

Indian Creek and Sixteen Mile Creek Tributaries Fluvial Geomorphological Assessment

Milton Link
Milton, Ontario



Prepared for:
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This report presents professional opinions and findings of a scientific and technical nature based on the knowledge and information available at the time of preparation. This document is prepared solely for the Client, and the data, interpretations, suggestions, recommendations, and opinions expressed in the report pertain only to the project being completed for the Client.

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1.0 Project Summary

The Proponent, Tribal Development Management Services Inc. (doing business as "Matthews"), is advancing the development of lands located adjacent to the CN Logistics Hub in the Town of Milton. Official Plan and Zoning By-law Amendments (OPA/ZBA) are being pursued to designate the subject lands as Industrial Area to be included within the Sustainable Halton Plan (SHP) Urban Area Boundary. The site will seek the entitlements associated with the Employment Zone, with site-specific provisions to support the intended development. The area comprises several parcels generally bounded by Britannia Road to the north, Highway 25 to the east, Burnhamthorpe Road West to the south, and Tremaine Road to the west, within the Town of Milton.

2.0 Introduction

GEO Morphix was retained to provide fluvial geomorphological services in support of municipal applications for the Milton Link Phase 1-4 development lands in Milton, Ontario (herein referred to as "subject lands"). The subject lands are generally located south of Britannia Road, east of Tremaine Road, west of Highway 25, and north of Burnhamthorpe Road West. The lands are situated adjacent to the CN Logistics Hub in the Town of Milton. The subject lands are separated into four phases and contain reaches of several tributaries to Indian Creek and Sixteen Mile Creek. Several warehouse structures are proposed on the subject lands. The location of the subject lands is shown in **Appendix A**, for reference.

Fluvial geomorphological services were required to characterize existing watercourses and drainage features on site, support development of an overall constraints plan, and inform preliminary stormwater management (SWM) and land use planning strategies. We have therefore characterized existing conditions through the completion of a desktop assessment. The assessment focused on detailed review of available reporting including watershed and subwatershed studies, topographic mapping, conceptual/draft plans provided to GEO Morphix by others, public data sets, and a review of our existing observations and datasets in nearby areas to support regional contextualization of data. The findings presented in this report incorporated cumulative and downstream geomorphological implications at a subwatershed scale and were used to delineate constraints to development and support future SWM modelling and design phases. It should be noted that the findings summarized here are subject to refinement through future planning studies.

The following specific activities were completed to support the current OPA/ZBA submission:

- Review of available background reports pertaining to watercourse form and function and controlling factors related to geomorphology (e.g., previous site-specific studies, watershed/subwatershed scale studies, topography, geology, conceptual development plans)
- Review of existing available mapping information (e.g., MNRF and Conservation Authority hydrographic layers), including watercourses, headwater drainage features, and other drainage conveyance features relevant to the subject lands
- Reach delineation for identified watercourses and drainage features based on channel form, valley setting, confinement, and observable changes in geomorphic condition
- Review of historical aerial photography to identify persistence of watercourses and drainage features on the landscape, support interpretation of historical channel alignment and stability, and inform preliminary estimates of meander belt widths (i.e., erosion hazards)
- LiDAR-based terrain analysis to identify valley settings and degree of confinement and support erosion hazard analysis for the subject lands and erosion mitigation assessments related to receiving watercourses
- Desktop characterization of watercourses and drainage features within the subject lands and downstream of future stormwater management (SWM) outlets
- Desktop delineation of the meander belt width or erosion hazard for the watercourses located on the subject lands using historical and recent aerial imagery, field observations, or empirical modelling approaches where required
- Desktop-level review of receiving watercourses to understand erosion sensitivity relative to proposed stormwater management plans
- Review of internal erosion threshold database and provision of unitary erosion thresholds to support the Project Engineer and inform target flows for erosion mitigation

At the time of preparation, site access for field investigations was not available. Accordingly, the findings, interpretations, and recommendations presented herein are based on a desktop assessment of available background information, including published mapping, topographic and LiDAR data, historical and recent aerial imagery, available borehole information, and conceptual plans provided by others. As such, all reach delineations, erosion hazard interpretations, erosion threshold estimates, and natural channel design considerations should be considered preliminary and subject to refinement through future field verification and subsequent stages of study.

3.0 Background Review

3.1 Study Area

The subject lands span a boundary between the Sixteen Mile Creek Subwatershed and the Bronte Creek Subwatersheds (MNR, 2025). Maps available from Conservation Halton (2025) and Ontario Hydrological Network (OHN, 2025) indicate the presence of several watercourses and drainage features within the subject lands, including Indian Creek and tributaries as well as tributaries to Sixteen Mile Creek. Published mapping also indicates the presence of wetlands within Phase 1 and 3 lands (Conservation Halton, 2025) and woodlands within Phase 1, 2, and 4 lands (MNR, 2023). Mapping also indicates there is no presence of aquatic species at risk or habitat thereof within the subject lands (DFO, 2025).

3.2 Background Studies

3.2.1 Town of Milton Official Plan and Planning Growth Map

The Town of Milton Official Plan indicates that the subject lands are within the town of Milton and are designated as rural area (Town of Milton, 2026a). The majority of the Phase 1 lands and a portion of Phase 3 lands are included within the boundary of the supplemental study area of the South Milton Urban Expansion Area Subwatershed Study (Town of Milton, 2021). A waste management site is located adjacent to the Phase 1 and 2 lands (Town of Milton, 2026a).

In the Town of Milton's Official Plan, the Milton Link Phase 1-4 lands are predominantly classified as rural and agricultural lands (Town of Milton, 2026b) and are located within a "Future Strategic Employment Area" (Town of Milton, 2026c). The subject lands have a range of different key environmental and hydrologic features, including linkages, enhancement areas, buffer designations and Greenbelt Natural Heritage Systems.

3.2.2 South Milton Urban Expansion Area Subwatershed Study (SMUEASWS)

The South Milton Urban Expansion Area Subwatershed Study (SMUEASWS; Town of Milton, 2021) provides an overall framework for the management of natural heritage and water resources within South Milton. In general, the study characterizes existing conditions, including reach delineation, rapid assessments, erosion hazard delineation, and erosion thresholds defined on a broad scale, and are subject to refinement under future stages of study. This provides important fluvial geomorphological background, and context to the lands adjacent to the subject area including environmental assessments, hazard delineation and management recommendations of downstream watercourses.

Although the SMUEASWS (Town of Milton, 2021) is focused primarily on the region to the east of the current subject lands, a portion of the Milton Link study area is encompassed within the boundary of the supplemental study area, providing a basis for reach delineation.

3.2.3 Sixteen Mile Creek Areas 2 and 7 Subwatershed Update Study (SUS)

The Sixteen Mile Creek Areas 2 and 7 Subwatershed Update Study (SUS) (AMEC, 2015), which focused on Derry Green and Boyne Survey lands, included observations of reaches upstream of the Phase 1 and Phase 2 lands. The geomorphological assessment component of the SUS was completed at a broad scale and included a review of historical aerial imagery, reach delineation, and rapid geomorphic assessments upstream of Britannia Road along tributaries that flow into Phase 1 and Phase 2 subject lands (i.e., SUS

Tributaries SWS-1, SWS-2, I-NE-2A, and I-NE-IB). A meander belt width of 30 m was assigned to SUS Reach SWS-2-A, which corresponds to **Reach TSMC(1)7-3c** in the reach delineation provided in **Section 3.5** of the current report. Meander belt widths are further discussed in **Section 5.1**.

3.2.4 Boyne Survey Block 1 Subwatershed Impact Study Addendum (SIS)

Recommendations outlined in the SUS were subsequently reviewed as part of the Subwatershed Impact Study (SIS) Addendum (TMIG, 2019). The Boyne Survey Block 1 Subwatershed Impact Study Addendum was predominantly scoped for the Block 1 lands located between Britannia Road and Louis St. Laurent Avenue and to the east of Tremaine Road.

The SIS Addendum included a fluvial geomorphology assessment to update and refine the findings of the SUS. The SIS Addendum included meander belt width recommendations for tributaries upstream of Britannia Road, including a 21 m meander belt width for the Indian Creek tributary that feeds into **Reach IC6-7** (TMIG et al, 2019). The SIS Addendum also recommended a unitary erosion control discharge value of 0.0009 m³/s/ha for reaches of Indian Creek located directly upstream of the Phase 2 lands.

3.3 Surficial Geology and Physiography

Stream morphodynamics are largely governed by the flow regime and the availability and type of sediments (e.g., surficial geology) within the stream corridor. Secondary variables that affect the channel include land use and riparian vegetation. These are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity. Understanding local surficial geology is important for delineating the erosion hazard, as the stability of the channel banks and bed is dependent on the composition of soils, sediment, and underlying parent materials.

The subject lands lie within the Peel Plain physiographic region, comprising low relief to gently undulating topography, lying around 180 to 200 m asl (OGS 2010). At a landscape scale, low relief topography encourages low gradient streams, reducing stream power and shear stress, resulting in lower erosion potential for a given discharge.

The dominant surficial sediment of the Peel Plain comprises the Halton Till, subglacial deposits of the last Laurentide Ice Sheet in the region. The Halton Till has variable texture across southern Ontario (Sharp and Russell, 2016), resulting in variable erodibility. Borehole logs (n = 96) from across the subject lands (EXP, 2025 a-d) describe the texture of the local Halton Till as very stiff to hard, clayey silt to silty clay. This hardened, fine-grained till is likely erosion resistant. Till commonly contains gravel clasts, often to cobble or boulder calibre, that often forms the bed material of smaller watercourses where discharges are too low to regularly mobilise these clasts. This gravel will act to reduce erosion of the bed, while the fine-grained till banks remain erodible and prone to slumps and channel widening.

Across much of the Peel Plain, and beneath the subject lands specifically, the Halton Till is mapped as overlain by a veneer of glaciolacustrine sediments, deposited in a shallow, late-glacial lake (OGS, 2010). These lake sediments comprise massive to laminated silt and clay, with minor facies of silt-clay diamicton ("flow till") and sorted sand and gravel also described (OGS, 2010). These generally fine sediments are likely cohesive and relatively erosion resistant when undisturbed, though the described differences in texture will create local variations in erosion resistance. Weathering and disturbance from agricultural land use will also likely reduce erosion resistance. These deposits have a maximum recorded thickness of around 1.3 m (Karrow, 1983).

The borehole logs from the subject lands reveal a consistent pattern of 0.25 to 0.3 m of topsoil over around 0.25 to 0.3 m of reworked till overlying the Halton Till (EXP, 2025 a-d). These borehole data are within areas mapped as surficial glacial lake sediments (OGS, 2010) but lack descriptions consistent with these facies. This implies that the occurrence or preservation of glacial lake sediments in this area is minimal or variable. Here, however, the reworked till described in the borehole logs is expected to be predominantly loose to fairly compact silt and clay with erodibility comparable to fine glacial lake sediments. It is assumed here that watercourses incised by approximately 0.5 m or more will have the underlying Halton Till or reworked gravel as the bed material, and further incision will result in till as the

bank material. Incision of less than 0.5 m will result in less compact silt and clay from glacial lake sediment or reworked till as the channel boundary material.

3.4 Terrain Analysis

The subject lands are situated within low relief to gently undulating topography, lying around 180 to 200 m asl (OGS 2010), consistent with the Peel Plain physiographic region. The surface topography displays subtle hummocks and hummocky ridges, and larger northwest to southeast lineations. These landforms resemble subdued eskers, moraines and drumlins, which would record the surface of the underlying Halton Till; the subdued appearance implies glacial landforms are draped with subsequent glaciolacustrine sediment from Lake Peel. These subtle landforms appear to direct local surface drainage into swales and small streams.

Minor streams and headwater drainage features are not deeply incised into the landscape surface. Larger watercourses (e.g., Sixteen Mile Creek, Bronte Creek, Indian Creek) are incised by around 5 metres into surficial sediment to form moderately confined meandering systems. Valley walls of these valley form slopes of 20-30°, with minimal evidence of slope instability (crown fractures, head scarps, displaced blocks and lobes, etc.) observed, though smaller tributary watercourses are frequently incised deeply into valley walls to form steep gullies. Many headwater drainage features for the subject lands rise on the scarp slope of the Niagara Escarpment to the northwest at around 250 m asl, forming steep (c. 5%) gullies. These gullies reduce in gradient at the foot of the scarp slope (c. 0.1%) and straighten significantly to largely follow roads and field boundaries. Many drainage features and watercourses also traverse urban development in Milton in engineered channels, which comprises around 20% of the drainage area to the subject lands.

At a landscape scale, low relief topography encourages low gradient streams, reducing stream power and shear stress. Excess stream power is likely to result in increased bank erosion and meandering rather than incision, as recorded in the current planform of the major watercourses in the area. However, the lack of observed valley wall erosion and slope instability suggests that larger watercourses are relatively stable within their confining valleys. The steeper headwaters under the escarpment may be more erosive and transport relatively coarse material (sand, fine pebbles), but it is expected that this sediment load will be deposited rapidly on the flatter Peel Plain topography and may not be reflected in the bedload within the subject reaches, though increased suspended sediment from upstream erosion may be observed downstream.

Bedload within smaller watercourses within the subject reaches is therefore likely to be fine, reflecting local till and lake sediments. Larger watercourses are likely excavating the lower subglacial sediments due to their deeper incision and are likely to have gravel bedload; the location and concentration of gravel beneath the finer Lake Peel sediments may be variable depending on the specific subglacial landforms and sediments beneath the surficial sediments. The urban development upstream of the subject land likely increases runoff, elevating either the peak discharge or duration of flows during rainfall events; it is likely that these watercourses and associated SWM plans are appropriately designed, but there may be impacts in downstream watercourses where systems are yet to establish equilibria to the urbanized catchment.

3.5 Reach Delineation

Reaches are generally homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a reach, for example, as it relates to a proposed activity. Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs

- Soil type and surficial geology
- Historical channel modifications

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field, where access permits.

Reaches within and near the subject lands were previously delineated in the South Milton Urban Expansion Area Subwatershed Study (SMUEASWS; Town of Milton, 2021) through a desktop assessment. Additionally, reaches adjacent to Britannia Road (primarily to the north) were delineated as part of the Sixteen Mile Creek Areas 2 and 7 Subwatershed Update Study (SUS) (AMEC, 2015). Reaches have been further refined by GEO Morphix based on a combination of the SMUEASWS work and additional desktop review of available information. At this time, GEO Morphix has only refined the delineation of reaches to the south of Britannia Road; reaches to the north of Britannia have not been refined. Mapping available from Conservation Halton (2025) and the Ontario Hydrological Network (OHN, 2025) indicate the presence of several watercourses and drainage features within the subject lands, including tributaries of Indian Creek and Sixteen Mile Creek.

Watercourses within the subject lands were divided into eight distinct reaches (three in the Sixteen Mile Creek subwatershed and five in the Indian Creek subwatershed). Four of the reaches traverse Phase 1 lands (**Reaches TSMC(1)7-3c, TSMC(1)7-4, TSMC(1)7-3b and IC6-6**), two flow through Phase 2 lands (**Reaches IC6-8 and IC6-7**), and two originate in Phase 4 lands (**Reaches IC2-2a and IC2-1a**). Phase 3 lands contain no designated watercourses or drainage features. Additional reaches adjacent to the subject lands within potential influence of the proposed development, were also included in the desktop delineation.

Seasonal presence of flows and lack of riparian vegetation factors suggest **Reaches TSMC(1)7-3b, IC2-2a, IC2-1a, and IC6-8** have been preliminarily classified as HDFs rather than watercourses. This preliminary conclusion is supported by the omission of these reaches from the watercourse layer in Conservation Halton mapping (Conservation Halton, 2025). Classification of these hydrologic features should ultimately be confirmed through field assessment as part of future planning stages.

The delineated reaches are shown graphically in **Appendix A**.

3.6 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use/cover. This information, in part, provides an understanding of the antecedent factors that have contributed to current channel morphodynamics as well as what may be expected in the future.

Aerial photographs and satellite images from 1954 (~1:60,000, University of Toronto), 1985 (1:40,000) and 1988 (1:50,000) from the National Air Photo Library (NAPL), 1995 (1:20,000) and 1999 (1:20,000) from Ontario GeoHub and 2004, 2014, 2016, 2020, 2024, and 2025 from Google Earth Pro were retrieved to complete the historical assessment. Select historical and recent imagery is provided in **Appendix B**.

The aerial photo from 1954 indicates that the subject lands and upstream and downstream lands were generally composed of agricultural fields and some rural residential land uses.

All reaches described in **Section 3.5** are identifiable across the aerial images, with varying degrees of channel definition and persistence of flow. Some have been consistently poorly defined with little to no riparian vegetation, while others have been well-defined and buffered with substantial riparian vegetation coverage. **Reach TSMC(1)7-3b**, while having minimal riparian vegetation and little evidence of active flow outside of spring conditions, has been persistent over time with defined channels and saturation in fields along its bank and indications of a culvert at an upstream road crossing. Similarly, **Reaches IC2-2a and IC2-1a** have poorly defined channel banks and little evidence of flow, but remain

persistent over time and appear to incorporate culverts to convey flow across Tremaine Road. All other defined reaches within the subject lands show consistent definition and indications of persistent flow.

Between 1988 and 1995, woodlands in lands adjacent to the Phase 1 and Phase 2 subject lands were removed and a new waste management facility was established. Berms were constructed which would limit abutment between the facility and the adjacent reaches (**Reaches TSMC(1)7-3a and IC6-5**).

Some developments (generally residential) have been gradually introduced west of the Phase 1 and Phase 2 subject lands starting in 2014. These developments incorporated channel realignment with meandering designs in the off-site reaches immediately upstream of **Reaches TSMC(1)7-3c, TSMC(1)7-3, and IC6-7**, along with construction of several SWM ponds.

An additional facility was constructed adjacent to **Reach IC6-1** between 2020 and 2024. In tandem, realignment of **Reach IC6-1** was undertaken, along with creation of a large SWM pond.

A large dirt road crossing **Reach IC6-7** is observable starting from 2024 images. The crossing incorporates a large culvert. Also observable from 2024 is a newly constructed water feature which, while not yet appearing to have regular flow, could feasibly convey flow from the Phase 3 lands towards Indian Creek. This feature incorporates apparent crossings through a service road and the CN railway. A large meander of **Reach IC4** has been hydrologically cut off by a channel realignment which bypasses most of the existing reach. The realignment incorporates a new channel with a shorter length, sinuous planform, extensive armouring, and adjacent SWM ponds.

As of 2025, land use within the subject lands remains primarily agricultural, with the CN railway and its associated service roads traversing generally northward and southward along the western bounds of the subject lands. The Sixteen Mile Creek tributary confluences and then flows through a nearby golf course, while the Indian Creek tributaries traverse agricultural areas, woodlands, and rural residential properties. Several residential and commercial properties are sparsely distributed throughout the area.

4.0 Erosion Hazard Assessment

Most watercourses in Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential erosion hazard to proposed activities adjacent to a given watercourse.

When defining the erosion hazard for a watercourse, Ministry of Natural Resources (MNR, 2002) guidelines treat unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well outside where the channel could realistically migrate. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible. Partially confined systems may also be observed where the watercourse may be partially restricted in migration and floodplain occupation on one side of the valley system only. Inputs to the determination of erosion hazards include meander belt widths, staked top of banks, toe erosion setbacks, and long-term stable top of slopes, depending on the confinement. A summary of preliminary erosion hazards for watercourses within the subject lands is provided below.

As a conservative measure, a meander belt width can be applied in unconfined systems based on 20 times the bankfull channel width. Alternatively, the limit of the erosion hazard and migration potential can be delineated based on the meander amplitude. Meander amplitude is defined by Leopold et al. (1964) as the lateral distance between tangential lines drawn to the center channel of two successive meander bends. This differs from meander belt, which is measured for a reach between lines drawn tangentially to the outside bends of the laterally extreme meander bends (TRCA, 2004). Both the meander belt width and amplitude quantify the lateral extent of a river's occupation on the floodplain (TRCA, 2004). In cases where the channel is not discernible in aerial photographs or has been substantially modified, empirical models can be used to estimate the meander belt width.

4.1 Meander Belt Width

Through desktop assessment, it was determined that all watercourse reaches within and adjacent to the subject lands (i.e., **Reaches TSMC(1)7-3c, IC6-8, IC6-7, IC6-6, and IC6-5**) flow within unconfined valley systems, indicating a meander belt width analysis is the appropriate approach to address the erosion hazard.

A review of recent and historical aerial imagery was completed to support desktop assessment of meander belt axis. Due to the straightened nature of the reaches and lack of change in planform between the earliest assessed aerial image (1954) and the most recent aerial image (2025), assessment via orthorectified aerial imagery did not yield reliable analysis. Given these limitations, an empirical modelling approach was used to determine potential meander belt widths and support the erosion hazard delineation for the unconfined reaches through and near the subject lands.

It should be noted that the meander belt widths outlined below are preliminary. Without site access and in-field assessments to verify feature geometries, at this time meander belt widths were only able to be modelled using drainage areas and discharge rates. The resulting meander belt widths determined from the TRCA (2004) and Ward Drainage Area (2001) models are outlined and compared below (**Table 1**). The meander belt width recommendations are considered preliminary and subject to refinement under future studies.

The TRCA (2004) empirical model calculates meander belt widths using the following equation:

$$B_w = -14.827 + 8.319 \ln(\rho g Q S * DA) \quad [\text{Eq. 1}]$$

where ρ is water density (1000 kg/m³), g is acceleration due to gravity (9.81 m/s²), Q is discharge (m³/s), S is channel slope (m/m), and DA is drainage area (km²). An additional standard factor of safety (8.6 m) was applied to the computed belt width value.

The Ward Drainage Area (2001) methodology results in a meander belt width including a 20% factor of safety, calculated as follows:

$$B_w = 120 * DA^{0.43} \quad [\text{Eq. 2}]$$

where DA is drainage area (sq. miles).

Inputs for the drainage area and discharge for the subject reaches were derived from correspondence with Envision (2026) and from OWIT / GeoFAT. Envision provided 2-year discharge rates for **Reach IC6-6**, but 2-year discharge values were not available for **Reaches TSMC(1)7-3c and TSMC(1)7-4**.

Gradients were calculated on a reach-by-reach basis using LiDAR data from 2023.

A summary of the values used as inputs into the TRCA (2004) and Ward Drainage Area (2001) meander belt width models is provided in **Table 1**.

Table 1: Meander belt width empirical model inputs

	Envision (2026)		OWIT / GeoFAT	LiDAR (2023)
	Drainage Area (ha)	2-year flow (m ³ /s)	2-year flow (m ³ /s)	Gradient
TSMC(1)7-3c	2.51	<i>Not available</i>	2.36	0.003
TSMC(1)7-4	1.87	<i>Not available</i>	0.87	0.004
IC6-6	1.72	0.95 ^a	<i>Not assessed</i>	0.014

^a Calculated by Envision using available upstream flow data pro-rated on drainage area

Results of the empirical modelling exercise, along with preliminary recommendations for meander belt widths, are outlined in **Table 2**.

Table 2: Meander belt width model outputs and preliminary recommendations

Reach	Meander Belt Width (m)			Preliminary Recommended Meander Belt Width
	SUS (2015)	TRCA (2004)	Ward Drainage Area (2001)	
TSMC(1)7-3c	30	36.7	36.08	36 m
TSMC(1)7-4	N/A	28.4	31.77	32 m
IC6-6	N/A	38.8	30.66	39 m

The TRCA model predicted meander belt widths ranging from approximately 28 to 39 metres, including one standard error to account for potential underprediction of the model. The Ward Drainage Area model predicted similar meander belt widths, ranging from approximately 31 to 36 meters, including a 20% factor of safety.

Based on these findings, we recommend applying a preliminary existing conditions meander belt width of 36 m for **Reach TSMC(1)7-3c** based on the Ward Drainage Area (2001) model. This recommendation is larger than the existing conditions meander belt width previously delineated for this reach under the SUS (2015). The SUS provided this meander belt width based on digital mapping sources and indicated the recommendation should be reviewed and potentially refined in future study. We therefore consider the proposed 36 m preliminary recommendation to be highly conservative and also subject to refinement in future study. We also note that this reach is proposed for realignment, as described further in **Section 6.0**. Given the potential realignment of the reach, the meander belt width is likely to be re-examined as part of the design process, given there would be possible changes to channel slope, hydrology, planform, and cross-sectional geometry of the reach, each of which would result in a meander belt width that is different from existing conditions.

We recommend applying a preliminary existing conditions meander belt width of 32 m for **TSMC(1)7-4**. This recommendation exceeds the outputs from the TRCA and Ward models.

As a conservative approach, we recommend applying a preliminary 39 m meander belt width, as calculated using the TRCA model, for **IC6-6**. Given that drainage area and flow information could not be derived for reaches **IC6-5** and **IC6-7**, we recommend applying the 39 m meander belt width for **IC6-6** to these reaches as a preliminary approach to erosion hazard delineation. This is a highly conservative approach given the gradient of **IC6-6** is substantially higher than that of **IC6-5** and **IC6-7** (0.002 and 0.003 respectively, as per 2023 LiDAR data).

Preliminary meander belt width delineations are mapped in **Appendix C**. Note that all meander belt widths outlined here are preliminary and subject to refinement during future stages of study (e.g., when field data and local hydrological information become available).

5.0 Erosion Mitigation for Stormwater Management

It is our understanding that stormwater management facilities are to be proposed as part of this development. According to preliminary conceptual plans provided by Envision (2026) and reviewed by GEO Morphix, multiple outfalls associated with stormwater ponds, piped systems, and overland flow are proposed to discharge to the tributaries of Sixteen Mile Creek and Indian Creek. When planning outfall locations, it is essential to consider fluvial geomorphology to ensure erosion mitigation and to avoid negative impacts on channel processes. Outfall locations should be sited to minimize interaction with active channel zones, areas of potential channel migration, and areas prone to scour or erosion. Where possible, outfalls should be in relatively straight and stable sections and should avoid meander bends or areas with high erosion or high sediment transport activity.

Several SWM outfalls are proposed along multiple water and wetland features within and downstream of the subject lands. All proposed outfall locations are considered to be conceptual and preliminary at the current stage of development. At detailed design stage, all outfalls should be considered through a formalized outfall mitigation assessment. This should be undertaken at the proposed outfall locations to characterize the local channel morphology, assess long-term stability, and develop outfall and end of pipe treatments as required.

5.1 Erosion Threshold Assessment

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material. An erosion threshold is often expressed as a critical streamflow discharge or shear stress, at which the material within the watercourse will be mobilised. Changes in the magnitude, duration, and frequency of streamflow may alter the pattern and rates of channel erosion. Erosion thresholds are defined by assessing the morphology of the channel and the characteristics and condition of the bed and bank materials.

In the absence of field data, erosion thresholds may be estimated through comparison to previously defined erosion thresholds through a unitary approach. Unitary erosion thresholds rates assume the erosion threshold scales linearly with drainage area where the bed and bank material and channel slope are similar. This results in channel geometries (width and depth) that scale with discharge, which in turn scales with drainage area. Erosion thresholds and unitary rates from the surrounding areas may therefore be utilized to estimate the erosion threshold in a given reach.

5.1.1 Reach Selection

The following analysis focuses on the reaches downstream of proposed SWM ponds that are assessed to be the most erosion sensitive. Without field data, the choice of reaches is led by remote data (surficial geology and channel slope) and the relative proportional contribution of the subject lands to discharge to the reach. With the current extent of information, **Reaches TSMC(1)7-1, TSMC(1)7-3, IC2 and IC5** were selected for erosion threshold assessments. Remote LiDAR-derived DEM data were analysed for the selected reaches to estimate their approximate bankfull geometry (width and depth) and channel slope. Such remote investigations are prone to under-estimation of bankfull conditions due to the inability to penetrate the water surface and survey the channel bed. Therefore, the remote assessment was used only to assess the similarity between the selected reaches and other watercourses in the area, allowing a comparison to accepted erosion thresholds. Field level reconnaissance is recommended in future study in order to verify observations and validate which reaches should be identified as the most erosion-sensitive.

At this time it is understood that Phase 1 lands are proposed for discharge into **Reach TSMC(1)7-3c** (Envision, 2026). Downstream reaches **TSMC(1)7-3** and **TSMC(7)1-1** were selected for erosion threshold analysis as they were determined to be the most erosion-sensitive reaches downstream of the proposed SWM outfall. Discharge from the subject lands is not anticipated to contribute significantly to erosion within the main branch of Sixteen Mile Creek due to its relative size compared to the tributary.

Stormwater from Phase 2 lands and the western SWM pond in Phase 3 lands are understood to be proposed to discharge into **Reach IC6-1** (Envision, 2026). **Reach IC6-1** was extensively realigned in 2022 and is expected to be stable; erosion risk was therefore assessed further downstream. **Reach IC5** was determined to be the most erosion sensitive through its full extent, as observed by a more consistent slope through its entirety in comparison to adjacent reaches.

The remaining stormwater from Phases 3 and 4 is understood to be proposed to discharge to Indian Creek either by a newly constructed channel towards **Reach IC4** or via road-side drainage ditches (**Reach IC2-2**) towards **Reach IC2**; clarification on the routing of stormwater may require updates to the selected reaches. In the former scenario, flow will pass through **Reach IC3**; the relatively low gradient of this reach (0.02%) greatly reduces the erosion potential. **Reach IC2** has an average channel slope of 0.2% and is therefore considered more erodible than upstream reaches given the expected similarity in bed and bank materials. **Reach IC2** has short sections of higher gradient (c. 0.6%) that will increase erosion potential. One such section is sited immediately downstream of **Reach IC2-2**

carrying proposed stormwater inputs from Phase 4 and is selected here as the most erosion sensitive section and representative of the whole reach.

5.1.2 Remote Assessment

A remote assessment using publicly available LiDAR data was conducted on the subject reaches. The results of the remote assessment of the selected reaches are presented in **Table 3**.

The surficial geology of the area, mapped as a veneer of glaciolacustrine clay, silt and sand, overlying the Halton Till (OGS, 2010; EXP, 2025 a-d), is consistent across the study area and throughout the region. These sediment units offer relatively high erosion resistance due to cohesion of fine sediment and bed armouring from gravel extracted from till units, as observed in other local watercourses. The low to moderate LiDAR-derived slopes of the subject reaches (between 0.002 and 0.014) are comparable to other watercourses in the area. Since these mapped surficial geology characteristics and LiDAR-derived channel slopes are comparable to those found by other studies in the area, conducting a desktop analysis of regional unitary erosion threshold values previously determined in nearby locations can aid development of erosion control recommendations for the current study.

Table 3. Results of remote LiDAR-derived channel characteristics.

Channel Parameter	Reach			
	IC2	IC5	TSMC(1) 7-3	TSMC(1) 7-1
Average bankfull channel width (m) ^a	9.07	6.34	5.26	4.34
Average bankfull channel depth (m) ^a	0.32	0.40	0.16	0.19
Channel gradient (%) ^b	0.60	0.18	0.49	1.40
Manning's n ^c	0.05	0.05	0.035	0.05
Drainage area (ha) ^d	3,528.8	3,174.5	452	769
Bankfull discharge (m ³ /s) ^a	2.323	3.199	0.483	0.759
Average bankfull velocity (m/s) ^a	0.71	0.45	0.56	0.95

a. LiDAR data; likely underestimation

b. LiDAR data; reliable

c. Estimated from remote data and previous local studies

d. Ontario Watershed Information Tool (OWIT)

5.1.3 Unitary Analysis

GEO Morphix maintains a database of erosion threshold values from watercourses across southern Ontario, with a unitary erosion threshold calculated where drainage areas are available. These data were analysed to determine a representative unitary erosion threshold and absolute erosion threshold estimates for the subject reaches. These refined erosion threshold estimates are presented for reference should local refinement of erosion risk for specific reaches be required.

Subsets of the dataset, representing local physiography (Peel Plain and South Slope) and surficial geology (till and glacial lake sediment) were extracted to determine a range of feasible unitary erosion threshold estimates. As the unitary erosion threshold values have a wide range (10^{-5} to 10^{-3}), geometric mean values were determined for each subset, with geometric standard error (GSE) calculated to determine upper and lower bounds for each estimate. The lower bound unitary erosion threshold for the appropriate surficial sediment was used to determine a conservative erosion threshold for each subject reach.

Lower-bound regional unitary erosion threshold estimates are **0.000828 m³/s/ha** for watercourses within till, and **0.000636 m³/s/ha** for glacial lake sediments. These lower-bound, conservative values

are broadly comparable to the established unitary erosion target of **0.0009 m³/s/ha** recommended in the SIS Addendum (TMIG, 2019). This previously established value did not incorporate assessment of the receiving watercourses of the current study but has been used previously to limit potential erosion in work adjacent to the subject lands, is acceptable as a representative local unitary erosion benchmark.

A summary of the regional unitary analysis is presented in **Table 4**.

Table 4. Results of unitary erosion threshold analysis for subject land surficial geology

Surficial geology and physiography	# Unitary erosion thresholds in database	Geometric mean unitary erosion threshold (m ³ /s/ha)	Geometric Standard Error	Lower Bound (m ³ /s/ha)
Peel Plain and South Slope (till)	36	0.00972	1.17	0.000828
Southern Ontario (fine glacial lake sediment)	13	0.00846	1.33	0.000636

Reaches **TSMC(1)7-1**, **IC5** and **IC2** are expected to be largely flowing through till substrate, either due to their mapped location compared to surficial geology mapping (OGS, 2010), or due to the LiDAR-determined bankfull depths implying they are eroded through the shallow glacial lake sediments. Applying drainage areas for each reach as derived from OWIT, the erosion thresholds for these reaches are estimated as **0.637 m³/s** for **TSMC(1)7-1**, **2.628 m³/s** for **IC5**, and **2.922 m³/s** for **IC2**.

Reach **TSMC(1)7-3** is relatively shallow (0.16 m) and flows through the mapped extent of glacial lake sediment; the unitary erosion threshold for glacial lake sediment observed throughout southern Ontario was applied, resulting in an erosion threshold estimate of reach **TSMC(1)7-3** of **0.287 m³/s**.

The estimated erosion thresholds for the selected reaches are presented in **Table 5**.

Table 5. Summary of erosion threshold analysis results.

Reach	Expected boundary materials	Drainage Area (ha)	Estimated Unitary Erosion Threshold (m ³ /s/ha)	Unitary-derived Erosion Threshold (m ³ /s)
TSMC(1)7-3	Glacio-lacustrine	452	0.000636	0.287
TSMC(1)7-1	Till	769	0.000828	0.637
IC5	Till	3174	0.000828	2.628
IC2(D)	Till	3529	0.000828	2.922

Future field assessment may lead to further refinement of these preliminary recommended erosion threshold values to ensure they are more reflective of local channel characteristics and erosion sensitivity observations.

We note that the estimated unitary erosion threshold values in **Table 5** are comparable to the unitary erosion control discharge value recommended in the SIS Addendum (TMIG, 2019) upstream of **Reach IC6-7** (0.0009 m³/s). It is important to distinguish the concept of erosion threshold from erosion control discharge: the erosion threshold represents the discharge at which bed and/or bank materials begin to mobilize, whereas erosion control discharge refers to the flow rate used as a design target to limit or manage erosive processes. These two values do not necessarily need to coincide, provided an erosion exceedance analysis demonstrates that discharges resulting from the SWM plan do not alter erosion potential in downstream reaches (Villard and Parish, 2003). In our professional opinion, at this stage of

development planning, it is reasonable to use the SIS Addendum's recommended unitary discharge rate for erosion control as a basis for developing the SWM plan.

6.0 Natural Channel Design

As per the concept plan shared by Armstrong on April 12, 2026, **Reach TSMC(1)7-3c** may be explored as a potential candidate for realignment, with a potential alignment generally parallel to Highway 25.

The subject tributary is situated within a historically altered system and is located immediately downstream of a previously realigned reach completed as part of adjacent development north of Britannia Road. Based on available background information, aerial imagery, and regional mapping, the existing channel exhibits characteristics typical of anthropogenically influenced systems, including alignment constraints, modified planform, and limited geomorphic complexity. In this context, the reach represents a candidate for future channel realignment and/or restoration to improve geomorphic function and long-term stability.

At the current OPA/ZBA stage of study, and in the absence of field verification and detailed hydraulic or sediment transport analyses, it is not appropriate to define a preferred channel alignment or design in detail. However, it is reasonable to anticipate that a natural channel design (NCD) approach would be suitable for this system, particularly given its position within a developing landscape and its connectivity to an upstream realigned reach. Implementation of a natural channel design approach would support improved channel stability, enhanced sediment continuity, and increased ecological function, while also aligning with current regulatory expectations for watercourse restoration within development contexts.

6.1 Future Design Objectives

Should channel realignment or restoration be advanced through future planning stages, the design should seek to achieve the following objectives:

- Establish a channel pattern, profile, and cross-sectional form that is geomorphologically stable over the long term
- Integrate appropriately with the upstream realigned reach and downstream receiving system to maintain continuity of channel processes
- Provide a well-defined bankfull channel and floodplain appropriate to the valley setting and anticipated flow regime
- Support improved riparian condition and opportunities for enhancement of aquatic and terrestrial habitat
- Support opportunities for improved water quality and thermal regime, which may include integration with online and/or offline wetland features, where compatible with the stormwater management and ecological restoration strategies
- Mitigate erosion hazards to the proposed development and surrounding lands
- Coordinate with stormwater management, grading, and ecological restoration requirements to support an overall functional corridor

6.2 Future Design Requirements

Advancement of a natural channel design for Reach TSMC17-3c should be supported by future field-based geomorphic assessments to confirm existing channel conditions, constraints, and processes. This would include detailed topographic survey, substrate characterization, bank stability assessment, and identification of active geomorphic processes. Hydrologic and hydraulic modelling will be required at future stages to define design flows, assess floodplain interactions, and confirm substrate materials sizing.

Development of a detailed channel realignment plan should consider integration with the upstream realigned reach to ensure continuity of channel pattern, profile, and dimension. The design should also be coordinated with the proposed stormwater management strategy to mitigate potential impacts related to altered flow regimes. Key design considerations would include meander geometry, meander

belt width, longitudinal profile, bankfull and floodplain configuration, and incorporation of natural channel substrates and in-stream habitat features.

Regulatory approvals are expected to require demonstration that the proposed realignment achieves long-term geomorphic stability, maintains or improves existing hydraulic capacity, and results in a net ecological benefit. Engagement with the Conservation Authority and municipal stakeholders early in the detailed design phase is recommended to confirm specific design criteria, modelling requirements, and permitting expectations.

While detailed channel design is beyond the scope of this desktop assessment, the subject reach is considered a suitable candidate for future natural channel realignment/restoration. Advancement of this component should proceed through a staged approach involving field investigation, detailed analysis, and iterative design development.

7.0 Summary

GEO Morphix was retained to complete a fluvial geomorphology assessment for the Milton Link Development lands in support of Official Plan and Zoning By-law Amendments applications for the Milton Link Phase 1-4 lands in Milton, Ontario. A desktop assessment was completed to characterize existing watercourses and drainage features on site, support development of an overall constraints plan, and inform preliminary stormwater management (SWM) and land use planning strategies. The desktop assessment also included a review of surficial geology and topographic mapping and historical and recent aerial imagery to understand existing conditions and previous work completed for the subject lands.

Erosion hazards delineations were completed for watercourse features within the study area. **Reaches TSMC(1)7-3c, TSMC(1)7-3, IC6-8, IC6-7, IC6-6, and IC6-5** were identified to be unconfined and as such, a meander belt width was recommended for each. Preliminary meander belt widths were determined using the TRCA (2004) modelling approach and preliminary flow data provided by Envision (2026). Using available data, a meander belt width of 37 m was preliminarily recommended for **Reach TSMC(1)7-3c**, 30 m for **TSMC(1)7-4**, and 39 m for **Reach IC6-6**. Through the extension of the meander belt width delineated for **IC6-6**, 39 m is also recommended as a preliminary meander belt width for **Reaches IC6-5 and IC6-7**.

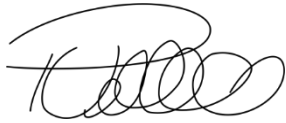
In support of the proposed SWM plan for the subject lands, preliminary erosion threshold modelling was completed. Based on sediment composition and channel gradients, **Reaches TSMC(1)7-1, TSMC(1)7-3, IC2 and IC5** were considered to be the most erosion-sensitive reaches downstream of SWM outfall locations. Results of the preliminary erosion threshold modelling indicated that the limiting unitary erosion threshold values for the assessed reaches are comparable to the unitary erosion control value used in the Boyne Survey Block 1 Subwatershed Impact Study Addendum (TMIG, 2019), indicating this value is reasonable to rely on for preliminary SWM plan development.

Based on the desktop review completed for this study, **Reach TSMC(1)7-3c** is considered a suitable candidate for future natural channel realignment and restoration. At the current OPA/ZBA stage, however, it is not appropriate to define a preferred alignment or complete a detailed natural channel design. Should this component advance through future planning stages, it should be supported by field-based geomorphic assessment, detailed survey, hydraulic analysis, and coordination with the broader SWM, grading, and ecological restoration strategies.

At this time, field access was not possible and all assessments and recommendations outlined in this report are based on a desktop review of the subject lands and available background information.

We trust this report satisfies your requirements at this time. Should you have any questions or concerns, please contact the undersigned.

Respectfully submitted,



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Senior Watershed Scientist, Technical Lead

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Appendix A: Study Area and Reach Delineation

Study Area

Sixteen Mile Creek and
Bronte Creek Tributaries
Town of Milton, Ontario

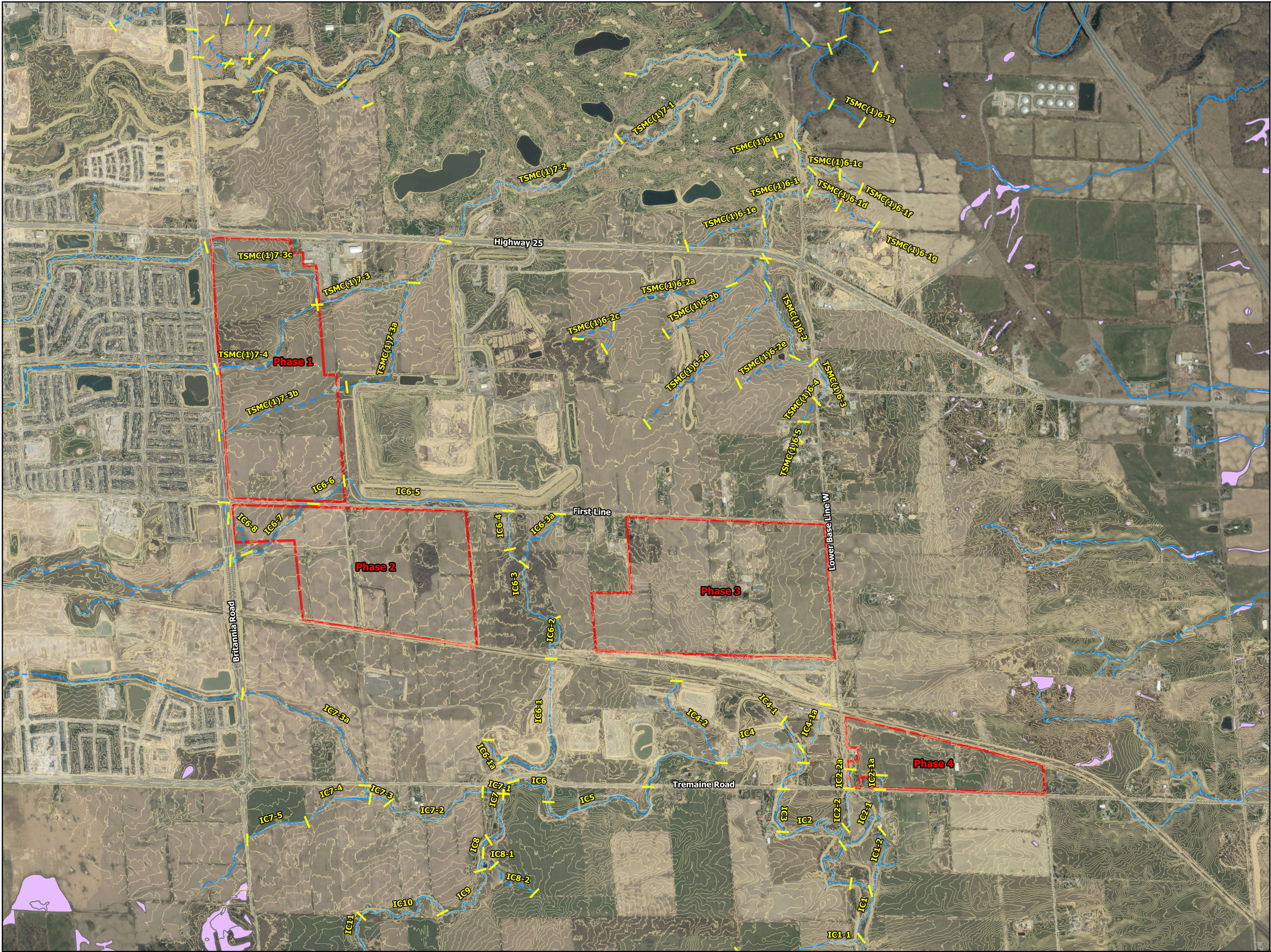
Legend

- Reach Break and ID
- Watercourse
- Drainage Feature
(Not Field Assessed)
- 0.5 m Contour
- Evaluated Wetland
- Not Evaluated
Wetland
- Approximate Study
Area

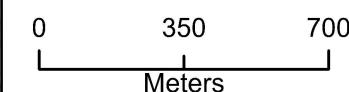


0 350 700
Meters

Imagery: MNR 2023. Watercourse and
Wetland: MNR, 2024. Reach Break and ID: MP4 SWS, 2021/
GEO Morphix Ltd., 2026. Approximate
Study Area: GEO Morphix Ltd., 2026.
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PN26021. Drawn By: D.B., M.O..

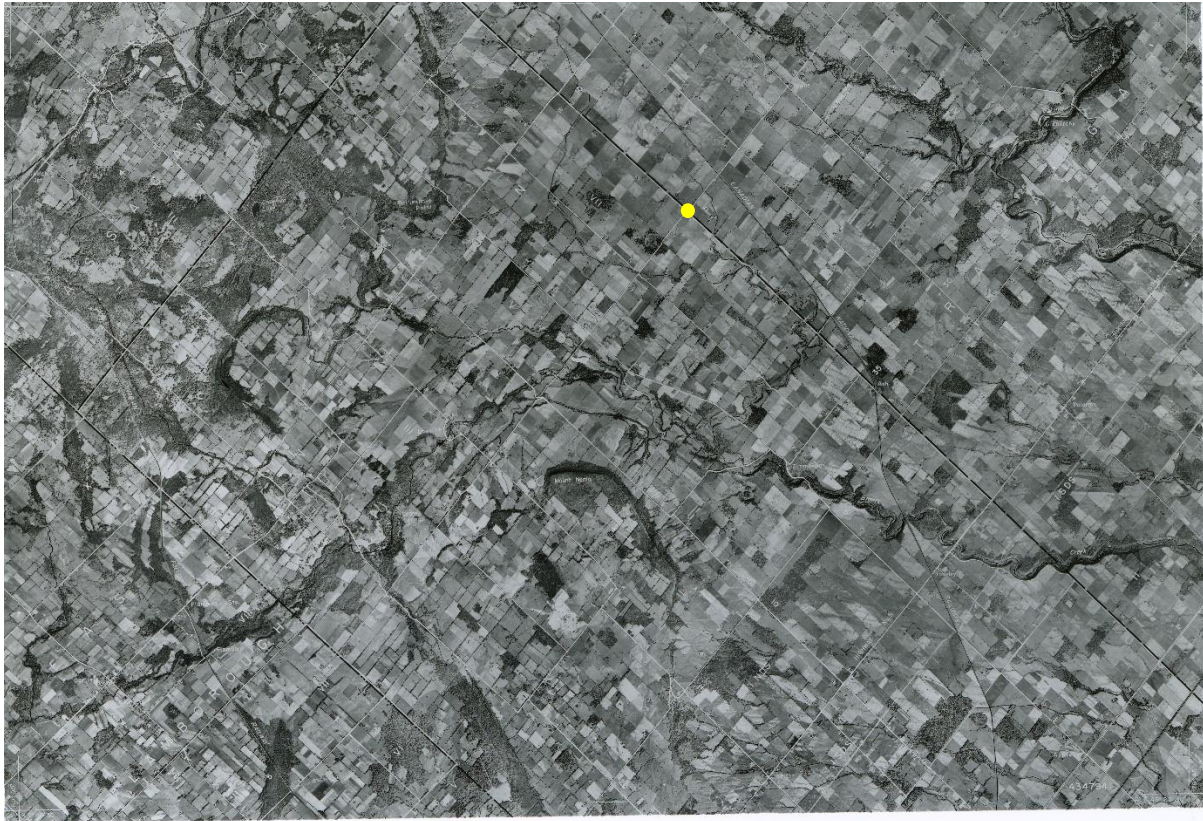


- Reach Break and ID
- Watercourse
- Drainage Feature
(Not Field Assessed)
- Approximate Study Area



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Appendix B: Historical Aerial Imagery



Location: Town of Milton, ON

Year: 1954

Scale: ~1:60,000

Source: University of Toronto

Yellow Point: Intersection of Tremaine Road and Britannia Road



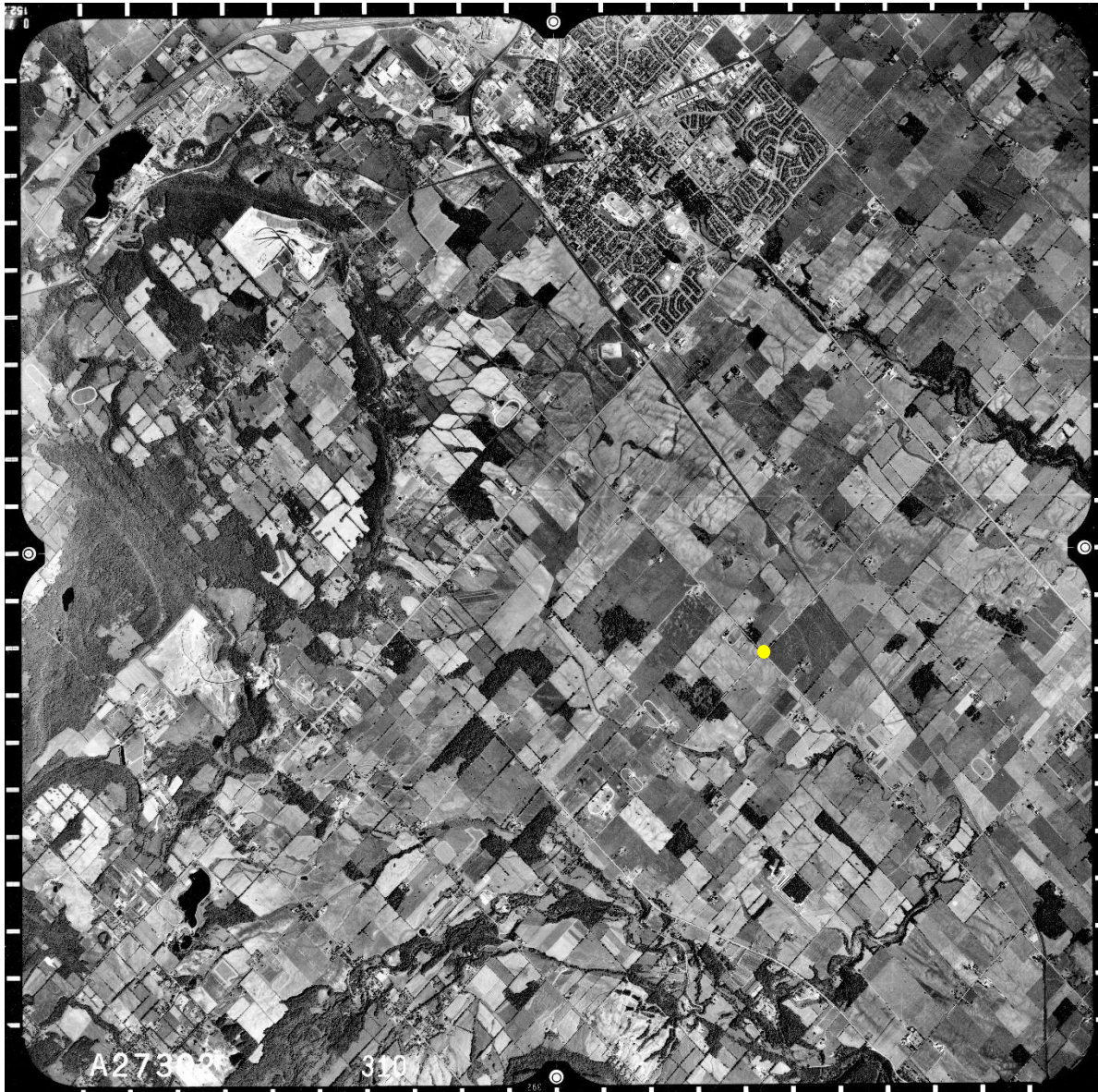
Location: Town of Milton, ON

Year: 1985

Scale: 1:40,000

Source: National Air Photo Library

Yellow Point: Intersection of Tremaine Road and Britannia Road



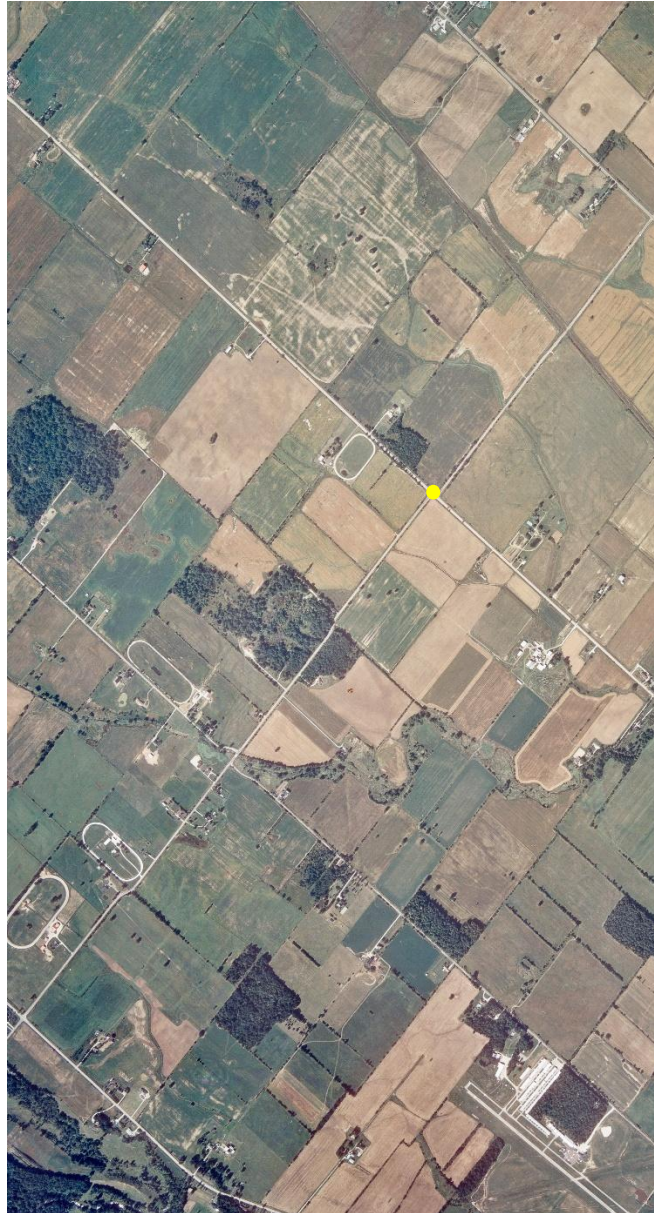
Location: Town of Milton, ON

Year: 1988

Scale: 1:50,000

Source: National Air Photo Library

Yellow Point: Intersection of Tremaine Road and Britannia Road



Location: Town of Milton, ON

Year: 1995

Scale: 1:20,000

Source: Ministry of Natural Resources

Yellow Point: Intersection of Tremain Road and Britannia Road



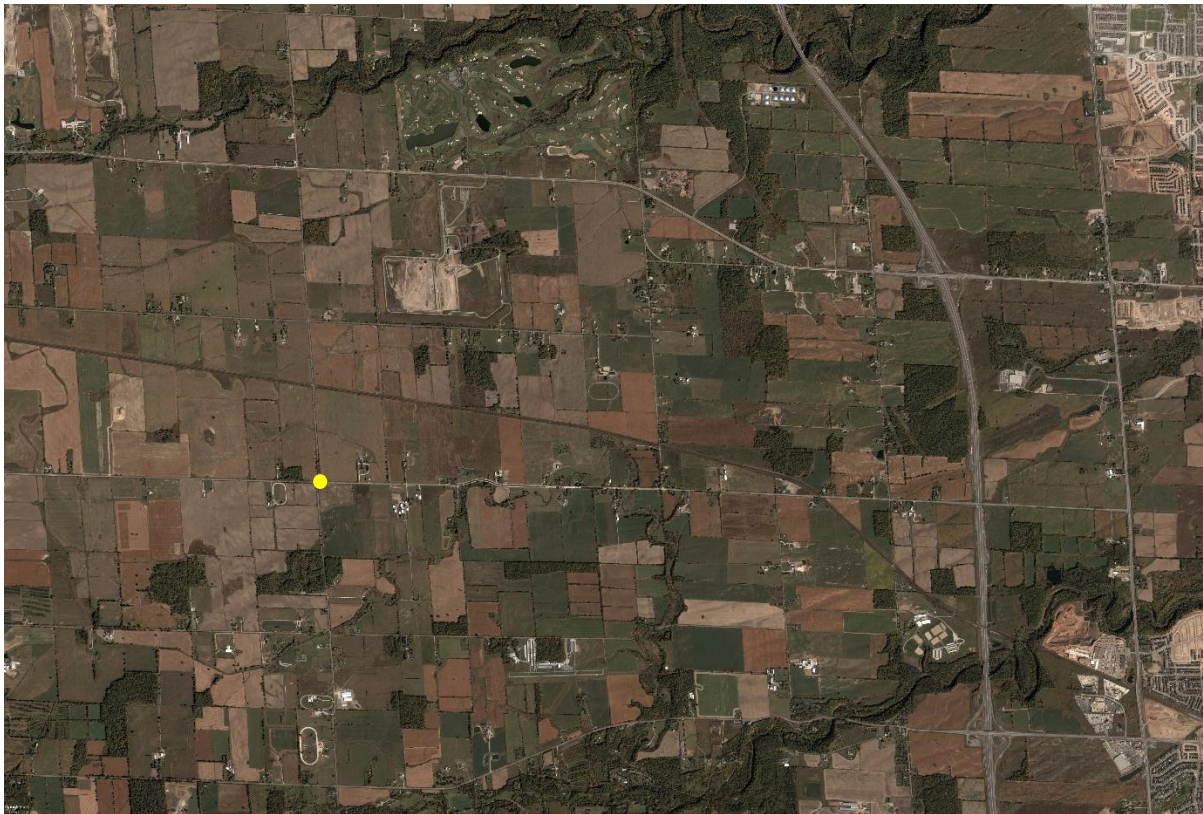
Location: Town of Milton, ON

Year: 1999

Scale: 1:20,000

Source: Ministry of Natural Resources

Yellow Point: Intersection of Tremaine Road and Britannia Road



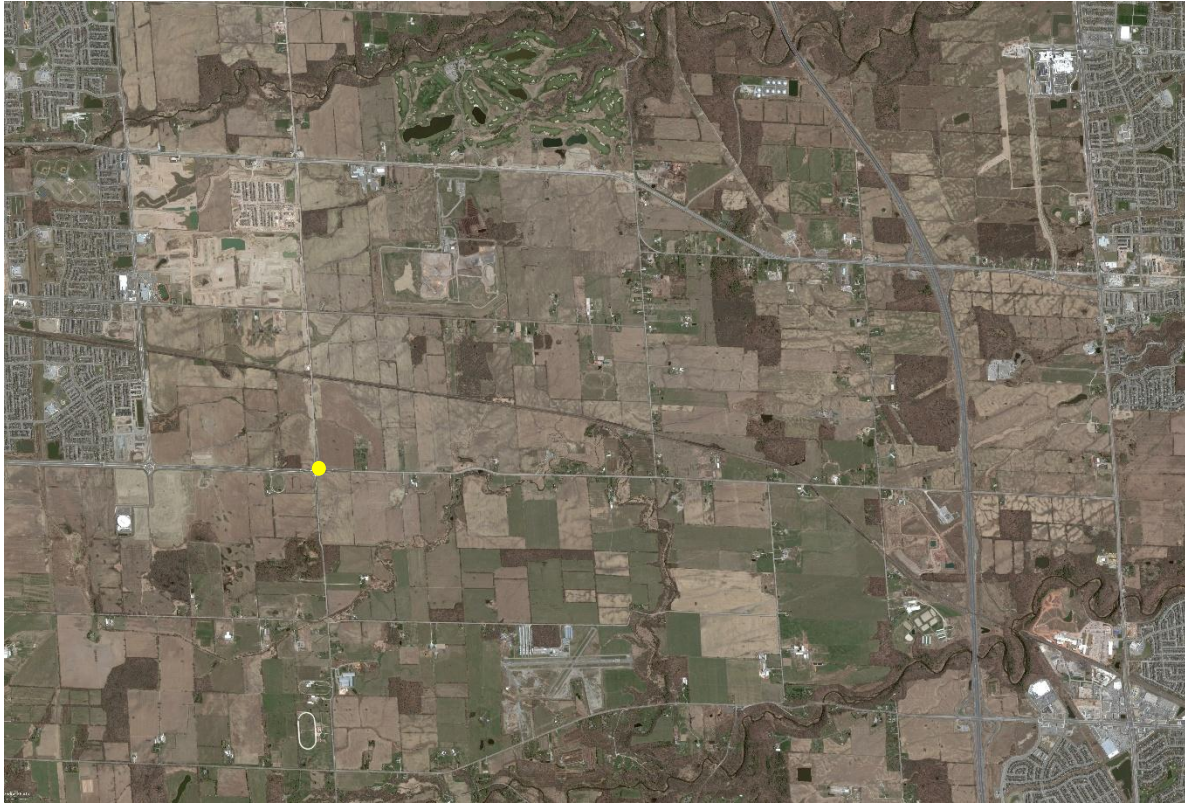
Location: Town of Milton, ON

Year: 2004

Scale: Digital Orthoimagery

Source: Google Earth Pro

Yellow Point: Intersection of Tremaine Road and Britannia Road



Location: Town of Milton, ON

Year: 2016

Scale: Digital Orthoimagery

Source: Google Earth Pro

Yellow Point: Intersection of Tremaine Road and Britannia Road



Location: Town of Milton, ON

Year: 2020

Scale: Digital Orthoimagery

Source: Google Earth Pro

Yellow Point: Intersection of Tremaine Road and Britannia Road



Location: Town of Milton, ON

Year: 2024

Scale: Digital Orthoimagery

Source: Google Earth Pro

Yellow Point: Intersection of Tremaine Road and Britannia Road



Location: Town of Milton, ON

Year: 2025

Scale: Digital Orthoimagery

Source: Google Earth Pro

Yellow Point: Intersection of Tremaine Road and Britannia Road

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Appendix C: Meander Belt Width Delineation

Meander Belt Widths

Sixteen Mile Creek and
Bronte Creek Tributaries
Town of Milton, Ontario

Legend

- Reach Break and ID
- 0.5 m Contour
- Watercourse (Not Field Assessed)
- Drainage Feature (Not Field Assessed)
- Preliminary Meander Belt Width
- Approximate Study Area

