to three times the average bankfull width of the watercourse determined within the study reach and is sufficient to support the long-term form and function of the channel.

- Two additional watercourses flow adjacent to Mississauga Road within the Location 1 and Location 2 study corridors; an unnamed tributary to the Credit River as well as Huttonville Creek. Meander belt widths are determined to be 43.2 m and 50.5 m respectively for these watercourses. While these watercourses do no directly cross Mississauga Road, widening of the roadway is expected to encroach within the belt width, however additional stabilizations measures are not recommended at this time. Based on observations made of the C3 Tributary, no restoration or mitigation measures are required at this point and sizing of the replacement culvert structure can be deferred to hydraulic requirements.

10 REFERENCES

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Trow Associates Inc (Trow). 2006b. *Meander Belt Width Assessment Huttonville Creek.* Report prepared for the Regional Municipality of Peel. Brampton, Ontario. April 2006.

APPENDIX A
Site Photographs

Matrix Solutions Inc.
September 29, 2016

1. Looking upstream towards Mississauga Road– flow limited to flow within the 16 m wide gap between two piers.

Matrix Solutions Inc.
September 29, 2016

2. Downstream of Credit River Bridge – bed composed primarily of partially embedded cobble with some clay and boulders.

Matrix Solutions Inc.
September 29, 2016

3. Downstream of Credit River Bridge – double outlet oval shaped concrete pipe with grates; rip rap lined outlet channel.

Matrix Solutions Inc.
September 29, 2016

4. Downstream of Credit River Bridge – channel hardening with gabion baskets along residential properties.

Matrix Solutions Inc.
September 29, 2016

5. Downstream of Credit River Bridge – minor debris jam with evidence of high flow.

Matrix Solutions Inc.
September 29, 2016

6. Downstream of Credit River Bridge – large boulder with downstream scour depth of 0.57 m.

Matrix Solutions Inc.
September 29, 2016

7. Downstream of Credit River Bridge – tall grasses with some trees along banks.

Matrix Solutions Inc.
September 29, 2016

8. Downstream of Credit River Bridge – golf car bridge spanning the watercourse.

Matrix Solutions Inc.
September 29, 2016

9. Downstream of Credit River Bridge – undercutting of trees and large boulders on right bank

Matrix Solutions Inc.
September 29, 2016

10. Credit River Bridge – channel over widens just downstream of the bridge to compensate for 16 m wide main opening.

Matrix Solutions Inc.
September 29, 2016

11. Credit River Bridge – left bank side of bridge pier shows no flow.

Matrix Solutions Inc.
September 29, 2016

12. Upstream of Credit River Bridge – channel hardening along left bank adjacent to River Road.

Matrix Solutions Inc.
September 29, 2016

13. Upstream of Credit River Bridge – island formation downstream of decommissioned dam.

Matrix Solutions Inc.
September 29, 2016

14. Unnamed Credit Trib – outlet of corrugated steel pipe to Credit River.

Matrix Solutions Inc.
September 29, 2016

15. Unnamed Credit Trib – wide, mature riparian corridor between rural residential houses.

Matrix Solutions Inc.
September 29, 2016

16. Unnamed Credit Trib – old weir with 35-40 cm drop.

Matrix Solutions Inc.
September 29, 2016

17. Unnamed Credit Trib – low flow channel with cobble and pebble substrate.

Matrix Solutions Inc.
September 29, 2016

18. Unnamed Credit Trib – approximately 20 cm of undercutting and minor debris jam.

Matrix Solutions Inc.
September 29, 2016

19. Unnamed Credit Trib – steep (>70°) embankment slope leading to Mississauga Road northeast of creek.

Matrix Solutions Inc.
September 29, 2016

20. Unnamed Credit Trib at Ostrander Boulevard – outlet of culvert.

Matrix Solutions Inc.
September 29, 2016

21. Unnamed Credit Trib at Ostrander Boulevard – channel is lined with gabion baskets and scour pad present.

Matrix Solutions Inc.
September 29, 2016

22. Unnamed Credit Trib at Ostrander Boulevard – dry channel downstream of culvert outlet.

Matrix Solutions Inc.
September 29, 2016

23. Huttonville Creek - box culvert outlet at Bovaird Drive W.

Matrix Solutions Inc.
September 29, 2016

24. Huttonville Creek – downstream of highly sinuous channel heavily vegetated with tall grasses and pockets of trees.

Matrix Solutions Inc.
September 29, 2016

25. Huttonville Creek – sediment composed predominantly of gravels with some cobbles and pebbles and silt.

Matrix Solutions Inc.
September 29, 2016

26. Huttonville Creek – wider section of channel with higher bank heights of approximately 0.6 m.

Matrix Solutions Inc.
September 29, 2016

27. Huttonville Creek – near the suspected confluence with its unnamed tributary

Matrix Solutions Inc.
September 29, 2016

28. Huttonville Creek unnamed tributary – box culvert under construction at the time of field investigations.