Appendix K:

Fluvial Geomorphology Report

Municipal Class Environmental Assessment Airport Road Between King Street and Huntsmill Drive, Town of Caledon

Fluvial Geomorphological Assessment Centreville Creek and East Credit River Tributary

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GEO MORPHIX
Geomorphology
Earth Science
Observations

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1 Introduction

The Regional Municipality of Peel is undertaking a Schedule C Municipal Class Environmental Assessment (Class EA) in support of long-term improvements to Airport Road (Regional Road 7) between King Street (Regional Road 9) and Huntsmill Drive in the Town of Caledon. Airport Road consists of two through lanes in a north-south orientation. Within the Community of Caledon East, the roadway has an urban cross section, while the remainder of Airport Road has a rural cross section. Airport Road currently supports a significant volume of commuter and truck traffic and is identified as a primary truck route. The Long Range Transportation Update (Region of Peel, 2012) recommended the widening of Airport Road by 2031 to include up to four lanes of through traffic, and other infrastructure to enable the efficient movement of people and goods.

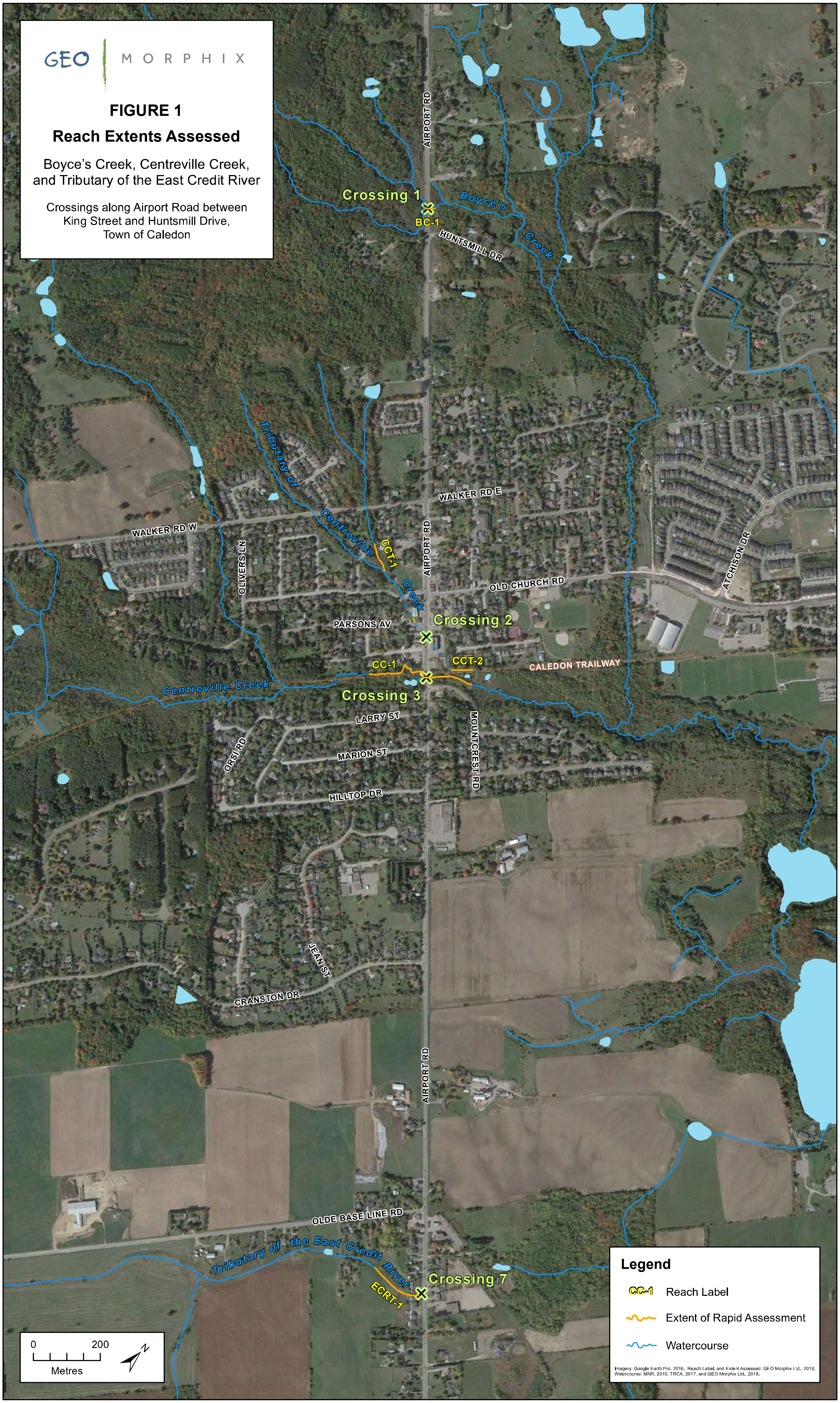
GEO Morphix Ltd. was retained as part of a multi-disciplinary consulting team led by IBI Group to provide fluvial geomorphological support for the Class EA process. Seven regulated watercourse crossings were identified as part of this study and are located within the jurisdictions of Credit Valley Conservation (CVC) and Toronto and Region Conservation Authority (TRCA). Three of the features that cross Airport Road are classified as headwater drainage features (HDFs) and were investigated by the TRCA as part of the Natural Environmental Existing Conditions Report (September 2017). As such, the HDFs were not included in the fluvial geomorphological assessments. The following four regulated watercourse crossings were assessed as part of this study:

- Boyce's Creek, a tributary of Centreville Creek (Crossing 1)
- Unnamed tributary of Centreville Creek (Crossing 2)
- Centreville Creek (Crossing 3)
- Unnamed tributary of the East Credit River (Crossing 7)

Centreville Creek and its tributaries travel from west to east across Airport Road, while the East Credit River tributary travels from east to west (**Figure 1**).

The activities listed below were completed in support of the geomorphological assessment:

- Review available background reports and mapping (e.g., soils, physiography, geology, and topography)
- Complete a historical assessment using aerial photographs to identify changes to the system due to land use and past channel modifications
- Delineate the meander belt width in the vicinity of Airport Road, where feasible
- Determine meander migration rates, where feasible
- Conduct rapid geomorphological field assessments for portions of accessible channel upstream and downstream of each of the three watercourse crossings to document channel conditions and verify the results of the desktop assessment
- Assess the effects of the existing crossing structures to channel form and function
- Evaluate the crossing structure alternatives with respect to potential impacts on channel form and function
- Provide recommendations, from a fluvial geomorphological perspective, on crossing structure spans for replacements and/or enhancements for culvert modifications/extensions, with consideration to other factors such as hydraulics, ecology, fisheries and various physical constraints as determined through the study.


GEO MORPHIX
FIGURE 1
Reach Extents Assessed
Boyce's Creek, Centreville Creek, and Tributary of the East Credit River
Crossings along Airport Road between King Street and Huntsmill Drive, Town of Caledon
AIRPORT RD
Crossing 1
BC-1
Boyce's Creek
HUNTSMILL DR
Tributary of Centreville Creek
WALKER RD E
WALKER RD W
CCT-1
OLIVERS LN
OLD CHURCH RD
ATCHISON DR
PARSONS AV
Crossing 2
CC-1
CCT-2
CALEDON TRAILWAY
Centreville Creek
Crossing 3
LARRY ST
MOUNTCREST RD
ORSI RD
MARION ST
HILLTOP DR
JEAN ST
CRANSTON DR
OLDE BASE LINE RD
Tributary of the East Credit River
Crossing 7
ECRT-1
0
200
Metres
N
Legend
CC-1 Reach Label
Extent of Rapid Assessment
Watercourse
Imagery: Google Earth Pro, 2016. Reach Label, and Extent Assessed: GEO Morphix Ltd., 2018.
Watercourse: MNR, 2010, TRCA, 2017, and GEO Morphix Ltd., 2018.

2 Study Site History

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 historical factors that have contributed to current channel morphodynamics, as well as the basis for understanding the potential future changes to the channel. Aerial photographs from 1954 (scale 1:15,840) and 1978 (scale 1:10,000) from the Ministry of Natural Resources and Forestry (MNRF) and recent satellite imagery from Google Earth Pro (2016) were reviewed to complete the historical assessment. Refer to **Appendix A** for copies of the imagery.

In 1954, the predominant land use was agricultural and rural residential. Several natural areas and woodlots were also present on either side of Airport Road. Innis Lake, Elliot Lake and Widget Lake were prominent natural features east of Airport Road. The Community of Caledon East, now with approximately 5,000 residents, had established by 1954. Boyce's Creek was not visible upstream and downstream of Airport Road at Crossing 1 due to the presence of woodlands. The channel appeared to have an extensive riparian buffer upstream (west) of Airport Road, but this buffer may have contained significant localized gaps in the vicinity of lands cleared for agricultural fields/pastures.

The upstream reaches of tributaries to Centreville Creek (west of Airport Road) travelled through forests that obscured the channel. Cultivated fields and/or pasture were present between tributaries upstream of Airport Road in the area of what is now Walkers Road West. These tributaries travelled through the Caledon East and across Airport Road (Crossing 2). It is likely that upstream portions of the tributary were piped prior to 1954 to facilitate rural development, with additional enclosures on the east side of Airport Road to accommodate development in subsequent years.

The former Canadian National Railway (CNR) rail line (now the Caledon Trailway) was present in 1954. Upstream reaches of Centreville Creek travelled through large woodlands west of Airport Road. Where the channel crossed agricultural fields farther upstream, west of Mountainview Road, there was no riparian buffer and the channel had been straightened. This likely increased stream power as well as the likelihood of subsequent systematic channel adjustments (e.g., widening, downcutting, meander bend development). The channel planform was only visible near Airport Road on the north side of the CNR rail line adjacent to rural residences before crossing the Trailway and then Airport Road to a woodland with agricultural/pasture lands on either side. Where the channel was visible, it was generally straight with the exception of a relatively large meander bend on rural property west of Airport Road. Riparian vegetation was likely also actively removed/maintained while the CNR rail line was in operation.

The tributary of the East Credit River was straightened prior to 1954 and lacked a riparian buffer. The channel appeared to originate in a relatively small woodland on the east side of Airport Road that had likely been impacted by selective tree clearing and adjacent agricultural/pasture land uses. It then crossed Airport Road at Crossing 7, and subsequently travelled through agricultural fields where it was previously straightened. Adjacent agricultural activities and the lack of a riparian buffer likely resulted in frequent fine sediment inputs.

By 1978, the Community of Caledon East had expanded south of the CNR rail line, and to the east and west of Airport Road. There was limited change near Crossing 1, except where agricultural fields had begun to naturalize farther upstream and two large ponds had been excavated west of Airport Road. A direct connection between Boyce's Creek and the ponds was not discernible due to the woody vegetation cover. At Crossing 2, additional sections of the tributary were likely piped east of Airport Road to facilitate construction of new residences and infrastructure along Robert

Carson Drive. Residential development had expanded south of the CNR line in 1978 near Crossing 3. Portions of visible channel planform upstream of Airport Road, adjacent to the rail line, were slightly more sinuous, while on the east side of Airport Road, former agricultural fields appeared to no longer be actively farmed immediately south of the CNR line. Rural residential and industrial/commercial development had expanded slightly in vicinity of Crossing 7, mostly on the east side of Airport Road; however, the watercourse remained largely unchanged. The upstream drainage area within the woodland on the east side of Airport Road had been allowed to expand and naturalize.

Between 1978 and 2015, the Community of Caledon East had expanded further. Naturally forested areas had also continued to expand along Boyce's Creek upstream of Crossing 1. Huntsmill Drive was constructed within the approximate footprint of a former access road that was visible in 1978 imagery. Several landscaped ponds were also constructed northeast of Airport Road and Crossing 1. Additional residences were constructed adjacent to the tributaries of Centreville Creek, upstream of Crossing 2, while maintaining a riparian buffer. There was limited change downstream of Crossing 2. At Crossing 3, riparian conditions west of Airport Road had improved since 1978 through the expansion of woody vegetation that now likely provides additional shade and cover to Centreville Creek. This is likely due to decommissioning of the CNR line in the 1980s and its conversion to the Caledon Trailway, a multi-use trail intended for non-motorized vehicles and pedestrians. The large meander bend upstream of Airport Road, within residential property, was more pronounced and had migrated northwards. In addition, a pond had been constructed on the south side of the Trailway and drained to Centreville Creek. On the immediate east side of Airport Road, agricultural fields were converted to residential housing; however, Centreville Creek travelled through a natural area with forest cover. A wetland had also formed between the Trailway and Centreville Creek and had a boardwalk/viewing platform extending from the Trailway to the south side of the watercourse.

Overall, land use within the study area has largely remained as rural residential, with the gradual expansion of the Community of Caledon East. With the exception of additional enclosures of sections of watercourse near Crossing 2 and the continued lack of a riparian buffer downstream of Crossing 7, the naturalization of several former agricultural fields and the conversion of the CNR line to the Caledon Trailway have likely allowed for the natural local improvement of channel form and function, as well as aquatic and riparian habitats, along Airport Road.

3 Subwatershed-scale Characteristics

3.1 Geology and Physiography

Geology and physiography act as primary governing variables with respect to channel geomorphology. 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. Although the crossings are in close proximity geographically, the local physiography and surficial geology varies and are summarized in the **Table 1**.

Crossings 1, 2 and 3 area located in the Oak Ridges Moraine, which serves as a drainage divide between the Lake Ontario drainage basin to the south and Georgian Bay and Trent River drainage basins to the north. This area is a significant source of groundwater due to the permeability of the soils (e.g., sand and gravel) and therefore helps to keep watercourses flowing year-round through the provision of baseflow.

Table 1: Local physiography and surficial geology at each crossing

Watercourse	Physiographic Region (Chapman and Putnam, 1984)	Local Physiography (Chapman and Putnam, 2007)	Surficial Geology (Ontario Geological Survey, 2010)
Boyce's Creek (Crossing 1)	Oak Ridges Moraine	Kame moraines	Ice-contact stratified deposits (sand and gravel, minor silt, clay and till)
Centreville Creek Tributary (Crossing 2)	Oak Ridges Moraine	Spillway	Glaciofluvial deposits with delta topset facies
Centreville Creek (Crossing 3)	Oak Ridges Moraine	Spillway	Glaciofluvial deposits with delta topset facies
East Credit River Tributary (Crossing 7)	South Slope	Drumlinized till plains	Clay to silt textured till derived from glaciolacustrine deposits or shale

Crossing 7, in contrast, is in the South Slope physiographic region, which, as the name suggests, is a gently sloping area. It is composed of a plain of clay to silt textured glacial till and is therefore less permeable.

The bedrock geology at the four crossings consists of shale, limestone, dolostone, and siltstone of the Queenston Formation (OGS, 2011). No exposed bedrock was encountered in any sections of channel assessed in the field.

4 Drainage Basin Characteristics

As noted in the Natural Environment Report (TRCA, 2017), the study area includes a number of designated natural areas, including wetlands, Environmentally Significant Areas (ESAs) and Areas of Natural and Scientific Interest (ANSIs). Two subwatersheds are located within the study area: Centreville Creek, which includes Boyce's Creek (a tributary), and the East Credit River.

4.1 Centreville Creek

Centreville Creek, which joins the main branch of the Humber River at Albion Hills Conservation Area, has a drainage area of approximately 47 km^2 and is located entirely within the Town of Caledon. Land use is predominantly rural with natural and managed forests, wetlands, croplands, pastures, dairy estate properties and major greenspace areas (TRCA, 2008). The majority of the subwatershed is located on the Oak Ridges Moraine, a significant groundwater recharge area, and a minor portion is located on the Niagara Escarpment (TRCA, 2008). Many kettle depressions occur in the subwatershed, forming locally and provincially significant wetlands (PSWs) and three small lakes (Elliot, Innis, and Widget Lakes), located east of Airport Road. Many of the watercourses in the subwatershed are coldwater streams providing high quality habitat for sensitive species including Brook Trout (*Salvelinus fontinalis*).

Due to highly permeable soils and the underlying surficial geology of the Oak Ridges Moraine, which favours infiltration over surface runoff, this system is influenced to a lesser degree by precipitation than those located on the South Slope and Peel Plain (TRCA, 2008). During dry periods, many of the first, second and third order watercourses contain baseflow due to groundwater inputs from the Oak Ridges Aquifer Complex (ORAC). However, downstream of the Community of Caledon East, Centreville Creek flows through the highly permeable sediments of the Caledon East Meltwater Channel, and this section of channel acts as a groundwater recharge area.

4.2 East Credit River

The East Credit River has a drainage area of approximately 51 km^2 and is located entirely within the Town of Caledon (CVC, 2002). Similar to Centreville Creek, the landscape is dominated by the Niagara Escarpment and the Oak Ridges Moraine. This subwatershed discharges to the Credit River upstream of the Village of Inglewood, located approximately 8 km southwest of the study area (CVC, 2002). Predominant land uses include intensive and non-intensive agriculture, which are largely located in the southern portion of the subwatershed.

The main channel of the East Credit River is approximately 11 km in length, with major tributaries draining from the northwest, originating along the Niagara Escarpment. The mainstem is positioned within glacial spillways and has a generally low gradient and wide floodplain, while the main tributaries have steep gradients where water flows down the escarpment (CVC, 2002). The Niagara Escarpment and Oak Ridges Moraine provide groundwater discharge to the East Credit River that helps to sustain healthy populations of Brook Trout (CVC, 2007).

5 Watercourse Characteristics

5.1 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 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

Reaches are delineated following scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). For this study, the full length of each reach was not verified due to site access limitations. Furthermore, limited details are available for portions of the Boyce's Creek channel upstream and downstream of Crossing 1 as permission to access the lands could not be obtained. **Table 2** provides a list of the portions of watercourses assessed upstream and downstream of each crossing, as well as their locations and defining characteristics.

Table 2: Portions of watercourse assessed along Airport Road from north of Huntsmill Drive to King Street

Watercourse	Reach	Extent Assessed	Length (m)	Defining Characteristics
Boyce's Creek (Crossing 1)	BC-1	Channel assessed within the Airport Road ROW	100	Unconfined valley, no channel development, heavily vegetated
Centreville Creek Tributary (Crossing 2)	CCT-1	North of Ivan Avenue, East of Ella Street	80	Unconfined valley, sinuous planform, no riffles or pools
Centreville Creek Tributary (Crossing 2)	CCT-2	North of Caledon Trailway from 60 m east of Airport Road to elevated boardwalk	80	Unconfined valley, minimal channel development, heavily vegetated, straight planform
Centreville Creek (Crossing 3)	CC-1	Caledon Trailway from Dufferin Street to elevated boardwalk east of Airport Road	330	Unconfined valley, straightened channel, riffle-pool morphology
East Credit River Tributary (Crossing 7)	ECRT-1	Airport Road 250 m south of Olde Base Line Road to 5943 Airport Road	220	Unconfined valley, minimal channel development, extensively vegetated, straight planform

5.1.1 General Reach Observations

Field investigations were completed on August 23, 2018 and included the following:

- Habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow patterns, geomorphological units (e.g., riffle, run, pool), and riparian vegetation for the extent of each reach assessed
- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- 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 below. The descriptions are supplemented and supported with representative photographs, which are included in **Appendix B**. Field sheets, including reach summaries, habitat sketch maps and rapid assessments, are provided in **Appendix C**.

Crossing 1 – Boyce's Creek

Reach BC-1

Crossing 1 was a 0.90 m diameter CSP culvert located approximately 70 m north of Huntsmill Drive. The culvert inlet was slightly perched (8 cm) above the channel bed. The area upstream (west) of Crossing 1, was occupied by a cattail marsh with no defined watercourse. This marsh likely developed as a result of the perched culvert inlet, which would create a backwater and a low-energy environment conducive to wetland vegetation establishment.

At the culvert outlet, there was a 0.3 m deep scour pool, but also backwatering into the culvert. Flows dispersed across a phragmites-dominated wetland such that there was no defined channel within the road allowance. As flows entered private property, the landscape changed to a forest and a well-defined channel formed. The channel had a riffle and pool morphology. Riffle substrate was predominantly gravel and cobble with some larger boulders, and pool substrate was composed of gravel and sand. Bankfull channel measurements were taken just within the road allowance, and the average bankfull width and average maximum bankfull depth were measured to be 2.20 and 0.6 m, respectively.

Through the private property, the TRCA (2017) documented a defined channel with an average width of 0.68 m and an average depth of 0.07 m. The channel was significantly smaller than it was within the road allowance as it was presumably no longer affected by culvert hydraulics (i.e., channel scouring at the culvert outlet). The TRCA also observed pools, glides and riffles with substrate up to cobble size.

Crossing 2 – Centreville Creek Tributary

Crossing 2 was a 0.85 m diameter CSP culvert with an inlet and outlet well outside of the Airport Road road allowance. The culvert inlet was approximately 30 m west of Airport Road on the north side of Parsons Avenue, and the outlet was 60 m east of Airport Road on the north side of the Caledon Trailway.

Reach CCT-1

Most of the tributary was piped in the vicinity of Airport Road due to the angled approach of the channel relative to Airport Road and the roads perpendicular to Airport Road. The upstream extent of observations was collected near the confluence of two branches of the tributary northeast of Ella Street and northwest of Ivan Avenue. The channel conveyed flows in a southeasterly direction through a sinuous, low-gradient channel with limited morphological bed variability. There was little instream vegetation, and the channel bed and banks were composed of predominantly sand and clay. The average bankfull width was 1 m, and the average maximum bankfull depth was 0.37 m. The channel travelled through woodland with dense immature deciduous trees and herbaceous vegetation.

As the channel approached the northeast to southeast bend of Ivan Avenue, which was not accessed as permission to enter the property was not obtained, flows entered a culvert and discharged to an open channel approximately 120 m southeast. The channel was only open for approximately 15 m before entering Crossing 2 on the north side of Parsons Avenue. Here, the channel was lined along one bank with flagstone. The average bankfull width of the channel was 0.82 m and the average maximum bankfull depth was 0.6 m.

Reach CCT-2

At the Crossing 2 outlet on the east side of Airport Road, there was a shallow pool with organic substrate. Beyond the pool, channel definition was poor as water flowed through a 4.6 m wide, 0.47 m deep ditch populated with reeds and cattails. Due to the lack of energy, there was a positive feedback relationship between in-channel vegetation establishment and sedimentation (i.e., bed aggradation), which created a roughly 0.4 m high backwater into the culvert outlet. The ditch was located between the fence line of the residential properties of Robert Carson Drive and the Caledon Trailway. An oily film was observed on the water surface at several locations within the ditch, and the water generally had an organic odour indicating poor water quality.

Crossing 3 – Centreville Creek

Crossing 3 was a 4.30 m span box culvert conveying flows of Centreville Creek across Airport Road from east to west. Immediately upstream (west) of the crossing, a channel conveying flows from a small pond formed a confluence with Centreville Creek. Flow occupied the full culvert span and the bed was uniformly composed of fine silt and sand. A woody debris accumulation that partially blocked flows was observed within the culvert. Two storm sewers outletted to the channel on the downstream (east) side of the culvert: a 1.45 m diameter CSP on the north side and a 0.70 m diameter concrete pipe on the south side.

Reach CC-1

Approximately 325 m of Centreville Creek, between Dufferin Street (west of Airport Road) and the elevated boardwalk adjacent to the Caledon Trailway (east of Airport Road), was assessed. The channel was unconfined (i.e., not in a valley setting) and had a riparian buffer generally composed of mature deciduous trees and grasses. The channel had a low gradient and was dominated by runs, with few riffles and pools. The channel substrate was predominantly composed of gravel, sand and silt, while cobbles were also observed in the few riffles. Average bankfull width was 3.45 m and average maximum bankfull depth was 0.65 m.

Crib walls, undermined and in generally poor condition, were observed along the creek at the rear of the properties located along Emma Street. These were previously constructed to prevent erosion and protect pedestrian bridges over the creek. Watercress, an indicator of possible groundwater input, was observed within the channel at several locations and was most abundant immediately downstream of a relatively large meander bend at 4 Emma Street. Downstream of Airport Road, the channel had a higher width-to-depth ratio, and the channel corridor was more akin to a wetland system.

Crossing 7 – East Credit River Tributary

The Crossing 7 outlet consisted of a 2 m span box culvert located approximately 250 m south of Olde Baseline Road. The culvert conveyed flows of a tributary of the East Credit River westwards across Airport Road. The culvert inlet was located at the rear of private property, which was not accessible and well outside of the road allowance, and therefore no observations were collected. On the west side of Airport Road, there was a culvert under a driveway at 15332 Airport Road that conveyed ditch flows to the north side of the creek. The rip-rap around the driveway culvert outlet partially blocked the Crossing 7 outlet at Airport Road.

Reach ECRT-1

Downstream of the culvert, a small, straight swale conveyed flows between two residential properties for approximately 45 m. Immediately downstream of the culvert and along the south side, the swale travelled along a small garden, at 15324 Airport Road, with a wooden retaining wall. The channel had no woody riparian cover as the channel was bounded by manicured grass, except for the portion with the small garden. The channel had an average width of 2.35 m and an average maximum depth of 0.6 m; these measurements were taken relative to the top of channel bank due to a lack of bankfull indicators. Bed material was uniformly composed of clay, silt and decomposing organic material. At the west property line, there was a high point in the channel and this created a backwater effect with no perceptible flow through the swale.

Beyond the residential properties on the west side of Airport Road, the channel lost definition upon entering a wet meadow where flows apparently dispersed through the vegetation. Approximately 50 m from the property line, however, a small channel conveying baseflow was observed within the wet meadow. This channel had an average bankfull width of 0.5 m and a maximum bankfull depth of 0.28 m.

5.1.2 Reconnaissance-level Assessments

Channel stability was semi-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 form adjustment. The index produces values that indicate whether the channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40) or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and 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.

Reaches were also classified according to a modified Downs (1995) Channel Evolution Model. The Downs Model describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system.

These reconnaissance-level assessments were applied to alluvial or semi-alluvial systems. For this study, only Reaches CCT-1 (Centreville Creek Tributary) and CC-1 (Centreville Creek) were eligible. The results are summarized in **Table 3**.

Table 3: Summary of reconnaissance-level assessments

Watercourse and Reach*	RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995) Channel Evolution Model
	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
Centreville Creek Tributary Reach CCT-1 (Crossing 2)	0.15	In Regime	Aggradation	28	Good	Channel Scouring/ Sediment Deposition	D - depositional
Centreville Creek Reach CC-1 (Crossing 3)	0.13	In Regime	Aggradation	29	Good	Channel Scouring/ Sediment Deposition	S - stable

*Boyce's Creek (Crossing 1), the downstream section of Centreville Creek Tributary Reach CCT-2 (Crossing 2) and East Credit River Tributary Reach ECRT-1 (Crossing 7) were not assessed due to the absence of a defined channel.

In Centreville Creek Tributary Reach CCT-1 at Crossing 2, the only significant morphological change observed was sediment deposition as evidenced by poor longitudinal sorting of bed materials, overbank sediment deposition, and point bar accretion. This is consistent with the depositional (D) stage of the Downs (1995) model. However, due to the lack of other channel adjustment observations, the RGA resulted in a score of 0.15, which indicates that the reach is 'in regime.' The RSAT indicates good stream health with a score of 28. The limiting factors in RSAT score were sediment deposition, and poor physical instream habitat due to the lack of morphological bed variability.

Similar to the tributary, Centreville Creek Tributary Reach CC-1 exhibited limited adjustments other than aggradation, which was indicated by pool siltation and overbank sediment deposition. This resulted in an RGA score of 0.15 (in regime) and indicated a stable (S) stage of evolution according to Downs (1995). The RSAT score was 29 (good condition) with sediment deposition as the limiting factor, although minor.

6 Meander Belt Width Delineation

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width, or 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, for example, the potential limit of an activity (e.g., land development) adjacent to a watercourse, or the floodplain width required to restore a stream to a naturally functioning state.

The meander belt widths of Boyce's Creek (Crossing 1) and Centreville Creek (Crossing 3) were delineated within the Airport Road road allowance to determine the potential erosion hazard to the road as well as other surrounding infrastructure, and to estimate the optimal corridor width needed for a dynamic, fully alluvial system. Centreville Creek Tributary (Crossing 2) was omitted from this part of the study as there is no open channel within the road allowance, and the likelihood of daylighting the creek within the road allowance is low due to the conflict with another road (Parsons Avenue) and private properties. Similarly, the meander belt width of East Credit River Tributary (Crossing 7) was not determined as the culvert inlet was located in private property well outside of the road allowance. It should be noted here that meander bends migrate laterally and in the downstream direction and therefore determining the potential erosion hazard of a channel downstream of a road does not provide useful information (unless the aim is to assess the hazard downstream of a road).

All years of the available historical imagery were examined to determine the largest meander amplitude in proximity to each crossing. Due to the size of the watercourses and limitations in aerial photography, meander amplitude could only be measured for Centreville Creek (Crossing 3). For this watercourse, meander amplitudes were measured upstream and downstream of Airport Road. The largest meander amplitude, 13 m, was measured downstream of Airport Road on the 2016 photograph as well as upstream of Airport Road on the 2005 photograph. To calculate the meander belt width, the average channel bankfull width was added to the maximum meander amplitude. A 20% factor of safety was also applied, resulting in a final meander belt width of 20 m. This approach is consistent with TRCA (2004) guidelines, where a 20% factor of safety is required for channels with a maximum meander amplitude less than 50 m.

A modelling approach can be used where the channel has been previously modified or its position cannot be determined in the imagery due to tree cover or poor photograph resolution, for example. These models are scientifically defensible and have been verified in past projects as suitable for use in southern Ontario. Empirical relations from Williams (1986) were applied using bankfull channel dimensions measured in the field to estimate the meander belt width (m), B_w:

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

$$B_w = 4.3{W_b}^{1.12} + W_b \quad \text{[Eq. 2]}$$

where A is bankfull cross-sectional area (m^2) and W_b is bankfull channel width (m). An additional 20% buffer, or factor of safety, was applied to the computed results to addresses issues of under prediction.

The Ward et al. (2002) model was also used to meander belt widths (ft), B_w:

$$B_w = 6{W_b}^{1.12} \quad \text{[Eq. 3]}$$

Again, an additional 20% buffer, or factor of safety, was applied to the results

The modelled meander belts for Boyce's Creek (Crossing 1) and Centreville Creek (Crossing 3) are provided in **Table 4**. Although a measured meander belt width has already been provided for Centreville Creek, the modelled results are presented for comparison. Moreover, it should be noted that the modelled results for Centreville Creek are based on the average channel measurements from TRCA (2017) as permission for field personnel to enter private property could not be obtained by the Region of Peel. Meander belts are shown graphically in **Appendix D**.

Table 4: Modelled meander belt widths for Boyce's Creek and Centreville Creek

Watercourse	Reach	Meander Belt Width (m)*		
		Williams – Area (1986)	Williams – Width (1986)	Ward et al. – Width (2002)
Boyce's Creek (Crossing 1)	BC-1	3.8	4.2	5.4
Centreville Creek (Crossing 3)	CC-1	34.9	24.8	33.2

*Includes 20% factor of safety

The modelled results for Centreville Creek (Crossing 3) in **Table 4** are higher than the measured 20 m meander belt width (including 20% factor of safety). This suggests that the modelled meander belt width for Boyce's Creek (Crossing 1) may also be conservative. It should be repeated that Boyce's Creek is a marsh on either side of Airport Road. There is therefore no erosion hazard to the road, unless a single-thread channel develops by replacing the Crossing 1 culvert with one that allows for upstream bed adjustments, for example.

Determination of the 100-year erosion limits at each crossing could not be completed as the channel banks could either not be accurately delineated or were not visible in historical aerial imagery. However, based on our historical assessment, where the channel was visible there were no significant changes in channel alignment in the vicinity of Airport Road. In addition, no significant erosion was observed during the field investigations.

7 Crossing Structure Recommendations

7.1 Proposed Road Improvements

Proposed improvements to Airport Road, between King Street and Huntsmill Drive generally include the following:

- Construction of roundabouts and turning lanes to improve intersections
- Local improvements to Old Church Road and an extension west of Airport Road to Ivan Avenue
- New or improved pedestrian and cycling facilities
- Stormwater drainage upgrades
- Replacement of all crossing structures, except Crossing 2 and 5 which will be maintained without modification

There is no proposed widening of Airport Road to accommodate additional lanes of through traffic.

7.2 Crossing Guidelines

TRCA (2015) and CVC (2015) have developed crossing guidelines to address natural hazards and the maintenance of channel form and function from a geomorphological perspective. TRCA recommends that crossing structures span the meander belt width, where feasible, or, at minimum, the 100-year erosion limit to avoid the migration of the channel into the crossing structure within the next 100 years. The TRCA guidelines also allow smaller crossing structures that accommodate relatively small, stable watercourses provided that they consider physical channel characteristics (e.g., alignment, width and depth) and fluvial processes (e.g., erosion and scour).

CVC (2015) highlights several recommendations from a geomorphological perspective:

- Where possible, the crossing structure design should avoid the need for channel armouring or adjustment
- Where feasible, the crossing structure should have a span that accommodates the channel's 100-year erosion limit or a lesser planning horizon determined through consultation with CVC
- The crossing should be at minimum three times the bankfull channel width for channels less than 4 m wide.
- The crossing should ensure that sediment transport processes and flow velocities are not impacted during frequent storm events

7.3 Other Crossing Considerations

The replacement, rehabilitation or modification of crossing structures must not only consider fluvial geomorphology but also hydraulics and their impacts to surrounding lands. According to the Stormwater Management Report, prepared by IBI Group (2019), Crossings 1 (Boyce's Creek) and 3 (Centreville Creek) have insufficient hydraulic capacity and therefore require replacement. **Table 5** provides a summary of existing and proposed crossing sizes at Crossings 1 and 3 to address this deficiency. Crossing 2 from this study has been omitted from the table as the existing crossing structure will be maintained.

Table 5: Existing and proposed crossing sizes

Crossing	Watercourse	Existing			Proposed		
		Size (mm)	Type	Length (m)	Size (mm)	Type	Length (m)
1	Boyce's Creek	900	CSP	22.35	3658 x 1067	Open Footing Concrete Box	24.1
3	Centreville Creek	4350 x 870	Concrete Box	18.18	12192 x 1370	Open Footing Concrete Box	18.4
7	East Credit River Tributary	450	CSP	23.19	1830 x 900	Concrete Box	23.7

Fish and fish habitat must also be considered, if applicable to the crossing. Based on the aquatic habitat assessment completed by the TRCA (2017), Boyce's Creek (Crossing 1) and Centreville Creek (Crossing 3), contain direct fish habitat. Crossing 2 (Centreville Creek Tributary) was assessed by the TRCA (2017) to be a barrier to fish passage due to the crossing configuration and the length of enclosure, and therefore the piped portion of the tributary provided indirect habitat. The TRCA (2018) also concluded that the East Credit River Tributary at Crossing 7 contributes to downstream features and habitats, suggesting that it is indirect habitat.

As Boyce's Creek (Crossing 1) and Centreville Creek (Crossing 3) are considered direct fish habitat, any need for culvert replacement, rehabilitation or modification should be coupled with enhancements to channel form and function to the extent possible. In doing so, aquatic habitat conditions would also be improved.

7.4 Crossing Recommendations

The proposed spans at Crossings 1 and 3 (3.658 m and 12.192 m, respectively) are satisfactory from a fluvial geomorphological perspective. In each case, the span of the box culvert is more than three times the bankfull channel width and exceeds CVC's (2015) recommendation (it is recognized that both crossings are located in TRCA jurisdiction). Neither watercourse warrants a crossing structure that spans the meander belt due to the lack of notable channel erosion or migration observed near Airport Road as well as the conflicts with existing surrounding infrastructure that such a structure would present.

Both replacement crossing structures are open footing box culverts and these are preferred over the alternatives as they allow for placement of natural substrate for better continuity with existing bed materials beyond the ends the culvert. Open footing culverts also locally facilitate groundwater connectivity with surface flows.

In general, both crossing structures should be designed to be as short as possible so as not to deter fish from entering. This would also help to limit channel disturbance as well as the need for restoration, although larger scale channel restoration may be warranted for reasons other than culvert replacement.

At Crossing 1, the presence of a cattail marsh and the lack of defined channel on the west (upstream) side of the road indicates that it is locally a low-energy system and there is limited erosion hazard and no risks associated with channel migration. This, however, assumes that a low-flow channel will not develop over time. The marsh can be maintained by ensuring that the bed elevation through the proposed culvert is also maintained, thereby preventing increased drainage. This can be accomplished by sizing the substrate through the culvert to resist entrainment over the expected range of stormflows, thus creating a base level control. A channel capable of conveying bankfull flows (e.g., flows associated with storms with a recurrence interval of 1.5 to 2 years) should also be established through the box culvert in order to concentrate flows and increase water depths during lower flow periods and improve conditions for fish passage.

Given the presence of a scour pool at the Crossing 1 outlet, a formal pool should be considered during detailed design. While the results of the hydraulic analysis may indicate that a scour pool is not required due to flow changes resulting from the larger culvert, it does offer other benefits such as a resting pool for fish. By using the downstream edge of the scour pool as a grade control, it can also create a backwater into the culvert. Beyond the culvert outlet, whether or not there is a scour pool, the disturbed portion of channel should be restored to a condition that ensures fish passage, preferably with habitat enhancements.

At Crossing 3, the Centreville Creek channel should be restored through the box culvert, ensuring that each bank is seamlessly aligned upstream and downstream of the culvert. The results of the hydraulic analysis can be used as a guide to determine a suitable method of achieving bank stability, keeping in mind that stability will likely not be provided by vegetation due to the lack of sunlight through the culvert. Consideration should also be given to scour prevention to avoid potential exposure of the box culvert footings. This can be accomplished by placing subsurface stones along the footings, for example.

Beyond the ends of the box culvert to the limit of channel disturbance, the banks can be bioengineered for stability and aquatic habitat benefits. While there was no strong evidence of channel migration at Airport Road, it would be prudent to promote bank stability with bioengineering, especially on the west (upstream) side of the culvert. The appropriate type of bioengineering measure can be determined largely based its anticipated long-term ability to resist degradation due to instream hydraulics.

If possible, the channel through the box culvert should be restored with substrate similar to that upstream and downstream so as not to impede movement of benthic organisms. This would also ensure that there is no disruption in sediment transport through the system.

The following additional recommendations are provided as standard best management practices:

- All work within areas regulated by the TRCA or CVC must be conducted during the appropriate in-water timing window to protect fish and fish habitat
- The in-water work area should be fully isolated to ensure that sediment is not released to the watercourse
- Any fish trapped within the isolated work area must be removed and transferred to a suitable downstream habitat by a technician with a Licence to Collect Fish for Scientific Purposes
- Natural flow levels upstream and downstream of the isolated work area must be maintained at all times
- Intake ends of pump hoses used for bypass pumping around isolated works areas must have a screen in accordance with Fisheries and Oceans Canada requirement
- Work within the isolated in-water work area should be conducted in the dry by pumping water into an approved water filtration system located at least 30 m from the receiving watercourse or other waterbody
- Minimize the area and duration of in-water works to the extent possible

8 Summary

A fluvial geomorphological assessment was completed for four of the seven regulated watercourses (associated with Crossings 1, 2, 3 and 7) that cross Airport Road between just north of Huntsmill Drive and King Street. The remaining three regulated watercourse crossings were previously assessed as headwater drainage features by the TRCA and therefore were not included in the fluvial geomorphology study. This investigation included a review of previously completed reports and secondary source information, a review of site history, meander belt width assessments (where appropriate), field reconnaissance along portions of accessible watercourse, and recommendations to be considered during the detailed design stage.

Land use within the study area has largely remained as rural residential over the period covered by historical imagery, with the gradual expansion of the community of Caledon East. With the exception of the enclosure of sections of the Centreville Creek Tributary in vicinity of Airport Road (Crossing 2) and the continued lack of a riparian buffer along the East Credit River Tributary downstream of Crossing 7, the naturalization of several former agricultural fields and the conversion of the CNR rail line to the Caledon Trailway have likely improved local channel form and aquatic and riparian habitats. Results of the field assessments indicated that all four regulated watercourses were generally stable, with limited evidence of active erosion within the extents assessed.

The meander belt widths for Boyce's Creek (Crossing 1) and Centreville Creek (Crossing 3) were determined based on a modelling approach and measurements, respectively. Boyce's Creek has a modelled width of 4.2 m, based on Williams (1986) using bankfull channel width as the independent variable, while Centreville Creek has a measured meander belt of 20 m. These meander belt widths are theoretical hazard limits and do not necessarily dictate crossing structure spans. Instead, given the lack of significant channel erosion and migration in the vicinity of Airport Road, particularly upstream of the road, the minimum recommended crossing structure spans were based on three times the bankfull channel width (CVC, 2015). In this case, the culvert dimensions deemed suitable based on hydraulic modelling exceeded the channel-width-based criterion.

The watercourses at Crossings 1 and 3 should be restored to a condition that is better than existing and more natural. Given the wider culvert spans, the channel banks can be re-established across Airport Road. This would not only help to partially restore channel form and function, but also improve habitat conditions for resident fish populations and encourage fish passage through the culverts. The recommended bed restoration strategy differs at these two crossings as the maintenance of the marsh (and prevention of box culvert footing exposure) at Crossing 1 requires a bed with materials that will be stable over the range of expected flows, while the substrate at Crossing 3 can be more natural to facilitate sediment transport.

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Appendix A:
Historical Aerial Imagery

Location: Caledon East (yellow circle)
Year: 1954
Scale: 1: 15,840
Source: Ministry of Natural Resources

Location: Caledon East (yellow circle)
Year: 1954
Scale: 1: 15,840
Source: Ministry of Natural Resources

Location: Caledon East (yellow circle)
Year: 1978
Scale: 1:10,000
Source: Ministry of Natural Resources

Location: Caledon East (yellow circle)
Year: 1978
Scale: 1:10,000
Source: Ministry of Natural Resources

Location: Caledon East
Year: 1978
Scale: 1:10,000
Source: Ministry of Natural Resources

Location: Caledon East (yellow circle)
Year: 2016
Scale: Not Applicable
Source: Google Earth Pro

Appendix B:
Photographic Record

Photo 1 **Boyce's Creek - Reach BC-1**	 Upstream of Crossing 1, flows travelled undefined through a marsh consisting of grasses, cattails and phragmites. Yellow arrow indicates flow direction.
Photo 2 **Boyce's Creek - Reach BC-1**	 Crossing 1 is a 0.9 m diameter corrugated steel pipe (CSP) culvert. The culvert was perched 8 cm above the channel bed.

Photo 3 **Boyce's Creek - Reach BC-1**	 The downstream end of Crossing 1 on the east side of Airport Road was free of debris.
Photo 4 **Boyce's Creek - Reach BC-1**	 Downstream of Crossing 1, flows entered a grass and phragmites-dominated marsh with no defined channel.

Photo 5
Boyce's Creek - Downstream of BC-1

Approximately 12 m downstream of Crossing 1 the watercourse became defined in a forest. The channel's substrate consisted of cobbles with several large boulders.

Photo 6
Centreville Creek Tributary - Reach CCT-1

Approximately 250 m upstream of Crossing 2, the Centreville Creek tributary meanders through an immature deciduous forest.

Photo 7 **Centreville Creek Tributary - Reach CCT-1**	
	The substrate within the reach consisted largely of silt, clay and sand. The channel had an average maximum bank full depth of 0.37 m and average bankfull width of 1m.
Photo 8 **Centreville Creek Tributary - Reach CCT-1**	
	An elliptical culvert directed flows from the upstream forest reach (CVT-1) into a short, open channel to the west of Airport Road. Watercress was observed at the upstream extent of the segment, evidence of a possible groundwater upwelling.

Photo 9 **Centreville Creek Tributary - Reach CCT-1**	
	The watercourse was bounded by manicured grass. One bank was largely armoured with flagstone.
Photo 10 **Centreville Creek k Tributary - Reach CCT-1**	
	Crossing 2 is a 0.8 m diameter CSP culvert.

Photo 11 **Centreville Creek Tributary - Reach CCT-2**	
	The downstream end of Crossing 2 (blue arrow) was backwatered, with standing water present within the culvert itself and downstream for approximately 10 m.
Photo 12 **Centreville Creek Tributary - Reach CCT-2**	
	Downstream of the backwatered area the watercourse was poorly defined and was encroached by riparian vegetation. This vegetation consisted of established deciduous trees, herbaceous plants and shrubs.

Photo 13
Centreville Creek Tributary - Reach CCT-2

Rooted emergent vegetation including reed canary grass and cattails were found throughout most of the channel downstream of Crossing 2.

Photo 14
Centreville Creek - Reach CC-1

Upstream extent of Centreville Creek observations. The channel was well-defined with a riparian buffer dominated by shrubs and mature trees. Riffles and pools were scarce within the reach, and the predominant substrates were sand and gravel.

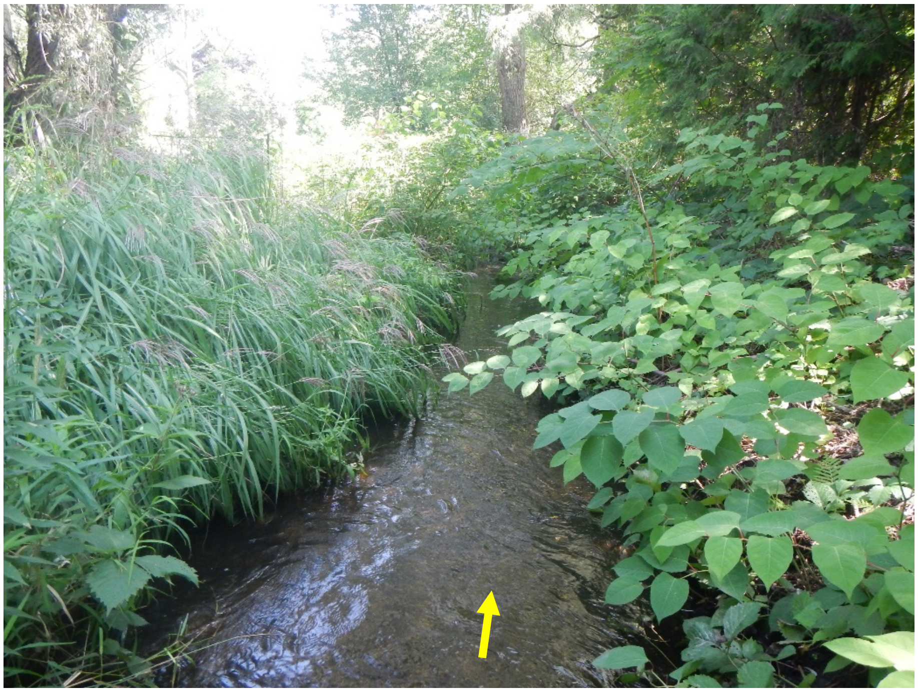
Photo 15 **Centreville Creek - Reach CC-1**	 Channel banks within the reach were generally well vegetated and stable.
Photo 16 **Centreville Creek - Reach CC-1**	 A crib wall was present along the outer bank of a left bend in the channel. There was significant loss of material within and behind the crib wall.

Photo 17 **Centreville Creek - Reach CC-1**	 Near the Caledon Trailway bridge spanning Centreville Creek, a meander bend passes through a residential property where manicured grass and herbaceous plants flanked the channel.
Photo 18 **Centreville Creek - Reach CC-1**	 The creek passes beneath the Caledon Trailway before crossing Airport Road. An artificial riffle composed of gravel and cobble was present downstream of the bridge.

Photo 19 **Centreville Creek - Reach CC-1**	 Upstream of Crossing 3 (concrete box culvert) on the west side of Airport Road, a shallow pool composed of silt and sand substrates was located downstream of the artificial riffle.
Photo 20 **Centreville Creek - Reach CC-1**	 Reach CC-1 formed a confluence with a small channel draining a violin shaped pond located south of the Caledon trailway path, immediately upstream of Crossing 3.

Photo 21
Centreville Creek - Reach CC-1

A woody debris jam was present which partially impeded flows within Crossing 3 beneath Airport Road.

Photo 22
Centreville Creek - Reach CC-1

A sandy lag deposit (blue arrow) was present downstream of the debris jam within Crossing 3. Downstream of the crossing was a shallow pool with bed material composed of sand and silt.

Photo 23 Centreville Creek - Reach CC-1	
	Downstream of Crossing 3 the riparian buffer was populated by grasses and deciduous trees. The channel had low entrenchment, and hydrophilic vegetation generally grew adjacent to the channel.
Photo 24 Centreville Creek - Reach CC-1	
	Approximately 80 m downstream of Crossing 3, deciduous trees lined both channel banks at a riffle, where the channel was narrower and more entrenched than near the crossing.

Photo 25 **Centreville Creek - Reach CC-1**	 Downstream of the forested area, the channel widened and was again less entrenched. Channel banks were composed of mucky soil, with little vegetation to provide stability.
Photo 26 **Centreville Creek - Reach CC-1**	 The downstream extent of the observed section of Centerville Creek was at the elevated boardwalk approximately 170 m downstream from Crossing 3.

Photo 27 **East Credit River Tributary - Reach ECRT-1**	
	On the west side of Airport Road, the Crossing 7 outlet was partially blocked by rip rap, limiting its capacity to convey flows.
Photo 28 **East Credit River Tributary - Reach ECRT-1**	
	Riparian vegetation consisted of manicured lawns within the residential properties. At the edge of the property material has accumulated against the fence, which spans the channel, and is creating a backwater which extended to Crossing 7.

Photo 29 **East Credit River Tributary - Reach ECRT-1**	
	Downstream of the residential properties, the watercourse became poorly-defined and entered a marsh populated with grasses, cattails, and phragmites.
Photo 30 **East Credit River Tributary - Reach ECRT-1**	
	Within the agricultural property the watercourse is a straightened ditch populated by cattails and reeds. On both sides of the ditch, there was a narrow riparian buffer composed of herbaceous vegetation.

Appendix C:
Field Sheets

GEO | MORPHIX
Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: 17101

Date:	Aug. 23/18	**Stream/Reach:**	BC-1
Weather:	Sunny, 26°C	**Location:**	Airport Rd.; Huntsmill Drive
Field Staff:	AB, CVM	**Watershed/Subwatershed:**	Humber River

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

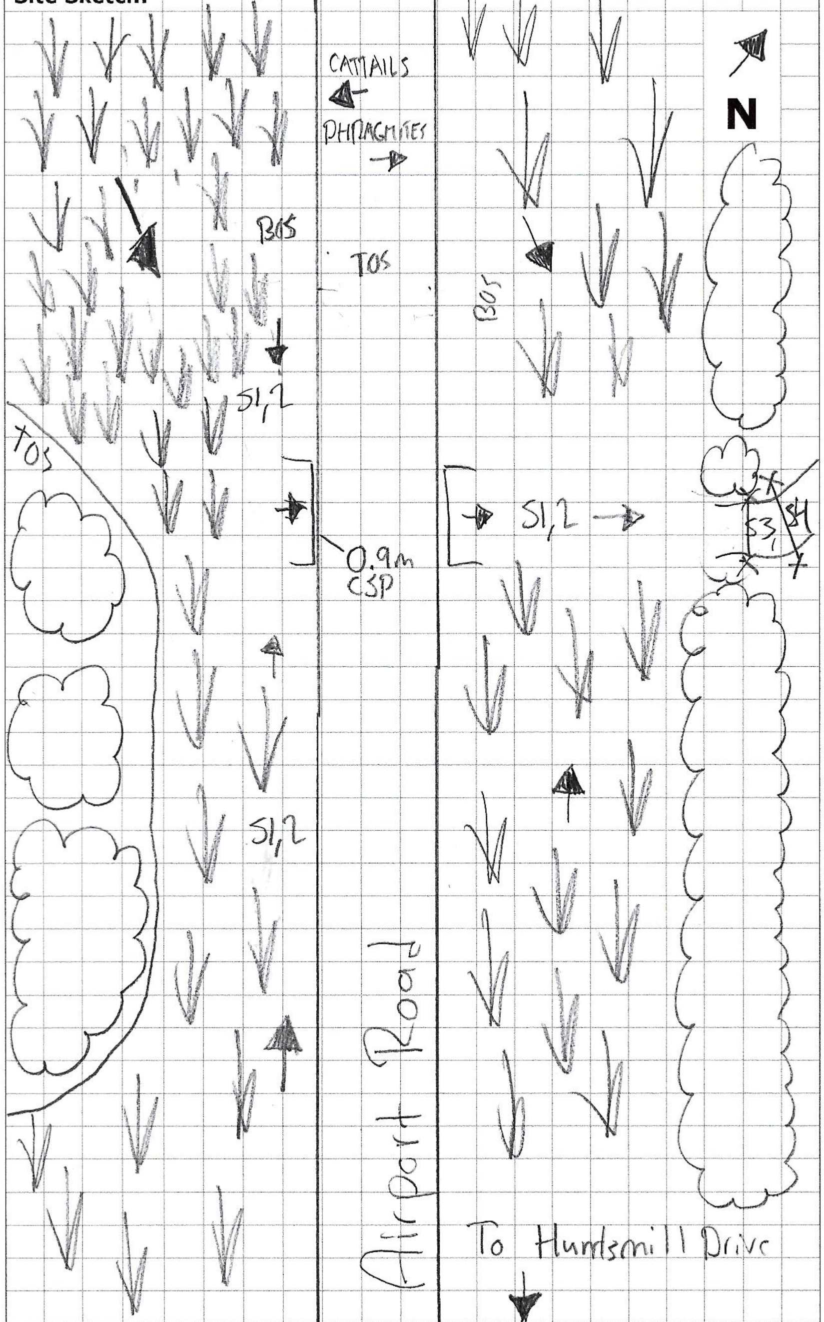
Substrate

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:



Scale:

Additional Notes:

Completed by: ________ Checked by: ________

GEO | MORPHIX Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 17101

Date:	Aug 23/2018	**Stream/Reach:**	Crossing 1 - Boyce Creek
Weather:	Sunny 22°C	**Location:**	Humbermill Drive, Airport Road
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Humber
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 8 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: ______

Riparian Vegetation

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

Aquatic/Instream Vegetation

- Type (Table8): 1
- Coverage of Reach (%): 5
- Woody Debris: ☐ Present in Cutbank ☒ Present in Channel ☐ Not Present
- Density of WD: ☒ Low ☐ Moderate ☐ High
- WDJ/50m: 0

Water Quality

- Odour (Table 16): 1
- Turbidity (Table 17): 1

Channel Characteristics

- Sinuosity (Type) (Table 9): 2
- Sinuosity (Degree) (Table 10): 3
- Gradient (Table 11): 2
- Number of Channels (Table 12): 1
- Entrenchment (Table 13): 1
- Type of Bank Failure (Table 14): 2
- Downs's Classification (Table 15):

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☐	☒	☒	☐	☐	☐
Pool Substrate	☐	☒	☒	☐	☐	☐	☐
Bank Material	☐	☒	☐	☐	☐	☐	☐

Bankfull Width (m)	0.60	1.9 (channel)	2.5
Wetted Width (m)	0.40	1.35	2
Bankfull Depth (m)	0.23	0.5	0.7
Wetted Depth (m)	0.05	0.08	0.41

riffle ↑ pool

- Riffle/Pool Spacing (m): 15
- % Riffles:
- % Pools:
- Meander Amplitude: N/A
- Pool Depth (m): 0.7
- Riffle Length (m): 0.15
- Undercuts (m): 0.2
- Comments: ______
- Velocity (m/s): [blank] | 0.4 | 0.07 — Wiffle ball / ADV / Estimated

Bank Angle: ☐ 0 – 30 ☐ 30 – 60 ☒ 60 – 90 ☐ Undercut

Bank Erosion: ☐ < 5% ☐ 5 – 30% ☒ 30 – 60% ☐ 60 – 100%

Notes: wetted area 5m wide
perched 0.08
culvert back water:
depth outlet: 30cm
0.30 Knickpoint

Completed by: ______ Checked by: ______

General Site Characteristics

Project Code: 17101

Date:	Aug 23/18	**Stream/Reach:**	CC-1 (2/2) CCT-2
Weather:	Sunny, 26°C	**Location:**	Airport Rd & Montcrest
Field Staff:	AB, CVM	**Watershed/Subwatershed:**	Humber River

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

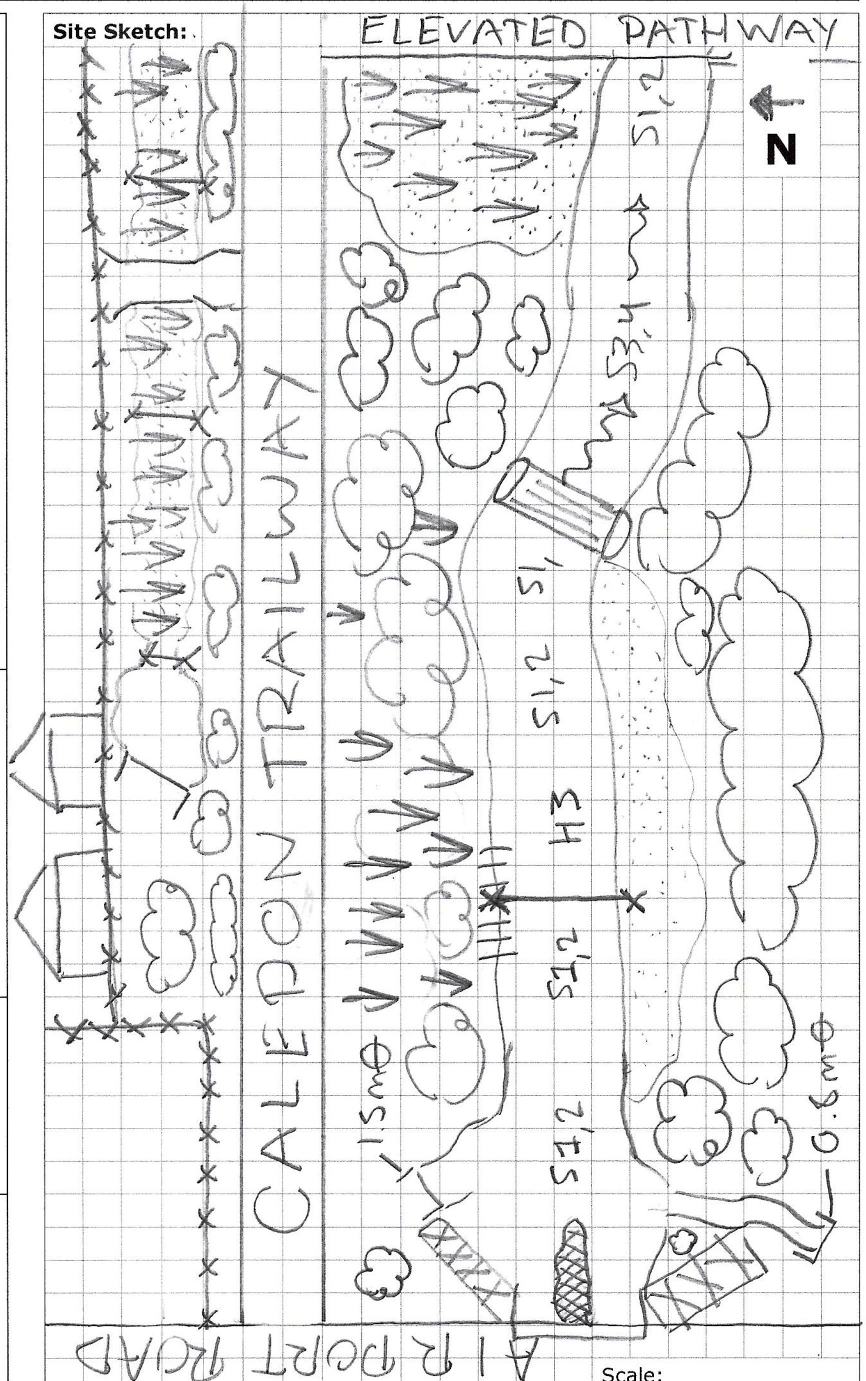
Substrate

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:



Scale:

Additional Notes:

Completed by: ________ Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code/Phase: 17101

Date:	Aug. 23/2018	**Stream/Reach:**	Crossing 1 - Boyce's Creek
Weather:	Sunny, 22°C	**Location:**	Huntsmill Drive; Airport Road
Field staff:	AB, CVM	**Watershed/Subwatershed:**	Humber
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): N/A | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☐ Groundwater | Evidence: /

Riparian Vegetation

Dominant Type: (Table 6) 1,3
Species: Conifers

Coverage:
- ☐ None
- ☐ Fragmented
- ☒ Continuous

Channel widths:
- ☐ 1-4
- ☐ 4-10
- ☒ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☒ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7) 2

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 100

Woody Debris
- ☐ Present in Cutbank
- ☐ Present in Channel
- ☒ Not Present

Density of WD:
- ☒ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 0

Water Quality

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

Channel Characteristics

Sinuosity (Type) (Table 9): / | **Sinuosity (Degree)** (Table 10): / | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 5

Entrenchment (Table 13): / | **Type of Bank Failure** (Table 14): / | **Downs's Classification** (Table 15): /

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☒	☐	☐	☐	☐	☐	☐
Pool Substrate	☒	☐	☐	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	0.6			**Wetted Width (m)**	0.4		
Bankfull Depth (m)	0.23			**Wetted Depth (m)**	0.05		

Riffle/Pool Spacing (m): / | **% Riffles:** / | **% Pools:** / | **Meander Amplitude:** /

Pool Depth (m): / | **Riffle Length (m)**: / | **Undercuts (m)**: / | **Comments:** US Culvert perched 0.08m

Velocity (m/s): / | / | / | **Wiffle ball / ADV / Estimated**

Bank Angle
- ☒ 0 – 30
- ☐ 30 – 60
- ☐ 60 – 90
- ☐ Undercut

Bank Erosion
- ☒ < 5%
- ☐ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Notes:
DS channel -
BFW = 1.9, 2.5
BFD = 0.5, 0.7
WW = 1.35, 2
WD = 0.08, 0.4

Completed by: AB   Checked by: ____

GEO | MORPHIX
Geomorphology
Earth Science
Observations

General Site Characteristics

Project Code: 17101

Date:	Aug. 23/18	**Stream/Reach:**	CC-1 (1/2)
Weather:	Sunny, 26°C	**Location:**	Airport Rd & Montcrest
Field Staff:	AB, CVM	**Watershed/Subwatershed:**	Humber River

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

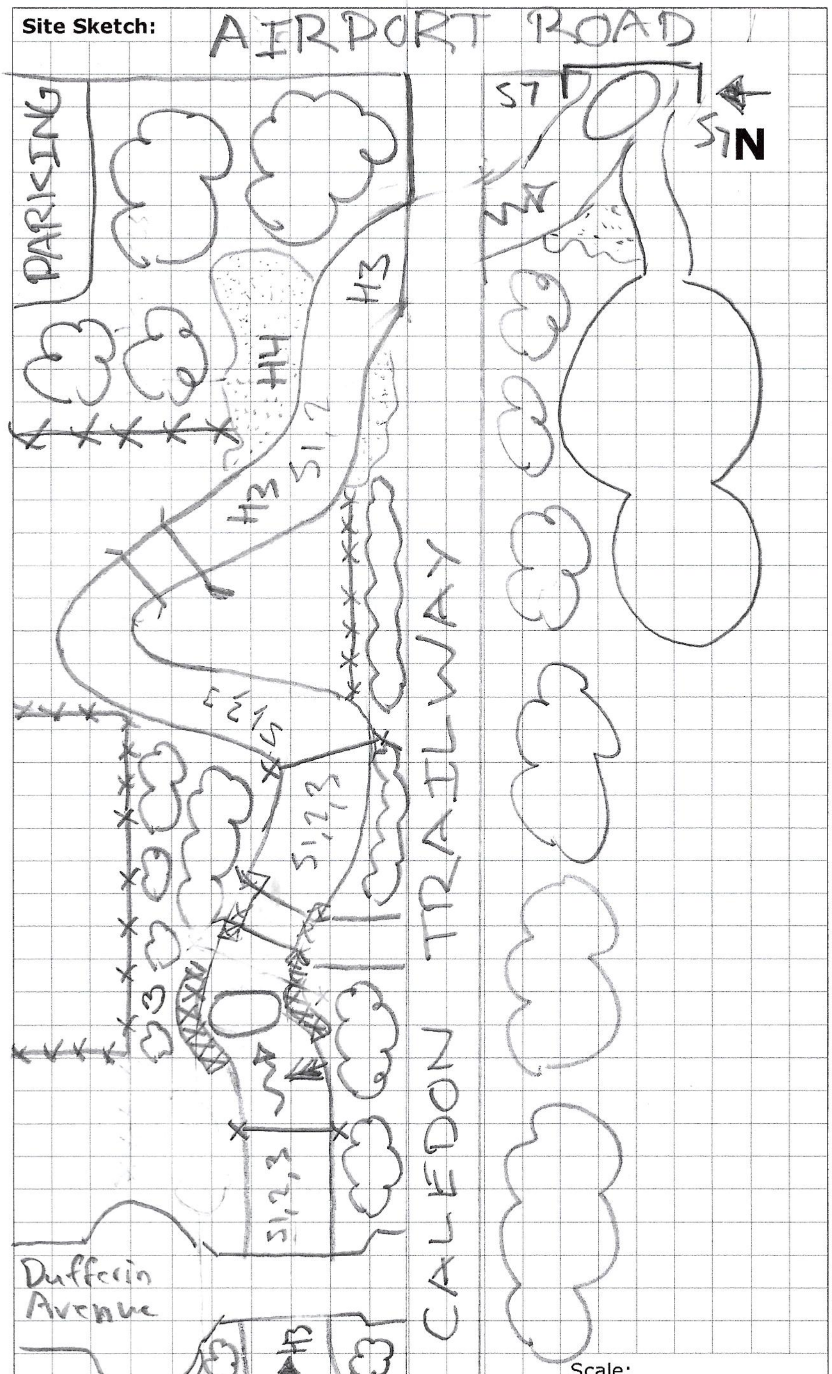
Substrate

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:



Scale:

Additional Notes:

Completed by: AB Checked by: ________

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Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 17101

Date:	Aug 23/2018	**Stream/Reach:**	CC-1 3
Weather:	Sunny 23°C	**Location:**	Caledon trail path
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Humber
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 7/5 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 7 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☒ Groundwater | Evidence: Watercress

Riparian Vegetation

Dominant Type: (Table 6) 1,3
Species: ____

Coverage: ☐ None ☐ Fragmented ☒ Continuous

Channel widths: ☒ 1-4 ☐ 4-10 ☐ > 10

Age Class (yrs): ☐ Immature (<5) ☒ Established (5-30) ☐ Mature (>30)

Encroachment: (Table 7) 2

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 5

Woody Debris: ☒ Present in Cutbank ☒ Present in Channel ☐ Not Present

Density of WD: ☒ Low ☐ Moderate ☐ High

WDJ/50m: 0

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

Sinuosity (Type) (Table 9): 1 | **Sinuosity (Degree)** (Table 10): 2 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 1

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): 1 | **Downs's Classification** (Table 15): D

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☒	☒	☒	☐	☐	☐
Pool Substrate	☒	☒	☐	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m)	2.7	3.1	3.9	**Wetted Width (m)**	2.4	2.55	3.65
Bankfull Depth (m)	0.6	0.65	0.65	**Wetted Depth (m)**	0.3	0.25	0.45

Riffle/Pool Spacing (m) 50 | **% Riffles:** 5 | **% Pools:** 10 | **Meander Amplitude:** 15

Pool Depth (m) 1.1 | **Riffle Length (m)** 15 | **Undercuts (m)** 0.24 | **Comments:**

Velocity (m/s) 0.3 | 0.42 | 0.1 | (Wiffle ball) / ADV / Estimated

Bank Angle: ☐ 0 – 30 ☒ 30 – 60 ☒ 60 – 90 ☐ Undercut

Bank Erosion: ☐ < 5% ☒ 5 – 30% ☐ 30 – 60% ☐ 60 – 100%

Notes:
0.80m concrete culvert
1.5m concret culvert

Completed by: AB Checked by: ____

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Rapid Geomorphic Assessment

Project Code: PN17101

Date:	Aug 23/2018	**Stream/Reach:**	CC-1
Weather:		**Watershed/Subwatershed:**	Humber
Field Staff:	AB CVM	**Location:**	Airport, Caledon Trail

Process	Geomorphological Indicator		Present?		Factor Value
	No.	Description	Yes	No	
Evidence of Aggradation (AI)	1	Lobate bar		✓	
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools	✓		
	4	Medial bars		✓	
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials		✓	
	7	Deposition in the overbank zone	✓		
		Sum of indices =	2	5	0.28
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)		✓	
	4	Undermined gabion baskets / concrete aprons / etc.	✓		
	5	Scour pools downstream of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms		✓	
	7	Head cutting due to knickpoint migration		✓	
	8	Terrace cut through older bar material		✓	
	9	Suspended armour layer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock		✓	
		Sum of indices =	1	6	0.125
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Outflanked gabion baskets / concrete walls / etc.		✓	
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation			
		Sum of indices =	1	7	0.125
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	
	2	Single thread channel to multiple channel		✓	
	3	Evolution of pool-riffle form to low bed relief form		✓	
	4	Cut-off channel(s)		✓	
	5	Formation of island(s)		✓	
	6	Thalweg alignment out of phase with meander form		✓	
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of indices =	0	7	0

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =	0.13		
Condition	**In Regime**	**In Transition/Stress**	**In Adjustment**
SI score =	☒ **0.00 - 0.20**	☐ **0.21 - 0.40**	☐ **0.41**

Completed by: AB Checked by: ________

Rapid Stream Assessment Technique

Project Code: PN 17101

Date:	Aug 23 / 2018	**Stream/Reach:**	CC-1
Weather:	Sunny	**Location:**	Caledon Trail at Airport Road
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Humber

Evaluation 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

Date:	Aug. 23/2018	Reach:	CC-1	Project Code:	17101

Evaluation 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) = 28	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: AB Checked by: ________

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Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17101

Date:	Aug. 23/2018	**Stream/Reach:**	CCT-1
Weather:	Sunny, 24°C	**Location:**	Ella St. & Ivan ave
Field Staff:	AB, CVM	**Watershed/Subwatershed:**	Humber River

Features

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

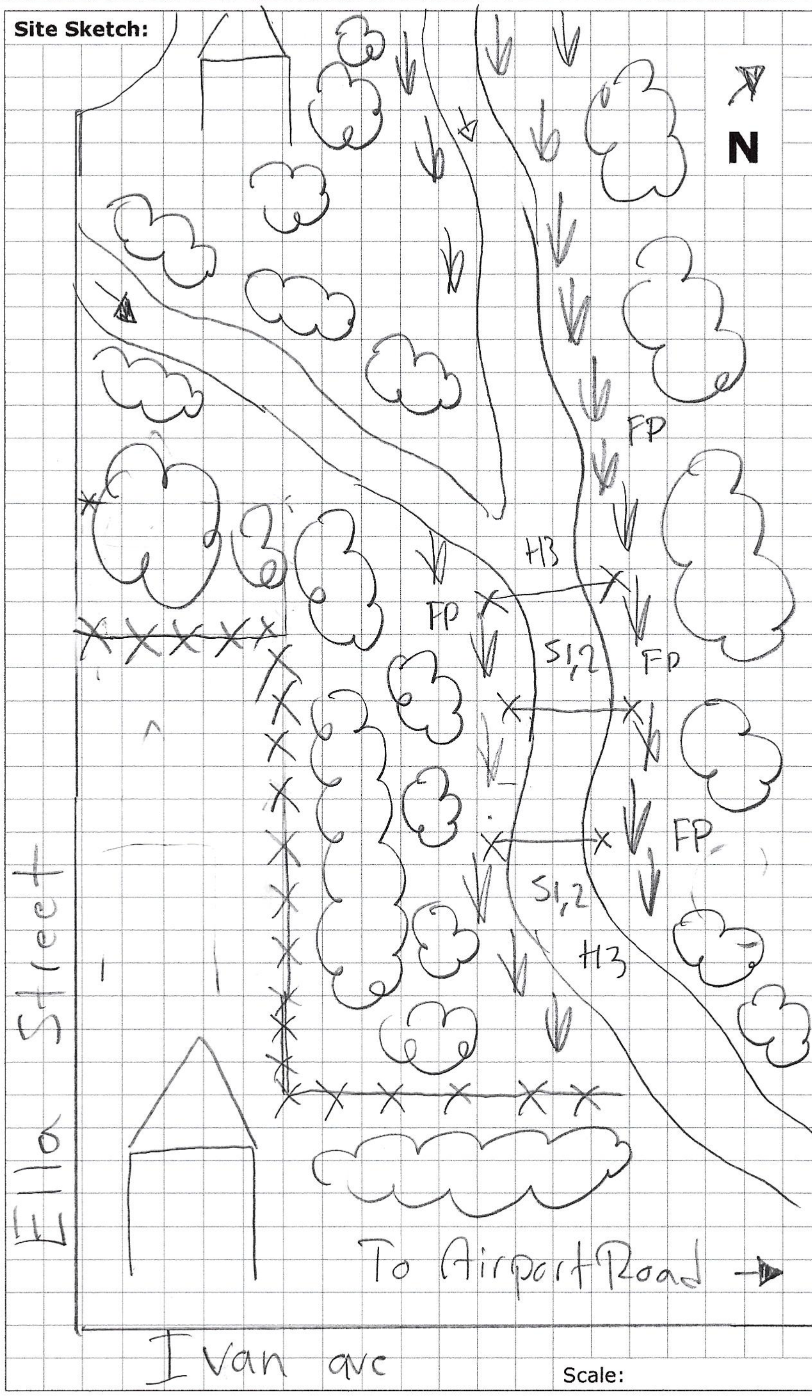
Substrate

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:



Scale:

Additional Notes:

Completed by: AB Checked by: ________

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Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 17101

Date:	Aug 23/18	**Stream/Reach:**	CCT-1
Weather:	Sunny	**Location:**	Airport road ' Ellacourt
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Humber
UTM (Upstream)		**UTM (Downstream)**	

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

Riparian Vegetation

Dominant Type: (Table 6) 1,4
Species: ______

Coverage:
- ☐ None
- ☐ Fragmented
- ☒ Continuous

Channel widths:
- ☐ 1-4
- ☐ 4-10
- ☒ > 10

Age Class (yrs):
- ☐ Immature (<5)
- ☒ Established (5-30)
- ☐ Mature (>30)

Encroachment: (Table 7) 4

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 5

Woody Debris
- ☐ Present in Cutbank
- ☐ Present in Channel
- ☒ Not Present

Density of WD:
- ☒ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 0

Water Quality

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

Channel Characteristics

Sinuosity (Type) (Table 9): 3 | **Sinuosity (Degree)** (Table 10): 2 | **Gradient** (Table 11): 1 | **Number of Channels** (Table 12): 2

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): (struck out) | **Downs's Classification** (Table 15): D

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☐	☒	☐	☐	☐	☐	☐
Pool Substrate	☐	☒	☐	☐	☐	☐	☐
Bank Material	☒	☒	☐	☐	☐	☐	☐

Bankfull Width (m)	1.2	0.9	0.9	**Wetted Width (m)**	0.63	0.55	0.6
Bankfull Depth (m)	0.45	0.35	0.30	**Wetted Depth (m)**	0.125	0.08	0.1

Riffle/Pool Spacing (m): (struck out) | **% Riffles:** 0 | **% Pools:** 0 | **Meander Amplitude:** 7

Pool Depth (m): 0.45 | **Riffle Length (m):** (struck out) | **Undercuts (m):** (struck out) | **Comments:** ______

Velocity (m/s): | | | **Wiffle ball / ADV / Estimated** ______

Bank Angle
- ☐ 0 – 30
- ☐ 30 – 60
- ☒ 60 – 90
- ☐ Undercut

Bank Erosion
- ☐ < 5%
- ☒ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

Notes:

Completed by: AB   Checked by: ______

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Rapid Geomorphic Assessment **Project Code:** 17101

Date:	Aug 23/2018	**Stream/Reach:**	CCT-1
Weather:	Sunny	**Watershed/Subwatershed:**	Airport Road Ella Court
Field Staff:	AB CVM	**Location:**	Humber

Process	No.	Description	Yes	No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		\	0.6
	2	Coarse materials in riffles embedded			
	3	Siltation in pools			
	4	Medial bars		\	
	5	Accretion on point bars	\		
	6	Poor longitudinal sorting of bed materials	\		
	7	Deposition in the overbank zone	\		
		Sum of indices =	3	2	
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			0
	2	Exposed sanitary / storm sewer / pipeline / etc.			
	3	Elevated storm sewer outfall(s)			
	4	Undermined gabion baskets / concrete aprons / etc.			
	5	Scour pools downstream of culverts / storm sewer outlets			
	6	Cut face on bar forms		\	
	7	Head cutting due to knickpoint migration		\	
	8	Terrace cut through older bar material		\	
	9	Suspended armour layer visible in bank		\	
	10	Channel worn into undisturbed overburden / bedrock		\	
		Sum of indices =	0	5	
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		\	0
	2	Occurrence of large organic debris		\	
	3	Exposed tree roots		\	
	4	Basal scour on inside meander bends		\	
	5	Basal scour on both sides of channel through riffle			
	6	Outflanked gabion baskets / concrete walls / etc.			
	7	Length of basal scour >50% through subject reach		\	
	8	Exposed length of previously buried pipe / cable / etc.			
	9	Fracture lines along top of bank		\	
	10	Exposed building foundation			
		Sum of indices =	0	6	
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		\	0
	2	Single thread channel to multiple channel		\	
	3	Evolution of pool-riffle form to low bed relief form		\	
	4	Cut-off channel(s)		\	
	5	Formation of island(s)		\	
	6	Thalweg alignment out of phase with meander form		\	
	7	Bar forms poorly formed / reworked / removed		\	
		Sum of indices =	0	7	

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =	0.15		
Condition	**In Regime**	**In Transition/Stress**	**In Adjustment**
SI score =	☑ **0.00 - 0.20**	☐ **0.21 - 0.40**	☐ **0.41**

Completed by: AB Checked by: ________

Rapid Stream Assessment Technique **Project Code:** 17101

Date:	Aug 23 /2018	**Stream/Reach:**	CCT-1
Weather:	Sunny	**Location:**	Airport Road, Ella Court
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Humber

Evaluation 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

Date:	Aug. 23/2018	Reach:	CCT-1	Project Code:	17101

Evaluation 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

Evaluation Category	Poor	Fair	Good	Excellent
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

Evaluation Category	Poor	Fair	Good	Excellent
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) = 28	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: AB Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 17161

Date:	Aug. 23/2018	**Stream/Reach:**	CRT-1
Weather:	Sunny, 26°C	**Location:**	Airport Road; Olde Baseline
Field Staff:	AB, CVM	**Watershed/Subwatershed:**	Credit River

Features
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

Flow Type

H1	Standing 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

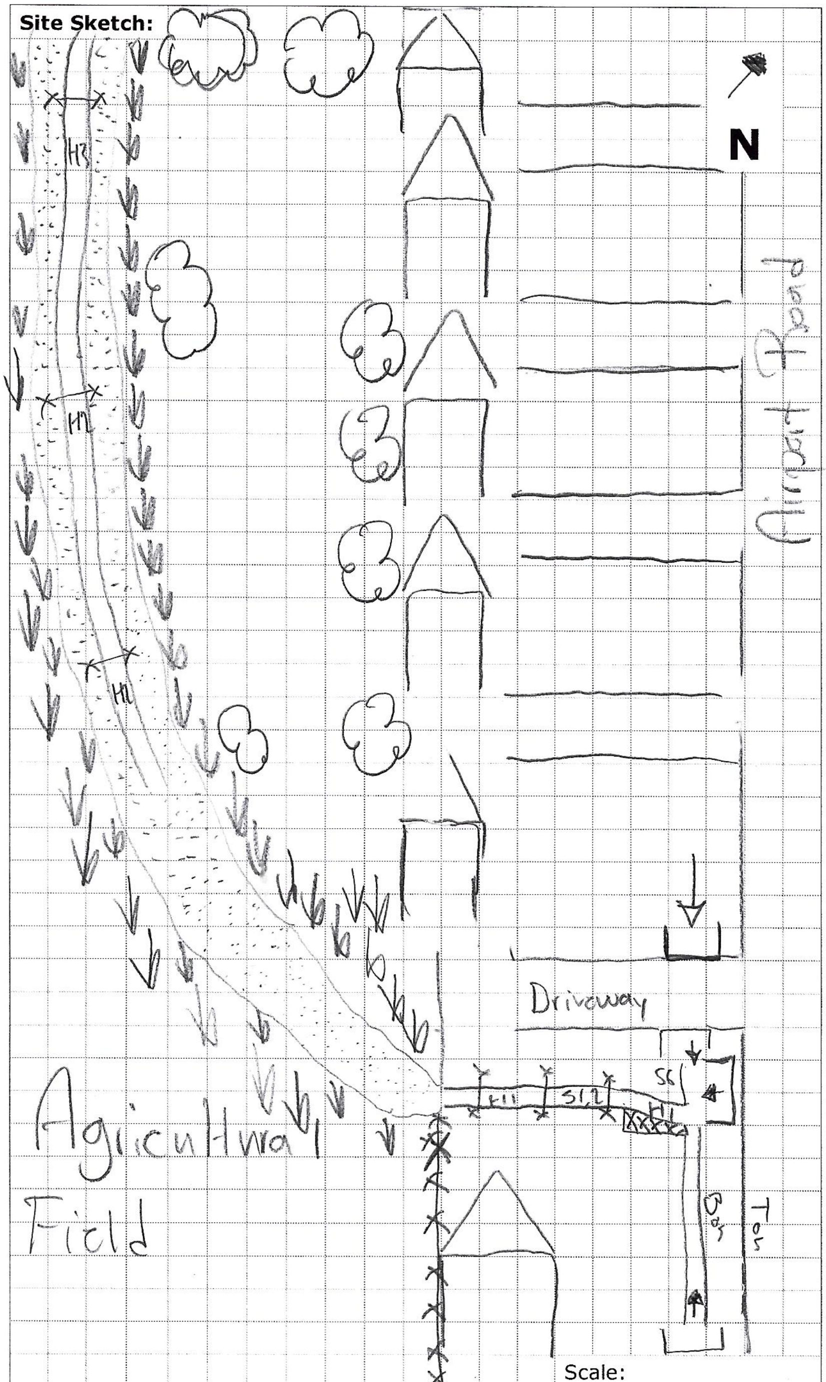
Substrate

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:



Scale:

Additional Notes:

Completed by: AB Checked by: ________

GEO | MORPHIX
Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 17101

Date:	Aug 23/2018	**Stream/Reach:**	Crossing 7
Weather:	Sunny 26°C	**Location:**	15324 Airport Road
Field Staff:	AB CVM	**Watershed/Subwatershed:**	Credit River
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 73 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 11 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 2 | ☐ Groundwater | Evidence: ______

Riparian Vegetation

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

Aquatic/Instream Vegetation

- **Type** (Table8): 1 — Coverage of Reach (%): 90
- **Woody Debris:** ☐ Present in Cutbank ☐ Present in Channel ☒ Not Present
- **Density of WD:** ☒ Low ☐ Moderate ☐ High
- WDJ/50m: 0

Water Quality

- **Odour** (Table 16): 1
- **Turbidity** (Table 17): 2

Channel Characteristics

- **Sinuosity (Type)** (Table 9): /
- **Sinuosity (Degree)** (Table 10): /
- **Gradient** (Table 11): /
- **Number of Channels** (Table 12): 1
- **Entrenchment** (Table 13): /
- **Type of Bank Failure** (Table 14): /
- **Downs's Classification** (Table 15): /

	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Riffle Substrate	☒	☐	☐	☐	☐	☐	☐
Pool Substrate	☒	☐	☐	☐	☐	☐	☐
Bank Material	☒	☐	☐	☐	☐	☐	☐

Bankfull Width (m) Top of bank	2.4	2.35	2.3	**Wetted Width (m)**	~~0.75~~	0.75	1.86
Bankfull Depth (m)	0.6	0.7	0.5	**Wetted Depth (m)**	0.09	0.10	0.18

- **Riffle/Pool Spacing (m):** N/A — **% Riffles:** / — **% Pools:** / — **Meander Amplitude:** /
- **Pool Depth (m):** / — **Riffle Length (m):** / — **Undercuts (m):** / — **Comments:**
- **Velocity (m/s):** / / / Wiffle ball / ADV / Estimated

Bank Angle: ☐ 0 – 30 ☒ 30 – 60 ☐ 60 – 90 ☐ Undercut

Bank Erosion: ☒ < 5% ☐ 5 – 30% ☐ 30 – 60% ☐ 60 – 100%

Notes: Wet meadow
bankfull width 0.45 m
depth 0.30 m
width 0.55
depth 0.25
Fcalm width = 3.7
depth = 0.5

Completed by: CVM   Checked by: [signature]

Appendix D:
Meander Belt Width Assessment

[redacted]

Meander Belt Width Delineation

Boyce’s Creek and Centreville Creek

Crossing 1 and Crossing 3
along Airport Road, Town of Caledon