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GUIDING SOLUTIONS IN THE
NATURAL ENVIRONMENT

Frisque Lands Geomorphic Assessment 3225 5th Concession Road (Part of Lots 3 and 4), City of Pickering

Carruthers Creek Watershed

Prepared For:

869547 Ontario Inc.

Prepared By:

Beacon Environmental Limited

Date:	*Project:*
October 2023	**221050.1**

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1. Introduction

Beacon Environmental Limited (Beacon) was retained by 869547 Ontario Inc. to undertake a geomorphic assessment for the lands located at 3225 5th Concession Road (Part of Lots 3 and 4) in the City of Pickering, Regional Municipality of Durham ("subject property" **Figure 1**). The subject property, which is situated within the Carruthers Creek Watershed, is located within the jurisdiction of the Toronto and Region Conservation Authority (TRCA). It is our understanding that, within the subject property, the Ontario Ministry of the Environment, Conservation and Parks (MECP) has classified the Carruthers Creek as occupied Redside Dace (*Clinostomus elongatus*) habitat and Carruthers Creek tributary contributing habitat.

The purpose of this geomorphic assessment is to characterize existing geomorphic conditions for the portions of watercourse relevant to the subject property, contribute to the determination of development limits through the delineation of Redside Dace occupied habitat limits (referencing 30 m from the meander belt), and to address the following comment issued by TRCA Water Resources (email dated August 25, 2022) regarding *Planning Act* Application submission requirements for the subject property

Comment #3

> *Please provide a fluvial geomorphology erosion threshold analysis for review as per Appendix B4 of the TRCA SWM Criteria (2012; link here: https:// sustainabletechnologies.ca /app/uploads/2013/01/SWM-Criteria-2012.pdf) to determine if the site requires greater than 5mm on-site retention as per the TRCA. Please provide this retention within the stormwater management approach.*

Specifically, the following tasks were undertaken in support of the study:

- Review of available background information, including the Beacon (2016) geomorphic assessment completed for the subject property, stormwater servicing plan, and TRCA Watershed Reports;
- Reach delineation based on underlying geomorphic controls;
- A field assessment to characterize existing geomorphic conditions, confirm degree of valley confinement, and document evidence of active channel processes;
- Following applicable policy and guidelines, delineation of the meander belt width on a reach basis, referencing recent aerial imagery, historic trends in channel planform (where feasible), and valley floor dimensions;
- In accordance with Ontario Regulation 242/08, delineation of the limit of regulated occupied Redside Dace habitat referencing 30 m from the meander belt;
- Detailed geomorphic data collection to support the determination of erosion thresholds; and
- Impact assessment of the proposed development concept plan from a geomorphic perspective, including stormwater erosion control analysis, and provision of recommendations to mitigate potential impacts.

2. Policy Context

2.1 *Endangered Species Act* (2007)

The ESA (2007) came into effect on June 30, 2008, with over 200 species in Ontario identified as extirpated, endangered, threatened, or of special concern. The MECP provides oversight of the ESA for the regulation of Species at Risk (SAR) in Ontario. Under the ESA, native species that are in danger of becoming extinct or extirpated from the province are identified as being extirpated, endangered, threatened and special concern. These designations are defined as follows:

- Extirpated - a species that no longer exists in the wild in Ontario but still occurs elsewhere;
- Endangered – a species facing imminent extinction or extirpation in Ontario which is a candidate for regulation under Ontario's *Endangered Species Act;*
- Threatened - a species that is at risk of becoming endangered in Ontario if limiting factors are not reversed; and
- Special Concern (formerly Vulnerable) - a species with characteristics that make it sensitive to human activities or natural events.

Under the ESA, protection is provided to threatened or endangered species and their habitat, as well as providing stewardship and recovery strategies for species. Any activities proposed within or adjacent to habitat regulated for threatened or endangered species require review under the ESA.

2.2 Provincial Policy Statement (2020)

The Provincial Policy Statement (MMAH 2020) issued under the *Planning Act* (1990) outlines areas of provincial interest with respect to natural hazards. In support of the Policy Statement, a Technical Guide - Rivers and Streams: Erosion Hazard Limit document was prepared by MNR (2002) to outline standardized procedures for the delineation and management of riverine erosion hazards in the Province of Ontario. The guide presents erosion hazard protocols based on two generalized landform systems through which watercourses flow: confined and unconfined valley systems. Through this approach, the meander belt width plus an erosion access allowance is defined to determine the erosion hazard limit of an unconfined valley system. For confined valley systems, the erosion hazard limit is governed by geotechnical considerations, including the stable slope allowance and an applicable toe erosion allowance (i.e., channel migration component).

2.3 Durham Regional Official Plan – Office Consolidation (2020)

The Durham Regional Official Plan is a document that outlines the policies of the Regional Municipality of Durham to guide economic, environmental and community building decisions which inform the strategic decisions of Durham Region and benefit its residents. The basis of the natural environment protection system in Durham Region is the Greenlands System, which is comprised of Oak Ridges Moraine, Waterfronts and Major Open Space Areas as well as the Greenbelt Natural Heritage System and key natural heritage and hydrologic features. It also identifies hazard lands as being primarily located within the Greenlands System, stating that development on adjacent lands may be permitted only if the necessary measures to address and mitigate the known hazards are implemented.

Site Location	Figure 1
Frisque Lands Geomorphic Assessment	
BEACON ENVIRONMENTAL	Project: 221050.1 Last Revised: July 2023
Client: 869547 Ontario Inc.	Prepared by: SZ Checked by: MA
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Ontario Orthoimagery Baselayer: FBS Durham Region (2022)

C:\ODB\OneDrive - Beacon Environmental\GeoSpatial\Geo Projects\2021\221050 Frisque EIS\MXD\2023-07-18_Figure01-SiteLocation_221050_1.mxd

2.4 City of Pickering Official Plan (2022)

The City of Pickering published its latest Official Consolidated Plan (Edition 9) dated March 2022. It builds on the framework presented in the Region of Durham's Official Plan and protects natural heritage features through the Open Space System, which incorporates three types of natural areas: core areas, corridors and linkages. Schedule III C – Resource Management: Key Natural Heritage Features/Key Hydrologic Features identifies Shorelines, Significant Valley Lands and Stream Corridors (May include Hazardous Lands) on the subject property.

2.5 Toronto and Region Conservation Authority Regulations and Guidelines

2.5.1 Conservation Authorities Act (Ontario Regulation 166/06)

The Toronto and Region Conservation Authority (TRCA) regulates hazard lands, including creeks, valleylands, shorelines, wetlands and some areas of lands that are adjacent to these features (ranging from 15 m to 120 m) (TRCA, 2006). Generally, Regulation 166/06 prohibits development within:

- The long-term stable slope (over a projected 100-year period), plus 15 metres, where a valley is apparent (i.e., confined systems); and
- The meander belt of a watercourse, expanded as required to convey the flood flows under the applicable regulatory flood event, plus 15 metres, where a valley is not apparent (i.e., unconfined systems).

Subject to conformity with the municipality's Official Plan, completion of appropriate studies and application for Conservation Authority permits, The Authority may grant permission for development within these areas if it can be proven that control of flooding, erosion, pollution, or the conservation of land will not be affected by the development.

2.5.2 The Living City Policies (2014)

The Living City Policies (LCP) supersede the 1994 Valley and Stream Corridor Management Program as TRCA's main policy document for planning and regulation. The LCP is issued under the authority of Section 20 of the Conservation Authorities Act and was endorsed by TRCA's Board on November 28, 2014. The LCP document applies to all new applications, matters, or proceedings submitted to TRCA on or after November 28, 2014. The purpose of the LCP is to clarify TRCA's role as a public commenting agency, service provider, resource management agency, representative of the provincial interest for natural hazards, a regulator, and a landowner in the context of the land use planning and development process.

For the purposes of implementing TRCA's Environmental Management Policies, stream valley systems are defined as follows:

- Confined River or Stream Valleys are considered **Valley Corridors**; and
- Unconfined River or Stream Valleys are considered **Stream Corridors**.

It is the policy of TRCA:

> *That erosion hazard limits will be determined through site specific field investigations and technical reports where required, in accordance with the text of TRCA's Regulation and Provincial and TRCA standards. Where erosion hazard limits are required and not available, or where existing erosion hazard information does not meet current Provincial or TRCA standards, TRCA may require the erosion hazard to be determined by a qualified professional, at the expense of the proponent, to the satisfaction of TRCA.*

The Belt Width Delineation Procedures (Parish Geomorphic Ltd. 2004) document outlines standards for delineating the meander belt width in TRCA jurisdiction.

3. Background Review

3.1 Climate

Climate provides the driving energy for a fluvial system and directly influences basin hydrology and rates of channel erosion, particularly through precipitation. Precipitation records obtained from climate normals (1981-2010) recorded at the Oshawa WPCP station, located southeast of the subject property, averaged 69 mm per month in winter (November through February), and 75 mm in summer (July and August; Environment Canada 2016). This increase over the summer months is likely a result of convective thunderstorms. While total precipitation amounts are greater during the summer months, snowmelt and rain-on-snow events tend to produce the highest flows within a watershed.

3.2 Watershed Conditions

In 2002, the TRCA prepared a Carruthers Creek State of the Watershed report as part of watershed strategy planning and as a reference document for land use planning. The subject property contains a portion of Carruthers Creek. Caruthers Creek drains a total area of 38.4 km^2 and captures portions of the City of Pickering and Town of Ajax within Durham Region (TRCA 2002).

3.2.1.1 Geology

The planimetric form of a watercourse is fundamentally a product of the channel flow regime and the availability of sediment (i.e., surficial geology) within the channel corridor. The 'dynamic equilibrium' of these inputs governs channel planform. These factors are influenced in smaller systems by physiography, riparian vegetation and land use. The subject property falls within the South Slope physiographic region (Chapman and Putnam 1984).

Within the subject property, the creek reworks alluvial sand and gravel deposits. East of the creek, surficial geology consists of glacial till deposits of silty sand to sand (TRCA 2002). West of the creek, the soils are underlain by glacial lake (glacial Lake Iroquois) deposits of gravel and sand (TRCA 2002). These surficial conditions are reflective of veneer of glacial till that was deposited across much of the land surface during the last glacial retreat.

3.2.1.2 Fluvial Geomorphology

In 2019, TRCA updated the Carruthers Creek watershed plan, including geomorphic data sets from the Regional Watershed Monitoring Program (RWMP) previously established by TRCA in 2003. One of the ten (10) monitoring stations established by TRCA was located within the subject property: GTCC-5. Rapid field assessment results for GTCC-5 characterized the site was being 'transitional' (Rapid Geomorphic Assessment score of 0.32), with a moderate Rapid Stream Assessment Technique (RSAT) score of 30. The report noted an overall percent change in cross-sectional area of 98% over the monitoring period (2003-2016) for GTCC-5 due to a combination of incision (downcutting) and widening. was calculated at cross-sections to evaluate changes in channel bed erosion or deposition. In total, the monitoring cross-section incised approximately 0.62 m based on the difference in maximum depth between the 2003 and 2016.

3.2.1.3 Aquatic Habitat

In 2000, a fish communities and habitat survey was completed by TRCA to provide a benchmark of current knowledge of the watershed. Ten (10) species were encountered, which was a lower number than 22 species historically encountered in Carruthers Creek (TRCA, 2002). Based on the low gradient and presence of young-of-the-year northern pike, the lower reaches of the creek (south of Bayley Street) are classified as a warmwater regime (TRCA, 2002). The upper and middle reaches of the watershed are coldwater habitat based on geology and the presence of temperature-sensitive species, (TRCA, 2002). The subject property is located in the middle reaches.

3.3 Historic Assessment

The following section presents an overview of historic conditions in the vicinity of the subject property with respect to land use, land cover and channel conditions. Historic analyses provide insight into the scale of natural and human-induced changes within a watershed, particularly the degree to which channel planform adjustment and land use has changed over time. In support of the historic assessment, black and white aerial photographs and digital colour imagery were analysed and compared to obtain a simple, qualitative assessment of the degree of land use and channel planform change over time (**Appendix A** and **Table 1**).

Table 1 provides a summary of specific observations regarding change in land use based on available historical aerial imagery. Due to significant tree cover within the valley, changes in channel planform could not be observed.

Table 1. Summary of Key Historic Observations

Time Period	Scale, Source	Observations
1963	1:12,000 Northway/Photomap/Remote Sensing Ltd.	Forested areas converted to agricultural fields, with the exception of the Carruthers Creek valley system. Channel planform along Carruthers Creek can be observed to be highly sinuous within the subject property.
		An informal farm crossing of the valley and Carruthers Creek at the upstream extent (northern) of the subject property can be observed. Upstream (north) of the subject property, a rail line crosses the Carruthers Creek. North of the rail line and adjacent to the creek, a quarry can be observed.
1972	1:12,000 Northway/Photomap/Remote Sensing Ltd.	Minimal change in surrounding land use can be observed. Increased riparian vegetation can be observed within the valley. Where discernible, Carruthers Creek channel planform is highly sinuous. A small pedestrian crossing of the creek can be observed within the subject property.
2008	1:4,000 First Base Solutions	Residential development and a golf course have been constructed south of the subject property and adjacent to the creek. Surrounding land use remains primarily agricultural with increased vegetation/forest within the subject property. Channel planform associated with Carruthers Creek (eastern tributary) within the subject property, where discernible, is highly sinuous. Immediately south of the property limit, formation of an oxbow feature (meander cutoff) can be observed.
2022	1:4,000 First Base Solutions	Minimal change in surrounding land use and channel planform can be observed.

4. Existing Conditions

4.1 Reach Delineation

To facilitate a systematic evaluation of the relevant portion of Carruthers Creek, the watercourse was delineated into reaches. Reaches are homogenous sections of channel with regard to form and function and can, therefore, be expected to behave consistently along their length to changes in hydrology and sediment inputs, as well as to other modifying factors (Montgomery and Buffington 1997; Richards *et al.* 1997).

For the purposes of this study, the section of Carruthers Creek (eastern tributary) within the subject property was delineated as two reaches (Reach CC-1 and CC-2) and the western tributary to Carruthers Creek was delineated as CCT-1 (**Figure 2**). The determination of reach extents was initially based on a desktop assessment of transitions in riparian vegetation, degree of valley confinement and meander geometry (channel planform) based on available aerial imagery and topographic mapping. Verification

Reach, Photo and Detailed Site Location

Figure 2

Frisque Lands Geomorphic Assessment

Legend

- Subject Property
- Reach Break
- Extent Assessed
- Watercourse (Beacon 2022)
- Photo Location

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Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

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C:\ODB\OneDrive - Beacon Environmental\GeoSpatial\Geo Projects\2021\221050 Frisque EIS\MXD\2023-08-28_Figure02-ReachPhotoandDetailedSiteLocation_221050_1.mxd of reach extents was subsequently undertaken in the field to confirm that mapped reach extents accurately reflect existing conditions and underlying geomorphic controls.

4.2 Rapid Assessment

4.2.1 Methods

In order to characterize existing geomorphic conditions along the relevant portions of Carruthers Creek and tributary within the subject property, rapid field assessments were conducted on August 30, 2016. The following standardized rapid visual assessment methods were applied:

i. Rapid Geomorphic Assessment (RGA – MOE 2003)

The RGA documents observed indicators of channel instability by quantifying observations using an index that identifies channel sensitivity. Sensitivity is 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 in adjustment (score >0.41).

ii. Rapid Stream Assessment Technique (RSAT – Galli 1996)

The RSAT uses an index to quantify overall stream health and includes the consideration of biological indicators (Galli, 1996). Observations concerning channel stability, channel scouring/sediment deposition, physical in-stream habitat, water quality, and riparian habitat conditions are used to calculate a rating that indicates whether the channel is in poor (<13), fair (13-24), good (25-34), or excellent (35-42) condition.

iii. Downs Classification Method (Downs 1995)

The Downs (1995, outlined in Thorne *et al.* 1997) classification method infers present and future potential adjustments based on physical observations, which indicate the stage of evolution, and type of adjustments that can be anticipated based on the channel evolution model. The resultant index classifies streams as stable, laterally migrating, enlarging, undercutting, aggrading, or recovering.

4.3 Results

4.3.1.1 Reach CC-1

Reach CC-1 was characterized as a highly sinuous, well-defined channel situated within a confined valley setting. The reach displayed a low gradient and moderate degree of entrenchment. Riparian vegetation was characterized as continuous, extending greater than 5 channel widths laterally. Vegetation consisted of mature cedar and deciduous trees with some shrubs and herbaceous understory. Bank angles ranged between 60-90 degrees with 30-60% of banks identified as exhibiting indicators of active erosion, such as undercutting, basal scour and fallen/leaning trees. Channel morphology was heavily influenced by woody debris in the channel and floodplain. Bank materials were dominated by sand, silt and clay with gravel present at the toe in some locations. Bankfull widths and depths ranged from 3.3-8.5 m and 0.6-1.2 m, respectively. Substrate consisted of silt/clay, sand and gravel.

Rapid assessment results indicated that Reach CC-1 was 'in transition', with a score of 0.35. Widening was identified as the dominant mode of adjustment with planimetric form adjustment and degradation as secondary processes. Evidence of widening included fallen and leaning trees, large organic debris, exposed tree roots and basal scour on both sides through riffles and slumping banks. Indicators of planimetric form adjustment included formation of chutes, misaligned thalweg and poorly formed/reworked bar forms. Evidence of degradation included cut face on bar forms and visible suspended armour layer. An RSAT score of 24.5 indicated a 'fair' degree of overall ecological health, with physical instream habitat and channel stability identified as the primary limiting factors. The Downs model reflected the RGA evaluation of this reach through a classification of U – 'undercutting' based on the observed active erosion along both banks, bend migration, low embeddedness.

4.3.1.2 Reach CC-2

Reach CC-2 was characterized as a highly sinuous, well-defined channel situated within a confined valley setting. The reach displayed a low gradient and low degree of entrenchment. Riparian vegetation was characterized as continuous, extending greater than 5 channel widths laterally. Vegetation consisted of mature cedar and deciduous trees with some shrubs and herbaceous understory. Bank angles ranged between 60-90 degrees with 30-60% of banks identified as exhibiting indicators of active erosion, such as undercutting, basal scour and fallen/leaning trees. Channel morphology was heavily influenced by woody debris in the channel and floodplain. Bank materials were dominated by sand, silt and clay. Bankfull widths and depths ranged from 4.6-6.6 m and 0.8-0.95 m, respectively. Substrate consisted of silt/clay, sand, gravel and cobble.

Rapid assessment results indicated that Reach CC-2 was 'in transition', with a score of 0.25. Widening was identified as the dominant mode of adjustment with degradation and planimetric form adjustment as secondary processes. Evidence of widening included fallen and leaning trees, exposed tree roots and basal scour on both sides through riffles. Evidence of degradation included scour pool downstream of culvert, exposed culvert footings and exposed till. Indicators of planimetric form adjustment included misaligned thalweg and poorly formed/reworked bar forms. An RSAT score of 24.5 indicated a 'fair' degree of overall ecological health, with physical instream habitat and channel stability identified as the primary limiting factors. The Downs model reflected the RGA evaluation of this reach through a classification of U – 'undercutting' based on the observed active erosion along both banks, bend migration, low embeddedness.

4.3.1.3 Reach CCT-1

Reach CCT-1 was characterized as a minimally sinuous, poorly-defined gully feature situated within a confined valley setting. The reach displayed a moderate gradient and low degree of entrenchment. Riparian vegetation was characterized as continuous, extending greater than 5 channel widths laterally. Vegetation consisted of mature trees with some shrubs and herbaceous understory. Bank angles ranged between 30-60 degrees where well-defined with 5-30% of banks identified as exhibiting indicators of active erosion, such as scour. The channel lacked riffle-pool morphology. Bank materials were dominated by sand, silt and clay. Bankfull widths and depths ranged from 1.4-1.5 m and 0.35-0.40 m, respectively, where defined. Substrate consisted of silt/clay and sand.

Rapid assessment results indicated that Reach CCT-1 was 'in regime' (or stable), with a score of 0.13. Minor evidence of widening (exposed tree roots, scour), degradation (headcutting due to knickpoint migration) and aggradation (siltation) were observed. An RSAT score of 24 indicated a 'fair' degree of overall ecological health, with physical instream habitat and sediment disposition identified as the primary limiting factors. The Downs model reflected the RGA evaluation of this reach through a classification of S – 'stable' based on a lack of observable morphological adjustment processes.

Table 2. General Reach Characteristics – Carruthers Creek and Tributary

Reach	Bankfull Width (m)	Bankfull Depth (m)	Riffle Substrate	Riparian Vegetation	Notes
CC-1	3.6-8.5	0.6-1.2	Sand, gravel	Trees, shrubs, herbaceous plants	• Channel morphology influenced by fallen trees/woody debris • Valley wall contact points
CC-2	4.1-6.6	0.8-0.95	Sand, gravel, cobble	Trees, shrubs, herbaceous plants	• Channel morphology influenced by fallen trees/woody debris • Valley wall contact points
CCT-1	1.4-1.5 (where defined)	0.35-0.40	Clay/silt, sand, till	Trees, shrubs, herbaceous plants	• Poorly defined bed/banks • No riffle-pool morphology • Knickpoint near confluence with CC-1/CC-2

Table 3. Rapid Assessment Results – Carruthers Creek and Tributary

Reach	Rapid Geomorphic Assessment			Rapid Stream Assessment Technique			Downs Classification Method
	Score	Condition	Dominant Mode of Adjustment	Score	Condition	Limiting Feature	
CC-1	0.35	In Transition	Widening	24.5	Good	Channel stability	U – 'undercutting'
CC-2	0.25	In Transition	Widening	24.5	Good	Channel stability	U – 'undercutting'
CCT-1	0.13	In Regime	Widening	24	Fair	Physical instream habitat	S – 'stable'

4.3.2 Detailed Assessment

A detailed field investigation was undertaken by Beacon staff on November 4, 2022 along a portion of Reach CC-1 within the subject property (**Figure 2**); this reach section was identified as the most sensitive through the rapid assessment results. Data collection consisted of a topographic survey utilizing a Real-Time Kinematic (RTK) surveying unit and Total Station. Eight (8) representative cross-sections were surveyed to characterize bankfull dimensions, in addition to a longitudinal profile of the channel centreline, and characterization of bed and bank materials using standard field protocols.

Table 4 provides a summary of field-based and calculated parameters for Reach CC-1. Within the extent assessed, Reach CC-1 had a governing energy (bankfull) gradient of 0.68%. Bankfull channel dimensions averaged 3.7 m in width and 0.29 m in depth. Bed and bank materials were generally consistent along the extent assessed and were comprised of clay, silt, sand, gravel, cobble and boulders. A detailed field data summary is provided in **Appendix C**.

Table 4. Summary of Detailed Field Data Results – CC-1

Channel Parameter	Reach CC-1
Field-Based Measurements	
Channel bankfull gradient (%)	0.68
Channel bed gradient (%)	0.71
Average bankfull width (m)	5.0
Average bankfull depth (m)	0.49
Particle size range	Coarse sand-Medium Boulder
Estimated Manning's 'n' value	0.038
Derived Parameters	
Bankfull discharge (m^3/s)	2.7
Bankfull velocity (m/s)	1.2
D_{50} (mm)	16
Tractive force (bankfull) (N/m^2)	33

5. Analysis

5.1 Meander Belt Width

The meander belt width is generally defined as the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. Where the watercourse is confined, such as for Reaches CC-1, CC-2 and CCT-1, the valley wall acts a constraint to channel migration. According to the *Technical Guide – Rivers and Streams: Erosion Hazard Limit* document (MNR 2002), in the case of unconfined river systems, the meander belt width plus an erosion access allowance is defined to determine the erosion hazard limit. Conversely, in the case of confined valley systems, the erosion hazard is governed by geotechnical considerations, including the stable slope allowance and an applicable toe erosion allowance (i.e., channel migration component). As Ontario Regulation 242/08 does not distinguish between confined and unconfined systems, delineation of the meander belt referenced historical and current channel processes, but also considered valley floor (floodplain dimensions).

Following the TRCA (2004) *Belt Width Delineation Procedures* document, meander belts were delineated for Reaches CC-1 and CC-2 based on the lateral extent of the outermost meander bends along the reach over the available historical record. The resultant dimensions were then reviewed relative to available topographic mapping and field observations to ensure that it considered valley floor dimensions and was sufficient to capture the active (bankfull) channel as well as evidence of lateral occupation of the floodplain at the reach scale. **Figure 3** illustrates the recommended meander belt dimensions of 57 m and 33 m for Reaches CC-1 and CC-2, respectively, as they pertain to the subject property.

5.1.1 Redside Dace Regulated Habitat

Figure 3 identifies all lands within 30 m of the meander belt as they pertain the to subject property.

5.2 Erosion Threshold Determination

The following sections provide an overview of methods and results associated with the site-specific erosion threshold assessment that was undertaken to determine localized stormwater erosion control targets for the subject property.

5.2.1 Methods

Erosion and deposition are natural processes that are necessary for the maintenance of channel form and function. Changes in land use can result in changes in the magnitude and duration of surface runoff produced by precipitation events, which can result in increased rates of erosion. Appropriate stormwater management techniques can typically mitigate the impacts associated with land use change by reducing the magnitude of post-development storm events. Surface runoff is collected and detained in stormwater management facilities (SWMF), then released at a prescribed flow rate. The total volume of post-development runoff can also be reduced through the implementation of low impact development techniques (LIDs). The overall objective of these management tools is to match, to the extent possible, pre-development and post-development flow conditions in the receiving watercourse.

Erosion thresholds represent the instream hydraulic parameter by which pre- and post-development flow conditions are compared. An erosion threshold defines the theoretical hydraulic conditions under which sediment is entrained and transported within the channel. Specifically, the threshold represents a depth, velocity, or discharge at which sediment of a particular size class (usually the median or average grain size material) may potentially be entrained. This does not necessarily imply that systemic erosion (i.e., widening or degradation of the channel) will occur if the threshold is exceeded; it simply indicates flow conditions at which sediment entrainment (i.e., initiation of motion) is likely to occur.

The TRCA (2012) Stormwater Management Criteria outlines standardized methods for erosion threshold assessments. **Table 5** presents an overview of some commonly used threshold analysis models, as presented in the refenced documents.

Table 5. Overview of Commonly Applied Sediment Entrainment Models

Sediment Entrainment Model	Type	Range of Applicability
Chow (1959)	Critical Shear Stress	Cohesive materials (clay and silt)
Fischenich (2001)	Critical Shear Stress	Cohesive and non-cohesive material
Hjulstrom (1967)	Critical Velocity	Non-cohesive material (sand and coarser)
Komar (1987)	Critical Velocity	Non-cohesive material (gravel and larger)
Miller *et al*. (1977)	Critical Shear Stress	Non-cohesive material (sand and coarser)
Neill (1967)	Critical Velocity	Non-cohesive material (sand and coarser)
Temple (1982)	Tractive Force	Vegetated channels
van Rijn (1984)	Critical Shear Stress	Non-cohesive material (medium sand and coarser)

It should be noted that, in natural systems, erosion thresholds are exceeded regularly, ensuring the downstream delivery of sediment. As such, the key to maintaining natural channel function of a system is not to prevent exceedance of the threshold, but to ensure that existing rates of erosion are not exacerbated under the future land use scenario.

5.2.2 Results

Table 6 provides a summary of erosion threshold parameters Carruthers Creek, which are presented in terms of a critical shear stress, velocity and discharge for the channel bed and banks. A detailed summary for the erosion threshold site can be found in **Appendix D**.

Determination of erosion thresholds for CC-1 considered water levels at the time of assessment (i.e., presence/absence of active transport) in addition to bed and bank composition and field observations of active erosion/deposition. The recommended threshold condition referenced a combination of permissible velocity in the range of 0.55-0.60 m/s (Fischenich 2001) for sandy loam (relatively high sand concentration, with silt and clay).

Table 6. Recommended Erosion Threshold

Reach	Threshold-Condition Hydraulic Parameters (calculated using representative cross-sections)						Critical Shear Stress as a Percentage of Bankfull Shear Stress (%)
	Channel Bed				Channel Banks		
	Critical Depth (m)	Critical Velocity (m/s)	Critical Shear Stress (N/m^2)	Critical Discharge (m^3/s)	Critical Velocity (m/s)	Critical Shear Stress (N/m^2)	
Reach CC-1	0.32	0.57	11.4	0.34	0.43	8.5	13

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Meander Belt

Figure 3

Frisque Lands Geomorphic Assessment

Legend

- Subject Property
- Reach Break
- Extent Assessed
- Meander Belt
- Meander Belt + 30 m

Historical Watercourses

- 2022
- 2008
- 1972
- 1963

BEACON ENVIRONMENTAL

Project: 221050.1
Last Revised: August 2023

Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

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1:2,500

0 50 100 m

6. Proposed Development

The subject property has a total area of 17.9 ha. The proposed development will consist of thirteen (13) low density single family residential estate lots with approximately 7.5 ha proposed for development and the remaining 10.4 ha being dedicated as open space. The proposed subdivision will include residences, private driveways and 6.5 m paved condominium roads.

6.1 Servicing

A summary of the Functional Servicing and Stormwater Management Report completed by Candevcon East Limited (2023) with respect to water servicing and stormwater is detailed below.

6.1.1 Water Servicing

The proposed development will be serviced by a proposed network within the roadway and through the lots adjacent to the existing watermain on 5th Concession to which it will connect.

6.1.2 Stormwater Management

Under existing conditions, the site generally drains towards Carruthers Creek located approximately through the centre of the site.

Under proposed conditions, two (2) separate storm sewers are proposed for the east and west group of residential lots and each will outlet to Carruthers Creek. The storm sewers have been designed to convey flows from the front of the lots including approximately half of the roof areas, the driveways and the roads. Rear roof leaders will be directed to splash pads with flows being conveyed overland as sheet flow towards Carruthers Creek. Major system flows will be captured and detained on site in portions of the storm sewer system that will be over-sized to store and release the major system flows in accordance with the Carruthers Creek unit rates.

An infiltration gallery or bioretention area is proposed at each storm outfall and will be designed with 5 mm of detention storage to meet water balance and erosion control criteria. Soakaway pits or infiltration swales are proposed to collect rear roof water and promote infiltration at the source. Each pit or swale will be designed to retain 5 mm of runoff. Feasibility of soakaway pits/ infiltration swales will be determined at the detailed design stage.

The following criteria are incorporated into the stormwater management design of the proposed development:

- Quality Control: An “Enhanced” level of protection for the minor system drainage as per Ministry of Environment guidelines is required (minimum 80% total suspended solids removal) by TRCA guidelines;
- Erosion Control: A target on-site retention of 5 mm of runoff will be provided infiltration galleries or bioretention areas at each storm outfall. A fluvial geomorphic assessment was

requested by TRCA (email August 25, 2022) to determine if site requires greater than 5 mm retention; and

- Quantity Control: Control post development flows to pre-development levels for all storm events for the 2 through 100-year return period events using the unit flow relationships for Carruthers Creek using the 24-hour AES design storms.

7. Impact Assessment

The following sections evaluate potential impacts that may result due to the proposed development and identify recommendations to mitigate potential adverse effects.

7.1 Stormwater Erosion Control Analysis

The following methodology was applied for the stormwater erosion control analyses:

- Continuous simulation hydrologic modelling (2020-2023 data record) to compare post-development conditions to existing conditions (completed by Candevcon East Limited);
- Integration of pre- and post-development continuous data with a representative surveyed cross-section of the active (bankfull) channel to calculate cumulative exceedance of the erosion threshold. Model outputs include:
  - Time of exceedance;
  - Cumulative effective velocity;
  - Cumulative effective discharge;
  - Cumulative effective work/shear stress; and
- Summary and review of exceedance results.

The erosion threshold for Reach CC-1 was referenced in the stormwater erosion control analysis. In addition to the raw time-step hydrologic model output data as provided by Candevcon East Limited, the following input parameters were utilized by the exceedance analysis model:

- Representative channel cross-section;
- Energy gradient – the governing (bankfull) gradient as determined through the detailed geomorphic field investigation were used for the exceedance analysis;
- Manning's 'n' roughness coefficient – a roughness coefficient of 0.038 was utilized for the bankfull channel, and a roughness coefficient of 0.08 was utilized for adjacent floodplain and corridor zones; and
- Erosion threshold in the form of a critical shear stress of 11.4 N/m^2 for Reach CC-1.

The model then generates a rating curve based on the representative cross-section and routes the hydrograph data through the cross-section, calculating associated hydraulic parameters and summarizing the cumulative exceedance for each hydraulic parameter in relation to the entered erosion threshold value. An illustrative example of a representative cross-section is provided in **Figure 4**. Effectively, the model represents a tool by which the volume, magnitude and duration of post-development hydrologic events can be compared to pre-development conditions. The erosion threshold represents the control point of comparison by which to evaluate difference and, as such, potential impact. Hydraulic parameters associated with the rating curve were validated by comparing generated data with field-based estimates of discharge and flow depths for assessed reaches.

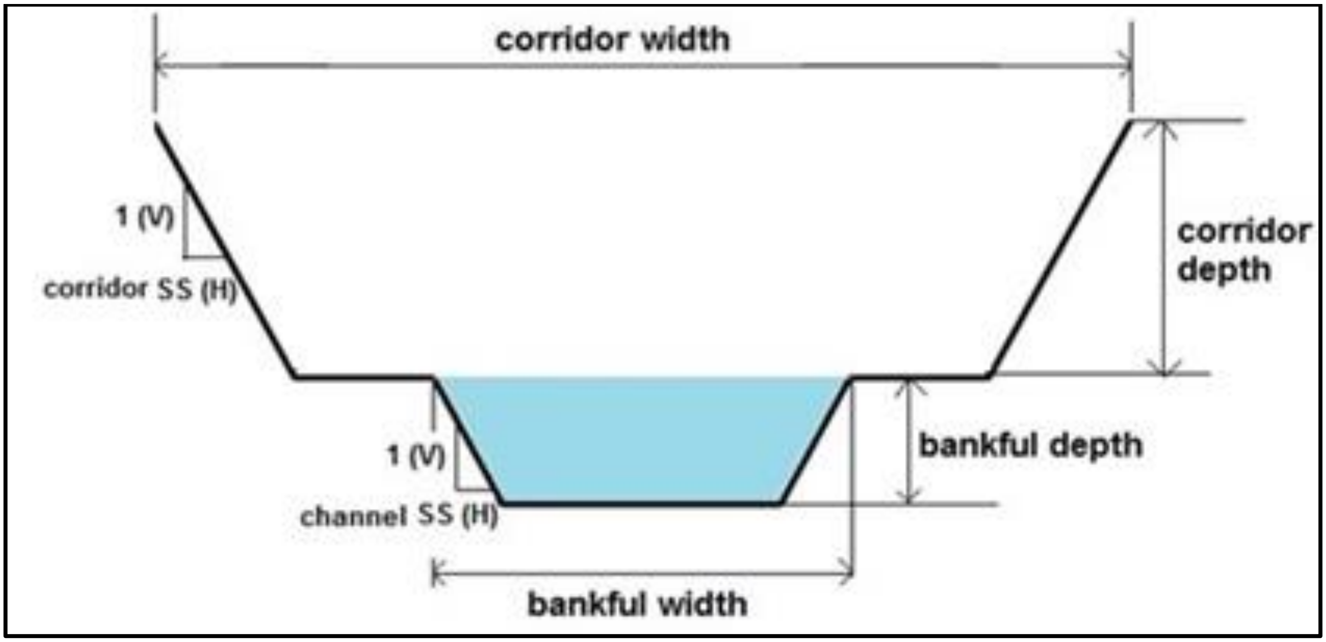

Figure 4. Schematic of Modelled Representative Cross-section

7.1.1 Exceedance Analysis Results

Continuous model output from the Visual Otthymo event-based hydrologic model prepared by Candevcon East Limited using rainfall data for Balsam station was analyzed for the pre-development and post-development (controlled) scenarios. Raw exceedance analysis results for the available 3 years of continuous flow data are presented in **Table 7**. These raw values were then converted to a percent difference to allow a quantitative comparison of pre-development and post-development hydraulic conditions. Results of the erosion exceedance analysis generally indicate a match to pre-development conditions. While duration of exceedance indicates a minor over-control condition under the post-development (controlled), the relative influence of this reduced duration is much lower in remaining hydraulic parameters (velocity, shear stress and work). Further, based on results of the background review, a level of stormwater control could benefit the system, which has been trending towards increases in cross-sectional area over TRCA's monitoring record.

Table 7. Continuous Modelling Exceedance Analysis Results – Reach CC-1

	Number of Events	Cumulative Effective Velocity (m/s)	Cumulative Effective Shear Stress (N/m^2)	Exceedance Duration (hrs)	Cumulative Effective Discharge (m^3/s)	Cumulative Effective Work/Stream Power (N/m)
PRE (Existing Conditions)	41	367449.26	10396668.27	621.7	1089231.59	9887520.07
POST (Controlled)	41	344792.87	9728563.18	536.34	1008444.38	9248942.47
Percent Difference		**-6%**	**-6%**	**-14%**	**-7%**	**-6%**

7.2 Storm Outfalls

The TRCA Stormwater Erosion Criteria (2012) document provides the following general guidance for the location of proposed SWM outfall structures so that minimal risk to the structure will occur over time due to erosion:

- Place infrastructure (e.g., outfall and plunge pool) outside of the meander belt wherever possible;
- Avoid placing outfalls, plunge pools and/or outfall channels in erosion prone areas;
- Avoid disturbance to low flow channel where possible; and
- Orient outfall and/or outfall channel appropriately to minimize impact on the receiving watercourse.

Two (2) storm outfalls are proposed in support of the development. The storm outfall for the west portion of the subject property is proposed to be located at the toe of valley slope (Frisque Lands Functional Servicing and Stormwater Management Report Figure 3; Candevcon 2023), outside of the meander belt. Results of the field investigation noted a floodplain drainage feature along the toe of slope in this area that will function to convey released flows to Carruthers Creek. The storm outfall for the east portion of the subject property is proposed to utilize an existing outfall structure, also located outside of the meander belt. Based on the proposed outfall locations, field observations and results of the stormwater erosion analysis, both SWM outfall locations can be supported from a geomorphic perspective.

8. Policy Conformity

It is our opinion that the methods and procedures outlined above are consistent with the applicable policy including the Regional Municipality of Durham Official Plan (2020 Office Consolidation) and the City of Pickering Official Plan (2022). Furthermore, it is our opinion that the intent of the PPS (2020), as well as the TRCA LCP (2014), Belt Width Delineation Procedures (2004) document, and Stormwater Management Criteria (2012) document have been met. It is our understanding that the meander belt procedures as identified in this document are also in conformance with Ontario Regulation 242/08.

9. Conclusion

Beacon was retained by 869547 Ontario Inc. to undertake a geomorphic assessment for the lands located at 3225 5th Concession Road (Part of Lost 3 and 4) in the City of Pickering. The purpose of this geomorphic assessment is to characterize existing geomorphic conditions for the portions of watercourse relevant to the subject property, contribute to the determination of development limits through the delineation of Redside Dace occupied habitat limits (referencing 30 m from the meander belt), and to address comments issued by TRCA (email dated August 25, 2022) regarding stormwater erosion control analysis requirements for the subject property.

The following points summarize the findings of this study:

- A review of historic aerial photographs and topographic mapping indicated that Carruthers Creek main tributary and western tributary within the subject property are situated within a densely treed, confined valley system;
- Rapid geomorphic assessment results identified Reaches of Carruthers Creek (CC-1 and CC-2) as in a transitional state of adjustment (score of 0.35 and 0.25, respectively) with widening as the dominant mode of adjustment. The tributary reach CCT-1 was identified to be in regime (stable) with only minor evidence of widening;
- The RSAT assessment indicated that Reaches CC-1 and CC-2 displayed a good degree of overall ecological health, with channel stability flagged as the limiting factor to overall stream health. Reach CCT-1 displayed a fair degree of overall ecological health with physical instream habitat (i.e., lack of deep pools) flagged as the limiting factor;
- To determine the extent of occupied Redside Dace habitat limits, meander belt widths were recommended for confined reaches of the Carruthers Creek (eastern tributary) following the TRCA (2004) guidelines and referencing field observations (existing channel planform), available mapping, and valley floor dimensions (57 m for Reach CC-1 and 33 m for Reach CC-2);
- In conformance with Ontario Regulation 242/08, the lands within 30 m of the meander belt have been identified in relation to the subject property;
- In support of stormwater management design requirements, a detailed geomorphic assessment was completed for a portion of Reach CC-1 of Carruthers Creek. An erosion threshold in the form of a critical shear stress of 11.4 N/m^2 was determined for Reach CC-1;
- Stormwater exceedance analysis was completed for the proposed 5 mm on-site retention scenario based on 3 years of continuous data. Results indicated a minor decrease in erosion potential for Reach CC-1 under post-development (controlled) conditions, indicating that the proposed stormwater management plan should mitigate potential erosion impacts under proposed development conditions; and
- As both proposed storm outfalls are to be located outside the meander belt, the locations conform with TRCA design criteria and can be supported from a geomorphic perspective.

Should you have any questions or require any additional information please contact the undersigned.

Report prepared by:
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Report reviewed by:
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Appendix A

Historical Aerial Imagery

Historical Aerial Imagery	1963

Frisque Lands Geomorphic Assessment

Legend

Subject Property

BEACON ENVIRONMENTAL

Project: 221050.1
Last Revised: July 2023

Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

N

1:4,000

0 80 160 m

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Historical Aerial Imagery | 1972

Frisque Lands Geomorphic Assessment

Legend

Subject Property

BEACON ENVIRONMENTAL

Project: 221050.1
Last Revised: July 2023

Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

N

1:4,000

0 80 160 m

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Historical Aerial Imagery	2008

Frisque Lands Geomorphic Assessment

Legend

Subject Property

BEACON ENVIRONMENTAL

Project: 221050.1
Last Revised: July 2023

Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

N

1:4,000

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Historical Aerial Imagery	2022

Frisque Lands Geomorphic Assessment

Legend

Subject Property

BEACON ENVIRONMENTAL

Project: 221050.1
Last Revised: July 2023

Client: 869547 Ontario Inc.

Prepared by: SZ
Checked by: MA

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Appendix B

Photographic Record

Photo 1
Reach CC-1
Looking downstream from property limit at downstream reach extent of CC-1.

Photo 2
Reach CC-1.
Looking upstream at erosion and undercutting on outer bank and gravel bar on inside bank.

Photo 3
Reach CC-1.
Erosion (slumping) on right bank.

Photo 4
Reach CC-1.
Erosion on right bank, exposing gravel armour layer in lower bank.

Photo 5
Reach CC-1.
Left bank valley wall contact on meander bend. Note: undercut bank and instream woody debris.

Photo 6
Reach CC-1.
Looking upstream at large meander bend (arrow) with cut off channel (dashed arrow). Note: large woody debris jam likely contributing to cut off.

Photo 7
Reach CC-1.
Looking upstream at general conditions. Note leaning and fallen trees and erosion along both banks.

Photo 8
Reach CC-1.
Looking downstream at the confluence with CCT-1 (arrow) and upstream reach extent.

Photo 9
Reach CC-2.
Looking downstream at meander bend with fallen trees and exposed tree roots.

Photo 10
Reach CC-2.
Looking upstream at meander bend and valley wall contact (left bank, arrow). Note fallen trees.

Photo 11
Reach CC-2.
Looking upstream at gravel lateral bar formation. Note: thalweg misaligned along outer bank (photo left, arrow).

Photo 12
Reach CC-2.
Looking upstream at undercut bank and exposed tree roots.

Photo 13
Reach CC-2.
Looking upstream at concrete culvert farm crossing at property limit and upstream reach extent. Reach break was determined by an increase in channel entrenchment and gradient.

Photo 14
Reach CCT-1.
Looking upstream at knickpoint formation.

Photo 15
Reach CCT-1.
Looking upstream at general conditions.

Photo 16
Reach CCT-1.
Looking upstream near property limit. Note poorly defined bed and banks and lack of riffle-pool morphology.

Appendix C

Summary of Detailed Field Data

Geomorphology Group

Summary of Detailed Field Data

Date:	2022-11-16	**Project:**	221050
Client:	869547 Ontario Inc.	**Watercourse:**	Carruthers Creek
Location:	3225 5th Concession Road, City of Pickering	**Reach:**	CC-1
Length Surveyed:	158 m	**Number of Cross Sections:**	8

General Site Characteristics

Drainage Area:	**6.9 km² (OFAT 2021)**	Riparian Vegetation:	
Geology/Soils:	**Clay till**	Dominant Type:	**Trees**
Surrounding Land Use:	**Golf Course and Residential**	Buffer Zone Continuity:	**Continuous**
Channel Disturbances:	**N/A**	Large Woody Debris:	**Moderate**

General Field Observations

Reach CC-1 was characterized as a highly sinuous, well-defined channel situated within a confined valley setting. The reach displayed a low gradient and moderate degree of entrenchment. Riparian vegetation was characterized as continuous, extending greater than 5 channel widths laterally. Vegetation consisted of mature cedar and deciduous trees with some shrubs and herbaceous understory. Bank angles ranged between 60-90 degrees with 30-60% of banks identified as exhibiting indicators of active erosion, such as undercutting, basal scour and fallen/leaning trees. Channel morphology was heavily influenced by the presence of woody debris in the channel and floodplain.

Planform Characteristics

Profile

Max Riffle Gradient:	**1.3**	%
Riffle Length:	**12**	m
Riffle-Pool Spacing:	**15**	m

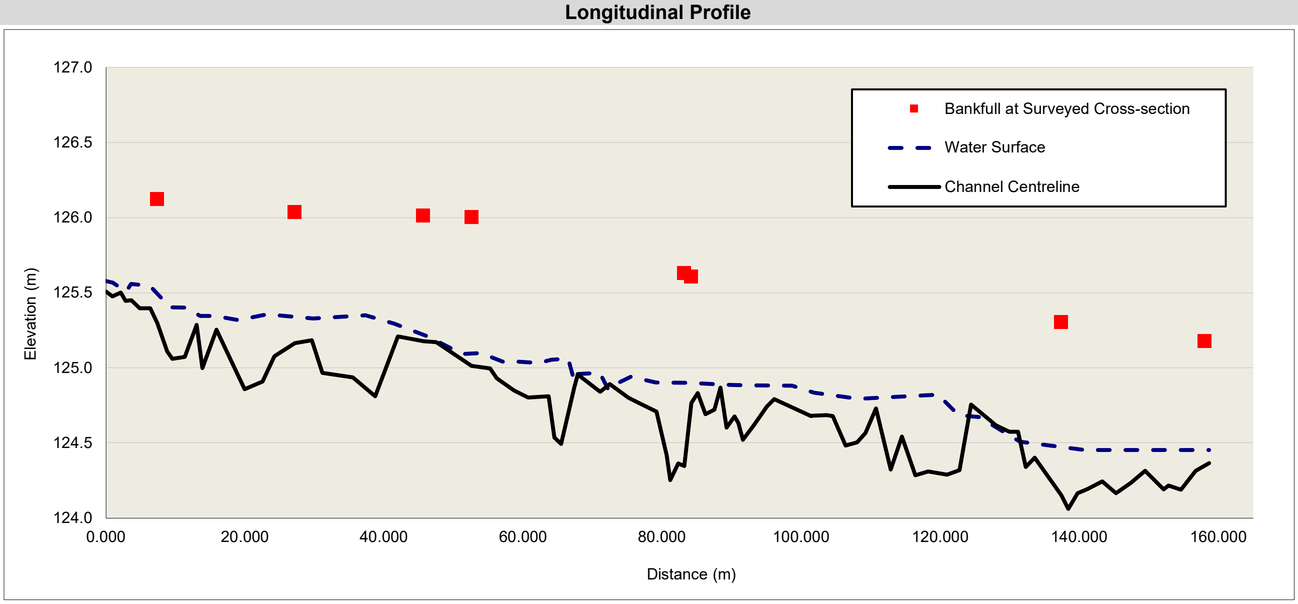
Meander Geometry

Sinuosity:	**2.8**
Belt Width:	**57**

Profile Characteristics

Bankfull Gradient:	**0.69** %	Channel Bed Gradient:	**0.71** %

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	**0.36**	**1.38**	**0.89**
Bank Angle (degrees):	**20**	**90**	**62**
Root Depth (m):	**0.10**	**1.0**	**0.10**
Root Density (%):	**20**	**60**	**38**
Undercut Banks (%)		**50**	
Depth of Undercut (m):		**0.25**	

Bank Strength:

Torvane Value (kg/cm^2):	**N/A**
Penetrometer Value (kg/cm^2):	**N/A**

Bank Material (range): **Clay and Sand with some silt, gravel and cobble**

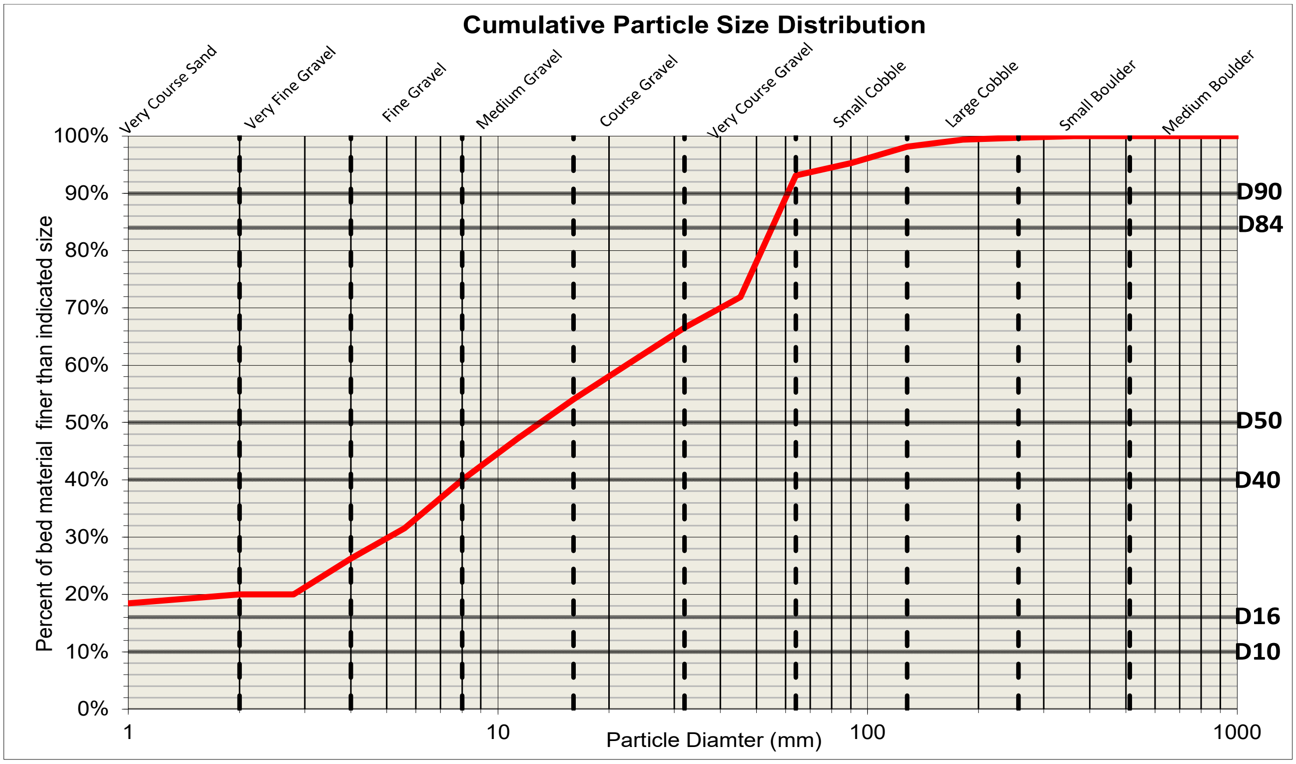
Cross-sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	**4.0**	**6.3**	**5.0**
Average Bankfull Depth (m):	**0.38**	**0.66**	**0.49**
Bankfull Width/Depth:	**7.0**	**14.5**	**10.6**
Wetted Width (m):	**0.0**	**3.8**	**2.3**
Average Water Depth (m):		**0.08**	
Manning's n:		**0.038**	

Representative Cross-Section (#3)

Substrate Characterization

Particle size (mm)			
D_{10}	Fines	Subpavement:	Till
D_{50}	16	Particle shape:	Sub-angular to Sub-rounded
D_{84}	56	Embeddedness (%):	N/A
		Particle range:	Clay, silt and sand



Appendix D

Summary of Erosion Threshold Analysis

BEACON ENVIRONMENTAL

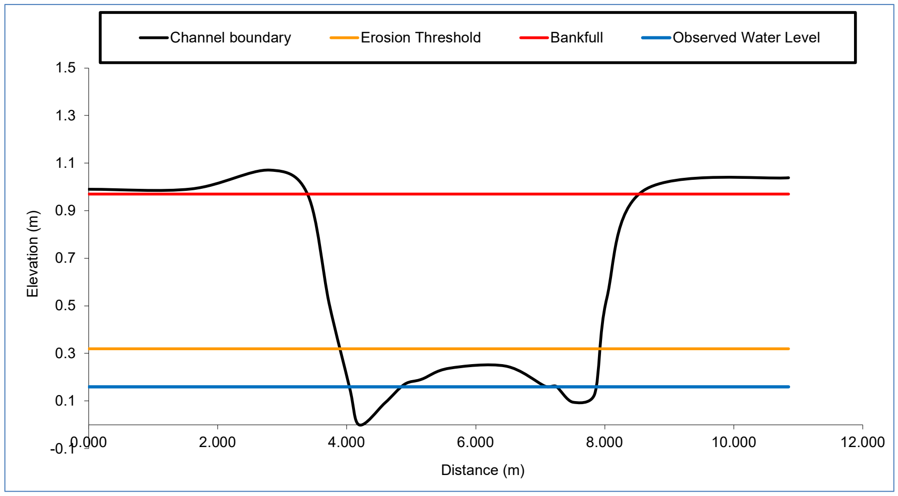
Geomorphology Group

Summary of Erosion Threshold Analysis

Survey Date:	2022-11-16	**Project:**	221050
Client:	869547 Ontario Inc.	**Watercourse:**	Carruthers Creek
Location:	3225 5th Concession Road, City of Pickering	**Reach:**	CC-1

Representative Cross-section:

Channel Bed:	
Critical Depth (m)	0.32
Slope (m/m)	0.0068
Manning's n	0.038
Average Water Depth (m)	0.17
* Critical Velocity (m/s)	0.57
Critical Discharge (m^3/s)	0.34
Critical Shear Stress (N/m^2)	11.4
Substrate	
D_{50} (m)	0.0160
D_{84} (m)	0.056
Channel Banks:	
Critical Velocity (m/s):	0.43
Critical Shear Stress (N/m^2)	8.5



* Fischenich 2001) for sandy loam (relatively high sand concentration, with silt and clay

Photo 1. Representative photo of Reach CC-1.