Technical Design Brief: Realignment of Unnamed Tributary of Bunkers Creek

105 - 111 Edgehill Drive, City of Barrie

Prepared for:
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PN21075

GEO MORPHIX
Geomorphology
Earth Science
Observations

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1 Introduction

This design brief provides design recommendations for a restoration design as part of the proposed 105-111 Edgehill Drive residential development in the City of Barrie, Ontario, as shown on the site map in **Appendix A** of this report. The channel design serves to improve channel form and function (e.g., sediment transport/ transfer) and aquatic habitat through increasing habitat variability, wetted width and low flow habitat, and providing a greater substrate and morphological variability.

In developing the design, the following activities were completed:

- Review of the available background materials, including historical and recent aerial photographs, geotechnical and hydrology reports
- Site visit to document existing channel conditions, including a detailed survey to estimate bankfull geometry
- Provide details for the channel design, including planform, cross sections, and necessary bioengineering details
- Hydraulic sizing of the channel materials
- Recommendations for design implementation, including construction timing, stabilization, and best management practices
- Development of a post-construction monitoring plan

This design brief outlines the current geomorphological condition of the unnamed Tributary, the design considerations, provides technical details and recommendations for implementing and monitoring the proposed design.

2 Existing Conditions

Channel morphology and planform are primarily governed by the flow regime and the stream corridor's sediment availability and type (i.e., surficial geology). Physiography, riparian vegetation and land use also physically influence the channel. These factors are explored as they offer insight into what governs stream geomorphology and potential changes that could be expected in the future as they relate to a proposed activity. Field observations provide an in-depth understanding of the factors that impact stream geomorphology within the study area.

2.1 Geology

The study area is within the Simcoe Lowlands physiographic region, which is characterized as a series of steep sided, flat floored valleys (Chapman and Putnam, 1984). The surficial geology consists of coarse textured glaciolacustrine deposits of sand and gravel with minor silt and clay deposits (OGS, 2003).

Toronto Inspection Ltd. (TIL) completed a geotechnical investigation report in May 2018, which involved analyzing eight boreholes, two were located near the proposed realignment of the unnamed Tributary (BH7 and BH8; TIL, 2018). The fieldwork for this investigation took place between April 5th and 6th, 2018. The purpose of the geotechnical investigation was to characterize subsurface soil and groundwater conditions and determine the geotechnical properties relevant to the development of the property (TIL, 2018). The native soils that were identified corroborated with the physiographical profile, as established above, according to the Ontario Geological Survey (OGS, 2003). Both indicated the presence of native soils mainly consisting of sand. Their study found that sand and sandy silt were predominant throughout the site (TIL, 2018). Water levels within the boreholes were also recorded. BH7 and BH8 were drilled to a depth of 5.0 m and 6.6 m below the surface, respectively. BH7 and BH 8 encountered water at 0.05 and 4.6 m below the surface.

2.2 Field Observations

Field observations of the unnamed Tributary were completed on July 10, 2018 with land use surrounding the study area observed to be residential. A photographic record is provided in **Appendix B** to provide context with field notes included in **Appendix C**. Field observations included:

- Instream measurements including estimates of bankfull and wetted depth and width, bed and bank material composition, and entrenchment
- Stream characterization of form and process by applying a Rapid Geomorphic Assessment (RGA) (Ministry of the Environment, 2003) and a Rapid Stream Assessment Technique (RSAT) (Galli, 1996), and classification of the watercourse using a modified version of the Downs (1995) method
- Longitudinal-profile and cross-sections of the watercourse
- Detailed instream measurements at each cross-section location, including bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density

The subject reach is a straight, single thread channel with a low gradient within an unconfined valley. The riparian zone was continuous, and vegetation consisted mainly of trees and shrubs. Instream vegetation was present for about 70% of the Reach and consisted mainly of grasses. Bankfull width and depth ranged between 1.08 m to 2.42 m and 0.05 m to 0.12 m, respectively. Bank angles ranged from 15° to 35°, and bank materials were comprised of silt and sand. Minimal bank erosion was observed along the channel with channel substrate consisting of silt, sand and a few cobbles. No riffle-pool sequences were present and runs dominated the channel.

2.2.1 Rapid Assessments

The RGA evaluates systematic adjustments characterized as degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The RGA method relies on the absence or presence of these indicators to evaluate the systematic adjustments in streams associated with natural causes or human activities. Systematic adjustments typically result in changes to the floodplain, channel or valley characteristics. The RGA aims to produce a score, or stability index, which evaluates the degree to which a stream has departed from the equilibrium condition. A stream with a score of less than 0.20 is *in regime*, indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that a stream is *in transition* or *stressed* and is experiencing significant change to process and form outside the natural range of variability. A score of greater than 0.41 indicates that a stream is in extreme adjustment, likely exhibiting a new stream type and will continue to adjust to the point of returning to equilibrium or is moving toward a new equilibrium (MOE, 2003). The RSAT evaluates stream health based on the inclusion of biological indicators. This technique relies on a scale ranging from '*poor*' to '*excellent*' for observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions to provide a qualitative assessment of stream health. The evaluation produces values that indicate whether the channel is in *poor* (score <13), *fair* (score 13-24), *good* (score 25-34), or *excellent* (score >34) condition (Galli, 1996).

The Downs (1995) channel evolution model is used to evaluate a channel's magnitude and potential for instability. This model uses physical indicators of systematic adjustment, including channel, bank and bar morphology and stability, to classify the type of channel evolution. By utilizing this model to classify channels, the nature of fluvial and hillslope processes that change the system can be inferred. Channels are classified as varying degrees of stable, depositional, migrating laterally, enlarging, and experiencing various types of erosion (Downs, 1995; Simon and Downs, 1995).

The unnamed Tributary had an RGA score of 0.22, indicating that the channel is *in transition or stressed*. The dominant mode of adjustment was aggradation, evident from siltation in pools, poor longitudinal sorting of bed materials and deposition in the overbank zone. The RSAT score of 27 indicated that the Reach was in *good* ecological health, with physical instream habitat being the limiting factor for this Reach. The Down's model classified this channel as '*S*' – *stable,* indicating no observable morphological change.

2.2.2 Detailed Assessment

A detailed survey was completed for the unnamed Tributary. The bank material consisted mainly of clay, silt, and fine sand with an average bankfull width and depth of 1.60 m and 0.10 m, respectively. The bankfull channel gradient was documented as 2.11%, and a bankfull discharge was back-calculated to be 0.08 m^3/s. A summary of the detailed survey results is provided in **Table 1**. An overview of the thorough assessment is provided in **Appendix D**.

Table 1 Bankfull parameters of the reference reach

Channel parameter	Results
Measured	
Average bankfull channel width (m)	1.60
Average bankfull channel depth (m)	0.10
Bankfull channel gradient (%)	2.11
D_{50} (mm)	<2
D_{84} (mm)	<2
Manning's n roughness coefficient	0.04
Calculated	
Bankfull discharge (m^3/s) *	0.08
Average bankfull velocity (m/s)	0.65
Unit stream power at bankfull discharge (W/m^2)	10.1
Tractive force at bankfull (N/m^2)	15.6
Critical shear stress (N/m^2) **	1.46
Flow competency for D_{50} (m/s) ***	0.27
Flow competency for D_{84} (m/s) ***	0.27

* Based on Manning's equation
** Based on Miller et al. (1997)
*** Based on Komar (1987)

Field observations illustrate that the channel has limited variability in geometry resulting in inefficient sediment transport and aggradation. Restoration of the channel provides an opportunity to improve channel form and function, reduce aggradation, and increase habitat and morphological variability.

3 Natural Channel Design

3.1 Design Objectives

Headwater features like this reach provide detention and retention functions with regard to both flow and sediment. To maintain and enhance these functions, the design needs to provide good communication with the floodplain and diversity in channel and floodplain morphology. Floodplain enhancement features in the form of online wetlands are proposed for the channel corridor. These features enhance aquatic and terrestrial habitats by increasing diversity and providing a more natural floodplain form. They also provide functional benefits by storing and discharging water over long attenuated periods.

From a habitat perspective, the important contributions of the watercourse are the supply of seasonal habitat, organic inputs to the system, and provision of a complex valley system with elements that provide a range of aquatic and terrestrial habitat elements. The inclusion of an undulating system with online wetlands features offers a wide range of hydroperiods.

Therefore, the primary objectives of the design are to:

- Restore the physical form of the channel, including planform and in-channel characteristics
- Improve the function of the channel as well as its interactions with the floodplain
- Improve retention and detention of flows upstream of the stormwater management pond
- Enhance aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows
- Improve riparian habitat by installing native woody plantings and floodplain features
- Mitigate potential hazards to the development as well as lands south of the development

3.2 Bankfull Channel

Shallow and deep undulations are proposed for the realigned bioswale, which will significantly improve the feature as it replicates a natural system and aquatic habitat. When it is assessed to be an appropriate channel type, a undulating system offers numerous benefits:

- Channel bed relief for flow variability
- Relatively quiescent flows in deep sections to provide refuge for fish during high flows
- Increased depths in the deep undulations to provide relatively cool water
- In-channel energy dissipation
- Improve the function of the existing headwater drainage features
- Improve water quality by extending detention of water through shallow and deep undulations
- Improve riparian habitat by installing woody plantings

Bioswale dimensions are determined by bankfull discharge, as this represents what is generally considered the channel-forming discharge or the dominant discharge. Several methods can be applied to select an appropriate bankfull discharge. For this reach, the back-calculated discharge is in the range of 0.08 m^3/s. However, due to the historical impacts on the watercourse, the computed discharge could not be considered accurate or reliable. Additionally, since changes to the hydrology are likely to occur due to the development, a more appropriate discharge based on hydrological modelling was determined for this channel. The bankfull discharge was determined to be 0.113 m^3/s for Reach 1 and 3 and 0.14 m^3/s for Reach 2, provided by Pinestone Engineering Limited (2018). The bankfull discharge for Reach 2 was approximated using two-thirds of the 2-year flow. Bankfull capacity for channels generally have a range from the 1- to 2-year return events.

Shallow and deep undulation cross section geometries, as well as anticipated swale conditions are provided in **Table 2** and **Table 3**. A simple Manning's approach was used to iteratively back-calculate bankfull dimensions for the proposed bioswale. Since deep undulations are designed to contain ineffective space, this model over-predicts the amount of discharge that they convey. However, the modelled values for the shallow undulations give a better prediction of the channel capacity. Reach 1 has an overall gradient of 1.40% for 33.47 m. The channel has widths and depths ranging from 1.00 m to 1.20 m and 0.15 to 0.25 m for the shallow and deep undulations, respectively. The average shallow section gradient for this reach is 4.50%. Reach 2 overall gradient is 1.60% for 25.20 m, with the width and depth of the channel ranging from 1.20 m to 1.40 m and 0.15 to 0.25 m for the shallow and deep undulations, respectively. The average shallow undulation gradient for this reach is 4.80%. Lastly, Reach 3's channel widths and depths range from 1.00 m to 1.20 m and 0.15 to

0.25 m for the shallow and deep undulations, respectively. The reach has an overall gradient of 0.94 % for 45.48 m and an average shallow undulation gradient of 4.50%.

Table 2. Bankfull parameters of the proposed channel

Channel parameter	Reach 1		Reach 2	
	Shallow††	Deep†	Shallow††	Deep†
Bankfull width (m)	1.00	1.20	1.20	1.40
Average bankfull depth (m)	0.10	0.13	0.11	0.14
Maximum bankfull depth (m)	0.15	0.25	0.15	0.25
Bankfull width-to-depth ratio	9.76	9.14	11.29	9.68
Channel gradient (%)	4.50	1.40	4.80	1.60
Bankfull gradient (%)	1.40		1.60	
Manning's roughness coefficient, *n*	0.04	0.03	0.04	0.03
Mean bankfull velocity (m/s) *	1.03	0.89	0.06	1.03
Bankfull discharge (m^3/s) *	0.11	0.14	0.14	0.21
Discharge to accommodate (m^3/s)	0.11	0.11	0.14	0.14
Tractive force at bankfull (N/m^2)	66	34	71	39
Stream power (W/m)	46	19	66	33
Unit stream power (W/m^2)	46	16	55	34
Froude Number (unitless)	1.02	0.79	1.08	0.86
Maximum grain size entrained (m) **	0.07	0.04	0.07	0.04
Mean grain size entrained (m)**	0.05	0.02	0.05	0.02

† Based on bankfull gradient
†† Based on shallow undulation gradient
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not presented
** Based on a modified Shields equation (Miller et al. 1977), assuming Shields parameter equals 0.06 for gravel

Table 3. Bankfull parameters of the proposed channel

Channel parameter	Reach 3	
	Shallow††	Deep†
Bankfull width (m)	1.00	1.20
Average bankfull depth (m)	0.10	0.13
Maximum bankfull depth (m)	0.15	0.25
Bankfull width-to-depth ratio	9.76	9.14
Channel gradient (%)	4.50	1.20
Bankfull gradient (%)	1.40	
Manning's roughness coefficient, *n*	0.04	0.03
Mean bankfull velocity (m/s) *	1.03	0.83
Bankfull discharge (m^3/s) *	0.11	0.13
Discharge to accommodate (m^3/s)	0.11	0.11
Tractive force at bankfull (N/m^2)	66	29
Stream power (W/m)	46	15
Unit stream power (W/m^2)	46	13
Froude Number (unitless)	1.02	0.73
Maximum grain size entrained (m) **	0.07	0.03
Mean grain size entrained (m)**	0.05	0.02

† Based on bankfull gradient
†† Based on shallow undulation gradient
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not presented
** Based on a modified Shields equation (Miller et al. 1977), assuming Shields parameter equals 0.06 for gravel

The sizing of proposed substrate materials was guided by a review of hydraulic conditions (i.e., tractive force, flow competency) in the typical cross sections. To provide for a stable bed and level of sorting, a mix of 70% granular 'b' and 30% native material is proposed for the shallow undulations. Granular 'b' consists of a stone mix where approximately 20% - 50% of the stone is greater than 0.005 m in diameter but nothing larger than 0.15 m in diameter. These materials will always have a core of sediment that is not entrained under bankfull flow conditions. This material maintains the character of the native material while providing slightly higher stability and opportunity for sediment sorting.

The channel banks will be restored using native plant species. This includes appropriate species for the various seed mixes as well as woody vegetation. The plantings are intended to enhance the terrestrial habitat by providing species and habitat diversity, increasing floodplain soil stability, and increasing floodplain roughness and sedimentation.

3.3 Habitat Features

Online wetland features will be constructed in addition to the channel to enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits such as short-term water retention and sediment banking. The irregular shape of the wetland features will maximize the perimeter for a given area, which increases the potential for edge effects.

A stone core wetland will be installed to accept discharge from the associated stormwater management system outlet. The stone core refers to hydraulically-sized rounded stone, which is the subsurface material used to ensure wetland stability. The proposed stone core is expected to be stable under the predicted flow conditions in the wetlands. A range of techniques will be utilized to determine the appropriate stone size, as summarized in the National Engineering Handbook (NRCS, 2007). These wetlands' short-term water retention function also helps to polish the water (e.g., sediment trapping) and moderate water discharge into the channel.

3.4 Stormwater Management Outlet Design

A stone-core wetland will also be installed at the proposed SWM pond and potential on-site control outfalls throughout the corridor and will accept discharge from the associated outlets. The stone core refers to hydraulically sized rounded stone, which is the subsurface material used to ensure wetland stability. The substrate within the outlet stone core will be comprised of a mix of 70% 200 mm – 250 mm diameter riverstone mixed with 30% granular 'B'. The stone sizing should be confirmed once the stormwater management design has been finalized. Submerged and dry mounds are proposed within the stone-core wetland to provide a topographically complex bottom that will increase habitat heterogeneity. The short-term water retention function of these wetland types helps to polish water and moderate discharge of water into the channel (in addition to the functions provided by the SWM pond).

3.5 Natural Erosion Control

Newly constructed channels can be vulnerable to erosion. This is particularly true before vegetation has established along the channel banks. While low-flow events should not cause severe erosion as the concern for erosion occurs when there are high flows or precipitation events during construction. The following recommendations are provided to manage and reduce the potential for erosion:

- For immediate erosion protection, mechanical stabilization in the form of biodegradable erosion control blankets (i.e., coir cloth, jute mat, etc.) should be used. As the blankets will biodegrade over time, this serves as a short-term stabilization measure.
- For long-term stability, the implementation of a planting plan is recommended. This includes deep-rooting native grasses and other herbaceous species seeded along and within channel sections, prescription of flood-tolerant native shrub and tree species and use of seed banks within the local soil. Shrubs should be planted close to the channel margins to provide maximum benefit regarding stabilization and channel cover.
- Potential erosion locations (i.e., along the outside meander bends, immediately downstream of wetland features, etc.) should be anticipated and reflected in the planting plan.
- Live staking and shrub stock should be used adjacent to the channel bank to provide immediate benefit and long-term infilling. If appropriate live staking methods are followed, this method should give greater benefits than simple potted or bare root shrub plating. This is because of the potential for higher densities with live staking.

4 Design Implementation

4.1 Construction Timing

Based on resident fish species and their respective life cycles, in-stream work will be restricted to July 1 to March 31, unless otherwise directed by the Ministry of Natural Resources and Forestry (MNRF).

4.2 Best Management Practices

Site inspection should be performed by an inspector with experience overseeing channel works, as this type of work differs considerably from engineering projects. An experienced inspector will be able to provide a quick and appropriate response to issues that may arise and ensure that construction proceeds per the approved design and contract.

The construction limits will be delineated to prevent unanticipated impacts on natural surroundings, including trees and the watercourse. Most of the channel can be constructed without interference to the existing watercourse. When the proposed channel crosses the existing channel, cofferdams will be installed upstream, and downstream of the work area with the water pumped around.

All isolated work areas will be dewatered to perform work under dry conditions. Water will be pumped to a sediment filtration system located at least 30 m from the receiving creek and be allowed to flow over a well-vegetation surface naturally and ultimately return to the channel downstream of the work area. This will allow particles to settle before reaching the watercourse.

All materials and equipment will be stored and operated in such a manner that prevents any deleterious substances from entering the water. Vehicle and equipment re-fuelling and/or maintenance will be conducted away from the watercourse and be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances.

4.3 Post-Construction Monitoring

A post-construction monitoring program is recommended to assess the performance of the implemented design. Monitoring observations can also be used to determine the need for remedial works. Monitoring is recommended for two full calendar years following the year of construction.

The following monitoring and reporting activities are proposed:

- General observations of the channel works should be documented after construction and after the first significant flooding event to identify any potential areas of erosion concern
- Collection of a photographic record of site conditions
- Total station as-built survey of the channel planform, longitudinal profile and cross sections just after construction to obtain reference data for the following two years
- Installation of erosion pins at monumented cross sections after construction
- A general vegetation survey in the spring of each year
- Re-survey of the longitudinal profile and cross sections, as well as monitoring of erosion pins at monumented cross sections for two years following construction
- A yearly report for the first year, with a final report at the end of the two-year period

The monitoring would commence immediately after construction, and sites would be reviewed annually to identify the system's natural variability. Reporting would be provided annually, with a summary report at the end of each year.

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

Respectfully submitted,

Paul Villard Ph.D., P.Geo., CAN-CISEC, EP, CERP
Director, Principal Geomorphologist

Lindsay Davis, M.Sc., P.Geo., CAN-CISEC,
Geomorphologist

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Appendix A
Site Map


LAYTON CRESCENT
ANNE STREET
HIGHWAY 400
EDGEHILL DRIVE
LEACOCK DRIVE
HIGHWAY 400
GEO MORPHIX
Unnamed Tributary of Bunkers Creek
105 - 111 Edgehill Drive, City of Barrie
0 30
Metres
N
Imagery: Google Earth Pro, 2016.

Appendix B
Photographic Record

Photo 1
Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive

Drainage feature begins at the North-Eastern quadrant of the property and runs toward the South-West direction. Yellow arrow indicates flow direction.

Photo 2
Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive

The drainage feature is dry, the channel bed and banks are covered by grasses and herbaceous vegetations, and are composed of a mixture of organic material, silt, and sand.

Photo 3 Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive	 Large woody debris fallen across the channel. Riparian zone transitions from herbaceous dominated to forest dominated.
Photo 4 Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive	 Shallow standing water was observed at the lower portion of the drainage feature, near the South-Western corner of the property, possibly groundwater seepage.

Photo 5 Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive	
	The channel bed is composed of organic materials (leaves, branches), silt, and sand, which is similar to bank material.
Photo 6 Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive	
	Lower portion of the drainage feature is a straight suspended load channel with an established forested riparian buffer. Non-vascular plant grows across shallow regions of the channel.

<table>
<tr><td rowspan="2">Photo 7
Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive</td><td></td></tr>
<tr><td>No signs of bank erosion or channel degradation was observed. The channel gradient is consistent and no apparent pools or riffles. Some siltation and overbank deposition suggest channel aggradation.</td></tr>
<tr><td rowspan="2">Photo 8
Reach M1: Drainage feature running from North-East to South-West within the property of 111 Edgehill Drive</td><td></td></tr>
<tr><td>Reach 1 ends at the South-Western corner the property boundary, but the drainage feature continues and enters Bunkers Creek at Highway 400.</td></tr>
</table>

Appendix C
Field Observations

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Geomorphology Earth Science Observations

General Site Characteristics

Project Code: 18095

Date:	July 10, 18	**Stream/Reach:**	Unnamed Tributary
Weather:	Sunny 26°	**Location:**	Edgehill Property
Field Staff:	LD EC	**Watershed/Subwatershed:**	Bunkers Creek

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

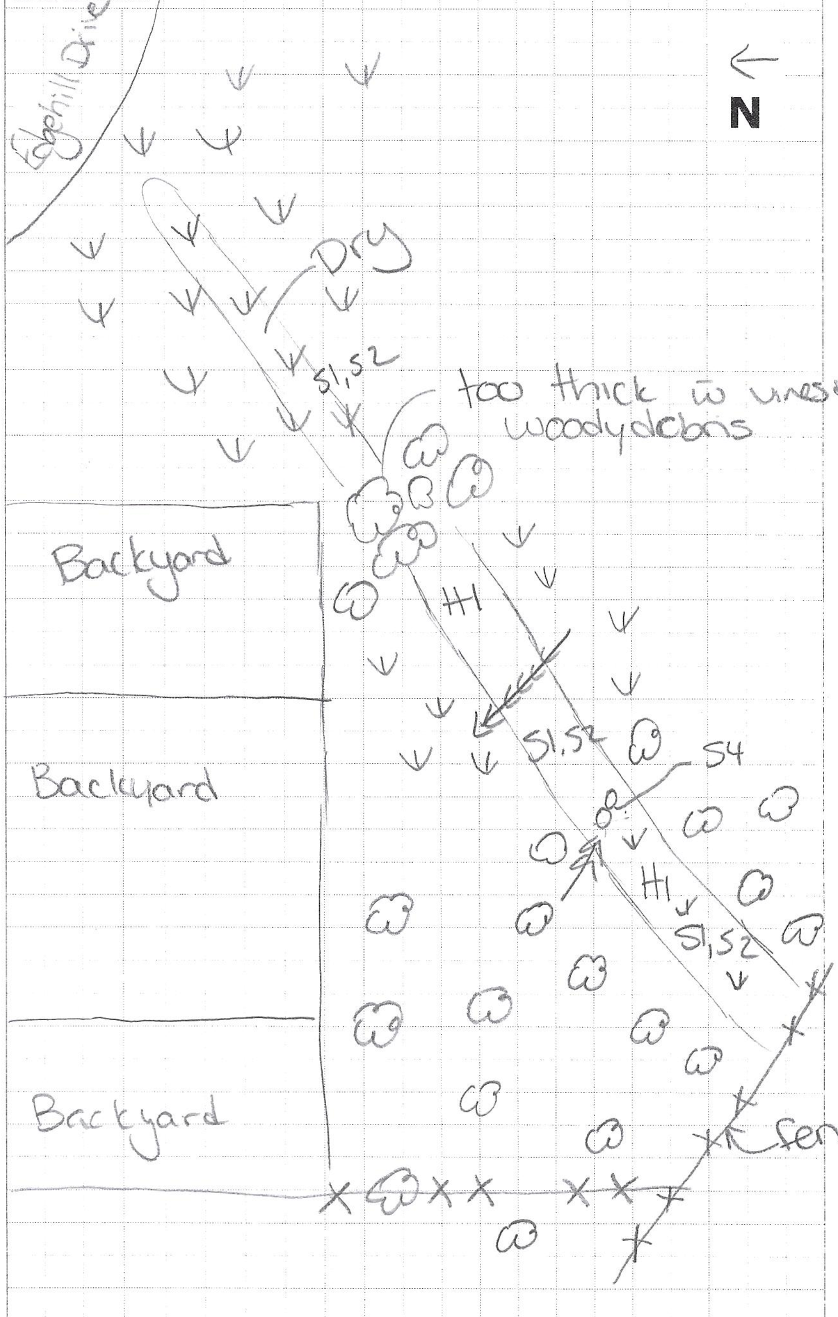
Substrate

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: LD Checked by: ________

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Geomorphology Earth Science Observations

Reach Characteristics

Project Code: 18095

Date:	July 10, 2018	**Stream/Reach:**	Unnamed Tributary
Weather:	Sunny 26°	**Location:**	Edgehill Property
Field Staff:	LD EC	**Watershed/Subwatershed:**	Bunkers Creek
UTM (Upstream)		**UTM (Downstream)**	

Land Use (Table 1): 1/7 | **Valley Type** (Table 2): 1 | **Channel Type** (Table 3): 11 | **Channel Zone** (Table 4): 1 | **Flow Type** (Table 5): 2 | ☐ Groundwater | Evidence: ________

Riparian Vegetation

Dominant Type: (Table 6) 1/2

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) 3

Aquatic/Instream Vegetation

Type (Table8): 1 | Coverage of Reach (%): 50

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

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

WDJ/50m: 1

Water Quality

Odour (Table 16): 1

Turbidity (Table 17): 1

Channel Characteristics

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

Entrenchment (Table 13): 1 | **Type of Bank Failure** (Table 14): N/A | **Downs's Classification** (Table 15): S

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

see detailed assessment

Bankfull Width (m) | | | | **Wetted Width (m)** | | |

Bankfull Depth (m) | | | | **Wetted Depth (m)** | | |

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

Pool Depth (m) / | **Riffle Length (m)** / | **Undercuts (m)** 0 | **Comments:** no riffle-pool sequence no meanders, standing water

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: LD   Checked by: ________

GEO | MORPHIX

Rapid Geomorphic Assessment

Project Code: PN 18095

Date:	10 July 2018	**Stream/Reach:**	Drainage feature
Weather:	Sun 27°C	**Watershed/Subwatershed:**	Unnamed trib
Field Staff:	LD EC	**Location:**	Bunkers Creek

Process	No.	Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		✓	3/7
	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	4	0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		N/A	0/5
	2	Exposed sanitary / storm sewer / pipeline / etc.		N/A	
	3	Elevated storm sewer outfall(s)		N/A	
	4	Undermined gabion baskets / concrete aprons / etc.		N/A	
	5	Scour pools downstream of culverts / storm sewer outlets		N/A	
	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	0
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	✓		2/7
	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.		N/A	
	7	Length of basal scour >50% through subject reach		✓	
	8	Exposed length of previously buried pipe / cable / etc.		N/A	
	9	Fracture lines along top of bank		✓	
	10	Exposed building foundation		N/A	
		Sum of indices =	2	5	0.29
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		✓	1/7
	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 =	1	6	0.14

Additional notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.215

Condition	**In Regime**	**In Transition/Stress**	**In Adjustment**
SI score =	☐ **0.00 - 0.20**	☑ **0.21 - 0.40**	☐ **0.41**

Completed by: EC Checked by: ________

Rapid Stream Assessment Technique

Project Code: PN 18095

Date:	10 July 2018	**Stream/Reach:**	Drainage feature
Weather:	Sun 25°C	**Location:**	Unnamed trib
Field Staff:	LD EC	**Watershed/Subwatershed:**	Bunkers Creek

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

Evaluation Category	Poor	Fair	Good	Excellent
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 N/A
Point range	☐ 0 ☐ 1 ☐ 2	☐ 3 ☐ 4	☑ 5 ☐ 6	☐ 7 ☐ 8

Date: 10 July 2018	Reach:		Project Code: PN 18095	
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) = 27	Poor (<13)	Fair (13-24)	Good (25-34)	Excellent (>35)

Completed by: EC Checked by: ________

Appendix D
Detailed Assessment Summary

Detailed Geomorphological Assessment Summary

Reach M1

Project Number:	PN18095	**Date:**	10 July 2018
Client:	Marco Vercillo	**Length Surveyed (m):**	99.8
Location:	111 Edgehill Drive, Barrie	**# of Cross-Sections:**	9

Reach Characteristics

Drainage Area:	Not measured	**Dominant Riparian Vegetation Type:**	Grasses, trees
Geology/Soils:	Glaciolacustrine deposits	**Extent of Riparian Cover:**	Continuous
Surrounding Land Use:	Residential	**Width of Riparian Cover:**	4-10 Channel widths
Valley Type:	Unconfined	**Age Class of Riparian Vegetation:**	Established (5-30 years)
Dominant Instream Vegetation Type:	Grasss	**Extent of Encroachment into Channel:**	Heavy
Portion of Reach with Vegetation:	70%	**Density of Woody Debris:**	Low

Hydrology

Measured Discharge (m^3/s):	N/A: No flow	**Calculated Bankfull Discharge (m^3/s):**	0.08
Modelled 2-year Discharge (m^3/s):	Not modelled	**Calculated Bankfull Velocity (m/s):**	0.65
Modelled 2-year Velocity (m/s):	Not modelled		

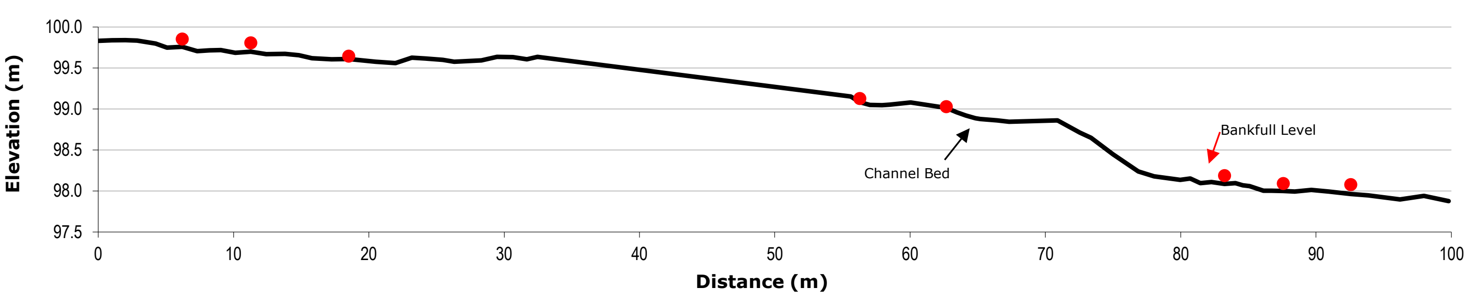
Profile Characteristics

Bankfull Gradient (%):	2.11
Channel Bed Gradient (%):	2.11
Riffle Gradient (%):	Not measured
Riffle Length (m):	Not measured
Riffle-Pool Spacing (m):	Not measured

Planform Characteristics

Sinuosity:	1.06
Meander Belt Width (m):	Not measured
Radius of Curvature (m):	Not measured
Meander Amplitude (m):	Not measured
Meander wavelength (m):	Not measured

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average
Bank Height (m):	0.15	0.35	0.26
Bank Angle (deg):	15	35	26
Root Depth (m):	0.00	0.10	0.09
Root Density (%):	50	70	63
Bank Undercut (m):	N/A: no bank undercuts		

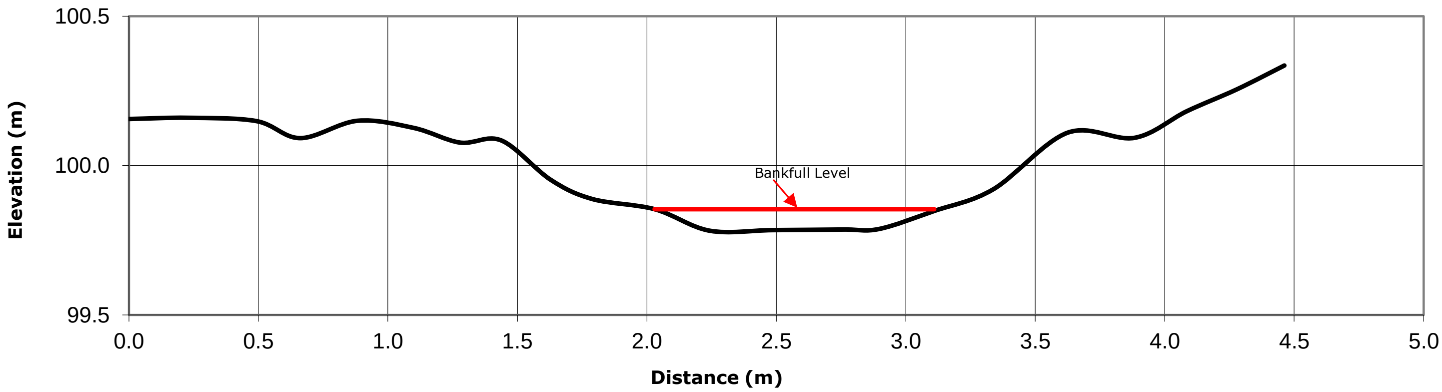
	Minimum	Maximum	Average
Torvane Value (kg/cm^2):		Not measured	
Penetrometer Value (kg/cm^3):		Not measured	
Bank Material (range):		silt, sand	

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	1.08	2.42	1.60
Average Bankfull Depth (m):	0.03	0.10	0.08
Bankfull Width/Depth (m/m):	16	37	22
Wetted Width (m):	N/A: dry at time of survey		
Average Water Depth (m):	N/A: dry at time of survey		
Wetted Width/Depth (m/m):	N/A: dry at time of survey		
Entrenchment (m):	Not measured		
Entrenchment Ratio (m/m):	Not measured		
Maximum Water Depth (m):	N/A: dry at time of survey		
Manning's *n* :	0.040		

Photograph at cross section 9 (looking downstream)

Representative Cross-Section 1



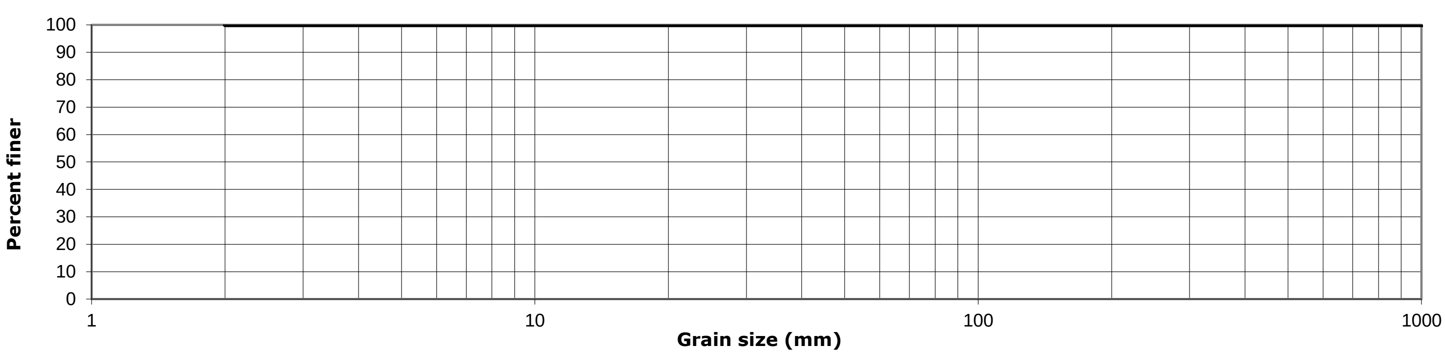
Substrate Characteristics

Particle Size (mm)

D_{10} :	<	2.0
D_{50} :	<	2.0
D_{84} :	<	2.0

Subpavement:	Till
Particle shape:	Not Applicable (sand/silt)
Embeddedness (%):	Not Applicable (sand/silt)
Particle range (riffle):	Not Applicable (sand/silt)
Particle Range (pool):	Not Applicable (sand/silt)

Cumulative Particle Size Distribution



Channel Thresholds

Flow Competency (m/s):		**Tractive Force at Bankfull (N/m^2):**	15.57
for D_{50}:	0.27	**Tractive Force at 2-year flow (N/m^2):**	Not modelled
for D_{84}:	0.27	**Critical Shear Stress (D_{50}) (N/m^2):**	1.46
Unit Stream Power at Bankfull (W/m^2):	10.08		

General Field Observations

Channel Description

Reach M1 is a drainage feature located within the property of 111 Edgehill Drive. The reach has no upstream connection and drains into Bunkers Creek at the downstream end after leaving the property boundary. Reach M1 flows through a residential area with moderate gradient and low sinuosity. Riparian vegetation is comprised of grasses, herbaceous plants, and trees, which provides a continuous buffer that is 1-4 channel widths wide. The channel was mostly dry with small pools of standing water at the time of assessment. There was no riffle-pool development. Bed and bank material was composed of mainly sand and silt. Average bankfull width and depth were 1.60 m and 0.08 m respectively. Woody debris was present in the channel but not due to channel widening. Little to no bank erosion was apparent.

Cross Section 1 - Facing Downstream