GEO MORPHIX™

Tributary of West Humber River Fluvial Geomorphological Assessment

12506 & 12698 Heart Lake Road, Caledon, ON

Prepared for:
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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained to complete a fluvial geomorphological assessment along Kilmanagh Creek in the town of Caledon, Ontario, to support proposed development activities located at 12506 & 12698 Heart Lake Road (herein referred to as the "subject property"). The subject property is bounded by Heart Lake Road to the east, Bonnieglen Farm Boulevard to the west, Kilmanagh Creek and forest to the north, and agricultural lands to the south (**Appendix A**). It is understood that the proposed development within the subject property will include four industrial buildings, a road extension for Larson Peak Road, and one stormwater management (SWM) facility. The proposed SWM pond is located in the northeastern corner of the subject property and is planned to outlet into Kilmanagh Creek.

To support the proposed development activities and planning studies within the subject property, this report provides a summary of existing geomorphological conditions, erosion hazard delineation, and a preliminary review of erosion sensitivity in the context of future stormwater management plans. The following activities were completed as part of the fluvial geomorphological assessment:

- Review available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Complete watercourse reach delineation through a desktop assessment, with field confirmation through an on site geomorphic feature assessment
- Review of recent and historical aerial photographs of the site to understand historical changes in channel form and function
- Complete rapid geomorphological assessments on a reach basis to document channel conditions and verify the desktop assessment where possible
- Complete an erosion hazard delineation on a reach basis using field observations, historical and recent aerial imagery
- Review watercourse sensitivity downstream of the proposed development and provide recommendations for future erosion mitigation strategies for stormwater management
- Provide erosion and surface water monitoring recommendations for baseline characterization and future post-development stages

2 Background Review and Desktop Assessment

2.1 Background Information

The subject property is situated within the Humber River watershed, which is located within the Toronto and Region Conservation Authority (TRCA) jurisdiction. The Humber River watershed originates in the Oak Ridges Moraine and outlets into Lake Ontario. This watershed encompasses approximately 911 square km of land (TRCA, 2021). Within the Humber River Watershed, the headwaters of the West Humber River originate in Caledon and flow over 45 km through Brampton before its confluence with the Main Humber River in Toronto (TRCA, 2021).

Within the subject property, Kilmanagh Creek (a tributary of the West Humber River) enters the northwestern corner of the study area and flows east towards Heart Lake Road for approximately 250 m, where it then exits the subject property, crossing under Heart Lake Road through a culvert. Kilmanagh Creek continues to flow for approximately 8 km towards its confluence with the West Humber River.

This section of Kilmanagh Creek is situated within the Greenbelt Plan Area and is designated by the Ministry of the Environment, Conservation and Parks (MECP) as redside dace (*Clinostomus elongatus*) habitat. This has implications to the limit of development as redside dace and the associated habitat are regulated under the provincial *Endangered Species Act, 2007 (ESA)* and the *Species at Risk Act, 2002 (SARA)*.

2.2 Geology and Physiography

Geology and physiography act as constraints to channel development and tendency. These factors determine the nature and quantity of the availability and type of sediment. Secondary variables that affect the channel include land use and riparian vegetation. These factors 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.

Within the subject property, the West Humber River and associated tributaries are dominated by the Till Plains (drumlinized) physiographic region of Ontario (Chapman and Putnam, 2007). In terms of surficial geology, the subject lands are characterized by till (OGS, 2010). Soils within these areas include clay to silt-textured clay derived from glaciolacustrine deposits or shale (OGS, 2010). Along Kilmanagh Creek within the subject property, soils are characterized by modern alluvial deposits, including clay, silt, sand, gravel, and organic remains (OGS, 2010).

2.3 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics.

Various aerial photographs and satellite images from 1960 to 2024 were retrieved to complete the historical assessment and inform the erosion hazard delineation. Specifically, aerial photographs from 1960, 1974 (National Air Photo Library), 1994 (University of Toronto), and satellite images from 2004, 2015, 2022 and 2024 (Google Earth Pro) were reviewed. All historical aerial photographs are provided in **Appendix B** for reference.

In 1960, a straightened channel planform is noted within the subject property as well as upstream and downstream. Further upstream of the subject property, south of Old School Road, Kilmanagh Creek exhibited a slightly meandering channel planform for approximately 400 m. Active agricultural fields were adjacent to the channel and two single rural dwellings are located north and south of the watercourse. The channel appears to have narrow grassy riparian edges. Upstream of the study area, a second flow path was noted parallel to the main channel. The secondary flow path confluences with the main channel within the subject property.

Between 1960 and 1994, no major changes to the watercourse were noted. Upstream of the subject property, multiple flow paths continue to develop, suggesting a low gradient and depositional environment. The grassy riparian edges continued to matured and vegetation appears to span the entire width of the corridor. Dominant land use remains as active agriculture.

Through to 2004, the Brampton Fairgrounds were constructed north of the subject property. No impacts to Kilmanagh Creek were noted. Land use within and surrounding the subject property remained actively cultivated. Within the subject property, as well as upstream, multiple flow paths were observed within a heavily vegetated riparian area.

Between 2015 and 2024, the subdivision to the west of the subject property continued to expand. A stormwater management pond located just outside the western corner of the subject property appears to outlet into the watercourse, however no changes within the subject property or downstream are noted. Multiple flow paths and several small ponds remain visible within the grassy floodplain.

3 Watercourse Characteristics

3.1 Reach Delineation

Reaches are 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 particular 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

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004) as well as others.

The watercourse was first reviewed through a desktop assessment using the Ontario Hydrological Network (OHN) shapefile obtained from the Ministry of Natural Resources and Forestry (MNRF) (2024). Reach delineation and naming were completed using previously established reach names located downstream of the subject property. One reach was delineated within the subject property and labelled **Reach 9.** Reach delineation is graphically displayed in **Appendix A**.

It is important to note that this section of Kilmanagh Creek is designated as wetland according to MNRF's 2024 wetland mapping and that wetland staking exercises have been completed by others. Based on the wetland presence and our review of aerial photographs, this feature clearly exhibits multiple flow paths and traverses a wide but partially confined valley setting. Mapping provided in **Appendix A** shows the OHN stream layer with a solid blue line, but an additional blue dashed line has been added to denote the approximate central valley flow path location. Given that there are multiple flow paths, we have delineated this central valley location to reflect a more average condition for where flow may be expected to occur.

3.2 Geomorphic Reach Observations

Field investigations were completed on July 9, 2025, and included the following:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, and channel disturbances such as crossing structures

These observations and measurements are summarized in **Table 1** below. The field descriptions are supported with representative photographs included in **Appendix C**. Field sheets, including those completed for the rapid assessment, are provided in **Appendix D**.

Table 1. General summary of reach observations

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Valley Type	Notes
Reach 9	2.12	0.53	No riffle-pool morphology. Bed composed of silt and sand		Grasses	Partially Confined	Tall grasses present throughout floodplain Multiple channels observed within the floodplain Slumping noted throughout

Reach 9 was situated within a wide, partially confined valley setting. The feature exhibited multiple flow paths within the wide, grassy floodplain. Along the edges of the floodplain, grasses and a few trees were present. Vegetation encroachment was common throughout the reach, except for the downstream portion of the reach where a single defined channel was more evident (near Heart Lake Road). Average bankfull channel geometry from **Table 1** was measured in the defined section of the channel. There was no riffle-pool morphology identified, and channel bed and banks (where observable and defined) were composed of silt and sand. There was no evidence of active sediment transport or erosion within the feature. Given the low gradient and wetland environment, the feature was stable.

3.3 Rapid Geomorphic Assessment

Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41). **Reach 9** was assigned an RGA score of 0.07, indicating the reach is "in regime". The dominant geomorphological indicator was evidence of planimetric form adjustment due to observations of multiple channels and poorly formed/re-worked bars, but this is a result of its location within a low-gradient wetland system.

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health. **Reach 9** had an RSAT score of 31, or "good". The limiting factor was riparian habitat conditions due to the lack of mature canopy coverage.

4 Erosion Hazard Delineation and Redside Dace Habitat

An erosion hazard 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 hazard to proposed activities in the vicinity of a watercourse.

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. When defining the erosion hazard for a watercourse, unconfined and confined systems are assessed differently (TRCA, 2004, and MNR, 2002).

Unconfined systems are those with watercourses in poorly defined valleys or slopes well outside where the channel could realistically migrate. Unconfined systems are generally found within glaciated plains with flat or gently rolling topography. In contrast, confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible. Partially confined systems are those where meander bends or the channel are adjacent to only one valley wall and the watercourse is therefore restricted in migration and floodplain occupation on one side of the valley system.

4.1 Meander Belt Width Delineation

As identified in **Section 3.2**, **Reach 9** was classified as partially confined. Due to the wide nature of the valley setting (approximately 105 m wide), and the identification of redside dace, a meander belt width was delineated for the reach as per the methodology for unconfined systems. It should be noted that a top of bank exists along the confined, southwestern portion of the valley. The top of bank was reviewed and staked in the field with TRCA staff.

In unconfined systems, a meander belt width can be applied, at minimum, based on 20 times the bankfull channel width. Alternatively, the meander belt width can be determined through a detailed geomorphological study that examines the largest channel meanders observed through historical and recent aerial photograph interpretation. The meander belt width can then be graphically defined using orthorectified aerial imagery by determining the channel's central tendency (i.e., meander belt axis). In cases where the channel is not discernible in aerial photographs or the channel has been substantially modified, empirical models can be used to estimate the meander belt width.

Due to small channel and flow path widths, vegetation cover, and aerial resolution, a historical aerial overlay analysis could not be completed to trace channel migration. To supplement, a suite of empirical models were used. These models are scientifically defensible and have been verified in past projects as suitable for use in southern Ontario. The relevant empirical equations/models are summarized below, noting that a summary of the results is provided in **Table 2.**

Variables that were referenced within the following models include:

- Average bankfull channel dimensions measured during field reconnaissance
- Drainage area obtained from the Ontario Watershed Information Tool
- 2-year flow calculated using the Index Flood Method (Moin & Shaw, 1985) as documented in the User Guide for the Ontario Flow Assessment Tool (OFAT) (MNR, 2020)
- Slope calculated using publicly available LiDAR data from the Ministry of Natural Resources (2023)

It should be noted that a watershed-wide hydrological model was not available at the time of assessment. Drainage area and 2-year discharge were supplemented using the Ontario Watershed Information Tool (OWIT) and in-house flow modelling that follows the Index Flood Method (Moin and Shaw, 1985) as documented in the User Guide for the Ontario Flow Assessment Tool (OFAT) (MNR, 2020), respectively. As such, the drainage area and 2-year flow estimates may be subject to change if updated hydrological modelling becomes available.

The following empirical models were used to complete the meander belt width assessment:

The empirical relations from Williams Area (1986) are described as follows and were modified to include channel width:

$$B_w = 18A^{0.65} + W_b \quad \text{[Eq. 1]}$$

where *Bw* is meander belt width (m), *A* is bankfull cross-sectional area (m^2), and *Wb* is bankfull channel width (m), with the understanding that a 20% buffer, or factor of safety, was applied to the computed belt widths to address issues of underprediction.

The TRCA (2004) empirical model is described as follows:

$$B_w = -14.827 + 8.319\ln(\rho g Q S * DA) \quad \text{[Eq. 2]}$$

where ρ is water density (1000 kg/m^3), g is acceleration due to gravity (9.8 m/s^2), Q is discharge (m^3/s), S is channel slope (m/m), and DA is drainage area (km^2), noting that:

Table 2. Summary of meander belt width estimates

Meander Belt Width (m)			
Reach	**Williams (1986) Channel Area***	**TRCA (2004)****	**Recommended MBW**
Reach 9	26	50	50

** Includes a 20% factor of safety*
***Includes 1 standard error (8.63), no change in hydrologic regime anticipated*

Results of the empirical modelling exercise provided meander belt width estimates in the range of 26 m to 50 m. The Williams (1986) resulted in a meander belt width of 26 m for the reach. Due to the lack of a single defined channel along the entire reach, specific models (such as Williams 1986) that reference channel geometries may not reflect the natural conditions and result in over- or under-estimation of erosion and channel migration potential.

The TRCA (2004) empirical model is generally based on drainage area and stream power relations. The TRCA model result also includes 1 standard error of 8.63 m to account for potential under prediction in the model. Given that the reach is within a low-gradient, depositional environment and that there is no single, well-defined channel throughout the subject property, a 50 m meander belt width is a very conservative estimate for the erosion hazard. There is no aerial record of a well-defined channel through the subject property, and there is no historical evidence of erosion, migration, or meander development. As such, the recommended meander belt width of 50 m is a conservative estimate of the erosion hazard.

The recommended 50 m meander belt width is graphically displayed in **Appendix E**. As noted in **Section 3.1**, the OHN stream layer does not appropriately reflect the extent of flow paths across the valley. As such, the meander belt width was not plotted along the central tendency of the OHN stream layer. Instead, a central valley tendency was delineated – denoted as "hydrologic connectivity" – in **Appendix E**. The meander belt width was plotted along this central tendency to better reflect and capture the extent of flow activity across the floodplain.

4.2 Redside Dace Habitat

It is understood that the **Reach 9** of Kilmanagh Creek within the subject property is considered regulated (occupied) Redside Dace habitat, a species classified as endangered both provincially and nationally. In accordance with the provincial Endangered Species Act, 2007 (ESA), Redside Dace habitat is defined as a 30 m vegetated buffer from the meander belt width of the watercourse. The 30 m setback represents the regulated limit of habitat according to the Recovery Strategy for Redside Dace (RDRT, 2010).

A 30 m Redside Dace habitat area line was offset from the meander belt width, and is graphically displayed in **Appendix E**.

5 Erosion Sensitivity Assessment

The stormwater management plan for the proposed development includes one stormwater management pond, which will outlet to **Reach 9** of Kilmanagh Creek. To provide recommendations for erosion mitigation strategies for the proposed stormwater management plan, a preliminary erosion sensitivity assessment was undertaken for the receiving watercourse downstream of the proposed SWM pond outlet. **Reach 4a** was determined to be the most erosion sensitive reach within the potential zone of impact of the proposed SWM pond outlet, and an erosion threshold was defined for this reach which is located downstream (east) of Dixie Road. Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material. As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. Erosion thresholds were modelled from detailed field observations of **Reach 4a**, downstream of the proposed SWM pond outlet.

Reach 4a was previously assessed by GEO Morphix Ltd. in 2023. **Reach 4a** was determined to be unstable based on an RGA score of 0.21 (in transition/stress) and an RSAT score of 23 (Fair). Slumping, scour, undercutting, siltation, and suspended armour layers were reported, indicating a change in many channel processes. On this basis, **Reach 4a** was determined to be one of the most erosion-sensitive reaches within the potential zone of impact downstream of the SWM outlet for the proposed development on the subject property. Additional confirmation of the downstream zone of sensitivity is encouraged through future study phases, particularly if other downstream field access is attainable.

The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the morphology of the channel and characteristics of the bed and bank materials. Due to variability between bed and bank composition and structure, erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides the more conservative and limiting estimate of erosion potential.

A theoretical erosion threshold is an inherently conservative value, as it represents the force required to initiate sediment motion rather than the force needed for systemic erosion within the reach. The methods applied also make assumptions necessary to adopt when the variability of a natural channel is reduced to variables in an equation, adding to the inherent conservatism. The shear acting on the bed material is assumed to be representative of the total shear in the hypothetical representative cross-section. At the same time, in a natural channel, there is additional resistance to erosion provided by vegetation and non-uniform channel bed geometry that dissipates a portion of the force. Subtracting the resistance from the total shear gives the effective shear, which is the force acting on the bed in a natural channel.

5.1 Methods

Erosion thresholds are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach can also be applied (Villard & Parish, 2003). For cohesive materials, a method such as that described by Komar (1987), or empirically derived values such as those compiled by Fischenich

(2001), Chow (1959) or Julien (1994), could be applied. Villard and Parish (2003) emphasize the importance of selecting methods that reflect local sediment conditions and integrating them into site-specific geomorphic assessments.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry, in the form of a critical discharge (Villard & Parish, 2003; TRCA 2012). Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity (*U*) or shear stress (τ) is calculated at various depths for a representative cross-section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using Manning's approach, where the Manning's *n* value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2} \qquad \text{[Eq. 3]}$$

where, *d* is depth of water, *S* is channel slope, and *n* is the Manning's roughness.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

$$\tau_0 = d \rho g S_{bed} \qquad \text{[Eq. 4]}$$

Where, τ_0 is shear stress, d is the water depth, ρ is water density, *g* is acceleration due to gravity, and *Sbed* is the channel bed slope. Because only 75% of bed shear stress and velocities applies to channel banks in uniform cross sections (Chow, 1959), the erosion threshold is scaled appropriately for these materials.

5.2 Results

The bed within **Reach 4a** was characterized as predominantly consisting of sediment ranging from silt to angular and platy gravel to cobble. These bed sediments were classified as graded loam to cobbles, based on the criteria of Julien (1994), giving an estimated critical velocity of 1.14 m/s, which was used to determine the threshold discharges for this reach. Manning's roughness values of *n* = 0.045 were adopted for the critical discharge calculations for each reach, based on the framework described by Acrement and Schneider (1989). Threshold discharge is an estimate of the discharge at which sediment entrainment begins to occur. Based on a critical velocity of 1.14 m/s, n of 0.045, and measured channel cross section (width and depth), the critical discharge for the bed materials within **Reach 4a** was predicted to be 6.331 m^3/s.

The banks within **Reach 4a** were characterized as predominantly consisting of sandy loam, based on the criteria of Fischenich (2001). A critical velocity approach was taken using the criteria of Fischenich (2001) for the silt loam bank material. This material is estimated to have a critical velocity of 0.50 m/s, which was used to determine the threshold discharges for these reaches. Based on a critical velocity of 0.50 m/s, the critical discharge for the bank materials within **Reach 4a** was predicted to be 0.599 m^3/s. The critical discharge derived from the bank materials is chosen here as the conservative estimate of the threshold conditions of **Reach 4a**.

The results of the erosion threshold assessment are provided in **Table 3** below.

Table 3. Detailed assessment and erosion threshold summary

Channel Parameter	R4a	
Channel Characteristics		
Average bankfull width (m)	4.32	
Average bankfull depth (m)	0.35	
Channel gradient (%)	0.55	
D_{50} (mm)	14.6	
D_{84} (mm)	64.0	
Manning's *n* roughness coefficient	0.045	
Average bankfull discharge (m^3/s)	1.21	
Average bankfull velocity (m/s)	0.76	
Drainage area (h)	1194	
Preliminary Erosion Threshold		
	Bed	**Banks**
Material	Silt to cobbles	Sandy loam
Reference	Julien (1994)	Fischenich (2001)
Critical velocity (m/s)	1.14	0.50
Apparent shear stress (N/m^2)	35.18	15.59
Critical depth (m)	0.65	0.29
Critical discharge (m^3/s)	6.331	0.599
Unitary threshold ($m^3/s/ha$)	0.0053	0.0005
Limiting critical discharge (m^3/s)	**0.599**	
Unitary threshold ($m^3/s/ha$)	**0.0005**	

Drainage area was used to derive preliminary unitary erosion thresholds for comparison across similar watersheds. A drainage area of 1,154 ha for **Reach 4a** resulted in a preliminary unitary erosion threshold of 0.0005 $m^3/s/ha$. This value is comparable to unitary erosion thresholds accepted for watercourses with similar characteristics, including other watercourses in the Humber River watershed and nearby watersheds within the TRCA as well as neighbouring conservation authority jurisdictions.

Our understanding is that post-development flow rates from the proposed storm pond have been guided by established unitary release rates from previous assessment studies completed within the subject watershed. An assessment of the effectiveness of the proposed SWM plan in mitigating downstream erosion impacts can be completed at future stages of the planning process when more detailed information is available. Future assessment should have consideration for the erosion threshold analysis outlined above.

6 Monitoring

6.1 Surface Water Quantity Monitoring

Two (2) surface water quantity monitoring locations, **US** and **DS**, were established September 24, 2025, along Kilmanagh Creek to establish baseline conditions within the subject property. The sampling locations were installed to capture the conditions entering and exiting the subject site (upstream and downstream). The following water quantity activities will be conducted at each site:

- Continuous water level and temperature monitoring at 15-minute intervals using U20 Onset HOBO Water Level Logger pressure and temperature sensors installed at the stream bed, with an additional atmospheric sensor installed nearby to measure air temperature and barometric pressure
- Discrete measurements of velocity and/or discharge, using an Acoustic Doppler Velocimeter (ADV), will be conducted several times a year under different flow conditions in order to develop stage-discharge rating curves

Daily precipitation data for 2025 will be obtained from a GEO Morphix weather station located approximately 5.4 km southwest of the subject property.

6.2 Surface Water Quality Monitoring

Sampling locations were established at the same sites as continuous surface water quantity monitoring to correlate the surface water quality with the study area hydrology. This information will be used to characterized existing, baseline conditions in the creek for comparison against future, post-development conditions.

Discrete baseline water quality sampling will occur at each site for three (3) dry events (i.e., 48 hours with no precipitation) and three (3) wet weather events (i.e., 10 mm of rain in 24 hours), capturing at least one (1) wet and one (1) dry event for each season. Surface water quality monitoring needs to be conducted between the months of April and November. Grab samples will be obtained at each monitoring location with the objective of characterizing the surface water chemistry under different instream conditions. All sampling activities adhere to the Ontario Stream Assessment Protocol outlined by the Ontario Ministry of Natural Resources. The following parameters are being measured at each monitoring location during each sampling event:

- Ammonia
- Anions (Nitrate, Nitrite, Phosphate, Chloride)
- BOD5 (Biochemical Oxygen Demand)
- Conductivity
- Dissolved Oxygen
- Metals (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, Tl, Sn, Ti, W, U, V, Zn, Zr)
- PAH (Polycyclic Aromatic Hydrocarbons)
- pH / Alkalinity
- Total Kjeldahl Nitrogen (TKN)
- Total Phosphorous
- Total Suspended Solids (TSS)
- Turbidity

Parameters will be compared against the Provincial Water Quality Objects (PWQO) to provide additional information on potential impacts to the watercourse. Discrete baseline water quality measurements of temperature, turbidity, dissolved oxygen, and conductivity will be completed during each site visit. Baseline observations/data collected will be used as a reference for pre-to-post construction comparisons. Additionally, monumented photographs of all activities will be completed to verify location and time on site. Monitoring will continue for the duration of the 2025 monitoring period and will be summarized in an annual report each year.

6.3 Fluvial Geomorphology / Erosion Monitoring

It is anticipated that the future SWM plan will mitigate any potential instream erosion; however, geomorphological instream monitoring should be completed downstream of proposed SWM outfalls to ensure that erosion mitigation has been adequately addressed. Baseline data should be collected for at least one year prior to development; data collected in the post-development period can then be compared to baseline information. The following annual post-construction monitoring activities are recommended for reaches immediately downstream of proposed outfalls:

- Re-survey of monumented cross sections established under baseline conditions
- Channel substrate characterization through a modified Wolman (1954) pebble count or sampling at each monumented cross-section
- Collection of monumented photographs of each cross-section
- Re-measurement of erosion pins installed at each cross-section
- Preparation of an annual report documenting results of the monitoring program, with a summary report provided at the end of the monitoring period

The post-construction monitoring activities outlined above should be completed on an annual basis for a period of three years, once the SWM pond is operational. Annual reports and the summary report are to include a comparison of pre- and post-development instream conditions and evaluate any changes in the context of anticipated natural variability.

7 Summary and Recommendations

This report summarizes the fluvial geomorphological assessment completed for the property at 12506 Heart Lake Road in the Town of Caldon, Ontario. A tributary of the West Humber River – known as Kilmanagh Creek – is situated along the northern extent of the subject property. The tributary contains an online wetland feature and exhibits multiple flows paths and limited erosion potential. The channel has been stable over the period of historical record and is characteristic of a depositional, low gradient environment with dense vegetation across the floodplain. A conservative meander belt width of 50 m has been applied to delineate the erosion hazard for the subject property. It is understood that the reach within the subject property is considered regulated (occupied) Redside Dace habitat. In accordance with the provincial Endangered Species Act, 2007 (ESA), Redside Dace habitat is defined as a 30 m vegetated buffer from the meander belt width of the watercourse.

Downstream erosion sensitivity was also reviewed in the context of the proposed SWM plan for the subject property. A sensitive, downstream reach was identified, and an erosion threshold has been provided. We understand that local and established unitary release rates have been applied as part of the preliminary SWM pond to address erosion mitigation requirement. We recommend that erosion mitigation strategies are reviewed at further stages of study through erosion exceedance analysis to determine the effectiveness of the SWM plan in mitigating downstream increases in erosion potential.

The results of the fluvial geomorphological assessment are summarized in the Local Subwatershed Study prepared by Envision in the context of other information and data collected by other disciplines.

We trust this report meets your current requirements. Should you have any questions or concerns, please contact the undersigned.

Respectfully submitted,

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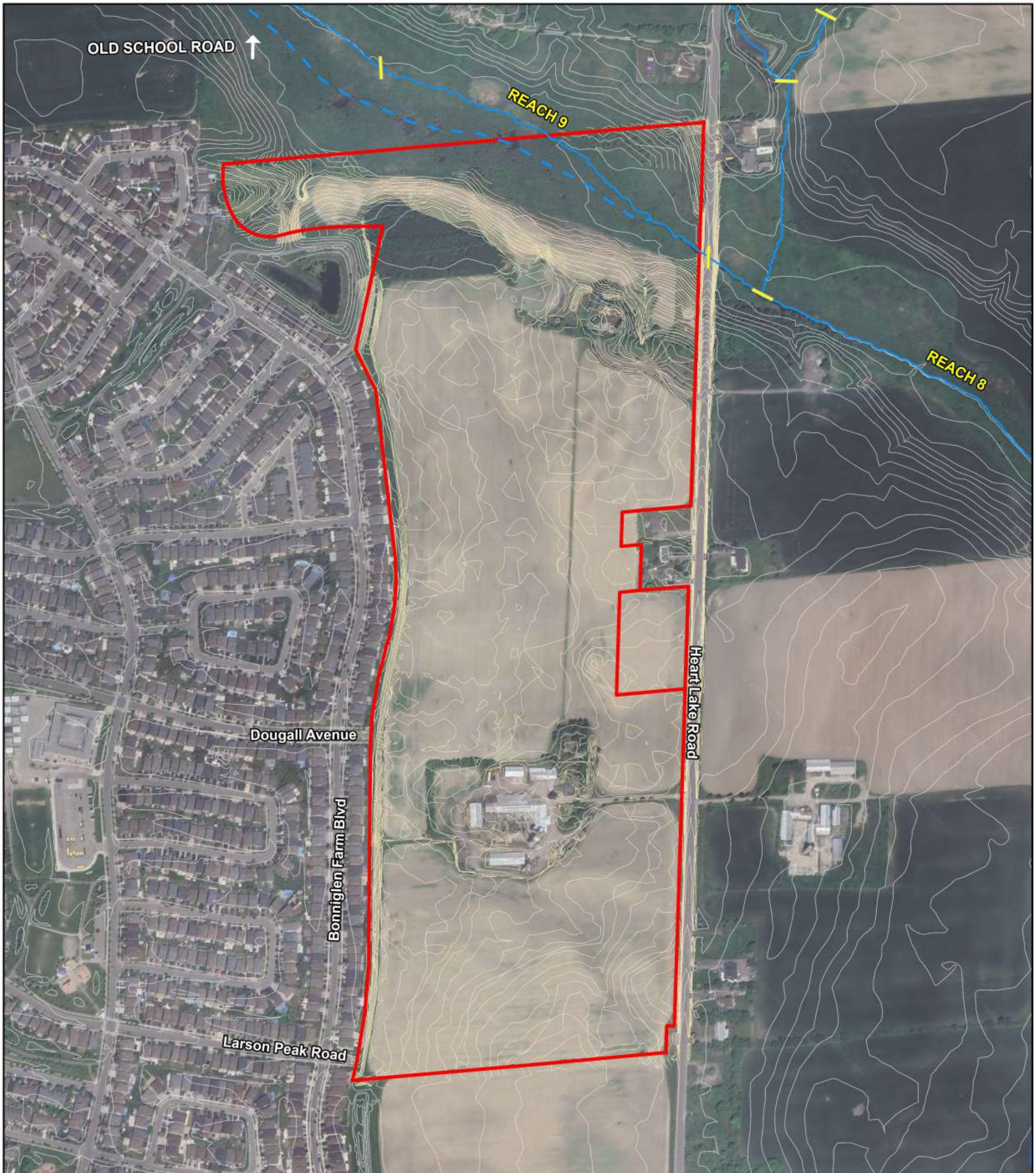
Appendix A:
Study Area



Legend

- Reach Break and ID
- Hydrological Connectivity
- Watercourse (OHN)
- 0.25 m Contour
- 1 m Contour
- Study Area

GEO MORPHIX™

Study Area

12506 Heart Lake Road

Caledon, ON

0 55 110

Metres

Imagery: Google Earth Pro, 2024. Watercourse, Wetland and Green Belt: MNRF, 2024/2021. Reach Break and ID: GEO Morphix, Ltd., 2025, 0.25 m Contour, Study Area: Tribal, 2025. 1.0 m Contour: Peel Region, 2021. Print Date: October 2025, PN25023. Drawn By: K.W., M.O.

Appendix B:
Historical Aerial Photographs

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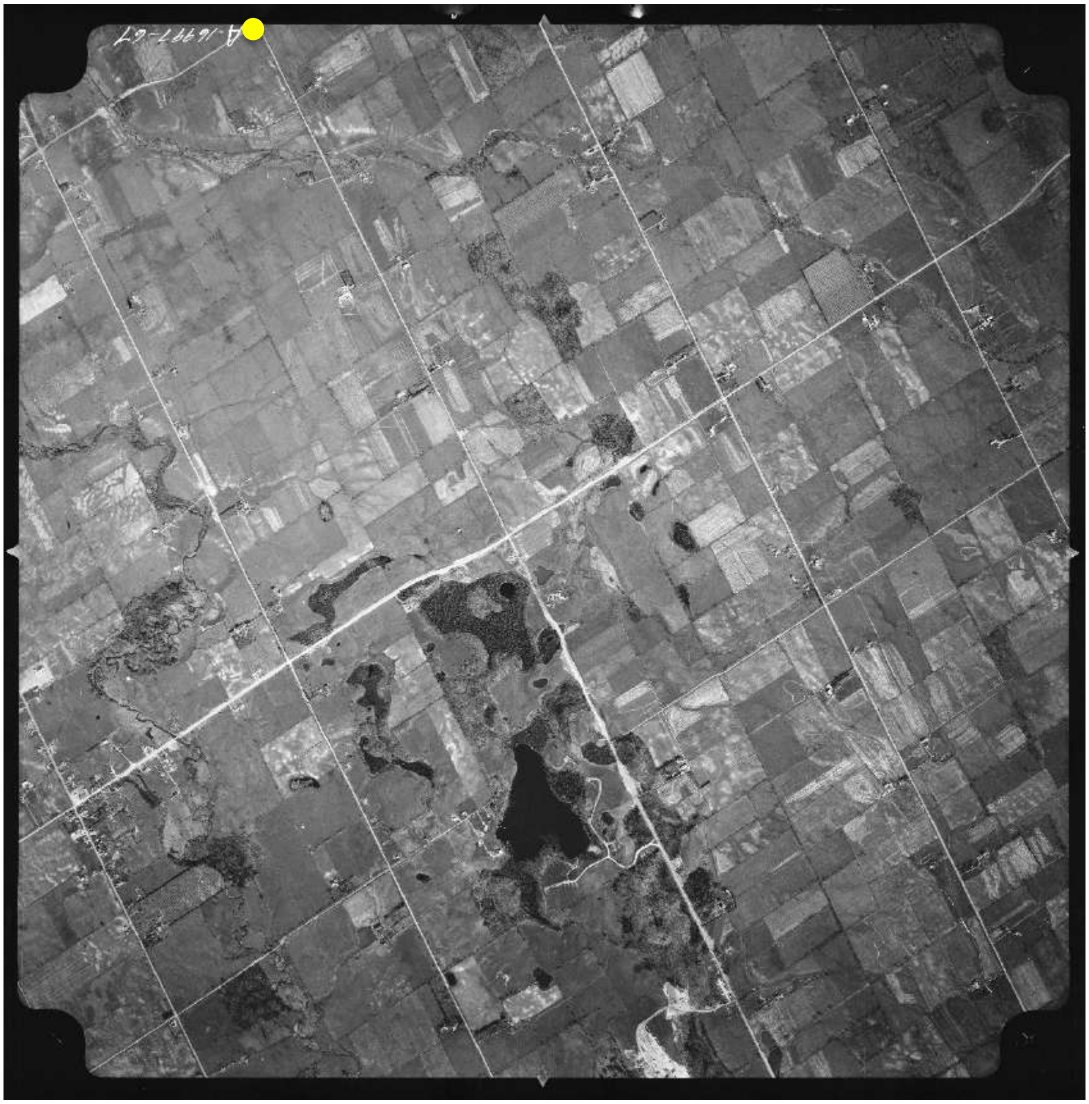
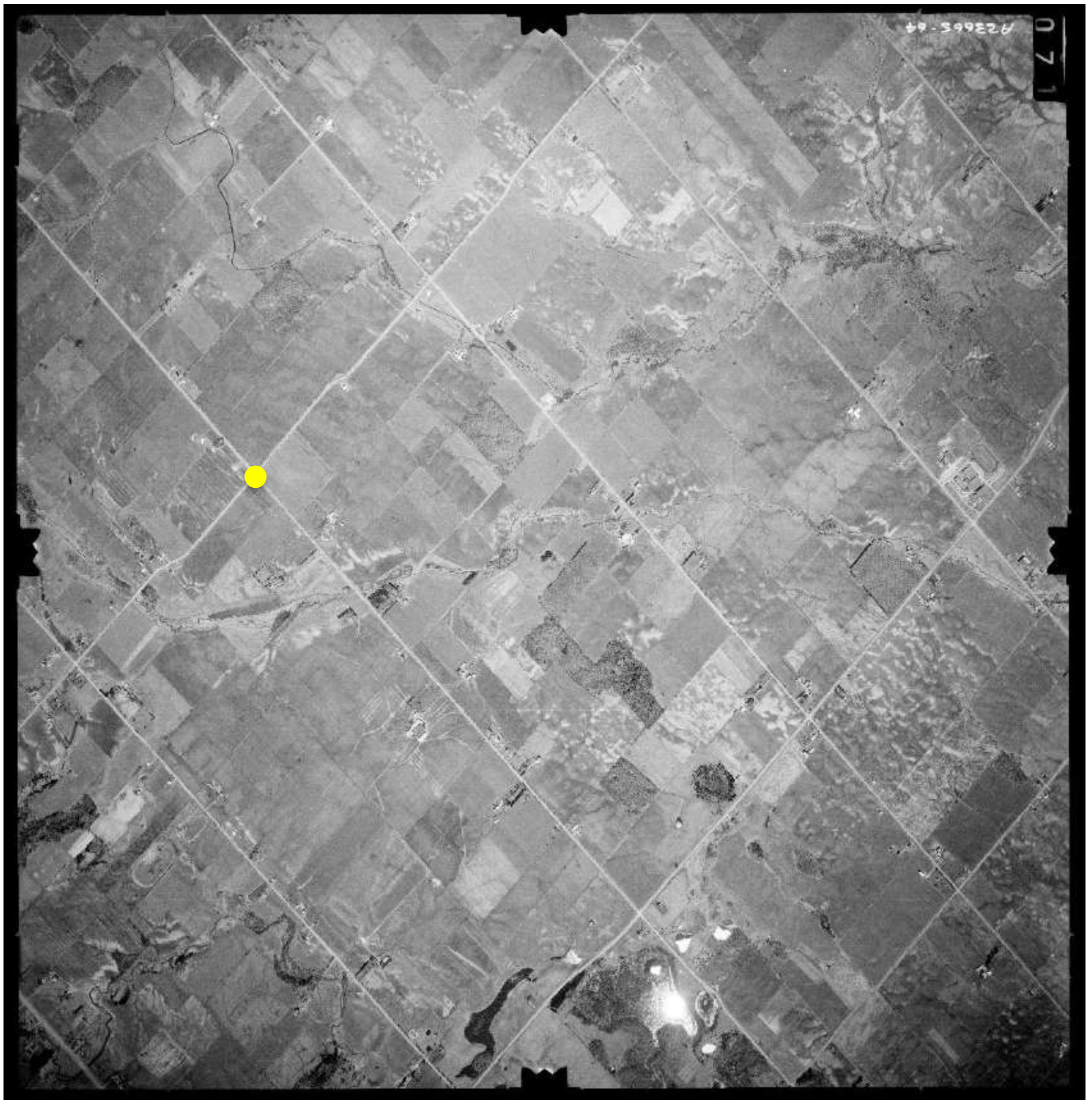
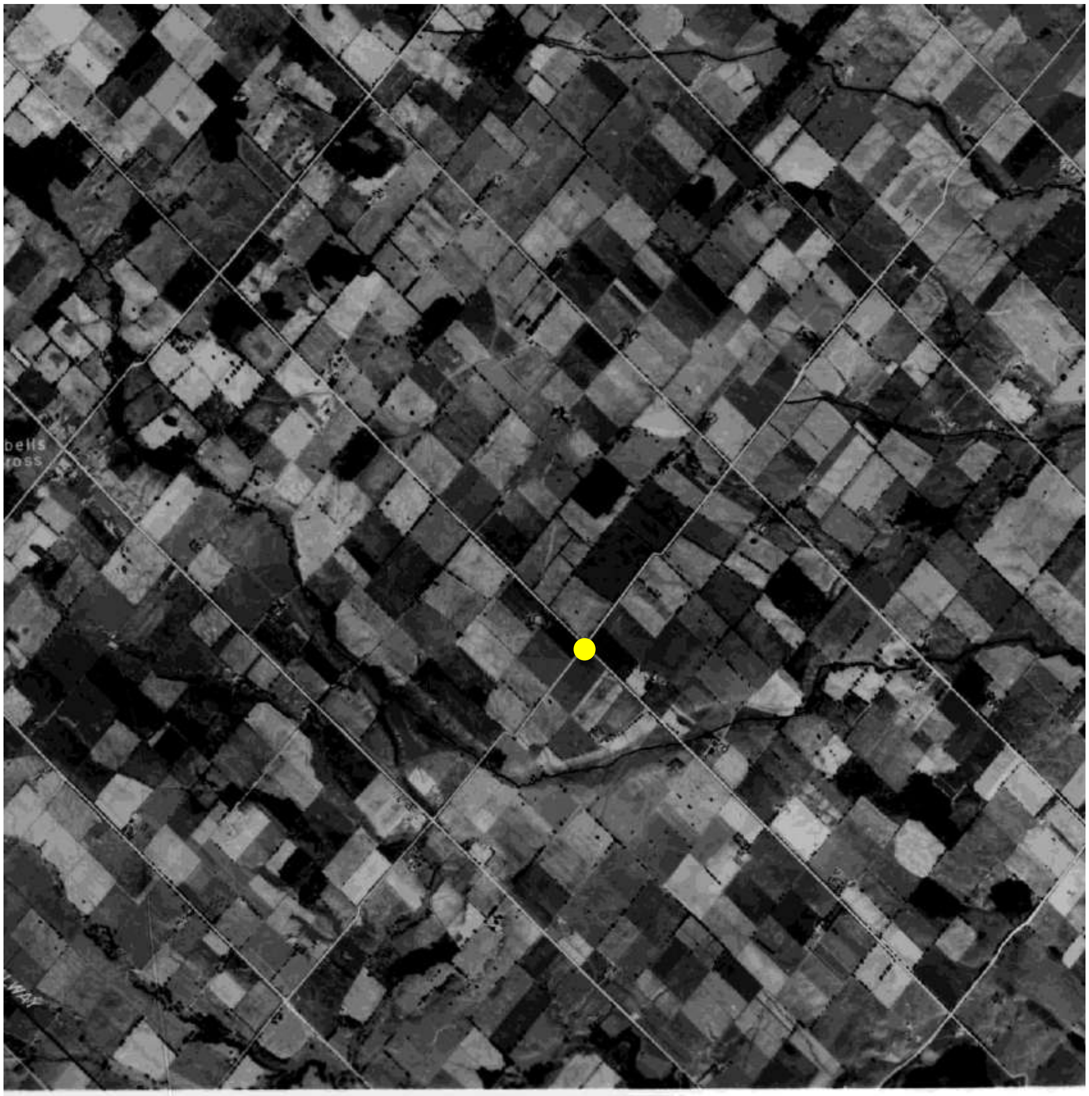


Location: Caledon, ON
Year: 1960
Scale: 1:25000
Source: National Air Photo Library
Yellow Point: Intersection of Old School Road and Heart Lake Road



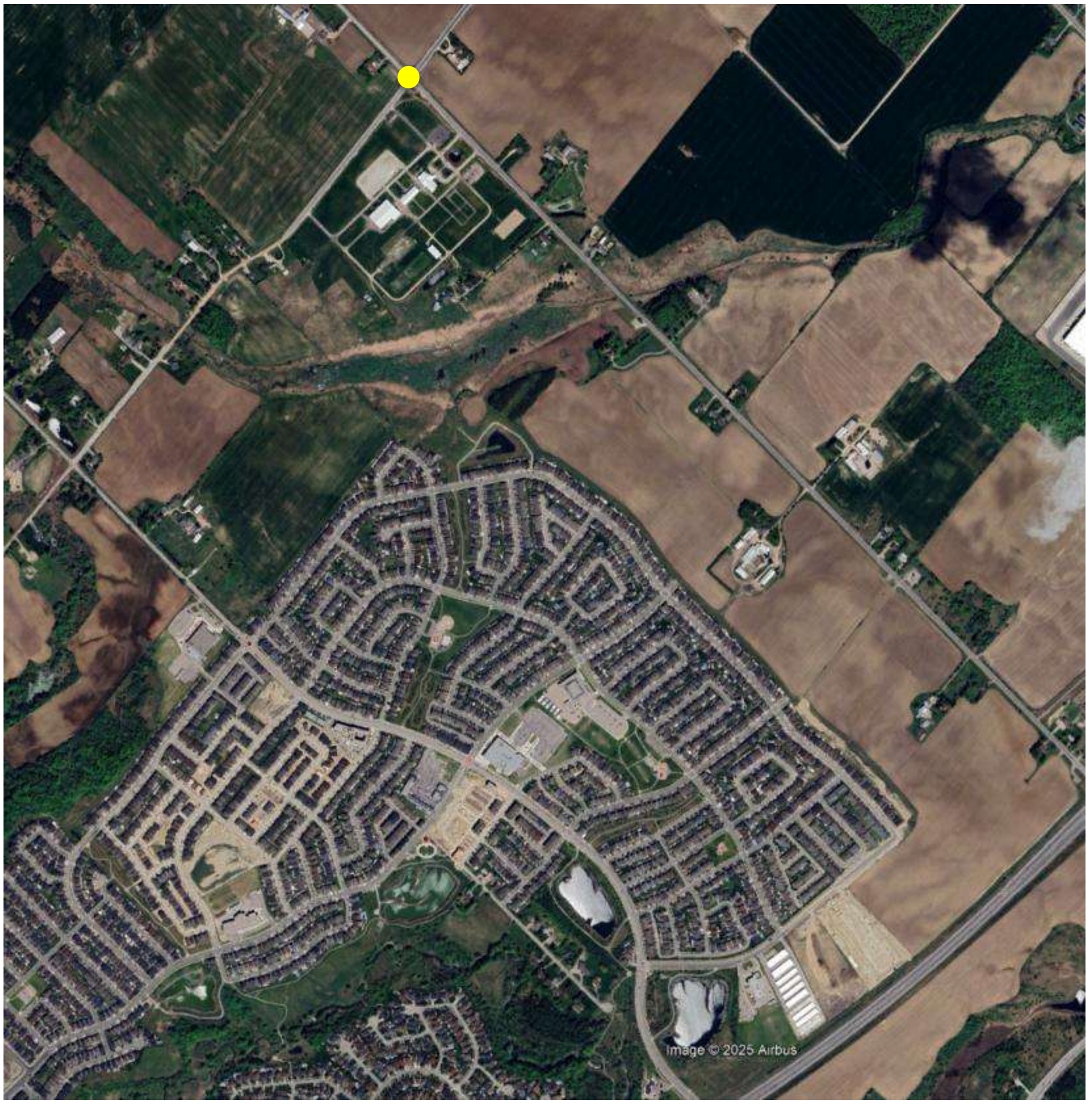
Location: Caledon, ON
Year: 1974
Scale: 1:25000
Source: National Air Photo Library
Yellow Point: Intersection of Old School Road and Heart Lake Road



Location: Caledon, ON
Year: 1994
Scale: Digital Orthoimagery
Source: University of Toronto
Yellow Point: Intersection of Old School Road and Heart Lake Road

Location: Caledon, ON
Year: 2004
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Old School Road and Heart Lake Road

Location: Caledon, ON
Year: 2015
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Old School Road and Heart Lake Road



Location: Caledon, ON
Year: 2022
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Old School Road and Heart Lake Road

Location: Caledon, ON
Year: 2024
Scale: Digital Orthoimagery
Source: Google Earth Pro
Yellow Point: Intersection of Old School Road and Heart Lake Road

Appendix C:
Photographic Record

Photo 1	
	Photograph looking upstream at Reach 9 from Heart Lake Road. Channel situated within a wide grassy floodplain/corridor.
Photo 2	
	Photograph taken facing upstream near downstream extent of Reach 9 on subject property. Single, defined channel with sand/silt/clay banks.

Photo 3

Photograph taken facing upstream in middle portion of Reach 9 on subject property. Limited channel definition with several flow paths observed across floodplain.

Photo 4

Photograph taken along the upstream extent of Reach 9 through the subject property. Pool of water was noted along the south side of the floodplain.

Photo 5

Photograph taken of substrate along the upstream extent of Reach 9 on the subject property. Materials consist of silt with some clay and sand.

Photo 6

Photograph demonstrates typical condition across corridor through majority of Reach 9 on the subject property. Vegetation encroachment is extensive with multiple flow paths across the floodplain area.

Appendix D:
Field Assessment Sheets

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General Site Characteristics

Project Number: PN25023

Date:	2025-07-04	**Stream:**	Campbell's Cross Creek
Time:	10:00	**Reach:**	Subject land watercourse
Weather:	20°C overcast	**Location:**	Caledon ON
Field Staff:	CG JA	**Watershed/Subwatershed:**	West Humber

Features	**Monitoring**
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Flow Type

H1	Standing water	H1A	Back water
H2	Scarcely perceptible flow		
H3	Smooth surface flow		
H4	Upwelling		
H5	Rippled		
H6	Unbroken standing wave		
H7	Broken standing wave		
H8	Chute		
H9	Free fall	H9A	Dissipates below free fall

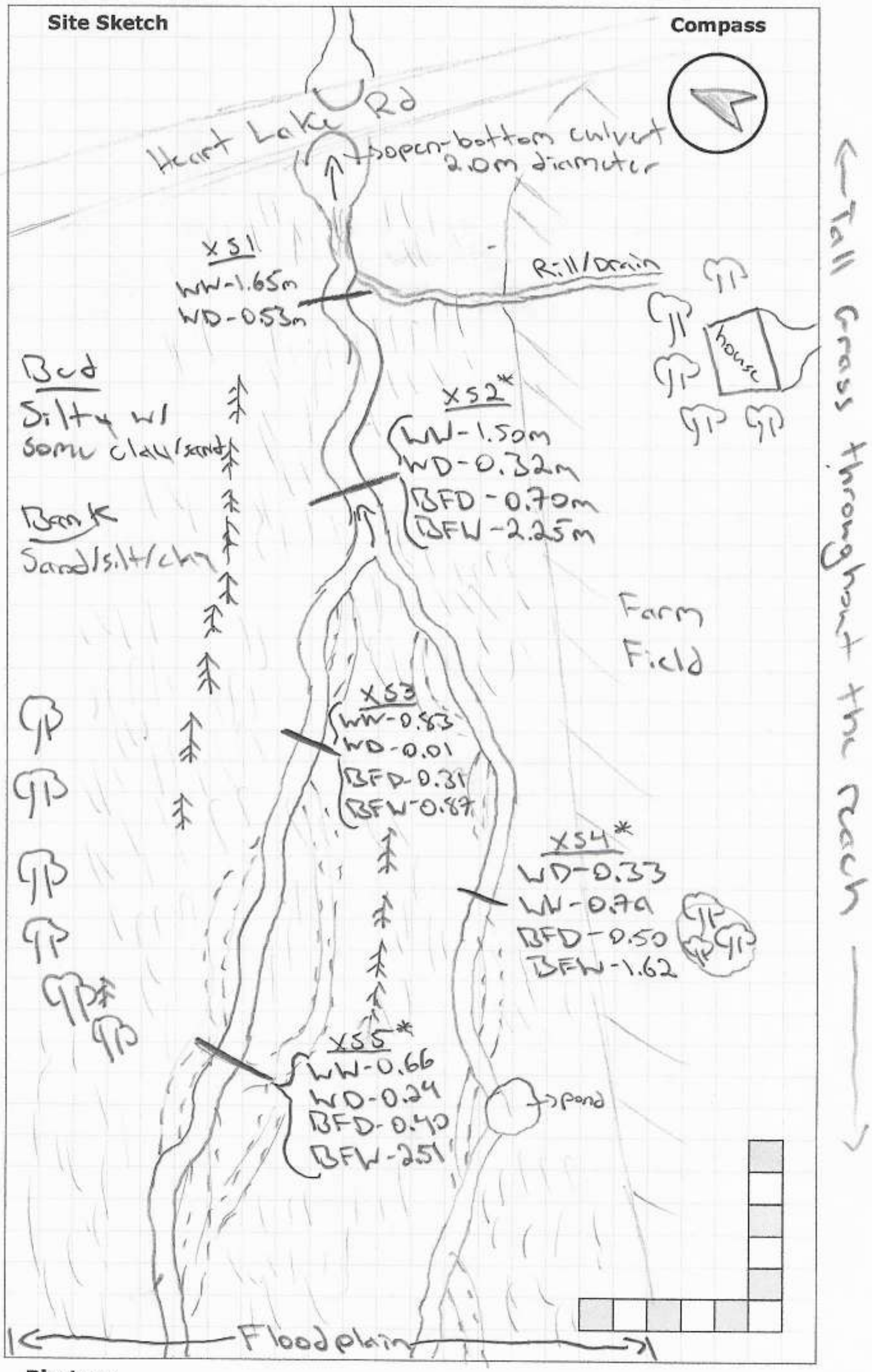
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch **Compass**



Photos:

Notes: XS 2/4/5 are most representative of watercourse
Multiple flow paths through wetland. Some Algae on banks
Instream Veg - submergent rooted. Slumping throughout

Version #4
Last edited: 21/02/2023

Senior staff sign-off (if required): ________ Checked by: ________ Completed by: CG

Page 1 of 1

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Reach Characteristics **Project Number:** 25023

Date:	2025-07-09	**Field Staff:**	CG JA	**Watershed/Subwatershed:**	West Humber River
Time:	10:00	**Stream:**	Campbells Cross Creek	**UTM (Upstream):**	
Weather:	20° overcast	**Reach:**		**UTM (Downstream):**	

Land Use (Table 1): 3/4/7 | **Valley Type** (Table 2): 3 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Evidence of Groundwater Location:______ Photo:______

Riparian Vegetation

Dominant Type (Table 6): 3	**Coverage**	**Channel Widths**	**Age (yrs)**
	☐ None	☐ 1 - 4	☒ Immature (<5)
	☐ Fragmented	☐ 4 - 10	☒ Established (5-30)
Encroachment (Table 7): 2	☒ Continuous	☒ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 2/5	**Woody Debris**	**WD Density**	WDJ/50m:
	☐ In Cutbank	☐ Low	
	☐ In Channel	☐ Mod	
Reach Coverage %: 90*	☒ Not Present	☐ High	

Water Quality

Odour (Table 16)	**Turbidity** (Table 17)
1	1

Channel Characteristics

Sinuosity Type (Table 9)	1	**Sinuosity Degree** (Table 10)	2		
Gradient (Table 11)	1	**# of Channels** (Table 12)	1*		
Entrenchment (Table 13)	3	**Bank Failure** (Table 14)	1/6		
Down's Model (Table 15)	S	**Bankfull Indicators** (Table 18)	1/5		
Sed Sorting (Table 20)	WS	**Sediment Transport Observed?**	☐ Yes ☒ No ☐ Not Visible		
Transport Mode (Table 21)	3	**% of Bed Active**	0		
Geomorphic Units (Table 22)	10	**Mass Movement** (Table 23)	6		
Riffle-Pool Spacing (m):	\	**% Riffles:**	\	**% Pools:**	\

Bank Angle	**Bank Erosion**
☐ 0 - 30	☒ < 5%
☒ 30 - 60	☐ 5 - 30%
☐ 60 - 90	☐ 30 - 60%
☐ Undercut	☐ 60 - 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☐	☐	☐	☐	☐
Riffle	☐	☐	☐	☐	☐	☐	☐
Pool	☐	☐	☐	☐	☐	☐	☐
Bed (if no riffle-pool morphology)	☒	☒	☐	☐	☐	☐	☐

Bankfull Width (m)	1.62	2.25	2.51	**Wetted Width (m)**	0.79	1.5	0.66
Bankfull Depth (m)	0.5	0.7	0.4	**Wetted Depth (m)**	0.33	0.32	0.24
Undercuts (m)				**Velocity (m/s)**			
Pool Depth (m)				**Velocity Estimate Method**			
Riffle Length (m)				**Meander Amplitude (m)**			

Notes:

*rooted submergent veg 90%

* multiple flow paths through wetland

Tall Grass was present throughout the floodplain

Photos:

Version #4
Last edited: 04/04/2023

Senior staff sign-off (if required): ______ Checked by: CG Completed by: JA

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MORPHIX™

Rapid Stream Assessment Technique **Project Number:** 25023

Date:	2025-07-09	**Stream:**	Campbells Cross Creek
Time:	10:00	**Reach:**	
Weather:	20° overcast	**Location:**	Caledon
Field Staff:	CG JA	**Watershed/Subwatershed:**	West Humber River

Category	Poor	Fair	Good	Excellent
Channel Stability	• < 50% of bank network stable • Recent bank sloughing, slumping or failure frequently observed	• 50-70% of bank network stable • Recent signs of bank sloughing, slumping or failure fairly common	• 71-80% of bank network stable • Infrequent signs of bank sloughing, slumping or failure	• > 80% of bank network stable • No evidence of bank sloughing, slumping or failure
	• Stream bend areas highly unstable • Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) • Bank overhang > 0.8-1.0 m	• Stream bend areas unstable • Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) • Bank overhang 0.8-0.9m	• Stream bend areas stable • Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas) • Bank overhang 0.6-0.8 m	• Stream bend areas very stable • Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) • Bank overhang < 0.6 m
	• Young exposed tree roots abundant • > 6 recent large tree falls per stream mile	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	• Exposed tree roots predominantly old and large, smaller young roots scarce • 2-3 recent large tree falls per stream mile	• Exposed tree roots old, large and woody • Generally 0-1 recent large tree falls per stream mile
	• Bottom 1/3 of bank is highly erodible material • Plant/soil matrix severely compromised	• Bottom 1/3 of bank is generally highly erodible material • Plant/soil matrix compromised	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally trapezoidally-shaped	• Channel cross-section is generally V- or U-shaped	• Channel cross-section is generally V- or U-shaped
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4 ☐ 5	☐ 6 ☐ 7 ☐ 8	☐ 9 ☒ 10 ☐ 11
Channel Scouring/ Sediment Deposition	• > 75% embedded (> 85% embedded for large mainstem areas)	• 50-75% embedded (60-85% embedded for large mainstem areas)	• 25-49% embedded (35-59% embedded for large mainstem areas)	• Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	• Few, if any, deep pools • Pool substrate composition >81% sand-silt	• Low to moderate number of deep pools • Pool substrate composition 60-80% sand-silt	• Moderate number of deep pools • Pool substrate composition 30-59% sand-silt	• High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) • Pool substrate composition <30% sand-silt
	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits common	• Streambed streak marks and/or "banana"-shaped sediment deposits uncommon	• Streambed streak marks and/or "banana"-shaped sediment deposits absent
	• Fresh, large sand deposits very common in channel • Moderate to heavy sand deposition along major portion of overbank area	• Fresh, large sand deposits common in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits uncommon in channel • Small localized areas of fresh sand deposits along top of low banks	• Fresh, large sand deposits rare or absent from channel • No evidence of fresh sediment deposition on overbank
	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	• Point bars common, moderate to large and unstable with high amount of fresh sand	• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☒ 7 ☐ 8

No Trees

Version #2
Last edited: 10/02/2023

Senior staff sign-off (if required): ________ Checked by: CC Completed by: CC

GEO MORPHIX™

Date:	2025-07-09	PN:	25023	Location:	Caledon

Category	Poor	Fair	Good	Excellent
Physical Instream Habitat	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40-60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	• Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	• Few pools present, riffles and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)	• Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	• Riffles, runs and pool habitat present • Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
	• Riffle substrate composition: predominantly gravel with high amount of sand • < 5% cobble	• Riffle substrate composition: predominantly small cobble, gravel and sand • 5-24% cobble	• Riffle substrate composition: good mix of gravel, cobble, and rubble material • 25-49% cobble	• Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand • > 50% cobble
	• Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	• Riffle depth 15-20 cm for large mainstem areas	• Riffle depth > 20 cm for large mainstem areas
	• Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	• Large pools generally 30-46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	• Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	• Extensive channel alteration and/or point bar formation/enlargement	• Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	• No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5-0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1
	• Summer afternoon water temperature > 27°C	• Summer afternoon water temperature 24-27°C	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☒ 5 ☐ 6	☐ 7 ☐ 8
Water Quality	• Substrate fouling level: High (> 50%)	• Substrate fouling level: Moderate (21-50%)	• Substrate fouling level: Very light (11-20%)	• Substrate fouling level: Rock underside (0-10%)
	• Brown colour • TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	• Slightly grey colour • TDS: 50-100 mg/L	• Clear flow • TDS: < 50 mg/L
	• Objects visible to depth < 0.15m below surface	• Objects visible to depth 0.15-0.5m below surface	• Objects visible to depth 0.5-1.0m below surface	• Objects visible to depth > 1.0m below surface
	• Moderate to strong organic odour	• Slight to moderate organic odour	• Slight organic odour	• No odour
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☐ 5 ☐ 6	☒ 7 ☐ 8
Riparian Habitat Conditions	• Narrow riparian area of mostly non-woody vegetation	• Riparian area predominantly wooded but with major localized gaps	• Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
	• Canopy coverage: <50% shading (30% for large mainstem areas)	• Canopy coverage: 50-60% shading (30-44% for large mainstem areas)	• Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	☐ 0 ☐ 1	☒ 2 ☐ 3	☐ 4 ☐ 5	☐ 6 ☐ 7

Total overall score (0–42) = 31	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Senior staff sign-off (if required): ________ Checked by: ________ Completed by: ________

GEO MORPHIX™

Rapid Geomorphic Assessment

Project Number: 25023

Date:	2025-07-09	**Stream:**	Campbells Cross Creek
Time:	10:00	**Reach:**	
Weather:	20° overcast	**Location:**	caledon
Field Staff:	CG JA	**Watershed/Subwatershed:**	West Humber River

Process	No.	Geomorphological Indicator – Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	0/5
	2	Coarse materials in riffles embedded N/A			
	3	Siltation in pools N/A			
	4	Medial bars		X	
	5	Accretion on point bars		X	
	6	Poor longitudinal sorting of bed materials		X	
	7	Deposition in the overbank zone		X	
		Sum of indices =		5	
Evidence of Degradation (DI)	1	Exposed bridge footing(s) N/A			0/6
	2	Exposed sanitary / storm sewer / pipeline / etc. N/A			
	3	Elevated storm sewer outfall(s) N/A			
	4	Undermined gabion baskets / concrete aprons / etc. N/A			
	5	Scour pools downstream of culverts / storm sewer outlets		X	
	6	Cut face on bar forms		X	
	7	Head cutting due to knickpoint migration		X	
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =		6	
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		X	0/7
	2	Occurrence of large organic debris		X	
	3	Exposed tree roots		X	
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle N/A			
	6	Outflanked gabion baskets / concrete walls / etc. N/A			
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation N/A			
		Sum of indices =		7	
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	2/7
	2	Single thread channel to multiple channel	X		
	3	Evolution of pool-riffle form to low bed relief form		X	
	4	Cut-off channel(s)		X	
	5	Formation of island(s)		X	
	6	Thalweg alignment out of phase with meander form		X	
	7	Bar forms poorly formed / reworked / removed	X		
		Sum of indices =	2	5	0.29

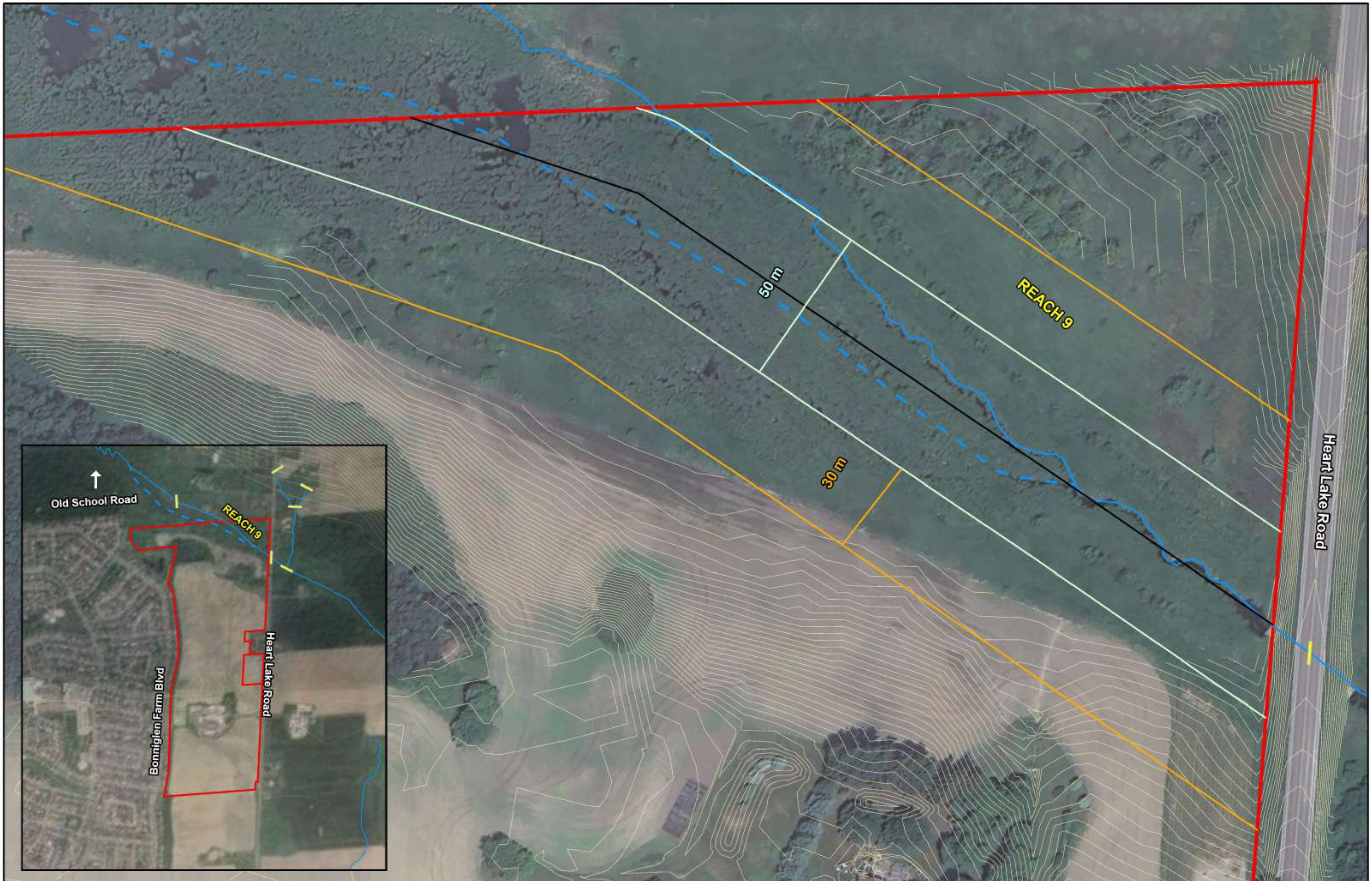
Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.07
In Regime	**In Transition/Stress**	**In Adjustment**
☒ **0.00 - 0.20**	☐ **0.21 - 0.40**	☐ **0.41**

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): ________ Checked by: CC Completed by: JA

Appendix E:
Meander Belt Width and Reside Dace Habitat Area



Legend

- Reach Break and ID
- Hydrological Connectivity
- Watercourse (OHN)
- 0.25 m Contour
- Central Tendency
- Meander Belt Width
- 30 m Redside Dace Habitat Area
- Approximate Study Area

Meander Belt Width and Redside Dace Habitat Area

12506 Heart Lake Road

Caledon, ON

GEO MORPHIX™

N

0 20 40

Metres

Imagery: Google Earth, 2024. Watercourse: MNRF, 2024/2021.
Reach Break and ID, MBW and RSD: GEO Morphix, Ltd., 2025.
0.25 m Contour, Study Area: Tribal, 2025.
Print Date: October 2025. PN25023. Drawn By: K.W., M.O.