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Preliminary Design and Municipal Class Environmental Assessment Schedule B Report

Harmony Creek Sites 2 & 3

Palmer Project #
1510208

Prepared For
City of Oshawa

August 19, 2022

August 19, 2022

Harshad Patel, M.Eng., P.Eng.
Water Resources Engineer
City of Oshawa
50 Centre Street South
Oshawa, ON L1H 3Z7

Dear Harshad Patel:

Re: Preliminary Design and Municipal Class Environmental Assessment Schedule B Report – Harmony Creek Sites 2 & 3
Project #: 1510208

Palmer is pleased to provide the City of Oshawa with our Preliminary Design and Class Environmental Assessment Schedule B Report to address erosion risk posed to private property and municipal infrastructure at Harmony Creek Sites 2 & 3, downstream of Rossland Rd, in Oshawa, Ontario. The report documents the process used to determine the preferred erosion mitigation strategy and describes and rationalizes its preliminary design.

Two alternatives for mitigating erosion risk, in addition to the 'do nothing' option, were developed and evaluated. The preferred alternative, which is recommended for implementation at Sites 2 & 3, represents the best compromise among hydraulic, geomorphological, ecological, permitting and cost considerations.

Should you have any questions, please do not hesitate to contact Robin McKillop at 647-795-8153 ext. 106 (robin.mckillop@pecg.ca), or Max Osburn at 647-527-8354 (max.osburn@pecg.ca).

Yours truly,

Palmer

Robin McKillop, M.Sc., P.Geo., CAN-CISEC
Vice President, Principal Geomorphologist

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1. Introduction

Palmer is pleased to provide the City of Oshawa ('the City') with our preliminary designs for mitigating erosion risk to infrastructure and private property at Harmony Creek Sites 2 & 3, between the tributary confluence and 590 Camelot Drive, in Oshawa (**Figure 1**). The associated study is meant to satisfy the conditions of the Schedule B Municipal Class Environmental Assessment (EA) process. This document includes project objectives (Section 2); description of channel and site-specific existing conditions (Section 3); a summary and evaluation of alternative concepts and identification of the preferred alternative (Section 4); details of public engagement (Section 5); preliminary design of the preferred alternative (Section 6); and next steps regarding implementation of the detailed design (Section 7).

1.1 Background

Sites 2 & 3 were initially prioritized after Palmer's (2021) completion of the detailed fluvial geomorphic analysis and erosion hazard assessment along Harmony Creek between Rossland Road East and Hillcroft Street. The assessment was in support of the City's objective of identifying and evaluating erosion hazards and developing strategies to mitigate corresponding unacceptable risks at prioritized sites. A total of 13 erosion hazard sites associated with failed or failing in-channel erosion control structures, private property, and/or stormwater infrastructure were identified and characterized. Of the 13 erosion hazard sites, conceptual erosion mitigation strategies were evaluated for sites deemed 'high priority', and preferred alternatives were identified.

Following the assessment, the City requested Palmer advance the preferred alternatives at Sites 2 & 3 through preliminary design. At Site 2, an anomalously large point bar has deflected the thalweg along the outer bank, outflanking and undermining a stormwater outfall. At Site 3, fluvial erosion has deteriorated a two-tiered gabion wall protecting several properties along the outer bank of a broad meander.

The preferred mitigation option determined through Palmer's multi-criteria evaluation involved channel realignment based on natural channel design principles to reposition the creek toward the center of the valley bottom, eliminating risk to the outfall and private properties. The channel would smoothly tie in with the gabion-lined meander at Site 3 at its downstream extent.

LEGEND:

- 3 — Erosion Hazard Site
- 2 — Photo Location and Direction
- Flow Direction
- 2020 Channel Centreline
- Harmony Creek Trail
- Existing Erosion Control Structure (Gabion Basket)
- Subject Property

Imagery (2020) provided by the City of Oshawa

TITLE:

Study Site

METRE SCALE: 0 5 10

NORTH:

CLIENT: City of Oshawa

PRINT SCALE: 1:350	PRINT SIZE: 11 x 17 "	
DATUM: NAD 1983	PROJECTION: UTM Zone 17	
DATE: Aug 18, 2022	DRAWN: SM	CHECKED: MB

PREPARED BY: Palmer

PROJECT: Harmony Creek
Site 2-3 Preliminary Design

FIGURE NO.	REVISION:	PROJECT NO.
1	1-1	1510208

Document Path: G:\Shared drives\Projects 2015\15102 - City of Oshawa\1510208 - Harmony Creek - Site 2-3 Preliminary Design\GIS\1_Workspace\Task 4 - Reporting Figures\1510208-1-1-Study Site.mxd

1.2 The Environmental Assessment Process

Municipalities in Ontario are subject to the provisions of the Environmental Assessment Act (EAA) and its requirements to conduct an Environmental Assessment for public works projects that have the potential for significant environmental effects. The Municipal Class Environmental Assessment (MCEA, 2015) document provides municipalities with a five-phase planning procedure that offers direction on how to plan and undertake municipal projects that recur frequently, are usually limited in scale, and have a predictable range of environmental impacts. Projects considered by the Class EA process include municipal roads and bridges, wastewater, stormwater management, water, and transit.

Table 1 illustrates the steps followed in the planning and design of projects covered under the Class EA process. Proposed projects with increasing complexity and higher likelihood for adverse environmental impacts are required to complete additional planning steps, termed 'Phases' by the MCEA document, prior to obtaining approval to proceed. The MCEA document provides the following description of the five phases.

Table 1. Phases of the Class EA Process

Phase	Description
Phase 1	Identify the problem (deficiency) or opportunity.
Phase 2	Identify alternative solutions to address the problem or opportunity by taking into consideration the existing environment, and establish the preferred solution considering public and review agency input.
Phase 3	Examine alternative methods of implementing the preferred solution, based upon the existing environment, public and review agency input, anticipated environmental effects and methods of minimizing negative effects and maximizing positive effects.
Phase 4	Document, in an Environmental Study Report, a summary of the rationale, and the planning, design and consultation process of the project as established through the above phases and make such documentation available for scrutiny by review agencies and the public.
Phase 5	Complete contract drawings and documents and proceed to construction and operation; monitor construction for adherence to environmental provisions and commitments. Where special conditions dictate, also monitor the operation of the completed facilities.

Figure 2 is an excerpt from the MCEA document and illustrates the process followed in the typical planning and design of projects covered by a Class EA.

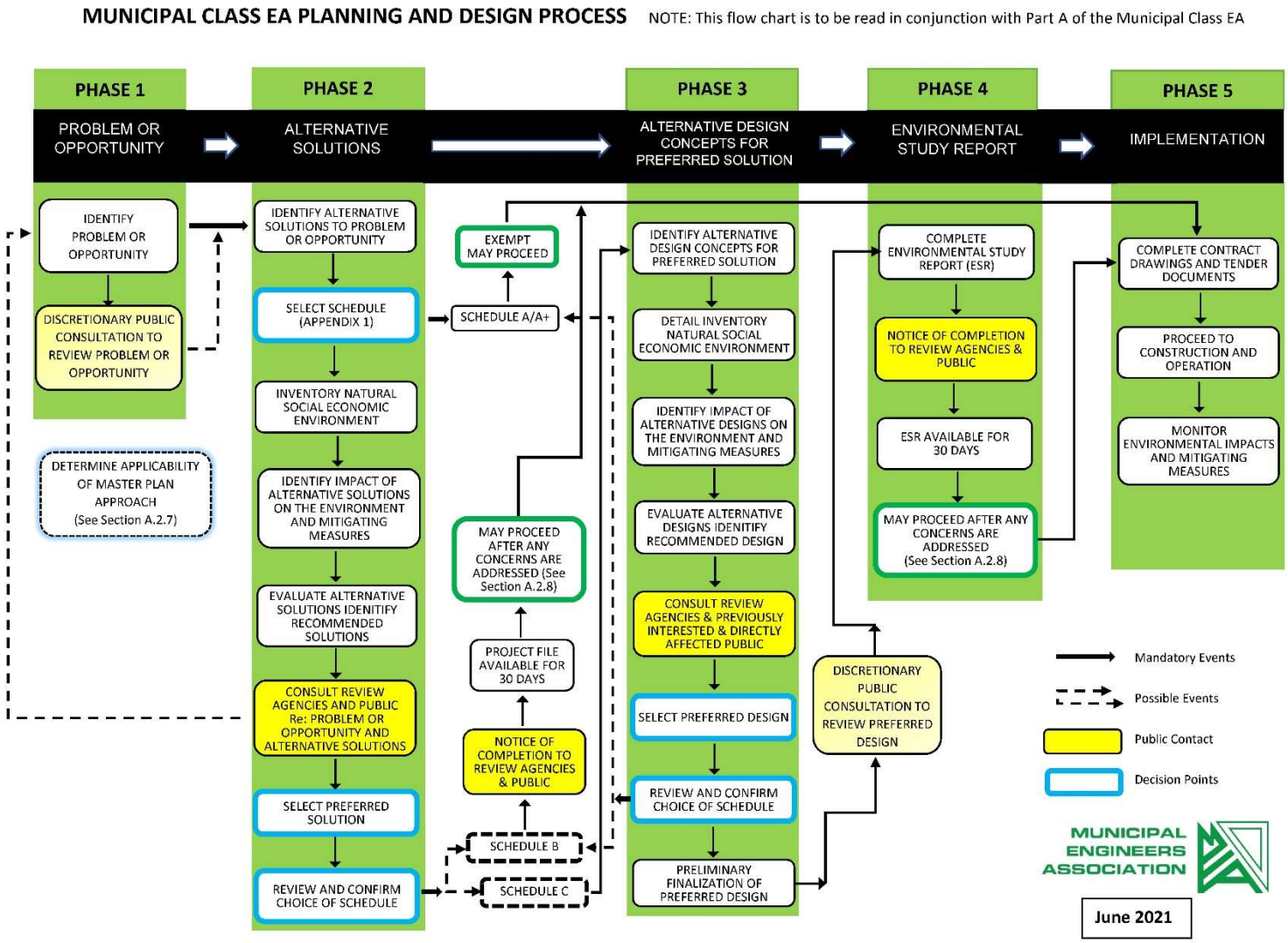

Figure 2. MEA Class EA Process

Based on the MCEA document, projects are classified as either Schedule A, A+, B or C depending on their expected level of environmental impact and public concern. Each of these classifications requires a different level of review to fulfill the requirements of the Class EA.

Schedule A projects are limited in scale, have minimal adverse environmental effects and include a number of municipal maintenance and operational activities. Only Phase 1 of the Class EA process must be completed prior to Phase 5 Implementation.

Schedule A+ projects are similar to Schedule A projects but include an additional consultation component wherein the public is to be advised prior to Phase 5 project implementation. The manner in which the public is advised is to be determined by the proponent.

Schedule B projects have the potential for some adverse environmental effects. The proponent is required to undertake a screening process involving mandatory contact with directly affected public, First Nations groups and relevant government agencies. These projects require completion of Phases 1 and 2 of the Class EA process, before proceeding to Phase 5 Implementation.

Schedule C projects are those that have the potential for significant adverse environmental impact and must proceed under the full planning and documentation procedures (Phases 1 to 5) specified in the MCEA document. A Schedule 'C' project is required to complete an Environmental Study Report (ESR), as opposed to a Project File Report for Schedule 'B' undertakings.

1.3 Project Classification

The MCEA document assists proponents in understanding the status of various projects with reference to environmental impact magnitude, and selection of an appropriate Schedule. Item 17, Schedule 'B' of the Municipal Water and Wastewater Projects section within Appendix 1 of the document, states:

"Works undertaken in a watercourse for the purposes of flood control or erosion control, which may include:

- bank or slope regrading
- deepening the watercourse
- relocation, realignment, or channelization of watercourse"

The preferred works at Harmony Creek Sites 2 & 3 involves realignment of the channel and existing Harmony Creek Trail, implementation of vegetated boulder revetments along the newly realigned channel banks, repair and redesign of the stormwater outfall, and removal of existing, deteriorated gabion baskets. As these works align closely with Item 17, the project is considered to be a Schedule 'B' undertaking. A Schedule 'B' project includes public and review agency consultation, an evaluation of alternatives, identification of a preferred alternative, and outline of measures to mitigate any adverse impacts.

2. Identification of Problems and Opportunities

2.1 Problem Statement

An anomalously large, cobbly point bar along Harmony Creek just downstream of the tributary confluence has deflected the thalweg and concentrated erosive energy along the outer bank toward a stormwater outfall (Site 2) (**Figure 1**). The outfall has been outflanked and undermined, which may lead to its eventual collapse. Adjacent private property at 608 and 612 Camelot Drive are at risk if outer bank erosion continues.

Seventy-five metres downstream of Site 2, a two-tiered gabion wall lines the outer bank of a broad meander (Site 3). The gabion wall protects several properties along Camelot Drive (addresses 596 to 590), including retaining wall and fence infrastructure. The 30 m-long gabion basket wall is deteriorated along its entire length; a number of baskets along the bottom tier have already released their stone and the upper tier has started to sag and lean into the channel. Infrastructure and private property are at risk if the gabion wall continues to deteriorate and eventually fails.

2.2 Opportunities and Objectives

The purpose of this study is to develop alternatives to mitigate erosion and protect stormwater infrastructure and private property along Harmony Creek at Sites 2 & 3. Rehabilitation objectives include the following:

- Protection of municipal infrastructure (i.e., the stormwater outfall) at Site 2.
- Protection of private property adjacent to the meander at Site 3.
- Prevention of further erosion at Sites 2 & 3.
- Minimize future maintenance.
- Minimize capital cost.
- Maintain hydraulic capacity of the creek.
- Minimize environmental impact during construction
- Restoration and enhancement of aquatic and riparian habitat, where feasible.

3. Existing Conditions

3.1 Watershed and Valley Form

Harmony Creek originates on the Oak Ridges Moraine and flows generally southward over the till plain and the former Glacial Lake Iroquois shoreline before draining into Lake Ontario (CLOCA, 2020). Harmony Creek between Rossland Road East and Hillcroft Street has a relatively steep gradient (average of 1.03%) and is surrounded by immature forest (CLOCA, 2020). The Harmony Creek watershed, a subwatershed of the larger Black/Harmony/Farewell watershed, has a drainage area of 47 km^2 (CLOCA, 2020). The Harmony Creek subwatershed becomes predominately urbanized south of Colin Road East and had a recorded land use of 24.8% urban in 2018 (CLOCA, 2020). Land use directly upstream of the study corridor remained agricultural until residential development began between 1974 and 1991. By 2020, the approximately 5 km channel segment upstream of the study corridor was surrounded by urban development.

Within the study corridor, Harmony Creek meanders along the bottom of a well-defined valley (**Figure 1**). The eastern valley wall has a gentle slope compared to the steeper western valley wall. Private property on adjacent tableland locally encroaches on the western valley wall, and valley wall geometry shows obvious signs of anthropogenic modification. Surficial deposits within adjacent tableland consist of fine- and coarse-grained glaciolacustrine deposits (OGS, 2010). Anthropogenic cobble/boulder placement and gabion baskets are locally evident along the study corridor. Continued urbanization combined with previous anthropogenic alterations pose an increased erosional risk to surrounding infrastructure and properties along the reach.

3.2 Topographic Survey

A detailed topographic survey of Harmony Creek encompassing Sites 2 & 3 was undertaken by Palmer in April of 2022. The survey was completed in sufficient detail to complete geomorphic analyses, hydraulic modeling, and preliminary design. The survey captured the following details:

- Longitudinal profile (bed at the thalweg, bottom/top of each bank) of Harmony Creek from the upstream tributary confluence to the pedestrian bridge downstream of Site 3 (**Figure 1)**;
- Cross sections of the bankfull channel at 10-15 m spacing;
- Municipal infrastructure including stormwater outfalls, the Harmony Creek Trail, the gabion wall, and a gabion grade control structure.
- Mature vegetation (>10 cm diameter at breast height (DBH)) potentially impacted as a result of the proposed works;
- Potential construction access and staging areas.

3.3 Channel Morphology

3.3.1 Historical Assessment

In 1927, the study corridor was surrounded by undeveloped, agricultural land, with only minor rural development to the west and Rossland Road to the north. The upstream tributary confluence and the Harmony Creek Trail bridge crossing define the upstream and downstream study corridor extents, respectively (**Figure 3**). The valley walls in the surrounding area were sparsely vegetated with young trees and shrubs. A small access road crossed the channel approximately 350 m downstream of the study corridor. The presence of an abandoned sand/gravel pit, located in the northwest corner of the valley, highlights past (pre-1927) anthropogenic influence.

Between 1927 and 1954, sparse rural development began to the west and north, and the access road crossing the channel was removed. By 1967, urban development had begun to encroach on the study corridor from the south and the west. Between 1967 and 1974, urban expansion continued adjacent to the channel on the south, east, and west side – leaving only land to the north undeveloped. Vegetation was cleared and fill was placed within the valley as part of the residential expansion along Wilson Road North and Cavendish Court (to the west of the channel). During this time, Hillcroft Street (crossing the channel approximately 450 m south of the study corridor) and Camelot Street (crossing the channel approximately 150 m upstream of the study corridor) were constructed. In 1976, a section of channel downstream of the study corridor was realigned in association the construction of Cavendish Court (W.T. Dempsey Ltd., 1976). The upstream tributary was re-aligned to flow into Harmony Creek at the upstream extent of the study corridor and other large sections of channel around the study corridor were straightened to accommodate these land developments.

Residential development around the study corridor continued to densify through the late 1990s and 2000s, reaching full build-out by 2013. A crib wall was constructed within the channel adjacent to Cavendish Court as a means of stabilizing the channel (City of Oshawa, 1998). Development had encroached to the valley edge, increasing risk from natural channel adjustment. Once dominated by meadow vegetation communities (e.g., 1954), the valley is now densely forested, with a predominately deciduous tree canopy that obscures much of the channel planform. Ongoing urbanization in the upper portions of the Harmony Creek watershed continues to modify the hydrological response (‘flashiness’), which is inferred to be contributing to recent erosion and localized increases in risk to property and infrastructure along the valley.

ROSSLAND RD E
ATTERSLEY DR
WILSON RD N
OAKWOOD AVE
CAVENDISH CRT
Harmony Creek Trail
HARMONY CREEK
CAMELOT DR
PERCIVAL CRT
GENTRY CRES
GAYLORD DR
MERLIN CRT
HILLCROFT ST
CAMELOT CRT

Pedestrian bridge crossing

Channel realigned to accomodate fill

TRIBUTARY

0 20 m

0.90
0.22
0.22
0.33

LEGEND:

- Study Corridor Limit
- Erosion Hazard Site
- Flow Direction
- Harmony Creek Meander Belt
- Tributary Meander Belt
- Migration Sites (m/year)
- Harmony Creek Trail
- Cross Section
- Contour (1 m)

Channel Centreline (year)

- 2020
- 2018
- 2010
- 2005
- 1999
- 1974
- 1967
- 1954
- 1927

TITLE:

Historical Changes and Meander Belt

METRE SCALE: 0 5 10 20 30 40 50

NORTH:

CLIENT: City of Oshawa

PRINT SCALE:	1:2200	PRINT SIZE:	11 x 17 "
DATUM:	NAD 1983	PROJECTION:	UTM Zone 17
DATE:	Aug 18, 2022	DRAWN: SM	CHECKED: AS

PREPARED BY: Palmer

PROJECT: Harmony Creek
Site 2-3 Preliminary Design

FIGURE NO.	REVISION:	PROJECT NO.
3	1-1	1510208

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3.3.2 Study Corridor

Harmony Creek flows within a well-defined valley and exhibits evidence of anthropogenic disturbance. Within the study corridor, the channel flows along the eastern portion of the valley. The channel exhibits a sinuous planform with remnant meanders fixed in place by bank hardening (e.g., gabion basket walls). Outer-bank erosion has caused meanders to undermine/outflank infrastructure (Site 2; **Photo 1**) and approach private property (Site 2; **Photo 1** and Site 3; **Photo 2**).

Average bed gradient along the study corridor is 0.85%. Bed gradient within the study corridor is gentler than the local reach-averaged gradient (1.03%), likely due to the grade-control structure at Site 3. Channel gradient along the study corridor is consistent with those typically associated with pool-riffle morphology (e.g., Montgomery and Buffington, 1997). However, historical anthropogenic modification (i.e. channel straightening) of Harmony Creek within the study corridor has resulted in a deviation from typical pool-riffle morphology. Riffles are typically situated downstream of deteriorated or failed erosion control structures and are largely composed of material released from the structures. Pools are located along the outer banks of the meanders present at Sites 2 & 3. Point and medial bars are present, dominantly composed of cobbles at least partly sourced from failed erosion control structures. These bars can promote concentration of erosion along the outer banks.

Photo 1. Undercutting and collapse of the outer (east) bank of a meander is beginning to outflank the stormwater outfall adjacent to private property (608 and 612 Camelot Drive) at Site 2. Note large bar in foreground. Flow: left to right.

Photo 2. A meander coincident with the toe of the gentle eastern valley wall adjacent to private property (596 to 590 Camelot Drive) at Site 3. Upstream view.

Bed material consists of a discontinuous veneer of dispersed anthropogenic stone redistributed from upstream riprap and gabion basket sources, locally embedded with natural alluvial gravels derived from erosion of underlying till (**Figure 4**). Coarsening of the bed via winnowing of fines has resulted in localized lag deposits punctuating the bed. The representative median grain size (D_{50}) within the study corridor was estimated to be 4 cm from the Wolman (1954) pebble count. Bank material within the study corridor consists of loose, fine-grained sediments with some embedded coarse-grained material. Banks without erosion protection (specifically along the outside of meanders) are significantly eroded, driving channel planform adjustment. Bank protection (e.g., gabion baskets) along meanders has started to deteriorate. Abundant woody debris has accumulated along the channel, derived mainly from trees that have fallen into the channel following erosion and undercutting of adjacent banks. Straight-trunked, leaning trees are more common along the banks than 'pistol-butt' trees, indicating growth adjustments are generally being outpaced by bank retreat.

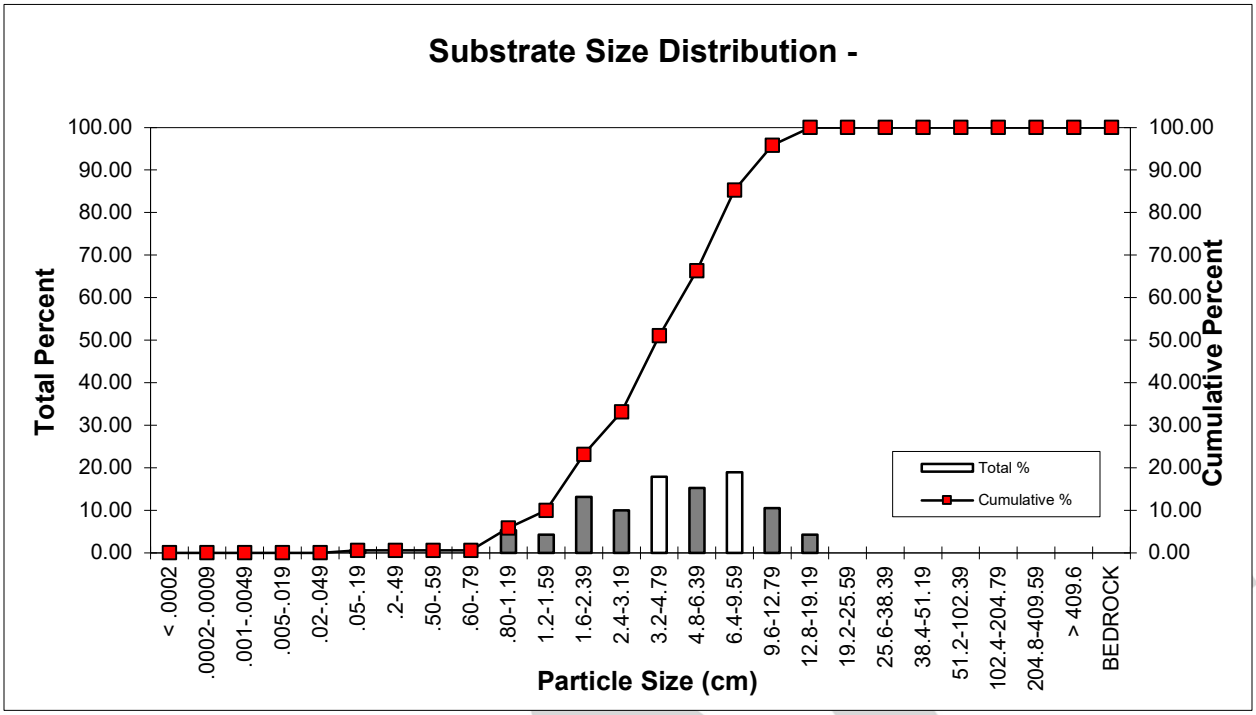

Figure 4. Integrated grain size distribution of bed material from pebble counts (100 count each at Sites 2 & 3) conducted along Harmony Creek.

The results of the RGA suggest that Harmony Creek between Hillcroft Street and Rossland Road is currently "in adjustment" due to evidence of degradation and channel widening (**Table 2**). The results of the RGA suggest that the tributary is "transitional" due to less severe but still frequent evidence of channel widening and degradation. The results of the RSAT indicate Harmony Creek has 'Good' quality, as it has good in-stream habitat, excellent riparian habitat and water quality conditions, and fair channel stability and sediment scouring/deposition (

Table 3). The results of the RSAT indicate the tributary has 'Fair' quality, as it has good water quality; fair channel stability, sediment scouring/deposition, riparian habitat conditions, and biological indicators; and poor physical instream habitat.

Table 2. Summary results of Rapid Geomorphic Assessment (RGA) for Harmony Creek and the tributary between Hillcroft Street and Rossland Road.

	Index	
Form/Process	**tributary**	**Main Branch**
Aggradation	0.14	0.33
Degradation	0.43	0.67
Widening	0.71	0.50
Planimetric Form Adjustment	0	0.14
Stability Index	**0.32**	**0.41**
Classification	**Transitional**	**In Adjustment**

Table 3. Summary results of Rapid Stream Assessment Technique (RSAT) for Harmony Creek and the tributary between Hillcroft Street and Rossland Road.

	Index	
Evaluation Category	**tributary**	**Main Branch**
Channel Stability	4	4
Channel Scouring/Sediment Deposition	4	4
Physical In-stream Habitat	1	5
Water Quality*	5	7
Riparian Habitat Conditions	3	6
Biological Indicators	4	5
Total:	**21**	**31**
Verbal Ranking:	**Fair**	**Good**

* Water quality score is based on CLOCA's watershed report card

Two existing erosion control structures were inventoried along the study corridor, including a gabion wall along an outer bank and a gabion basket on the bed. The structures reflect a history of ongoing erosion control and channel adjustment. The gabion wall and gabion basket were intended to mitigate outer bank erosion and provide grade control, respectively, but both have deteriorated and failed, releasing stone. The gabion wall is directly protecting private property. The structures were constructed prior to the 1990s and consist of 'hard' engineered solutions. The introduction of these smooth and hardened banks more readily accelerates flow and transfers erosive energy downstream. Evidence of the effects of downstream energy transfer from existing erosion control structures has been considered in the development of the conceptual and preliminary designs.

3.3.3 Meander Belt and Migration Rates

The meander belt for Harmony Creek between Rossland Road East and Hillcroft Street was delineated by considering historical meander migration and the local confinement by valley walls (**Figure 3**). The meander belt width is 86 m along the study corridor, including a 20% factor of safety added to the existing belt width. Based on systematic trends observed in the historical channel centerline delineations, a migration rate was calculated at Site 2 (outflanked stormwater sewer) (**Figure 1**). At MS2, systematic erosion began in 2012 and was documented between 2012 and 2020 (**Table 4**).

Table 4. Meander migration rate calculation table based on comparative analysis of historical channel centrelines derived from aerial photography for Harmony Creek

Migration Site (MS)	Start	End	Period	Direction	Distance	Rate
	year	year	years	cardinal	m	m/year
MS2	2012	2020	8	E	1.3	0.2

Note: The migration rate at Site 2 was calculated starting from 2012, as this is when systematic erosion at the site began.

3.3.4 Identification of Erosion Hazard Sites

Erosion along the study corridor is most pronounced along meanders where the channel is eroding into the channel banks and/or along the valley wall. A total of 13 erosion hazard sites were identified and characterized during Palmer's detailed geomorphic analysis (2021). Site 2 was prioritized for more detailed follow-up investigation and the development of conceptual strategies to mitigate erosion-related risks to private property and infrastructure (**Figure 1**). Site 3 was incorporated into the detailed assessment and mitigative concepts for Site 2, due to its proximity.

3.3.5 Harmony Creek Sites 2 & 3

A stormwater outfall and private property are at risk due to fluvial erosion within the channel segment encompassing Sites 2 & 3, located approximately 200 to 300 m downstream of Rossland Road East.

Site 2 encompasses the unprotected outer bank of a slight channel bend that is adjacent to private property and interrupted by a stormwater outfall. Site 2 is located 100 m downstream of the confluence of Harmony Creek and the upstream tributary (**Figure 1**). An oversized point bar exists along the western (inner) bank just upstream of the outfall, likely formed as a result of a large flood event between 2012 and 2013. Although some water flows through a chute that has formed within the point bar, most is deflected towards the eastern (outer) bank at the outfall (**Figure 5**). The modification to channel hydraulics as a result of this bar form promotes erosion of the eastern bank at Site 2. This erosion is observed in the undercutting and bank collapse occurring just upstream of the stormwater outfall (**Photo 1**). The crest of the outer bank is on municipal land adjacent to private property (608 and 612 Camelot Drive) along the entire bend. Continued undercutting of the eastern bank is eventually expected to erode private property. Outer bank erosion (occurring at a rate of approximately 0.16 m per year since 2012, just before the formation of the point bar) has begun to outflank the stormwater outfall (**Photo 1**, **Photo 3**). A deep scour pool has also formed at the stormwater outfall, resulting in pronounced cross sectional asymmetry (**Figure 6**)**.** The outfall now projects approximately 1.5 m into the thalweg and is at risk of being undermined.

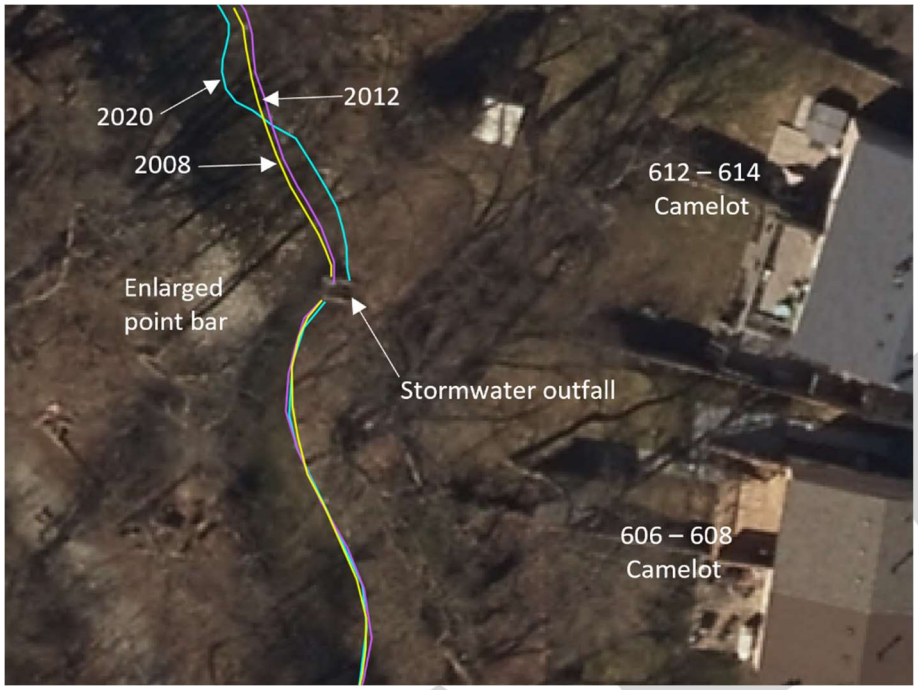

Photo 3. Photo highlights the position of the left bank around Site 2 in 2008, 2012, and 2020. A large flood event between 2012 and 2013 appears to have formed an enlarged point bar upstream of the stormwater outfall, which concentrates erosive energy along the eastern bank and has initiated outflanking of the stormwater outfall. Flow: top to bottom. Photo location not shown in Figure 3.

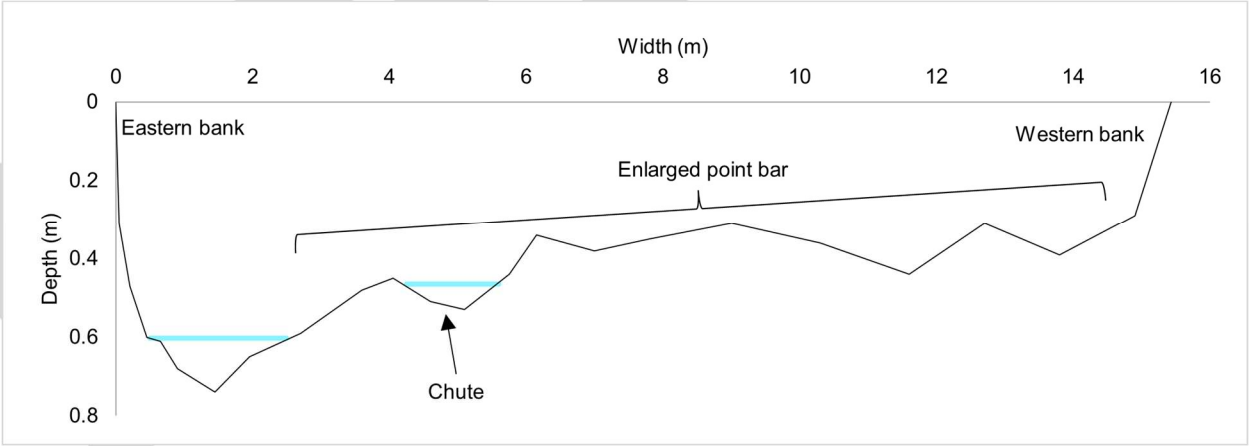

Figure 5. An enlarged point bar just upstream of the stormwater outfall concentrates flow along the left (eastern) bank. Downstream view.

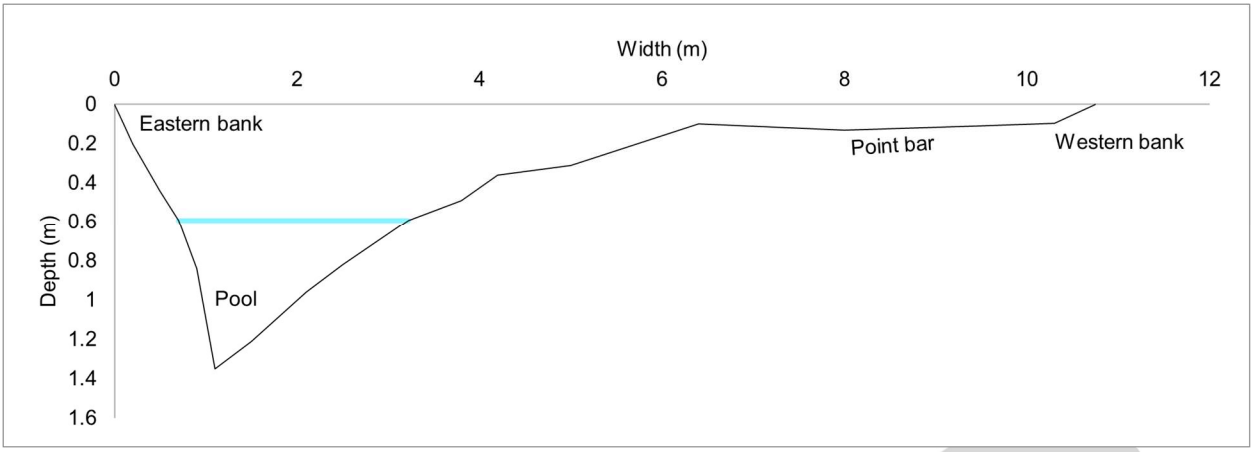

Figure 6. Cross section 2-2. Concentration of erosive energy along the left (eastern) bank has created a deep pool with pronounced cross sectional asymmetry. Stormwater outfall is being outflanked and at risk of being undermined. Downstream view.

Site 3 starts approximately 75 m downstream of Site 2 and encompasses the eastern (outer) bank of a 30 m-long, broad meander reinforced by a two-tiered gabion wall (**Photo 4**). Private property limits are coincident with the eastern bank. The meander geometry along this section maintains the position of the thalweg along the eastern bank, concentrating erosion along the gabion wall (**Figure 7**). The smooth and hardened bank also concentrates erosive energy along the bed, promoting scour and undermining of the gabion wall. The stone has dropped out of some of the constituent gabion baskets with deteriorated wire cages and limited underlying support (**Photo 5**). Though the gabion wall has historically maintained channel planform, private property adjacent to the outer bank is at risk if failure of the gabion wall continues.

Photo 4. Meander geometry at Site 3 concentrates erosive energy along the left (eastern) bank, along the base of the two-tiered gabion wall. Downstream view.

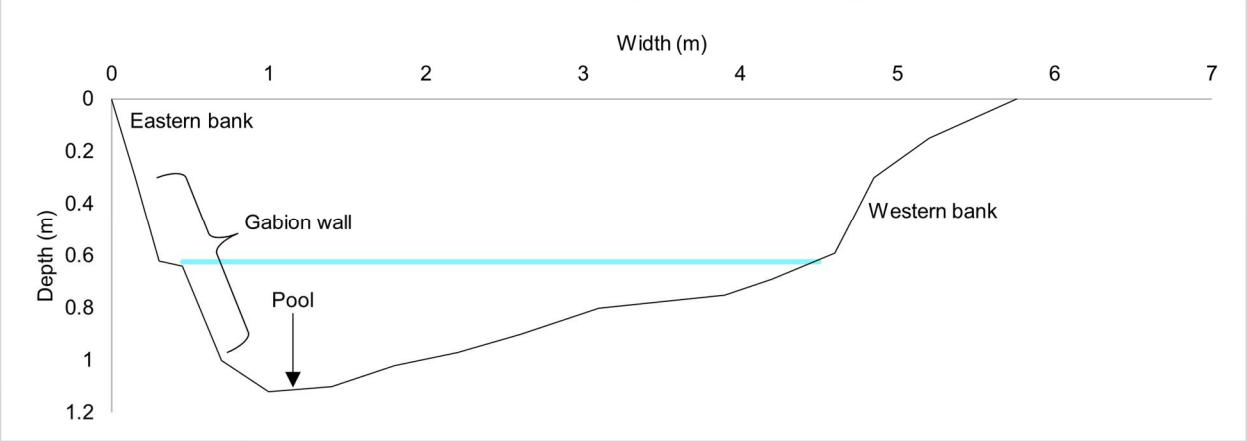

Figure 7. Cross section 3-1. Concentration of erosive energy along the gabion-protected left (eastern) bank has scoured a relatively deep pool. The gabion wall has begun to fail and is at risk of being undermined and collapsing into the channel. Downstream view.

Photo 5. Concentration of erosive energy along the bed and subsequent channel deepening have undermined the gabion basket wall at 594 Camelot Drive, causing stone to drop out of those with deteriorated wire cages. Downstream view.

The average of all surveyed bankfull depths for the entire study reach is 0.6 m and average bankfull width is 7.5 m (

Table 5). The average width-to-depth ratio along the study corridor (12.8) is smaller than channels with similar morphologies to Harmony Creek (15 – 20 m). Average bankfull discharge is 7.9 m^3/s. The critical discharge to mobilize bed materials, averaged across cross sections, is approximately 64% of the bankfull discharge (5.1 m^3/s).

Table 5. Estimated bankfull flow conditions and erosion threshold at surveyed cross sections

Site	XS	Type	Bankfull Hydraulics						Erosion Threshold
			Q_{bfl} (m^3/s)	W_{bfl} (m)	D_{bflA} (m)	D_{bflM} (m)	$W_{bfl}:D_{bflA}$	V_{bfl} (m/s)	Q_{cr} (m^3/s)
2 & 3	1	Run	7.1	8.0	0.6	0.9	14.5	1.6	6.5
	2	Riffle	5.1	6.3	0.5	1.3	13.2	1.7	1.8
	3	Pool	9.9	8.1	0.7	0.8	12.2	1.8	6.5
	4	Riffle	7.0	8.3	0.5	0.7	15.7	1.6	7.0
	5	Riffle	8.6	5.8	0.7	1.1	8.1	2.1	2.5
	6	Pool	9.8	8.5	0.6	0.8	13.3	1.8	6.0
Study Corridor Average			**7.9**	**7.5**	**0.6**	**0.9**	**12.8**	**1.8**	**5.1**

Notes:

1. Abbreviations: XS: cross section, Q_{bfl}: bankfull discharge, W_{bfl}: bankfull width, D_{bflA}: average bankfull depth, D_{bflM}: maximum bankfull depth, V_{bfl}: average bankfull velocity, Q_{cr}: critical discharge.
2. Width-to-depth ratio (e.g., 14.5) calculated simply as the bankfull width (e.g., 8.0 m) divided by the average bankfull depth (e.g., 0.6 m). The reach-average ratio is calculated as the average of the column values as opposed to the average of the quotient of the reach-average widths and depths. Width-to-depth ratios can give an indication of channel stability, as values in the order of 15-20 are common for in-regime channels with morphologies similar to Harmony Creek.
3. Average velocity corresponds to the discharge back-calculated from site-specific channel geometry (cross section and slope) and roughness (Manning's n), using Manning's equation.
4. Critical discharge is calculated using a combination of shear stress, Manning's and continuity equations, as outlined in Section 2.
5. Based on surveyed cross sections, local water surface slopes, and Manning's n values of 0.04.
6. Bankfull discharge and velocity estimates are most reliable for riffle cross sections situated along straight portions of channel free of obstructions.
7. Cross sections at each erosion hazard site ordered from upstream to downstream.
8. Critical discharges above bankfull, such as those included for certain cross sections indicate that the channel lacks competence to mobilize the bed material at bankfull flow. The specific values that exceed bankfull importantly convey the relative erosional sensitivity (or lack thereof) of the channel but should be considered conservative given that they were estimated without detailed overbank topographic information. The energy required to mobilize sediment is instead dispersed into the floodplain.

3.4 Hydrology and Hydraulics

3.4.1 Existing Hydraulic Conditions

A hydraulic analysis of Harmony Creek Sites 2 & 3 was completed using the Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model, which was used to conduct a one-dimensional steady flow analysis for a range of flow events. The existing Harmony Creek HEC-RAS model (Black_Harmony_Farewell_Creek.prj) was provided by CLOCA. The 2-Year, 5-Year, 10-Year, 25-Year, 50-Year, 100-Year and Regional Storm Events were modelled with no revisions to the design flows. Flows for these storms through the study area are shown in **Table 6.** Locations of cross sections in the project area are shown in **Figure 8** (stations 1051.100 through 1335.879).

Figure 8. Location of cross sections through Harmony Creek study site (HEC-RAS 6.2 Geometry Schematic per CLOCA)

Table 6. Harmony Creek existing conditions flows throughout limit of study area (per CLOCA)

Flood Event Return Period	Oshawa Creek Reach 1 Existing Flow (m^3/s)
2 Year	20.87
5 Year	35.13
10 Year	46.41
25 Year	57.64
50 Year	63.18
100 Year	71.67
Regional	132.65

3.4.2 Updated Existing Hydraulic Conditions

Using topographic survey data collected by Palmer in April, 2021, and LiDAR data from the Ontario Digital Terrain Model, the existing CLOCA HEC-RAS model was re-produced to characterize the current 'updated existing' conditions. Appropriate Manning's '*n*' roughness coefficients were used for the overbank floodplain and bankfull channel. The 'updated existing' model was run to establish key hydraulic parameters including water surface elevation (WS Elev), velocity, and shear stress for various storm events. A detailed summary of hydraulic parameters for the existing conditions in Harmony Creek is provided in **Table 7**. For reference, critical velocities capable of mobilizing typical stone materials used in erosion mitigation works are summarized below in

Cross Section	Storm Event	Total Flow	Min. Ch El	W.S. Elev	Vel Chnl	Top Width Chnl	Froude #	Power Chan	Shear Chan
		(m3/s)	(m)	(m)	(m/s)	(m)		(N/ms)	(N/m2)
1335.88	2 Year	20.87	106.05	107.46	2.08	27.4	0.68	112.44	54.14
	5 Year	35.13	106.05	107.68	2.65	31.13	0.8	220.62	83.24
	10 Year	46.41	106.05	107.81	3.06	33.36	0.87	327.68	107.05
	25 Year	57.64	106.05	107.93	3.41	35.32	0.93	439.91	129.02
	50 Year	63.18	106.05	107.98	3.56	36.2	0.95	493.19	138.67
	100 Year	71.67	106.05	108.05	3.74	37.47	0.98	562.68	150.55
	Regional	132.65	106.05	108.45	4.9	44.24	1.14	1172.32	239.25
1273.94	2 Year	20.87	105.43	107.05	2.19	65.14	0.65	121.92	55.6
	5 Year	35.13	105.43	107.22	2.65	66.6	0.73	204.81	77.43
	10 Year	46.41	105.43	107.31	2.95	67.45	0.78	277.66	94.12
	25 Year	57.64	105.43	107.4	3.2	68.2	0.83	346.38	108.36
	50 Year	63.18	105.43	107.44	3.31	68.53	0.85	382.63	115.48
	100 Year	71.67	105.43	107.49	3.49	69	0.88	442.2	126.71
	Regional	132.65	105.43	107.83	4.35	75.09	0.99	805.18	185.01
1204.3	2 Year	20.87	105.11	106.01	0.82	106.8	0.34	8.03	9.76
	5 Year	35.13	105.11	106.04	1.31	106.98	0.52	31.72	24.26
	10 Year	46.41	105.11	106.18	1.36	107.82	0.49	33.41	24.56
	25 Year	57.64	105.11	106.36	1.33	108.9	0.43	28.85	21.76
	50 Year	63.18	105.11	106.43	1.34	109.32	0.42	29.11	21.72
	100 Year	71.67	105.11	106.53	1.36	109.94	0.41	29.57	21.71
	Regional	132.65	105.11	106.97	1.75	112.83	0.45	56.38	32.2
1051.1	2 Year	20.87	103.04	104.07	4.94	12.56	1.83	1615.75	327.19
	5 Year	35.13	103.04	104.85	3.16	23.02	0.82	332.96	105.41
	10 Year	46.41	103.04	105.13	3.27	26.75	0.78	347.92	106.54
	25 Year	57.64	103.04	105.14	4	26.96	0.95	639.3	159.67
	50 Year	63.18	103.04	105.22	4.11	28.06	0.95	681.72	165.84
	100 Year	71.67	103.04	105.34	4.27	29.6	0.96	748.78	175.39
	Regional	132.65	103.04	106.06	4.14	95.03	0.8	616.53	148.91

Table 8.

Table 7. HEC-RAS Hydraulic parameters for Harmony Creek site cross sections

Cross Section	Storm Event	Total Flow	Min. Ch El	W.S. Elev	Vel Chnl	Top Width Chnl	Froude #	Power Chan	Shear Chan
		(m^3/s)	(m)	(m)	(m/s)	(m)		(N/ms)	(N/m^2)
1335.88	2 Year	20.87	106.05	107.46	2.08	27.4	0.68	112.44	54.14
	5 Year	35.13	106.05	107.68	2.65	31.13	0.8	220.62	83.24
	10 Year	46.41	106.05	107.81	3.06	33.36	0.87	327.68	107.05
	25 Year	57.64	106.05	107.93	3.41	35.32	0.93	439.91	129.02
	50 Year	63.18	106.05	107.98	3.56	36.2	0.95	493.19	138.67
	100 Year	71.67	106.05	108.05	3.74	37.47	0.98	562.68	150.55
	Regional	132.65	106.05	108.45	4.9	44.24	1.14	1172.32	239.25
1273.94	2 Year	20.87	105.43	107.05	2.19	65.14	0.65	121.92	55.6
	5 Year	35.13	105.43	107.22	2.65	66.6	0.73	204.81	77.43
	10 Year	46.41	105.43	107.31	2.95	67.45	0.78	277.66	94.12
	25 Year	57.64	105.43	107.4	3.2	68.2	0.83	346.38	108.36
	50 Year	63.18	105.43	107.44	3.31	68.53	0.85	382.63	115.48
	100 Year	71.67	105.43	107.49	3.49	69	0.88	442.2	126.71
	Regional	132.65	105.43	107.83	4.35	75.09	0.99	805.18	185.01
1204.3	2 Year	20.87	105.11	106.01	0.82	106.8	0.34	8.03	9.76
	5 Year	35.13	105.11	106.04	1.31	106.98	0.52	31.72	24.26
	10 Year	46.41	105.11	106.18	1.36	107.82	0.49	33.41	24.56
	25 Year	57.64	105.11	106.36	1.33	108.9	0.43	28.85	21.76
	50 Year	63.18	105.11	106.43	1.34	109.32	0.42	29.11	21.72
	100 Year	71.67	105.11	106.53	1.36	109.94	0.41	29.57	21.71
	Regional	132.65	105.11	106.97	1.75	112.83	0.45	56.38	32.2
1051.1	2 Year	20.87	103.04	104.07	4.94	12.56	1.83	1615.75	327.19
	5 Year	35.13	103.04	104.85	3.16	23.02	0.82	332.96	105.41
	10 Year	46.41	103.04	105.13	3.27	26.75	0.78	347.92	106.54
	25 Year	57.64	103.04	105.14	4	26.96	0.95	639.3	159.67
	50 Year	63.18	103.04	105.22	4.11	28.06	0.95	681.72	165.84
	100 Year	71.67	103.04	105.34	4.27	29.6	0.96	748.78	175.39
	Regional	132.65	103.04	106.06	4.14	95.03	0.8	616.53	148.91

Table 8. Critical Velocity for Typical Bed and Bank Treatments

Boundary Material	*Critical Velocity (m/s)**
300-400 mm Boulders	2.72 – 3.11
400-500 mm Boulders	3.11 – 3.45
500-600 mm Boulders	3.45 – 3.75
1-2 Tonne Armourstone	4.28 – 4.74

Note:
*Velocity threshold at which a particle on a plane bed will begin to move (Komar, 1987)

3.4.3 Proposed Hydraulic Conditions

A proposed HEC-RAS model was developed to assess hydraulic conditions once the erosion mitigation works are implemented, and to ensure the works do not adversely impact flood depths or velocities within Oshawa Creek in the project area. Results from the proposed HEC-RAS modeling are discussed in Section 6.2.

3.5 Terrestrial and Aquatic Ecology

Palmer conducted a tree inventory on May 16, 2022, to inform vegetations impacts resulting from channel design works. Aquatic habitat and terrestrial ecology was based on Palmer's (2021) completion of the detailed fluvial geomorphic analysis and erosion hazard assessment along Harmony Creek between Rossland Road East and Hillcroft Street. During this time, an ecologist from Palmer undertook an aquatic and terrestrial inventory of the property and an initial analysis of conditions and potential impacts, which have been further developed for this preliminary design report.

3.5.1 Tree Inventory

The tree inventory was initially conducted on May 5, 2022, for all trees greater than 10 cm in DBH. A total of 188 trees were inventoried (**Appendix B**), one of which (tree teg: 63) has since been cut down. Information collected during the inventory includes species name, tree tag number, tree size, dripline, general tree health, and location.

3.5.2 Aquatic Habitat

The following aquatic habitat descriptions interpret the aquatic habitat mapping provided in **Appendix C.** The aquatic habitat within the study corridor was surveyed on April 28, 2020, with the conditions reflecting a high-baseflow period and standard habitat conditions for spring spawning fish. This reach of Harmony Creek reflects standard conditions found throughout the section from Rossland Road to Hillcroft Street, with more channelized sections due to the proximity to houses along Camelot Drive.

Habitat conditions for fish are generally contiguous for the entire reach and have some well-developed riffle-run-pool stream morphology, although channelized riffles and runs predominate. Pools and deeper runs are up to 1.0 m deep, with most of the reach averaging only 0.3 m, limiting potential fish habitat available to larger-bodied fish. Given the generally shallow conditions, the location of riffles and runs are likely to change somewhat throughout the year as runs turn to riffles during low water events and vice versa. Bankfull channel width averages 7.7 m and can be as narrow as 5 m in the areas where banks have been anthropogenically modified. The bed materials within the reach are primarily cobble and gravel, with limited organic accumulation due to the frequency of rapid flows and the rarity of deep pools with slackwater areas.

Despite its semi-urban surroundings, the Harmony Creek valley is primarily vegetated with the exception of the Harmony Creek Trail. This vegetation provides riparian cover habitat and buffering potential as it is mostly undisturbed. The reach has a sinuous planform with few remnant meanders, which reflect past

anthropogenic disturbance of the watercourse. Erosion mitigation structures like gabion baskets are used to help stabilize the channel. Barriers to fish passage, both natural log jams and anthropogenic structures (e.g., gabion basket grade control), occur throughout Harmony Creek and limit the potential for fish from Lake Ontario to reach the study reach. The two pedestrian bridges that crosses the creek, along this reach, occupy riparian area and provide some shade, but they offer little benefit to fish habitat availability or quality.

The riparian area is densely vegetated and includes overhanging woody plants and grasses. In some areas, large Weeping Willow *(Salix × sepulcralis)* and Crack Willow *(Salix fragilis)* trees and Red-osier Dogwood and European Buckthorn *(Rhamnus cathartica)* shrubs overhang the watercourse and provide significant in-water cover. Despite the urban location of the study corridor, the riparian area is highly functional due to its protection within a well-defined valley. Gravel bars and the exposed gravelly edges of the creek contain some Creeping Bentgrass *(Agrostis stolonifera),* Jointed Rush *(Juncus articulatus)*, Reed Canary Grass *(Phalaris arundinacaea)*, Common Plantain *(Plantago major*) and Coltsfoot *(Tussilago farfara)*. In-stream vegetation is limited to some submerged Creeping Bentgrass and emergent Reed Canary Grass; the majority of the in-water habitat, however, is devoid of vegetation.

General recommendations to improve fish habitat within the study corridor include:

- Looking for opportunities to deepen pools through proposed channel works;
- Limiting installation of hard structures along channel banks and, where bank stabilization is critical, using natural materials such as large wood, native vegetation, and riverstone to the extent possible; and
- Increasing shading near anthropogenic structures (e.g. bridge crossings) to improve riparian cover and increase allochthonous food sources for aquatic biota in cleared areas.

3.5.2.1 Fisheries Communities

Previous correspondence with CLOCA has indicated that temperature logger data have established Harmony Creek as a coolwater system, while containing fish known to occur in warmwater, coolwater and coldwater systems, including Rainbow Trout *(Oncorhynchus mykiss).* The reach within the study corridor has relatively few pools and features normal water levels that average less than 0.3 m, limiting suitability for larger-bodied fish and potential spawning habitat for warmwater species. Rainbow trout spawning would have the potential to occur based on the presence of sorted gravels and cobble within riffles, but it is unknown if water quality or in-stream barriers hinders suitability. Suitability for warmwater fish spawningis highly limited within this reach, as there is limited pool or in-water vegetation, which generally supports this spawning timing.

Considering the breadth of thermal regime fish species that occur in Harmony Creek, CLOCA should be consulted prior to in-water work to confirm an appropriate timing window based on site-specific data that may have collected to better understand the aquatic function of this reach.

3.5.3 Terrestrial Ecology and Ecological Land Classification (ELC)

The study corridor is located within a naturalized system, which predominantly exhibits a deciduous tree canopy. In the northwest corner of the study corridor, a strip mall and associated parking and lawn abut the valley. The restriction of development from within the valley has allowed vegetation and forest succession to occur since land clearing associated with European settlement of the region. Based on available ELC mapping and related information provided by CLOCA and the Land Information Ontario (LIO) provided by the Ministry of Natural Resources and Forestry (MNRF), no wetland communities of significant size have been mapped in the area (CLOCA, 2022; MNRF, 2021). The site investigation by Palmer similarly did not discover any wetland communities.

Screening for any SAR will be required through Ontario Ministry of the Environment, Conservation and Parks (MECP) in advance of, and to inform, any proposed works along the Harmony Creek valley. Butternut (*Juglans cinerea*) or other SAR vegetation and several species of bats are at risk and may be present, for example, although neither was observed during Palmer's ecological field reconnaissance. No rare vegetation species or vegetation communities (S-ranked 1-3) were found within the valley during field investigations.

With the exception of the creek bed, the cleared and paved Harmony Creek Trail and some manicured lawn in the north near the strip mall, the study corridor is primarily represented by a contiguous forest (**Figure 2**). The creek and riparian areas occur within the forest, with the riparian area being primarily cobble and sandy banks and willow *(Salix spp.)* shrubs within the treed community described below.

3.5.3.1 Ecological Land Classification

Fresh – Moist Willow Lowland Deciduous Forest (FOD7-3)

This forest type represents the primary cover of the contiguous forest across the study corridor. It represents lowland forest occurring along the valley bottom of Harmony Creek, with a canopy that is primarily dominated by non-native canopy trees indicating historical clearing or disturbance. Canopy trees include Crack Willow *(Salix fragilis)*, Golden Weeping Willow *(Salix × sepulcralis)*, Sweet Cherry *(Prunus avium),* White Ash *(Fraxinus americana)*, Basswood *(Tilia americana)* and Manitoba Maple *(Acer negundo)*, with a dense shrub layer of European Buckthorn, Tartarian Honeysuckle *(Lonicera tatarica)* White Mulberry *(Morus alba)*, Multiflora Rose *(Rosa multiflora)* and an understory of Urban Avens *(Geum urbanum)*, Broad-leaved Dock *(Rumex crispus)*, Common Self-heal *(Prunella vulgaris)*, CreepingBellflower *(Campanula rapunculoides)* and European Lily-of-the-valley *(Convallaria majalis)* . In the northern half of the forested valley, some areas contain larger natural Basswood and White Ash trees, with an understory that features a few remnant native mature interior forest species: Canada Bloodroot *(Sanguinaria canadensis)*, Wild Ginger *(Asarum canadense)* and Zig-zag Goldenrod *(Solidago flexicaulis)*.

4. Evaluation of Alternative Solutions

Two individual conceptual alternatives for Sites 2 & 3 are evaluated, in comparison to the 'do nothing' alternative, and an additional alternative is provided that would allow coordinated works at Sites 2 & 3. Alternatives aim to protect the stormwater outfall from being undermined and outflanked, the gabion wall from further deterioration, and preserve the properties from 596 to 612 Camelot Court.

4.1 Site 2

4.1.1 Do Nothing Alternative

This represents the "Do Nothing" strategy without any intervention. Natural fluvial erosion has been influenced by the development of a large cobble point bar opposite a stormwater outfall. The development of the point bar has initiated erosion along the outer bank by deflecting the thalweg and erosive energy toward the outfall. Erosion has outflanked and undermined the outfall, which may result in its eventual collapse. Erosion upstream and downstream of the outfall may result in a loss of private property at 608 and 612 Camelot Drive. Without intervention, the developing meander will further exacerbate erosion along the outer bank, affecting municipal infrastructure, as sinuosity increases. The "Do Nothing" alternative is unacceptable.

4.1.2 Alternative 1: Mirror Meander and Vegetated Boulder Revetment

This concept involves local realignment of Harmony Creek approximately along its 1954 alignment, mirroring the existing meander. Mirroring the meander would increase separation distance and alleviate risk to private property and the stormwater outfall while maintaining channel length. The channel cross section would be narrowed to restore natural channel form and function and match upstream and downstream widths. A vegetated boulder revetment would be required along the western bank to protect the Harmony Creek Trail. The outfall would be repaired and designed to outlet at an acute angle to smoothly tie in at the downstream extent of the proposed realignment. The existing channel would be backfilled with clean fill and compacted to minimize the risk of erosion and reoccupation during floods and ensure cut and fill are balanced.

4.1.3 Alternative 2: Channel Narrowing and Vegetated Boulder Revetment

Alternative 2 involves protecting the outfall in place and narrowing the channel cross section to re-establish a more natural channel form. Vegetated boulder revetment would protect the east (outer) bank and outfall. The revetment would be approximately 20 m in length and extend far enough upstream and downstream to minimize risk of further outflanking. The bank would be smoothed to broaden the meander, limiting potential for the revetment to deflect flow toward the opposite bank and increase risk to the trail. It is expected that the undermined section of outfall will be removed and that a new headwall constructed with a setback from the outer bank. The large cobble bar would be removed to reinstate a more natural channel width and accommodate projection of the revetment into the channel instead of into adjacent private property. A low floodplain bench would be constructed along the inner bank as part of cross section resizing to maintain cut and fill balance and help dissipate erosive energy.

4.1.4 Evaluation of Concept Alternatives

A basic evaluation of alternatives for Site 2 (**Table 9**) was conducted based on consideration of local hydraulic implications, anticipated geomorphological adjustments (and related risks to people, property, and/or infrastructure), local aquatic and terrestrial ecology, permitting requirements[1], and approximate capital and maintenance costs.

[1] *Key environmental approvals/permits include: CLOCA permit for development, interference with wetlands and alterations to shorelines and watercourses; DFO Request for Review (RfR); and MNRF fish collection permit. Species at Risk (SAR) screening has been transferred from MNRF to Ministry of the Environment, Conservation and Parks.*

Table 9. Erosion Mitigation Concept Evaluation – Site 2

Objective	Criteria	Comment	Do Nothing	Alternative 1 Mirror Meander and Vegetated Boulder Revetment	Alternative 2 Channel Narrowing and Vegetated Boulder Revetment	Notes
Physical and Natural Environment	Flooding	Impact on surface drainage, flooding; meet legislated criteria for flooding and water	3	3	3	Both concepts would alter planform and cross sectional geometry. Proposed changes to the cross section would restore a more natural width:depth ratio. A low floodplain bench associated with narrowing would avoid any adverse impacts to flood storage/conveyance. An update to the HEC-RAS model will be required in association with detailed design.
	Erosion	Impacts on soils, geology, rate of erosion	1	4	4	Both concepts would help reinstate natural channel form and function (e.g. sediment transport). The concepts would address existing erosion concerns and not impact erosional processes downstream.
	Terrestrial Habitat	Impact on connectivity, diversity and sustainability	2	4	4	Alternatives 1 and 2 would result in localized short-term impacts to riparian vegetation, including mature trees.
	Aquatic Habitat	Impact on connectivity, spawning and sustainability	3	5	5	Both concepts would maintain existing bed characteristics (well sorted gravel and cobble matrix), where possible, and/or enhance bed habitat through natural channel design to maintain potential Rainbow Trout spawning areas. Alternatives 1 and 2 incorporate live stakes (vegetated boulder revetment) for channel-edge habitat cover and diversity.
Social/Cultural Environment	Aesthetic Value	Impact on existing and proposed development aesthetic value	1	4	4	The inclusion of a vegetated boulder revetment and local improvements would improve the aesthetic of erosion mitigation measures (Alternatives 1 and 2).
	Benefit to Community	Access to trails, enjoyment of valley	3	2	2	Conservatively assumes construction activities for each concept could disrupt nearby park users and necessitate temporary partial and/or full closure of the trail.
	Archaeological Features	Impacts on existing archaeological features	N/A	N/A	N/A	
Technical Criteria	Regulatory Agency Acceptance	Satisfy CLOCA, DFO, MNRF and MECP mandates	5	3	3	Both concepts would require regulatory approvals associated with in-stream work, floodplain cut and tree removals. In-stream works would trigger a need for DFO review. Consultation with MECP is required for all concepts to determine if any Species at Risk (SAR) have been reported within the study area.
Financial Criteria	Capital Costs	Rough Order Magnitude (ROM) capital costs for the detailed design, permitting and installing proposed concept	5	2	4	Do Nothing would not address erosion risk and may result in emergency works and/or additional construction costs in the long-term. Alternatives 1 has slightly higher cost associated with a longer revetment and increased cut. Alternative 2 has a shorter length of revetment but requires a new set-back headwall and fill to narrow the channel.
	Maintenance Costs	Rough Order of Magnitude costs to maintain the proposed structure	1	3	3	Alternatives 1 and 2 may require additional maintenance requirements to ensure that the trail and outfall structure are protected and stone revetments are functioning as designed.
Constructability	Complexity of Treatment	Requirement for specialized services to design or install unique or proprietary specifications that must be completed by a certified contractor/consultant	5	3	3	Emergency works could be completed by non-specialists in channel works. Each concept would require implementation by those experienced in natural channel works.
Risk	Potential Risks to Existing Infrastructure	Protection or potential exposure of infrastructure (fence, wall, building, etc.)	1	5	4	Alternative 1 repositions the channel such that the stormwater outfall is situated along the inner bank, where erosion risk is reduced, providing long-term protection. Alternative 2 protects the outfall in place but erosive forces are still concentrated near the outfall structure.
	Potential Risks to Public	Impact on public safety and requirement for safety features (e.g., safety fences)	1	4	3	Each concept would address erosion concerns in close proximity to the trail and private properties, thereby improving public safety.
	Potential Risks to Private Property	Potential for loss of p recession				rd 608 and 612 Camelot Drive. Failure e property. Alternative 1 would create ut maintain erosional forces along f properties from erosion-related
Total Score:						
Combined Rank:						

Note: For each alternative concept, the criteria are evaluated such that higher scores are related to varying degrees of positive effect that an alternative, for the defined criteria, would have on the outcome. In general, the following scoring can be used – 1 = unfavourable, 2 = Satisfactory 3 = acceptable, 4 = positive and 5 = favourable – such that the sum of criteria can be scored for each alternative, with the highest score deemed to be preferred.

4.2 Site 3

4.2.1 Do Nothing Alternative

Without intervention, a 30 m-long section of private properties along Camelot Drive (addresses 596, 594 and 590) is at risk from erosion if an existing gabion basket wall continues to deteriorate and fail. A number of baskets have already released stone along the bottom tier. The upper tier has started to sag and lean into the channel. If the wall were to fall into the channel, flow would outflank the structure and scour unprotected banks, posing a risk to retaining walls and fences situated behind the gabions. The wall, although deteriorated along its entire length, still provides adequate erosion protection.

4.2.2 Alternative 1: Mirror Meander and Vegetated Boulder Revetment

Alternative 1 would mirror the existing meander, centring it along the valley bottom and drawing erosive energy away from private properties. A riffle is proposed at the downstream extent to inhibit upstream migration of a knickpoint that may form as a result of the failed gabion basket grade control immediately downstream. The failed gabion basket would be removed. To accommodate the proposed channel alignment, the Harmony Creek Trail would be realigned as well. The trail would follow the proposed channel alignment and be separated by a 5 to 10 m buffer to avoid the need for 'hard' bank protection. The existing channel would be backfilled with clean fill and compacted to prevent reoccupation during overbank flood events. The proposed channel, based on natural channel design principles, would be naturalized with pool-riffle sequences and vegetated banks. Channel length would be maintained to ensure no in-stream aquatic habitat is lost.

4.2.3 Alternative 2: Channel Narrowing and Vegetated Boulder Revetment

This concept involves the construction of a vegetated boulder revetment to replace the existing, deteriorated gabion basket wall protecting private properties along Camelot Drive (addresses 596 to 590). The revetment would be approximately 60 m long and extend further upstream and downstream of the existing gabion basket wall to minimize risk of outflanking. The revetment would be founded below the channel bed to accommodate anticipated scour. A grade control riffle would be constructed at the downstream extent to tie-in with existing channel and prevent upstream knickpoint migration. The failed gabion basket would be removed. A compensatory inner bank cut would offset the projection of the regraded bank into the channel. The proposed cut would result in a wider cross section to reduce shear stresses along the outer bank.

4.2.4 Evaluation of Concept Alternatives

A basic evaluation of alternatives for Site 2 (**Table 10**Error! Reference source not found.) was conducted based on consideration of local hydraulic implications, anticipated geomorphological adjustments (and related risks to people, property, and/or infrastructure), local aquatic and terrestrial ecology, permitting requirements[2], and approximate capital and maintenance costs.

[2] *Key environmental approvals/permits include: CLOCA permit for development, interference with wetlands and alterations to shorelines and watercourses; DFO Request for Review (RfR); and MNRF fish collection permit. Species at Risk (SAR) screening has been transferred from MNRF to Ministry of the Environment, Conservation and Parks.*

Table 10. Erosion Mitigation Concept Evaluation – Site 3

Objective	Criteria	Comment	Do Nothing	Alternative 1 Mirror Meander and Trail Realignment	Alternative 2 Channel Widening and Vegetated Boulder Revetment	Notes
Physical and Natural Environment	Flooding	Impact on surface drainage, flooding; meet legislated criteria for flooding and water	3	4	4	Both concepts would alter planform and/or cross sectional geometry. Proposed changes to the cross section would restore a more natural width:depth ratio. An update to the HEC-RAS model will be required to reflect changes to the channel and floodplain.
	Erosion	Impacts on soils, geology, rate of erosion	1	4	4	Do Nothing would allow erosional processes to continue, increasing risk to private property, and Alternative 1 would eliminate fluvial scour near private properties. Alternative 2 would provide long-term erosion protection. Assumes each concept would not impact erosional processes downstream.
	Terrestrial Habitat	Impact on connectivity, diversity and sustainability	3	2	5	Alternative 1 would require a greater area of disturbance/vegetation removal, associated with channel and trail realignment. Alternative 2 would result in localized short-term impacts to riparian vegetation, including mature trees.
	Aquatic Habitat	Impact on connectivity, spawning and sustainability	3	4	4	Both concepts would maintain existing bed characteristics (well sorted gravel and cobble matrix), where possible, and/or enhance bed habitat through natural channel design to maintain potential Rainbow Trout spawning areas. Alternatives 1 and 2 would incorporate vegetated banks via live stakes (vegetated boulder revetment) and/or brush layers for channel-edge habitat cover and diversity.
Social/Cultural Environment	Aesthetic Value	Impact on existing and proposed development aesthetic value	2	4	4	Alternatives 1 and 2 would eliminate need for 'hard' bank armouring associated with mitigative works. Replacement of gabion basket with vegetated boulder revetment would improve the aesthetic of the erosion mitigation structure. Realigned channel and trail offer the greatest opportunity for improving aesthetic value
	Benefit to Community	Access to trails, enjoyment of valley	3	2	2	Conservatively assumes construction activities for each concept could disrupt nearby park users and necessitate temporary partial and/or full closure of the trail.
	Archaeological Features	Impacts on existing archaeological features	N/A	N/A	N/A	
Technical Criteria	Regulatory Agency Acceptance	Satisfy CLOCA, DFO, MNRF and MECP mandates	3	3	3	Each concept would require regulatory approvals associated with in-stream work, floodplain cut and tree removals. In-stream works would trigger a need for DFO review. Consultation with MECP is required for all concepts to determine if any Species at Risk (SAR) have been reported within the study area.
Financial Criteria	Capital Costs	Rough Order Magnitude (ROM) capital costs for the detailed design, permitting and installing proposed concept	5	3	4	Alternative 1 would require localized channel and trail realignment. Alternative 2 would increase the length of bank protection, necessitating excavation of the inner bank. Do Nothing assumes no in-channel remedial works will be implemented.
	Maintenance Costs	Rough Order of Magnitude costs to maintain the proposed structure	1	4	4	Do Nothing may necessitate emergency works and/or increased maintenance frequency if not robustly designed or implemented; Alternative 1 would minimize maintenance requirements by creating additional separation between channel and at-risk properties. Alternative 2 would reduce maintenance requirements compared to those associated with the existing gabion basket wall.
Constructability	Complexity of Treatment	Requirement for specialized services to design or install unique or proprietary specifications that must be completed by a certified contractor/consultant	5	3	3	Both concepts would require implementation by those experienced in natural channel works.
Risk	Potential Risks to Existing Infrastructure	Protection or potential exposure of infrastructure (fence, wall, building, etc.)	1	5	4	Alternative 1 would mitigate existing erosion risk and future impacts to private property. Alternative 2 would mitigate erosion risk but not create long-term separation between private property and fluvial scour.
	Potential Risks to Public	Impact on public safety and requirement for safety features (e.g., safety fences)	1	4	4	Alternative 1 would address erosion concerns and increase separation distance between private property and the trail. Alternative 2 would address erosion concerns in close proximity to the private properties, thereby improving public safety.
	Potential Risks to Private Property	Potential for loss of private property due to bank recession	1	5	4	Without intervention, the private properties from 596 to 590 Camelot Drive are at-risk if the deteriorated gabion basket wall fails. Each concept would provide long-term protection. Alternative 1 would additionally draw erosive energy well away from the properties.
Total Score:			**32**	**47**	**49**	
Combined Rank:			3	2	1	Alternative 2 is the preferred mitigative solution.

Note: For each alternative concept, the criteria are evaluated such that higher scores are related to varying degrees of positive effect that an alternative, for the defined criteria, would have on the outcome. In general, the following scoring can be used – 1 = unfavourable, 2 = Satisfactory 3 = acceptable, 4 = positive and 5 = favourable – such that the sum of criteria can be scored for each alternative, with the highest score deemed to be preferred.

4.3 Sites 2 & 3 Coordination

4.3.1 Alternative 3 – Channel and Trail Realignment

Alternative 3 coordinates works described in the preferred alternatives for Sites 2 & 3. Coordination would allow the City to avoid repeated disturbance, reduce cost through economies of scale and implement sub-reach scale design that promotes continuity in channel form and function. Channel realignment would reposition the creek toward the center of the valley bottom, eliminating risk to the outfall and private properties. Channel realignment would require local realignment of the Harmony Creek Trail. The channel would smoothly tie in with the gabion-lined meander, at its downstream extent, to avoid moving the existing bridge crossing. Channel realignment, based on natural channel design principles, affords the opportunity to use a relatively 'soft' approach to bank protection. A sinuous planform would be constructed to maintain and/or slightly increase channel length to the extent possible. The existing channel would be backfilled with clean fill and compacted to prevent reoccupation during overbank flood events.

4.3.2 Coordination of Additional Works

It is recommended that the City explore repairing and/or replacing deteriorated abutments of the pedestrian bridge while proposed works at Sites 2 & 3 are taking place to avoid additional disturbance to the creek and park users in the near future. The city's 2019 bi-annual inspection report of the pedestrian bridge (Structure No. 6-2033C) noted that the side slopes should be repaired in the next 1 to 5 years (2020 to 2024). The report recommends that support beams should be replaced in 10 years (2029). The bridge span and position should be re-examined during preliminary design.

4.3.3 Evaluation of Concept Alternative

A basic evaluation of alternatives for Site 2 (**Table 11**Error! Reference source not found.) was conducted based on consideration of local hydraulic implications, anticipated geomorphological adjustments (and related risks to people, property, and/or infrastructure), local aquatic and terrestrial ecology, permitting requirements[3], and approximate capital and maintenance costs.

[3] *Key environmental approvals/permits include: CLOCA permit for development, interference with wetlands and alterations to shorelines and watercourses; DFO Request for Review (RfR); and MNRF fish collection permit. Species at Risk (SAR) screening has been transferred from MNRF to Ministry of the Environment, Conservation and Parks.*

Table 11. Erosion Mitigation Concept Evaluation – Sites 2 & 3 Coordination

Objective	Criteria	Comment	Do Nothing	Site 2 - **Alternative 1** *(preferred)* Mirror Meander and Vegetated Boulder Revetment	Site 3 - **Alternative 2** *(preferred)* Channel Widening and Vegetated Boulder Revetment	**Alternative 3** Channel and Trail Realignment	Notes
Physical and Natural Environment	Flooding	Impact on surface drainage, flooding; meet legislated criteria for flooding and water	3	4	4	4	Each concept would alter planform and cross sectional geometry. Proposed changes to the cross section would restore a more natural width:depth ratio An update to the HEC-RAS model will be required in association with detailed design.
	Erosion	Impacts on soils, geology, rate of erosion	1	4	4	4	each concept would help reinstate natural channel form and function (e.g. sediment transport). The concepts would address existing erosion concerns and not impact erosional processes downstream.
	Terrestrial Habitat	Impact on connectivity, diversity and sustainability	2	4	4	2	Alternatives 1 and 2 would result in localized short-term impacts to riparian vegetation, including mature trees. Alternative 3 requires a greater area of disturbance/vegetation removal in association with channel and trail realignment. Extensive tree removal allows for the removal of non-native species.
	Aquatic Habitat	Impact on connectivity, spawning and sustainability	3	4	4	5	Each concept would maintain existing bed characteristics (well sorted gravel and cobble matrix), where possible, and/or enhance bed habitat through natural channel design to maintain potential Rainbow Trout spawning areas. Alternatives 1 and 2 incorporate live stakes (vegetated boulder revetment) for channel-edge habitat cover and diversity. Alternative 3 would include a naturalized pool-riffle sequence along the realigned section.
Social/Cultural Environment	Aesthetic Value	Impact on existing and proposed development aesthetic value	1	4	4	3	The inclusion of a vegetated boulder revetment and local improvements would improve the aesthetic of erosion mitigation measures (Alternatives 1 and 2). Alternative 3 requires extensive mature *riparian* vegetation removal, which counteracts *in-stream* aesthetics improvements.
	Benefit to Community	Access to trails, enjoyment of valley	3	2	2	2	Conservatively assumes construction activities for each concept could disrupt nearby park users and necessitate temporary partial and/or full closure of the trail.
	Archaeological Features	Impacts on existing archaeological features	N/A	N/A	N/A	N/A	
Technical Criteria	Regulatory Agency Acceptance	Satisfy CLOCA, DFO, MNRF and MECP mandates	5	3	3	3	Each concept would require regulatory approvals associated with in-stream work, floodplain cut and tree removals. In-stream works would trigger a need for DFO review. Consultation with MECP is required for all concepts to determine if any Species at Risk (SAR) have been reported within the study area.
Financial Criteria	Capital Costs	Rough Order Magnitude (ROM) capital costs for the detailed design, permitting and installing proposed concept	5	2	3	4	Do Nothing would not address erosion risk and may result in emergency works and/or additional construction costs in the long-term. Alternatives 1 and 2 have similar lower costs associated with a smaller work area, similar length of revetement and no trail realignment. Alternative 3 has the highest estimated construction cost, although less expensive than the combined cost of Sites 2 & 3, in association with cut of the new channel alignment. It would, however, address two high priority erosion sites, restore a larger portion channel and reinstate naturalized pool-riffle morphology.
	Maintenance Costs	Rough Order of Magnitude costs to maintain the proposed structure	1	3	3	4	Alternatives 1 and 2 may require additional maintenance requirements to ensure that the trail and outfall structure are protected and stone revetments are functioning as designed. Alternative 3 would require reduced maintenance as the trail and outfall would be positioned away from the channel banks.
Constructability	Complexity of Treatment	Requirement for specialized services to design or install unique or proprietary specifications that must be completed by a certified contractor/consultant	5	3	3	3	Emergency works could be completed by non-specialists in channel works. Each concept would require implementation by those experienced in natural channel works.
Risk	Potential Risks to Existing Infrastructure	Protection or potential exposure of infrastructure (fence, wall, building, etc.)	1	5	4	5	Alternatives 1 and 3 reposition the channel such that the stormwater outfall is situated along the inner bank, where erosion risk is reduced, providing long-term protection. Alternative 2 would mitigate erosion risk but not establish long-term separation between private property and fluvial scour.
	Potential Risks to Public	Impact on public safety and requirement for safety features (e.g., safety fences)	1	3	4	4	Each concept would address erosion concerns in close proximity to the trail and private properties, thereby improving public safety.
	Potential Risks to Private Property	Potential for loss of private property due to bank recession	1	4	4	5	Without intervention, erosion at Site 2 will continue to toward 608 and 612 Camelot Drive. Failure of the stormwater outfall may also negatively impact private property. At Site 3, private properties from 596 to 590 Camelot Drive are at-risk if the deteriorated gabion basket wall fails. Alternative 1 would create additional separation. Alternative 2 would protect in place but maintain erosional forces along property limit. Alternative 3 would protect all private properties and infrastructure from erosion-related risks.
Total Score:			**32**	**45**	**46**	**48**	
Combined Rank:			4	2	2	1	Alternative 3 is the preferred mitigative solution should the City choose to coordinate restorative works

Note: For each alternative concept, the criteria are evaluated such that higher scores are related to varying degrees of positive effect that an alternative, for the defined criteria, would have on the outcome. In general, the following scoring can be used – 1 = unfavourable, 2 = Satisfactory 3 = acceptable, 4 = positive and 5 = favourable – such that the sum of criteria can be scored for each alternative, with the highest score deemed to be preferred.

4.4 Selection of Preferred Alternative

At Site 2, an existing stormwater outfall has been outflanked and undermined, which may lead to its eventual collapse. Adjacent private property at 608 and 612 Camelot Drive are at risk if outer bank erosion continues. Seventy-five metres downstream of Site 2, a two-tiered gabion wall lines the outer bank of a broad meander (Site 3). The 30 m-long gabion basket wall is deteriorated along its entire length; a number of baskets along the bottom tier have already released their stone and the upper tier has started to sag and lean into the channel. Infrastructure and private property are at risk if the gabion wall continues to deteriorate and eventually fails. Concept 3 (Channel and Trail Realignment) is the preferred option to mitigate the observed erosion risks, based on the reduced area of disturbance, Rough Order of Magnitude (ROM) costs and elimination of fluvial/valley wall interaction.

5. Public Consultation

This Study is being carried out under *Schedule B* in accordance with the requirements of the MEA's *Municipal Class Environmental Assessment for Municipal Projects*. The Study process includes identification of problems and solutions, an inventory of existing conditions, measures to mitigate adverse impacts and public consultation. The Project Team has invited public input and comments and will incorporate them into the planning and design of this project. Project information, background studies, mitigation options and the preferred concept will be posted online on the City's website to provide an opportunity for the public to review and comment on the study findings. The project Notice of Commencement and list of stakeholders is included in **Appendix E.**

5.1 Public Information Centre

A Public Information Centre (PIC) for this project is scheduled for September of 2022. The open house presentation material will outline the following items:

- Overview of the study area;
- Problem definition;
- Review of technical assessments and results;
- Major erosion risks identified by the study; and
- Conceptual alternatives and preliminary evaluation

6. Preliminary Design of Preferred Alternative

6.1 SUE Level C

A Subsurface Utility Engineering (SUE) Quality Level D and C investigation was completed by Mutiview Locates Inc. in June 2022. The following work was completed:

- Existing utility records search (QL-D).
- Above ground utility survey (QL-C) of visible above ground utility features
- Measurement of pipe inverts and pipe opening diameter for sewer piping at each accessible manhole/catch basin within the project area. Inverts measured from grade level at chamber opening.
- Using differential GPS system, survey of the spatial position of field markings where site conditions allow.

Multiview is currently in the process of compiling the collected data. Results will be presented in the Final Preliminary Design Package.

6.2 Hydrology and Hydraulics

The proposed works require a channel realignment and modifications to the channel cross sectional area; therefore, a review and analysis of channel hydraulics was completed, using the HEC-RAS model previously discussed in Section 3.4. To model the new bank restoration works, a ‘proposed’ conditions scenario was created using the ‘updated existing’ model as a base. The proposed channel realignment, riffle-pool sequence and armourstone wall geometry were incorporated into cross sections within the Harmony Creek HEC-RAS model to investigate the impact the works may have on flood levels and/or channel hydraulics.

A summary of the hydraulic changes within the proposed design is provided in **Table 12.**

Table 12. Hydraulic changes between existing and proposed conditions

Cross Section	Storm Event	Q Total (m^3/s)	Flood Elevation			Channel Velocity			Channel Shear Stress		
			Existing	Proposed	Change in Flood Elevation	Existing	Proposed	Change in Velocity	Existing	Proposed	Change in Shear
			(m)	(m)	(m)	(m/s)	(m/s)	(m/s)	(N/m^2)	(N/m^2)	(N/m^2)
1335.88	2 Year	20.87	107.47	107.54	0.07	2.07	1.86	-0.21	53.7	42.54	-11.16
	5 Year	35.13	107.69	107.74	0.05	2.64	2.5	-0.14	82.2	72.73	-9.47
	10 Year	46.41	107.82	107.88	0.06	3.04	2.87	-0.17	105.56	92.16	-13.4
	25 Year	57.64	107.94	108	0.06	3.39	3.17	-0.22	127.17	109.72	-17.45
	50 Year	63.18	107.99	108.05	0.06	3.53	3.31	-0.22	136.44	118.1	-18.34
	100 Year	71.67	108.06	108.12	0.06	3.72	3.51	-0.21	148.72	131.11	-17.61
	Regional	132.65	108.46	108.5	0.04	4.86	4.71	-0.15	234.8	219.44	-15.36
		0	0	0		0	0		0	0	
1273.94	2 Year	20.87	107.05	106.9	-0.15	2.19	2.21	0.02	55.6	65.23	9.63
	5 Year	35.13	107.22	107.1	-0.12	2.65	2.18	-0.47	77.43	82.56	5.13
	10 Year	46.41	107.31	107.18	-0.13	2.95	2.4	-0.55	94.12	95.23	1.11
	25 Year	57.64	107.4	107.24	-0.16	3.2	2.6	-0.6	108.36	115.23	6.87
	50 Year	63.18	107.44	107.28	-0.16	3.31	2.64	-0.67	115.48	125.12	9.64
	100 Year	71.67	107.49	107.34	-0.15	3.49	2.67	-0.82	126.71	135.22	8.51
	Regional	132.65	107.83	107.69	-0.14	4.35	2.93	-1.42	185.01	191.11	6.1
		0	0	0		0	0		0	0	
1204.3	2 Year	20.87	106.01	106.01	0	0.82	0.82	0	9.76	9.76	0
	5 Year	35.13	106.03	106.03	0	1.32	1.32	0	24.61	24.61	0
	10 Year	46.41	106.17	106.17	0	1.37	1.37	0	24.98	24.98	0
	25 Year	57.64	106.34	106.34	0	1.36	1.36	0	23.09	23.09	0
	50 Year	63.18	106.4	106.4	0	1.38	1.38	0	23.12	23.12	0
	100 Year	71.67	106.51	106.51	0	1.4	1.4	0	23.13	23.13	0

Cross Section	Storm Event	Q Total (m^3/s)	Flood Elevation			Channel Velocity			Channel Shear Stress		
			Existing	Proposed	Change in Flood Elevation	Existing	Proposed	Change in Velocity	Existing	Proposed	Change in Shear
			(m)	(m)	(m)	(m/s)	(m/s)	(m/s)	(N/m^2)	(N/m^2)	(N/m^2)
	Regional	132.65	106.95	106.95	0	1.77	1.77	0	33.05	33.05	0
		0	0	0		0	0		0	0	
1051.1	2 Year	20.87	104.46	104.46	0	2.87	2.87	0	96.13	96.13	0
	5 Year	35.13	104.85	104.85	0	3.17	3.17	0	105.98	105.98	0
	10 Year	46.41	105.12	105.12	0	3.28	3.28	0	107.39	107.39	0
	25 Year	57.64	105.14	105.14	0	4	4	0	159.67	159.67	0

The hydraulic analysis demonstrates that proposed works increase the Regional Flood elevation by up to 0.04 m at cross section 1335.88 and decrease the Regional Flood elevation by 0.14 m at cross section 1273.94. Water surface elevation reductions of up to 0.16 m are observed during the 50-Year flood event at Section 1273.94, while increases of up to 0.07 m are observed during the 2-Year event at Section 1335.88, with no significant increase in flood risk to public safety, adjacent property, or infrastructure. Considering these factors, the proposed works are unlikely to result in adverse flooding impacts.

The analyses reveal overall decreases in velocity and minor increases shear stress between existing and proposed conditions at Section 1273.94. These increases are related to the corresponding decreases in water surface elevation at this location and have been accounted for in the Scour Analysis and Stone Sizing described in Section 6.3.

6.3 Scour Analysis and Stone Sizing

Analyses were completed to assess the scour potential along the proposed channel banks and determine an appropriate riverstone size and mix. Hydraulic data from the HEC-RAS model, including flow depth, flow area, shear stress and velocity, were reviewed for a range of flows (2-year through Regional storm event). A stone size gradation for the proposed bank works was determined based on the results of the hydraulic analysis and the permissible velocity approach (Komar, 1987), represented by the following equation:

$$V_c = 57(D)^{0.46}$$

Where D is the stone diameter (m) and V_c is the critical velocity (m/s). The stone sizes were also checked against the permissible shear stress approach (Miller *et al*. 1977), the MTO Drainage Design Standards (MTO, 2010), and the USACE Maynord Method (USACE, 1994).

Table 13 summarizes the stable stone size for flood event return periods ranging from the 2-year to the Regional flood event. As a comparison, bed material in the existing channel is dominated by gravels but ranges from silt to cobble-sized stone with a median grain size of approximately 4 cm, as determined during the geomorphic field assessment. The median grain size is mobilized by the 2-year storm event.

Table 13. Storm event velocity and stable stone size

Flood Event Return Period	Channel Velocity* (m/s)	Stable Stone Size** (cm)
2 Year	1.86	13
5 Year	2.5	25
10 Year	2.87	33
25 Year	3.17	41
50 Year	3.31	46
100 Year	3.51	52
Regional	4.71	98

**Flow velocity observed at HEC-RAS cross section 1335.88.*

***Stable stone size based on the permissible velocity approach (Komar, 1987).*

In order to maintain a stable channel that resists erosion over a wide range of return period events, but also allows for natural transport of sediment during storm events, the maximum velocity observed during the 25-year storm was used to size the D_{50} of the gradation. The D_{15}, D_{30}, D_{85} and D_{100} were sized to form a well-graded distribution around the D_{50}. The maximum velocity in the project vicinity during the 25-year storm event is 3.17 m/s at cross section 1335.88, at the upstream limit of the channel realignment works.

Table 14 provides the recommended stone size gradation for the channel bed and banks based on the permissible velocity approach. The proposed stone type should be sub-angular riverstone. Existing native material should be added to the stone mix to fill voids and provide planting media for vegetation. The larger stone is intended to enhance stability during larger storm events, protect municipal infrastructure and private property, and anchor the finer substrate.

Table 14. Proposed stone sizing gradation

% Finer	Proposed Stone Size	
	(cm)	(in)
D_{100}	60	24
D_{85}	50	20
D_{50}	40	16
D_{30}	25	10
D_{15}	15	6
Placed 70 cm Thick		

** Stone type shall be sub-angular riverstone.*

Armourstone retaining walls consisting of 1-2 tonne armourstone units are proposed along 3 sections of outer bank where public infrastructure or private property are at risk. The first wall will protect the right bank from station 0+000 to 0+025 where the channel is coincident with the pedestrian trail and replace the existing gabion basket wall. The second wall will be placed along the left bank from station 0+025 to 0+050 to provide additional protection to the concrete stormwater outfall and proposed outfall channel. The third wall will span from station 0+115 to 0+140 and protect the left bank adjacent to 590 Camelot Dr, where properties are currently at risk. The stone works are to be embedded and keyed into the bed of the channel in order to accommodate minor toe scour.

A median (D_{50}) stone size of 400 mm for the channel stone should provide sufficient scour protection for flow events that yield the greatest potential for scour. The proposed 700 mm thickness of stone cover will accommodate minor, localized settlement or displacement. The armourstone retaining walls will provide additional redundancy at vulnerable outer meander bends to ensure public infrastructure and private property are protected from erosion in the long-term. Appropriately sized existing material can be recycled and incorporated into the proposed works at the discretion of the engineer. Plantings of native shrubs within the stone revetment and along the floodplain bench will further enhance stability through increased channel roughness and root reinforcement. Embedment of the stone works and keying-in at its upstream tie-in will accommodate minor channel adjustments that occur naturally.

6.4 Vegetation Impacts and Restoration Plan

Based on the field findings and the proposed works, all young to mid-aged trees (greater than 10 cm DBH) are suggested to be removed and compensated with replacement tree plantings and all samplings (less than 10 cm DBH) are recommended to be transplanted. Therefore, the proposed works are anticipated to require the removal of 64 young to mid-aged trees and the relocation of 16 tree saplings.

6.5 ROM Cost Estimate

A rough order of magnitude (ROM) cost estimate was developed from the preliminary design drawings based on recent bid prices for similar work. It is assumed construction work will be completed by a third-party contractor with previous experience completing channel restoration and erosion control projects. The full cost estimate breakdown is provided in **Appendix G**. Please note the following:

- Unit rates are based on recently tendered projects of a similar nature in southern Ontario.
- The items and quantities are based on preliminary engineering drawings and are for estimation purposes only.
- Rapid inflation and pandemic-related supply chain issues have resulted in substantial price volatility in 2022. Assumed rates may vary from actual rates by the time of construction.
- The cost estimate includes detailed design engineering and tendering, contract administration and construction inspections.

The estimated cost to implement erosion control works at Harmony Creek Sites 2 & 3 is $968,000 based on assumed rates and including a 20% contingency.

7. Next Steps – Detailed Design and Implementation

It is recommended that the City of Oshawa proceed with implementation of the preferred mitigation alternative within the next 1-2 years, subject to budgetary constraints. The following steps must be considered at the detailed design stage to ensure effective implementation:

Detailed Design and Investigations – The detailed design should include the preparation of draft and final design drawings for review by the City, CLOCA and relevant stakeholders. The design package should include specifications for access routes, staging/stockpiling areas, critical construction sequences and practices, a vegetation removal and protection plan, an erosion and sediment control plan, and a restoration plan for all areas of disturbance. Sufficient plan and profile views and cross sections should be provided to show all major transitions in structure shape, grade, and property ownership. A detailed design brief should be prepared to support the design drawings.

Tree Protection Fencing – Temporary tree protection/construction fencing should be erected along all construction access routes and work areas. Fencing should be located a minimum distance of 1 m from the dripline of potentially affected trees.

Construction Staging, Erosion and Sediment Control Plan – The construction phasing plan must recognize site constraints, access routes, staging and storage requirements, and construction timing windows to facilitate the approved activities. The plan should ensure that existing channel flows are maintained downstream of the work area without interruption, during all stages of construction. During, and immediately after construction, soil material will be especially susceptible to erosion, as stabilizing vegetation may not have established. The erosion and sediment control plans require that Best Management Practices (BMPs) are followed during all phases of construction in accordance with site conditions. The erosion and sediment control plan should include, but is not limited to: flow maintenance, transfer and dewatering operations, fish rescue requirements, storage and operation of materials and equipment, spills management, and site-specific watercourse protection measures.

Agency Consultation and Approvals – In addition to approvals by the City's works and parks departments, applications will be required for permits from CLOCA under Ontario Regulation 42/06, "Application for Development, Interference with Wetlands and Alterations to Shorelines and Watercourses". Consultation with CLOCA is recommended to receive input into technical aspects of the design, particularly as this pertains to aquatic and terrestrial habitat enhancement and flood hazard. The detailed design of the proposed works, supporting documentation and permit application must be submitted to CLOCA. The application must be approved and have a permit issued prior to initiation of any construction activities.

Approval from the MNRF is also required for a fish collection permit (fish rescue). A Request for Review from the Department of Fisheries and Oceans (DFO) will be required for any work that is to take place below the high water mark (e.g. channel realignment, creek bed grade control and bank protection). A *Fisheries Act* Authorization is not expected to be required for the proposed works, based on the extent

and nature of proposed changes to habitat, but this must be confirmed by DFO especially given the importance of this creek to salmonids.

Tendering, Construction Administration and Supervision – A tender package for the proposed works will need to be developed, consisting of Special Provisions, Specifications, Form of Tender and a Schedule of Prices. The final detailed drawings would be issued as a set of contract drawings within the tender package. The contract drawings must be stamped by a professional engineer, signed and labeled "Issued for Tender" complete with all necessary material and performance specifications. The consultant would typically assist the City during the tendering and procurement period as required, providing responses and clarification to bidders during the procurement process.

Inspection and administration services are typically required during construction under the guidance of the design engineer. A qualified inspector with extensive experience in stream restoration and erosion and sediment control should be present or available during construction to ensure proper implementation of approved drawings, design details, construction techniques, and ultimately the permit conditions. Inspection and supervision will enable immediate and appropriate response to construction issues, ensure function of the design, and that the constructed design elements are stable prior to connection with the active channel system.

Construction Timing – All instream works are to be completed within the warmwater timing window between July 1 and March 31. All in-water work works should be completed in the dry, and not during or after a significant rain event. No equipment should enter the active flowing watercourse. In-water works should be completed in isolation from the main channel and a fish salvage should be completed during isolation and dewatering of the work area.

Post-construction Monitoring - Most adjustments to channel form occur during the first year following construction, and subsequently during large flow events. For this reason, a general field reconnaissance along the entire length of the constructed design should be completed immediately after construction and after the first large flooding event to identify any potential areas of concern. Detailed monitoring of constructed design elements should commence immediately after construction to obtain reference data to which subsequent monitoring results can be compared. The following detailed monitoring plan for the proposed erosion mitigation design is suggested for the first three years after construction:

- Collect a photographic record of site conditions (annually).
- Total station as-built survey of the channel planform, long profile and cross sections just after construction to obtain reference data.
- A general vegetation survey in the spring of each year.
- Monitoring reports to be submitted annually.

8. Certification

This report was prepared, reviewed, and approved by the undersigned:

Prepared By:

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Appendix A

Standard Overview of Erosion Hazard Sites

Description: Development of a large cobble point bar has deflected flow toward the stormwater outfall and exacerbating erosion along the outer bank. The outfall has begun being outflanked, at a rate of approximately 0.2 m per year since 2012, and now projects into the channel where it further disrupts flow. A deep pool has also formed at the stormwater outfall such that the outfall is perched above the bed. Flow: left to right.

Site 2

Feature at Risk:	Distance to Feature	Condition of Bank and/or Existing Erosion Protection:	Mechanism(s) of Failure:	Risk	Recommended Action(s):
Private property and stormwater outfall	0 m (contact)	Eroded, unprotected bank, outflanked stormwater outfall	Outflanking, undermining	High	Design and implement erosion mitigation measures to mitigate risk to outfall

Description: A three-tiered gabion basket wall protects five properties along Camelot Driver (600 to 590) along a broad meander. Private properties encroach to the edge of the channel along the gently sloping eastern valley wall. The bottom tier of the gabion basket wall has deteriorated and started to release stone. The wall has started to lean toward the channel. Flow: bottom to top.

Site 3

Feature at Risk:	Distance to Feature	Condition of Bank and/or Existing Erosion Protection:	Mechanism(s) of Failure:	Risk	Recommended Action(s):
Private property	0 m (contact)	Deteriorated	Undermining	High	Design and implement erosion control measures to replace role of existing structure

Appendix B

Tree Inventory

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
1	Manitoba Maple	*Acer negundo*	19,22,20	5	F	G	F	Slight lean, some dead branches
2	Manitoba Maple	*Acer negundo*	30	4	F	G	F	Slight lean
3	Balsam Fir	*Abies balsamea*	18	2	G	G	G	
4	Balsam Fir	*Abies balsamea*	13	3	G	G	G	
5	Little-leaved Linden	*Tilia cordata*	14	4	G	G	G	
6	Manitoba Maple	*Acer negundo*	28	4	G	G	G	
7	Manitoba Maple	*Acer negundo*	29	4	F	G	F	Leaning
8	Norway Maple	*Acer platanoides*	27	5	G	G	G	
9	White Elm	*Ulmus americana*	49	4	G	G	G	
10	Manitoba Maple	*Acer negundo*	10	12	F	F	F	
11	Manitoba Maple	*Acer negundo*	12	2	F	F	F	
12	Manitoba Maple	*Acer negundo*	16	3	F	G	F	Leaning
13	Manitoba Maple	*Acer negundo*	16	4	F	G	F	Slight lean
14	Crack Willow	*Salix × fragilis*	55	8	F	G	F	Trunk wound , reaches over path
15	Norway Maple	*Acer platanoides*	15	4	G	G	G	
16	Manitoba Maple	*Acer negundo*	15	3	G	G	G	
17	Crack Willow	*Salix × fragilis*	50	5	F	F	F	Epicormic growth
18	Crack Willow	*Salix × fragilis*	52	6	F	F	F	Epicormic growth
19	Crack Willow	*Salix × fragilis*	46	3	F	F	F	Dieback
20	Crack Willow	*Salix × fragilis*	42	5	F	F	F	Slight Leaning towards creek
21	Crack Willow	*Salix × fragilis*	32	0	D	D	D	
22	White Elm	*Ulmus americana*	48,22	5	G	G	G	
23	Manitoba Maple	*Acer negundo*	16	3	G	G	G	
24	White Elm	*Ulmus americana*	17	3	G	G	G	
25	Manitoba Maple	*Acer negundo*	18	3	G	G	G	
26	Manitoba Maple	*Acer negundo*	25	4	F	F	F	Epicormic growth
27	Basswood	*Tilia americana*	10,9	3	G	G	G	
28	White Elm	*Ulmus americana*	32	6	G	G	G	
29	Manitoba Maple	*Acer negundo*	18	2	P	F	P	Broken top, epicormic growth

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
30	Manitoba Maple	*Acer negundo*	36	5	F	G	F	Slight lean
31	Manitoba Maple	*Acer negundo*	29	4	G	G	G	
32	Manitoba Maple	*Acer negundo*	20	4	G	G	G	
33	Green Ash	*Fraxinus pennsylvanica*	8	2	F	F	F	
34	Manitoba Maple	*Acer negundo*	27,31	5	F	G	F	Slight lean
35	Basswood	*Tilia americana*	36,54	4	G	G	G	
36	White Elm	*Ulmus americana*	38	4	G	G	G	Slight lean over creek
37	Basswood	*Tilia americana*	17	3	F	G	F	Leaning away from creek
38	Norway Maple	*Acer platanoides*	32	5	G	G	G	
39	White Elm	*Ulmus americana*	32	4	G	G	G	At creek bank but doing well
40	Manitoba Maple	*Acer negundo*	32	4	F	F	F	Dieback
41	Manitoba Maple	*Acer negundo*	38,24	5	F	F	F	Dieback, slight lean
42	Basswood	*Tilia americana*	19	4	G	G	G	
43	Siberian Elm	*Ulmus pumila*	32	4	G	G	G	
44	Basswood	*Tilia americana*	12	3	G	G	G	
45	Basswood	*Tilia americana*	14	3	G	G	G	
46	Green Ash	*Fraxinus pennsylvanica*	20	1	F	P	P	
47	Manitoba Maple	*Acer negundo*	10	2	G	F	F	
48	Manitoba Maple	*Acer negundo*	10	3	P	F	P	Leaning over creek
49	Manitoba Maple	*Acer negundo*	12	3	P	F	F	Leaning somewhat
50	Norway Maple	*Acer platanoides*	13	5	G	G	G	
51	Manitoba Maple	*Acer negundo*	36	4	G	G	G	
52	Manitoba Maple	*Acer negundo*	44	8	F	G	F	Leaning over path
53	Basswood	*Tilia americana*	16	3	G	G	G	
54	Manitoba Maple	*Acer negundo*	50	5	F	G	F	Leaning
55	Manitoba Maple	*Acer negundo*	36	2	P	P	P	Leaning, broken top
56	Manitoba Maple	*Acer negundo*	26	4	F	G	F	

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
57	European Buckthorn	*Rhmanus cathartica*	12,7,6	3	G	G	G	Trunk curves
58	Manitoba Maple	*Acer negundo*	38	4	P	F	P	Main stem dead
59	Basswood	*Tilia americana*	11	4	G	G	G	
60	European Buckthorn	*Rhmanus cathartica*	10	2	F	F	F	
61	Norway Maple	*Acer platanoides*	12	3	G	G	G	
62	Manitoba Maple	*Acer negundo*	50,27	5	G	G	G	
63	Manitoba Maple	*Acer negundo*	65	-	D	D	D	Tree has been cut down
64	Manitoba Maple	*Acer negundo*	46	5	F	F	F	Large trunk crack
65	European Buckthorn	*Rhmanus cathartica*	10	2	G	G	G	
66	Manitoba Maple	*Acer negundo*	52	4	P	F	P	One stem broken
67	White Elm	*Ulmus americana*	14	2	G	G	G	
68	White Elm	*Ulmus americana*	25	5	G	G	G	
69	White Elm	*Ulmus americana*	52	6	G	G	G	
70	Norway Maple	*Acer platanoides*	14	3	G	G	G	
71	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	
72	Manitoba Maple	*Acer negundo*	38	5	G	G	G	
73	Manitoba Maple	*Acer negundo*	26	3	F	G	F	Pruned
74	Green Ash	*Fraxinus pennsylvanica*	27	0	D	D	D	
76	Manitoba Maple	*Acer negundo*	28,28;32	6	F	G	G	
77	Manitoba Maple	*Acer negundo*	40	5	P	G	F	Leaning towards path
78	Balsam Fir	*Abies balsamea*	13	2	G	G	G	
79	Siberian Elm	*Ulmus pumila*	38	5	G	F	G	
80	Manitoba Maple	*Acer negundo*	27,41	5	F	G	F	
81	Basswood	*Tilia americana*	13	4	G	G	G	
82	Manitoba Maple	*Acer negundo*	44	2	P	P	P	Broken top, epicormic shoots

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
83	White Elm	*Ulmus americana*	22	4	P	F	P	Trunk leaning, supporting another tree. Dieback
84	Manitoba Maple	*Acer negundo*	42	5	P	F	P	Trunk leaning , main stem broken
85	Norway Maple	*Acer platanoides*	10	3	G	G	G	
86	White Elm	*Ulmus americana*	28	5	G	F	F	Covered in grape
87	White Elm	*Ulmus americana*	22	3	G	G	G	
88	Manitoba Maple	*Acer negundo*	34	4	G	F	F	Covered in grape vines
89	Manitoba Maple	*Acer negundo*	39	5	G	F	F	Slight lean over path, grape vines
90	White Elm	*Ulmus americana*	24	3	F	F	F	Covered in grape vines
91	White Elm	*Ulmus americana*	12	1	P	P	P	Broken top
92	Basswood	*Tilia americana*	14	3	F	G	G	Included bark
93	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	Covered in grape vines
94	Green Ash	*Fraxinus pennsylvanica*	18	2	F	P	P	Smothered in grape
95	Green Ash	*Fraxinus pennsylvanica*	14	0	D	D	D	EAB holes
96	Green Ash	*Fraxinus pennsylvanica*	7	1	P	F	P	Leaning and covered in grape
97	Norway Maple	*Acer platanoides*	24	3	G	G	G	
98	Manitoba Maple	*Acer negundo*	40	4	F	G	F	Slight lean
101	Manitoba Maple	*Acer negundo*	30	4	G	G	G	
102	Green Ash	*Fraxinus pennsylvanica*	12	1	G	P	P	Dieback
103	Manitoba Maple	*Acer negundo*	24	4	D	D	G	
104	Manitoba Maple	*Acer negundo*	38	4	F	G	F	Leaning, pruned
105	Manitoba Maple	*Acer negundo*	42	5	F	G	F	Slight lean
106	Crack Willow	*Salix × fragilis*	43	5	G	G	G	
107	White Elm	*Ulmus americana*	28	0	D	D	D	
108	Crack Willow	*Salix × fragilis*	42	4	D	D	G	
109	Manitoba Maple	*Acer negundo*	35	4	D	D	G	

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
110	Manitoba Maple	*Acer negundo*	28	3	F	G	F	Slight lean, trunk wound
111	Manitoba Maple	*Acer negundo*	42	3	P	P	P	Leaning over creek, dieback
112	Siberian Elm	*Ulmus pumila*	13	3	F	F	F	Slight lean
113	White Willow	*Salix alba*	65	5	F	G	F	Leaning over creek
114	White Willow	*Salix alba*	70	5	F	G	F	Slight lean
115	Manitoba Maple	*Acer negundo*	28	4	F	G	F	Lean
116	Norway Maple	*Acer platanoides*	18	3	G	G	G	
117	Manitoba Maple	*Acer negundo*	44	6	F	G	F	Leaning
118	Manitoba Maple	*Acer negundo*	34	5	F	G	F	Leaning
119	Manitoba Maple	*Acer negundo*	63	5	F	G	F	Grape vines
120	Manitoba Maple	*Acer negundo*	54	4	P	F	P	Leaning, major limb broken and dead
121	Manitoba Maple	*Acer negundo*	40	5	F	P	P	One limb broken, other leaning. Dieback
122	White Elm	*Ulmus americana*	16	4	F	G	F	Covered in grape
123	Basswood	*Tilia americana*	10	3	F	G	F	
124	Manitoba Maple	*Acer negundo*	14	2	P	F	P	Leaning, dieback
125	Manitoba Maple	*Acer negundo*	16,8	4	P	F	P	Covered in grape, leaning
126	Basswood	*Tilia americana*	21	3	G	P	F	Covered in grape
127	Green Ash	*Fraxinus pennsylvanica*	13	0	D	D	D	Covered in grape
128	Green Ash	*Fraxinus pennsylvanica*	16	2	F	P	P	Covered in grape
129	Manitoba Maple	*Acer negundo*	15	4	F	G	F	Leaning
130	Basswood	*Tilia americana*	24	4	G	G	G	
131	Basswood	*Tilia americana*	16	3	G	G	G	
132	Basswood	*Tilia americana*	19,13	4	G	G	G	
133	Norway Maple	*Acer platanoides*	22	3	G	G	G	
134	Manitoba Maple	*Acer negundo*	59	7	F	G	G	
135	Manitoba Maple	*Acer negundo*	58	7	P	F	F	Limbs broken and leaning
136	Manitoba Maple	*Acer negundo*	26	3	G	G	G	
137	Manitoba Maple	*Acer negundo*	42	6	F	G	F	Leaning over path

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
138	Manitoba Maple	*Acer negundo*	24	4	F	G	G	
139	Manitoba Maple	*Acer negundo*	31	4	F	G	G	
140	Eastern Hop-hornbeam	*Ostrya virginiana*	14	4	G	G	G	
141	Manitoba Maple	*Acer negundo*	36	5	F	G	F	
142	Manitoba Maple	*Acer negundo*	22	4	F	G	F	Leaning over creek
143	Norway Maple	*Acer platanoides*	15,16	4	G	G	G	
144	Basswood	*Tilia americana*	14	3	G	G	G	
145	Manitoba Maple	*Acer negundo*	14	3	F	G	F	Leaning to creek
146	Manitoba Maple	*Acer negundo*	12	3	F	G	F	Leaning to creek
147	Manitoba Maple	*Acer negundo*	15	3	G	G	G	
148	Basswood	*Tilia americana*	11	4	F	G	F	Slight lean to creek, near edge of bank
149	Manitoba Maple	*Acer negundo*	14	4	F	G	G	
150	Basswood	*Tilia americana*	10	3	G	G	G	
151	Manitoba Maple	*Acer negundo*	20	4	P	F	P	Leaning over creek, dieback
152	Manitoba Maple	*Acer negundo*	14	3	F	G	F	Slight lean over creek
153	Manitoba Maple	*Acer negundo*	15	3	P	F	P	Leaning over creek, dieback
154	Manitoba Maple	*Acer negundo*	18	4	F	F	F	Slight lean to creek
155	Manitoba Maple	*Acer negundo*	14	4	P	F	P	Leaning over creek, dieback
156	Manitoba Maple	*Acer negundo*	25	4	F	G	F	Slight lean to creek
157	Manitoba Maple	*Acer negundo*	23	4	F	G	F	Slight lean to creek
158	Manitoba Maple	*Acer negundo*	26	4	F	G	F	Slight lean to creek
159	Basswood	*Tilia americana*	14	4	P	G	P	At edge of bank, leaning to creek
160	Manitoba Maple	*Acer negundo*	29	4	F	F	F	
161	Manitoba Maple	*Acer negundo*	38	4	F	G	F	Slight lean to creek
162	Manitoba Maple	*Acer negundo*	48	5	G	G	G	
163	Manitoba Maple	*Acer negundo*	33,38	5	F	F	F	Broken stem, lean to creek
164	Manitoba Maple	*Acer negundo*	48,16	5	P	F	P	Lean over creek
165	Manitoba Maple	*Acer negundo*	36	4	F	F	F	Pruned, leaning away from creek
166	Basswood	*Tilia americana*	46	5	G	G	G	

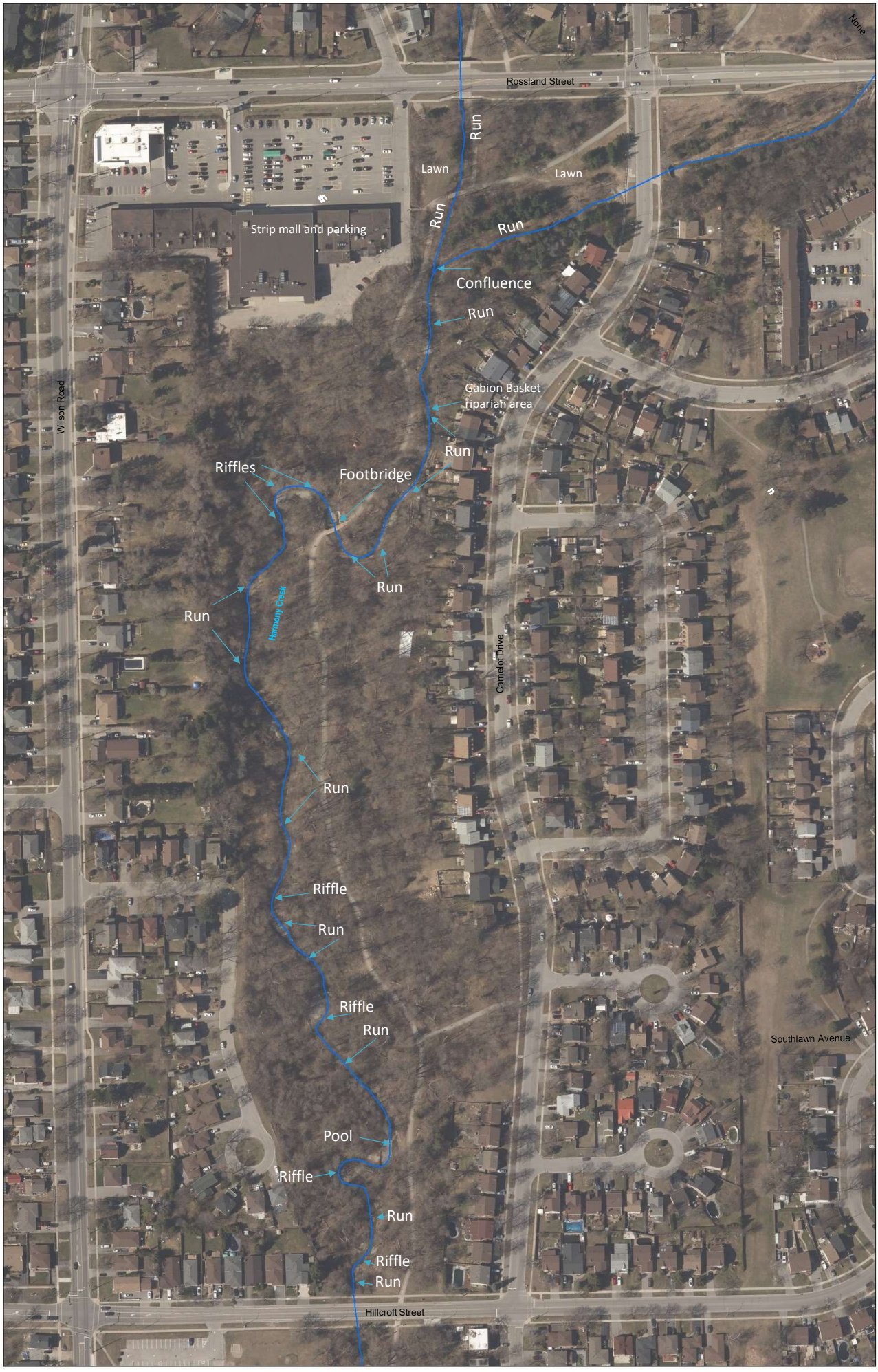
Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
167	Manitoba Maple	*Acer negundo*	28,29	5	F	G	F	Trunks leaning
168	Crack Willow	*Salix × fragilis*	75	4	F	F	F	
169	Manitoba Maple	*Acer negundo*	34	5	F	G	F	Leaning towards creek
170	Manitoba Maple	*Acer negundo*	13	3	F	G	F	Leaning towards creek
171	Basswood	*Tilia americana*	21	3	F	F	F	Leaning towards creek
172	Manitoba Maple	*Acer negundo*	18	4	F	G	F	Leaning towards creek
173	Crack Willow	*Salix × fragilis*	140	5	P	F	F	Main stem fine, but others dead
174	Manitoba Maple	*Acer negundo*	27	4	G	G	G	
175	White Elm	*Ulmus americana*	34	0	D	D	D	
176	Manitoba Maple	*Acer negundo*	23	4	P	F	P	Lean over creek
177	Manitoba Maple	*Acer negundo*	21	4	P	F	P	Leaning over creek
178	Manitoba Maple	*Acer negundo*	12	3	G	G	G	
179	Siberian Elm	*Ulmus pumila*	26	4	G	F	G	
180	Siberian Elm	*Ulmus pumila*	28	4	G	F	G	
181	Basswood	*Tilia americana*	12	2	F	F	F	Uneven crown
182	Basswood	*Tilia americana*	23,32	5	G	G	G	
183	Black Walnut	*Juglans nigra*	20	4	G	G	G	
184	Crack Willow	*Salix × fragilis*	19	2	G	G	G	
185	Norway Maple	*Acer platanoides*	16	3	G	G	G	
186	Green Ash	*Fraxinus pennsylvanica*	17	0	D	D	D	
187	Green Ash	*Fraxinus pennsylvanica*	20	0	D	D	D	
188	European Buckthorn	*Rhmanus cathartica*	18,11	4	G	G	G	
189	Green Ash	*Fraxinus pennsylvanica*	12	1	F	F	F	Dieback
190	Green Ash	*Fraxinus pennsylvanica*	15	0	D	D	D	

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
191	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	

**Condition Rating: G = Good, F = Fair, P = Poor, VP = Very Poor*

Appendix C

Aquatic Habitat Mapping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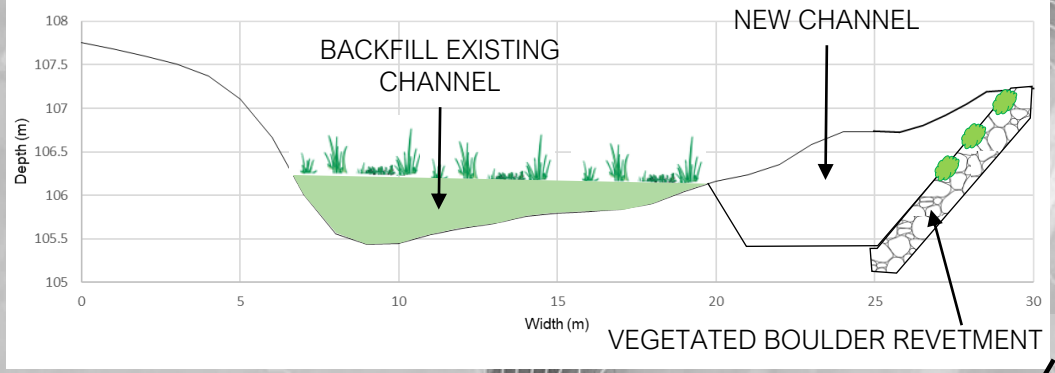
Rossland Street
Run
Lawn
Lawn
Run
Strip mall and parking
Run
Confluence
Run
Gabion Basket
riparian area
Wilson Road
Run
Riffles
Footbridge
Run
Harmony Creek
Run
Camelot Drive
Run
Riffle
Run
Riffle
Run
Southlawn Avenue
Pool
Riffle
Run
Riffle
Run
Hillcroft Street

Appendix D

Concept Sketches

Site 2 – Concept 1 – Mirror Meander and Vegetated Boulder Revetment

SECTION A (Downstream View)



Approx. 1954 channel centerline

Harmony Creek Trail

Flow

SMOOTH TIE-IN WITH EXISTING GABION BANK PROTECTION

BACKFILL EXISTING CHANNEL WITH COMPACTED, CLEAN FILL TO PREVENT REOCCUPATION OF FORMER CHANNEL

SECTION A

VEGETATED BOULDER REVETMENT

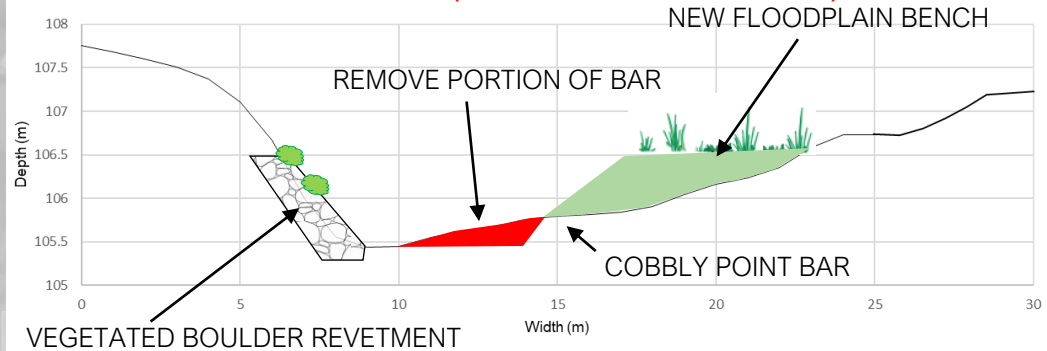
612 Camelot

CUT OF SMALL ANOMALOUS PROJECTION TO SMOOTH PLANFORM

KEEP EXISTING HEADWALL WITH NEW OUTLET CHANNEL

Site 2 – Concept 2 – Channel Narrowing and Vegetated Boulder Revetment

SECTION A (Downstream View)



Harmony Creek Trail

Flow

VEGETATED BOULDER REVETMENT

FLOODPLAIN BENCH TO NARROW CHANNEL

SECTION A

SMOOTH CHANNEL PLANFORM TO AVOID DEFLECTING THALWEG TOWARD OPPOSITE BANK

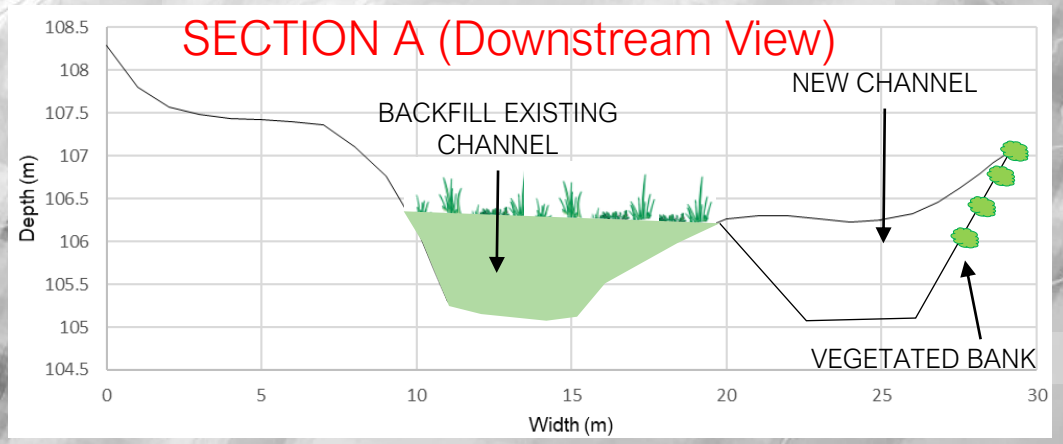
612 Camelot

REMOVE A PORTION OF LARGE COBBLE BAR

CUT OF SMALL ANOMALOUS PROJECTION TO SMOOTH PLANFORM

NEW HEADWALL SETBACK FROM CHANNEL BANK

Site 3 – Concept 1 – Mirror Meander and Trail Realignment



Proposed trail tie-in location

TRAIL REALIGNED TO INCREASE SEPARATION FROM CHANNEL

RIFFLE

Harmony Creek Trail

Flow

SECTION A

BACKFILL EXISTING CHANNEL WITH COMPACTED, CLEAN FILL TO PREVENT REOCCUPATION OF FORMER CHANNEL

VEGETATED BANK (e.g., BRUSH LAYER, LIVE STAKES)

596 to 590 Camelot

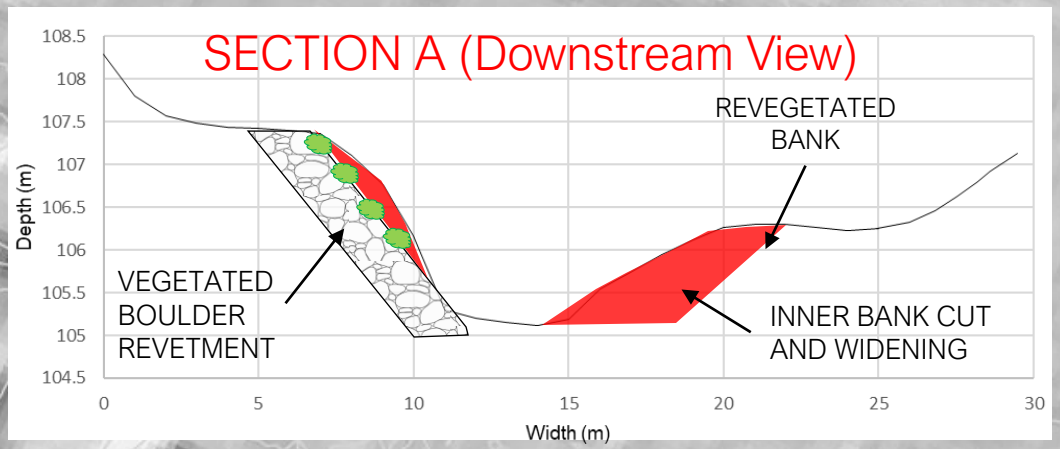
GABION TO REMAIN IN PLACE

Proposed trail tie-in location

RIFFLE

REGRADED FLOODPLAIN TO PROVIDE POSITIVE DRAINAGE TOWARD CHANNEL

Site 3 – Concept 2 – Channel Widening and Vegetated Boulder Revetment



Harmony Creek Trail

Flow

RIFFLE

EXTENTED UPSTREAM OF GABION TO MITIGATE OUTFLANKING RISK

VEGETATED BOULDER REVETMENT

INNER BANK COMPENSATORY CUT AND CHANNEL WIDENING

SECTION A

VEGETATED BANK (e.g., BRUSH LAYER, LIVE STAKES) TO STABILIZE REGRADED BANK

596 to 590 Camelot

RIFFLE

Site 2/3 – Concept 3 – Channel and Trail Realignment

RIFFLE

Proposed trail tie-in location

VEGETATED BANK (e.g., BRUSH LAYER, LIVE STAKES)

Flow

TRAIL REALIGNED TO INCREASE SEPARATION FROM CHANNEL

KEEP EXISTING HEADWALL WITH NEW OUTLET CHANNEL

612 Camelot

SECTION A

BACKFILL EXISTING CHANNEL WITH COMPACTED, CLEAN FILL TO PREVENT REOCCUPATION OF FORMER CHANNEL

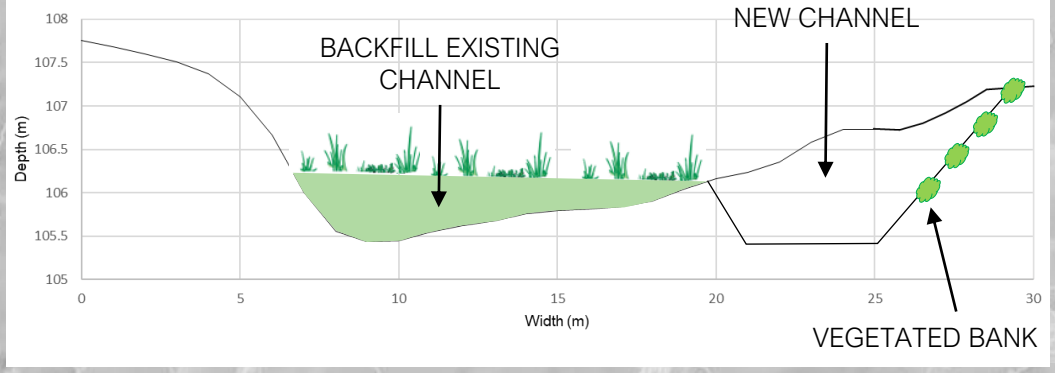
REGRADED FLOODPLAIN TO PROVIDE POSITIVE DRAINAGE TOWARD CHANNEL

Proposed trail tie-in location

Harmony Creek Trail

596 to 590 Camelot

SECTION A (Downstream View)



Appendix E

Public Consultation

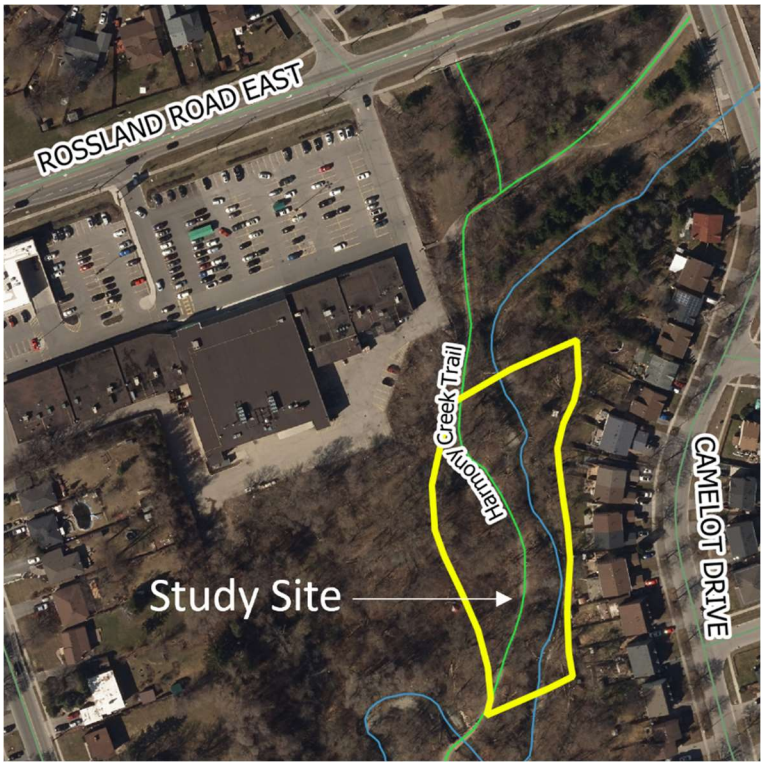
NOTICE OF COMMENCEMENT

Municipal Class Environmental Assessment

Harmony Creek Site 2 – 3 Preliminary Design

The Study

The City of Oshawa (the City), through their consultant Palmer Environmental Consulting Group is undertaking a Municipal Class B Environmental Assessment to address significant erosion concerns on Harmony Creek, between Rossland Road East and Hillcroft Street in the City of Oshawa. The attached map shows the location of the study site.



The Process

The Study will be carried out under *Schedule 'B'* in accordance with the requirements of the Municipal Engineers Association (MEA), *Municipal Class Environmental Assessment for Municipal Projects*. The Study process includes public and stakeholder consultation and identification of measures to mitigate adverse impacts. Public consultation is a key component of this study. The Project Team invites public input and comments and will incorporate them into the planning and design of this project. A Public Information Centre (PIC) will be held as part of the process to provide an opportunity for the public to review and comment on the study findings. Notice of the PIC will be provided to the public and agencies as the study progresses.

Comments

The City wishes to ensure that anyone with an interest in this study has the opportunity to provide input on the study alternatives. With the exception of personal information all comments will becomes part of the public record. To provide your comments, request additional information concerning this project or to join the study mailing list, please contact either of the Project Team members.

Mr. Harshad Patel, M.Eng., P.Eng. Water Resources Engineer **City of Oshawa** 50 Centre Street South, Oshawa, ON L1H 3Z7 hpatel@oshawa.ca	**Mr. Robin McKillop** Vice President, Principal Geomorphologist **Palmer** 74 Berkeley Street, Toronto, Ontario, M5A 2W7 robin.mckillop@pecg.ca

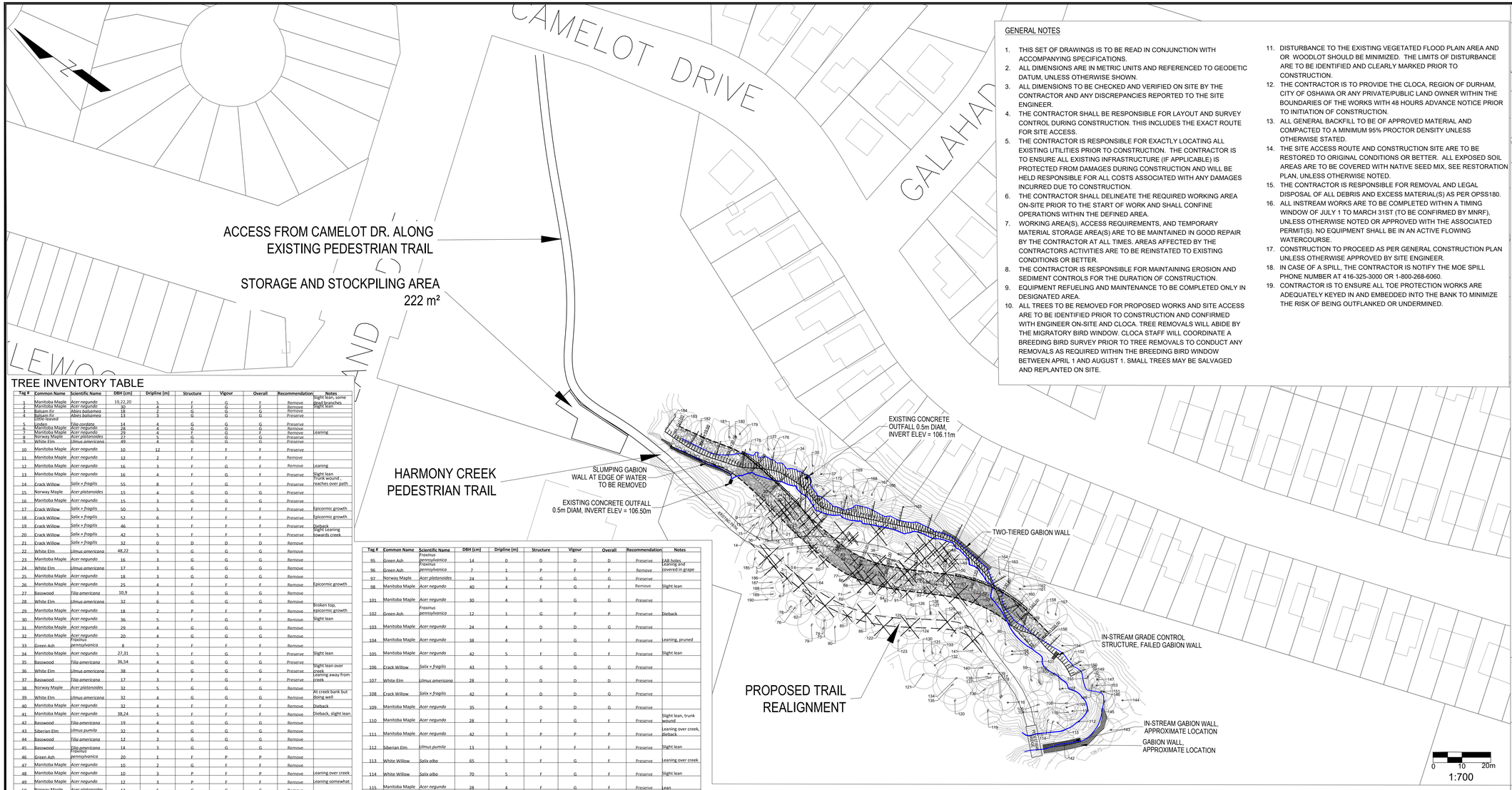
This notice issued X, 2022

Email Sent	Online Email	Letter Sent	Group	Company Name/Title	First Name	Last Name	Mailing Address	City	Prov.	Postal Code	Email	Phone
			CLOCA	Central Lake Ontario Conservation Authority			100 Whiting Avenue	Oshawa	ON	L1H 3T3	mail@cloca.com	905-579-0411
			City of Oshawa									
			City to populate with relevant departments									
			Hydro One	Residential and Small Business Inquiries				Markham	ON	L3R 1C8		1-888-664-9376
			Durham Region	Durham Region			605 Rossland Road East	Whitby	ON	L1N 8Y9	chair@durham.ca	905-666-6239
			MECP	York-Durham MECP District	Celeste	Dugas	5th floor, 230 Westney Rd. S.	Ajax	ON	L1S 7J5	celeste.dugas@ontario.ca	905-442-3105
			Ministry of Natural Resources and Forestry	Aurora District Manager	Brad	Allan	50 Bloomington Rd	Aurora	ON	L4G 0L8	brad.allen@ontario.ca	905-713-7322
			Ministry of Natural Resources and Forestry	Aurora District Senior District Planner	Steven	Strong	50 Bloomington Rd	Aurora	ON	L4G 0L8	steven.strong@ontario.ca	905-713-7366
			Ministry of Municipal Affairs and Housing	Central Municipal Services Office - Regional Director	Aly N.	Alibhai	College Park 13th Floor, 777 Bay Street	Toronto	ON	M5G 2E6	aly.alibhai@ontario.ca	416-585-7264
			Environment Canada	Canadian Wildlife Services - Ontario	Bryan	Graham	4905 Dufferin Street	Toronto	ON	M3H 5T4	enviroinfo@ec.gc.ca	1-800-668-4333
			Environment Canada	EA Section, Ontario Region - Manager	Robert	Dobos	867 Lakeshore Road, P.O. Box 5050	Burlington	ON	L7R 4A6	rob.dobos@ec.gc.ca	905-336-4953
			Fisheries and Oceans Canada	Fisheries Protection Ontario			867 Lakeshore Road	Burlington	ON	L7S 1A1	fisheriesprotection@dfo-mpo.ga.ca	1-855-852-8320
			Ministry of Indigenous Relations and Reconciliation	Ministry Partnerships Division	Heather	Levecque	160 Bloor Street East, 9th Floor	Toronto	ON	M7A 2E6	heather.levecque@ontario.ca	416-325-7032
			Ministry of Transportation	Central Region - Regional Director	Calvin	Curtis	Bldg D 7th Floor, 159 Sir William Hearst Ave	Downsview	ON	M3M 0B7	calvin.curtis@ontario.ca	416-235-5412
			Ministry of Transportation	Central Region - Corridor Management Head	Tom	Hewitt	Bldg D 7th Floor, 159 Sir William Hearst Ave	Toronto	ON	M3M 0B7	tom.hewitt@ontario.ca	416-235-3744
			Union Gas	Toronto Head Office			500 Consumers Road	Toronto	ON	M2J 1P8	ONTUGLLandsINQ@spectraenergy.com	1-877-362-7434
			Ontario Clean Water Agency	South Peel Facilities Regional Hub Office - Vice President	Alicia	Fraser	1300 Lakeshore Road East	Mississauga	ON	L5E 1E9	afraser@ocwa.com	905-274-1223
			Infrastructure Ontario	Environmental Advisor, Environmental Management	Lisa	Myslicki	1 Dundas Street West, Suite 2000	Toronto	ON	M5G 2L5	lisa.myslicki@infrastructureontario.ca	416-212-3768
			Friends of the Greenbelt Foundation				661 Yonge St. Suite 500	Toronto	ON	M4Y 1Z9	info@greenbelt.ca	416-960-0001
			Water Survey of Canada		Paul	Mawhinney	867 Lakeshore Road	Burlington	ON	L75 1A1	paul.mawhinney@canada.ca	

			Mississaugas of Scugog Island First Nations	Administrative Building			22521 Island Road	Port Perry	ON	L9L 1B6	info@scugogfirstnation.com	905-985-3337
			Private residents to be contacted by City of Oshawa									

Appendix F

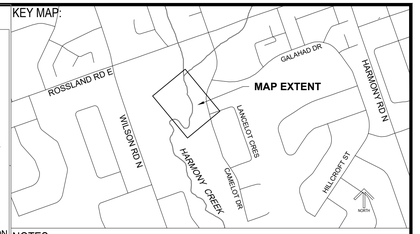
Sites 2 & 3 Preliminary Design and Restoration Plan



GENERAL NOTES

1. THIS SET OF DRAWINGS IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING SPECIFICATIONS.
2. ALL DIMENSIONS ARE IN METRIC UNITS AND REFERENCED TO GEODETIC DATUM, UNLESS OTHERWISE SHOWN.
3. ALL DIMENSIONS TO BE CHECKED AND VERIFIED ON SITE BY THE CONTRACTOR AND ANY DISCREPANCIES REPORTED TO THE SITE ENGINEER.
4. THE CONTRACTOR SHALL BE RESPONSIBLE FOR LAYOUT AND SURVEY CONTROL DURING CONSTRUCTION. THIS INCLUDES THE EXACT ROUTE FOR SITE ACCESS.
5. THE CONTRACTOR IS RESPONSIBLE FOR EXACTLY LOCATING ALL EXISTING UTILITIES PRIOR TO CONSTRUCTION. THE CONTRACTOR IS TO ENSURE ALL EXISTING INFRASTRUCTURE (IF APPLICABLE) IS PROTECTED FROM DAMAGES DURING CONSTRUCTION AND WILL BE HELD RESPONSIBLE FOR ALL COSTS ASSOCIATED WITH ANY DAMAGES INCURRED DUE TO CONSTRUCTION.
6. THE CONTRACTOR SHALL DELINEATE THE REQUIRED WORKING AREA ON-SITE PRIOR TO THE START OF WORK AND SHALL CONFINE OPERATIONS WITHIN THE DEFINED AREA.
7. WORKING AREA(S), ACCESS REQUIREMENTS, AND TEMPORARY MATERIAL STORAGE AREA(S) ARE TO BE MAINTAINED IN GOOD REPAIR BY THE CONTRACTOR AT ALL TIMES. AREAS AFFECTED BY THE CONTRACTORS ACTIVITIES ARE TO BE REINSTATED TO EXISTING CONDITIONS OR BETTER.
8. THE CONTRACTOR IS RESPONSIBLE FOR MAINTAINING EROSION AND SEDIMENT CONTROLS FOR THE DURATION OF CONSTRUCTION.
9. EQUIPMENT REFUELING AND MAINTENANCE TO BE COMPLETED ONLY IN DESIGNATED AREA.
10. ALL TREES TO BE REMOVED FOR PROPOSED WORKS AND SITE ACCESS ARE TO BE IDENTIFIED PRIOR TO CONSTRUCTION AND CONFIRMED WITH ENGINEER ON-SITE AND CLOCA. TREE REMOVALS WILL ABIDE BY THE MIGRATORY BIRD WINDOW. CLOCA STAFF WILL COORDINATE A BREEDING BIRD SURVEY PRIOR TO TREE REMOVALS TO CONDUCT ANY REMOVALS AS REQUIRED WITHIN THE BREEDING BIRD WINDOW BETWEEN APRIL 1 AND AUGUST 1. SMALL TREES MAY BE SALVAGED AND REPLANTED ON SITE.
11. DISTURBANCE TO THE EXISTING VEGETATED FLOOD PLAIN AREA AND OR WOODLOT SHOULD BE MINIMIZED. THE LIMITS OF DISTURBANCE ARE TO BE IDENTIFIED AND CLEARLY MARKED PRIOR TO CONSTRUCTION.
12. THE CONTRACTOR IS TO PROVIDE THE CLOCA, REGION OF DURHAM, CITY OF OSHAWA OR ANY PRIVATE/PUBLIC LAND OWNER WITHIN THE BOUNDARIES OF THE WORKS WITH 48 HOURS ADVANCE NOTICE PRIOR TO INITIATION OF CONSTRUCTION.
13. ALL GENERAL BACKFILL TO BE OF APPROVED MATERIAL AND COMPACTED TO A MINIMUM 95% PROCTOR DENSITY UNLESS OTHERWISE STATED.
14. THE SITE ACCESS ROUTE AND CONSTRUCTION SITE ARE TO BE RESTORED TO ORIGINAL CONDITIONS OR BETTER. ALL EXPOSED SOIL AREAS ARE TO BE COVERED WITH NATIVE SEED MIX, SEE RESTORATION PLAN, UNLESS OTHERWISE NOTED.
15. THE CONTRACTOR IS RESPONSIBLE FOR REMOVAL AND LEGAL DISPOSAL OF ALL DEBRIS AND EXCESS MATERIAL(S) AS PER OPSS180.
16. ALL INSTREAM WORKS ARE TO BE COMPLETED WITHIN A TIMING WINDOW OF JULY 1 TO MARCH 31ST (TO BE CONFIRMED BY MNRF), UNLESS OTHERWISE NOTED OR APPROVED WITH THE ASSOCIATED PERMIT(S). NO EQUIPMENT SHALL BE IN AN ACTIVE FLOWING WATERCOURSE.
17. CONSTRUCTION TO PROCEED AS PER GENERAL CONSTRUCTION PLAN UNLESS OTHERWISE APPROVED BY SITE ENGINEER.
18. IN CASE OF A SPILL, THE CONTRACTOR IS NOTIFY THE MOE SPILL PHONE NUMBER AT 416-325-3000 OR 1-800-268-6060.
19. CONTRACTOR IS TO ENSURE ALL TOE PROTECTION WORKS ARE ADEQUATELY KEYED IN AND EMBEDDED INTO THE BANK TO MINIMIZE THE RISK OF BEING OUTFLANKED OR UNDERMINED.

KEY MAP:



NOTES:

1. SURVEY PERFORMED BY CITY OF OSHAWA STAFF ON APRIL 7, 2022.
2. VERTICAL CONTROL IS IN METERS (CGVD28). ELEVATIONS HAVE BEEN DERIVED FROM CITY OF OSHAWA BENCHMARK #180. WILSON ROAD NORTH AT HILLCROFT STREET. CUT CROSS TO SOUTHWEST CORNER OF TOP OF BOTTOM STEP. HOUSE #453 WILSON ROAD NORTH. ELEVATION 107.460 m.
3. HORIZONTAL CONTROL IS NAD83 UTM17N. COORDINATES HAVE BEEN DERIVED FROM CITY OF OSHAWA HCM # 07119910188.
4. CONTOUR INTERVAL IS 0.25 METERS.

LEGEND:

SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS

1678 TREE TAG NUMBER

TREE CROWN
TREE LOCATION

TREE FOR PRESERVATION

TREE FOR REMOVAL

EXISTING GABION WALLS

TREE INVENTORY TABLE

Tag #	Common Name	Scientific Name	DBH (cm)	Dripline (m)	Structure	Vigour	Overall	Recommendation	Notes
1	Manitoba Maple	*Acer negundo*	19,22,20	5	F	G	F	Remove	Slight lean, some dead branches
2	Manitoba Maple	*Acer negundo*	30	4	F	G	F	Remove	Slight lean
3	Balsam Fir	*Abies balsamea*	18	2	G	G	G	Remove	
4	Balsam Fir	*Abies balsamea*	13	3	G	G	G	Preserve	
5	Little-leaved Linden	*Tilia cordata*	14	4	G	G	G	Preserve	
6	Manitoba Maple	*Acer negundo*	28	4	G	G	G	Remove	
7	Manitoba Maple	*Acer negundo*	29	4	F	G	F	Remove	Leaning
8	Norway Maple	*Acer platanoides*	27	5	G	G	G	Preserve	
9	White Elm	*Ulmus americana*	49	4	G	G	G	Preserve	
10	Manitoba Maple	*Acer negundo*	10	12	F	F	F	Preserve	
11	Manitoba Maple	*Acer negundo*	12	2	F	F	F	Remove	
12	Manitoba Maple	*Acer negundo*	16	3	F	G	F	Remove	Leaning
13	Manitoba Maple	*Acer negundo*	16	4	F	G	F	Preserve	Slight lean
14	Crack Willow	*Salix × fragilis*	55	8	F	G	F	Preserve	Trunk wound , reaches over path
15	Norway Maple	*Acer platanoides*	15	4	G	G	G	Preserve	
16	Manitoba Maple	*Acer negundo*	15	3	G	G	G	Preserve	
17	Crack Willow	*Salix × fragilis*	50	5	F	F	F	Preserve	Epicormic growth
18	Crack Willow	*Salix × fragilis*	52	6	F	F	F	Preserve	Epicormic growth
19	Crack Willow	*Salix × fragilis*	46	3	F	F	F	Preserve	Dieback
20	Crack Willow	*Salix × fragilis*	42	5	F	F	F	Preserve	Slight Leaning towards creek
21	Crack Willow	*Salix × fragilis*	32	0	D	D	D	Remove	
22	White Elm	*Ulmus americana*	48,22	5	G	G	G	Remove	
23	Manitoba Maple	*Acer negundo*	16	3	G	G	G	Remove	
24	White Elm	*Ulmus americana*	17	3	G	G	G	Remove	
25	Manitoba Maple	*Acer negundo*	18	3	G	G	G	Remove	
26	Manitoba Maple	*Acer negundo*	25	4	F	F	F	Remove	Epicormic growth
27	Basswood	*Tilia americana*	10,9	3	G	G	G	Remove	
28	White Elm	*Ulmus americana*	32	6	G	G	G	Remove	
29	Manitoba Maple	*Acer negundo*	18	2	P	F	P	Remove	Broken top, epicormic growth
30	Manitoba Maple	*Acer negundo*	36	5	F	G	F	Remove	Slight lean
31	Manitoba Maple	*Acer negundo*	29	4	G	G	G	Remove	
32	Manitoba Maple	*Acer negundo*	20	4	G	G	G	Remove	
33	Green Ash	*Fraxinus pennsylvanica*	8	2	F	F	F	Remove	
34	Manitoba Maple	*Acer negundo*	27,31	5	F	G	F	Preserve	Slight lean
35	Basswood	*Tilia americana*	36,54	4	G	G	G	Preserve	Slight lean over creek
36	White Elm	*Ulmus americana*	38	4	G	G	G	Preserve	Leaning away from creek
37	Basswood	*Tilia americana*	17	3	F	G	F	Preserve	
38	Norway Maple	*Acer platanoides*	32	5	G	G	G	Preserve	At creek bank but doing well
39	White Elm	*Ulmus americana*	32	4	G	G	G	Remove	
40	Manitoba Maple	*Acer negundo*	32	4	F	F	F	Remove	Dieback
41	Manitoba Maple	*Acer negundo*	38,24	5	F	F	F	Remove	Dieback, slight lean
42	Basswood	*Tilia americana*	19	4	G	G	G	Remove	
43	Siberian Elm	*Ulmus pumila*	32	4	G	G	G	Remove	
44	Basswood	*Tilia americana*	12	3	G	G	G	Remove	
45	Basswood	*Tilia americana*	14	3	G	G	G	Remove	
46	Green Ash	*Fraxinus pennsylvanica*	20	1	F	P	P	Remove	
47	Manitoba Maple	*Acer negundo*	10	2	G	F	F	Remove	
48	Manitoba Maple	*Acer negundo*	10	3	P	F	P	Remove	Leaning over creek
49	Manitoba Maple	*Acer negundo*	12	3	P	F	F	Remove	Leaning somewhat
50	Norway Maple	*Acer platanoides*	13	5	G	G	G	Remove	
51	Manitoba Maple	*Acer negundo*	36	4	G	G	G	Remove	
52	Manitoba Maple	*Acer negundo*	44	8	F	G	F	Remove	Leaning over path
53	Basswood	*Tilia americana*	16	3	G	G	G	Remove	
54	Manitoba Maple	*Acer negundo*	50	5	F	G	F	Preserve	Leaning
55	Manitoba Maple	*Acer negundo*	36	2	P	P	P	Preserve	Leaning, broken top
56	Manitoba Maple	*Acer negundo*	26	4	F	G	F	Preserve	
57	European Buckthorn	*Rhmanus cathartica*	12,7,6	3	G	G	G	Preserve	Trunk curves
58	Manitoba Maple	*Acer negundo*	38	4	F	F	P	Preserve	Main stem dead
59	Basswood	*Tilia americana*	11	4	G	G	G	Preserve	
60	European Buckthorn	*Rhmanus cathartica*	10	2	F	F	F	Remove	
61	Norway Maple	*Acer platanoides*	12	3	G	G	G	Preserve	
62	Manitoba Maple	*Acer negundo*	50,27	5	G	G	G	Preserve	
63	Manitoba Maple	*Acer negundo*	65	-	D	D	D	Preserve	Tree has been cut down
64	Manitoba Maple	*Acer negundo*	46	5	F	F	F	Remove	Large trunk crack
65	European Buckthorn	*Rhmanus cathartica*	10	2	G	G	G	Remove	
66	Manitoba Maple	*Acer negundo*	52	4	P	F	P	Remove	One stem broken
67	White Elm	*Ulmus americana*	14	2	G	G	G	Remove	
68	White Elm	*Ulmus americana*	25	5	G	G	G	Remove	
69	White Elm	*Ulmus americana*	52	6	G	G	G	Preserve	
70	Norway Maple	*Acer platanoides*	14	3	G	G	G	Preserve	
71	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	Preserve	
72	Manitoba Maple	*Acer negundo*	38	5	G	G	G	Remove	
73	Manitoba Maple	*Acer negundo*	26	3	F	G	F	Preserve	Pruned
74	Green Ash	*Fraxinus pennsylvanica*	27	0	D	D	D	Preserve	
76	Manitoba Maple	*Acer negundo*	28,28,32	6	F	G	G	Preserve	Leaning towards path
77	Manitoba Maple	*Acer negundo*	40	5	P	G	F	Remove	
78	Balsam Fir	*Abies balsamea*	13	2	G	G	G	Preserve	
79	Siberian Elm	*Ulmus pumila*	38	5	G	F	G	Preserve	
80	Manitoba Maple	*Acer negundo*	27,41	5	F	G	F	Preserve	
81	Basswood	*Tilia americana*	13	4	G	G	G	Remove	
82	Manitoba Maple	*Acer negundo*	44	2	P	P	P	Remove	Broken top, epicormic shoots
83	White Elm	*Ulmus americana*	22	4	P	F	P	Remove	Trunk leaning, supporting another tree. Dieback
84	Manitoba Maple	*Acer negundo*	42	5	P	F	P	Remove	Broken top, main stem broken
85	Norway Maple	*Acer platanoides*	10	3	G	G	G	Remove	
86	White Elm	*Ulmus americana*	28	5	G	F	F	Remove	Covered in grape
87	White Elm	*Ulmus americana*	22	3	G	G	G	Remove	
88	Manitoba Maple	*Acer negundo*	34	4	G	F	F	Remove	Covered in grape vines
89	Manitoba Maple	*Acer negundo*	39	5	G	F	F	Remove	Slight lean over path, grape vines
90	White Elm	*Ulmus americana*	24	3	F	F	F	Remove	Covered in grape vines
91	White Elm	*Ulmus americana*	12	1	P	P	P	Preserve	Broken top
92	Basswood	*Tilia americana*	14	3	F	G	G	Remove	Included bark
93	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	Remove	Covered in grape vines
94	Green Ash	*Fraxinus pennsylvanica*	18	2	F	P	P	Remove	Smothered in grape
95	Green Ash	*Fraxinus pennsylvanica*	14	0	D	D	D	Preserve	EAB holes, leaning and covered in grape
96	Green Ash	*Fraxinus pennsylvanica*	?	1	P	F	P	Remove	
97	Norway Maple	*Acer platanoides*	24	3	G	G	G	Preserve	
98	Manitoba Maple	*Acer negundo*	40	4	F	G	F	Remove	Slight lean
101	Manitoba Maple	*Acer negundo*	30	4	G	G	G	Preserve	
102	Green Ash	*Fraxinus pennsylvanica*	12	1	G	P	P	Preserve	Dieback
103	Manitoba Maple	*Acer negundo*	24	4	D	D	G	Preserve	
104	Manitoba Maple	*Acer negundo*	38	4	F	G	F	Preserve	Leaning, pruned
105	Manitoba Maple	*Acer negundo*	42	5	F	G	F	Preserve	Slight lean
106	Crack Willow	*Salix × fragilis*	43	5	G	G	G	Preserve	
107	White Elm	*Ulmus americana*	28	0	D	D	D	Preserve	
108	Crack Willow	*Salix × fragilis*	42	4	D	D	G	Preserve	
109	Manitoba Maple	*Acer negundo*	35	4	D	D	G	Preserve	
110	Manitoba Maple	*Acer negundo*	28	3	F	G	F	Preserve	Slight lean, trunk wound
111	Manitoba Maple	*Acer negundo*	42	3	P	P	P	Preserve	Leaning over creek, dieback
112	Siberian Elm	*Ulmus pumila*	13	3	F	F	F	Preserve	Slight lean
113	White Willow	*Salix alba*	65	5	F	G	F	Preserve	Leaning over creek
114	White Willow	*Salix alba*	70	5	F	G	F	Preserve	Slight lean
115	Manitoba Maple	*Acer negundo*	28	4	F	G	F	Preserve	Lean
116	Norway Maple	*Acer platanoides*	18	3	G	G	F	Preserve	
117	Manitoba Maple	*Acer negundo*	44	6	F	G	F	Preserve	Leaning
118	Manitoba Maple	*Acer negundo*	34	5	F	G	F	Preserve	Leaning
119	Manitoba Maple	*Acer negundo*	63	5	F	G	F	Preserve	Grape vines
120	Manitoba Maple	*Acer negundo*	54	4	P	F	P	Preserve	Leaning, major limb dead, top dead, One limb broken, other leaning, Dieback
121	Manitoba Maple	*Acer negundo*	40	5	F	P	P	Preserve	
122	White Elm	*Ulmus americana*	16	4	F	G	F	Remove	Covered in grape
123	Basswood	*Tilia americana*	10	3	F	G	F	Preserve	
124	Manitoba Maple	*Acer negundo*	14	2	P	F	P	Preserve	Leaning, dieback
125	Manitoba Maple	*Acer negundo*	16,8	4	P	F	P	Remove	Covered in grape, leaning
126	Basswood	*Tilia americana*	21	3	G	P	F	Preserve	Covered in grape
127	Green Ash	*Fraxinus pennsylvanica*	13	0	D	D	D	Preserve	Covered in grape
128	Green Ash	*Fraxinus pennsylvanica*	16	2	F	P	P	Preserve	Covered in grape
129	Manitoba Maple	*Acer negundo*	15	4	F	G	F	Preserve	Leaning
130	Basswood	*Tilia americana*	24	4	G	G	G	Preserve	
131	Basswood	*Tilia americana*	16	3	G	G	G	Preserve	
132	Basswood	*Tilia americana*	19,13	4	G	G	G	Preserve	
133	Norway Maple	*Acer platanoides*	22	3	G	G	G	Preserve	
134	Manitoba Maple	*Acer negundo*	59	7	F	G	G	Preserve	
135	Manitoba Maple	*Acer negundo*	58	7	P	F	F	Preserve	Limbs broken and leaning
136	Manitoba Maple	*Acer negundo*	26	3	G	G	G	Preserve	
137	Manitoba Maple	*Acer negundo*	42	6	F	G	F	Preserve	Leaning over path
138	Manitoba Maple	*Acer negundo*	24	4	F	G	G	Preserve	
139	Manitoba Maple	*Acer negundo*	31	4	F	G	G	Preserve	
140	Eastern Hop-hornbeam	*Ostrya virginiana*	14	4	G	G	G	Preserve	
141	Manitoba Maple	*Acer negundo*	36	5	F	G	F	Preserve	
142	Manitoba Maple	*Acer negundo*	22	4	F	G	F	Preserve	Leaning over creek
143	Norway Maple	*Acer platanoides*	15,16	4	G	G	G	Preserve	
144	Basswood	*Tilia americana*	14	3	G	G	G	Preserve	
145	Manitoba Maple	*Acer negundo*	14	3	F	G	F	Preserve	Leaning to creek
146	Manitoba Maple	*Acer negundo*	12	3	F	G	F	Preserve	Leaning to creek
147	Manitoba Maple	*Acer negundo*	15	3	G	G	G	Preserve	
148	Basswood	*Tilia americana*	11	4	F	G	F	Preserve	Slight lean to creek, near edge of bank
149	Manitoba Maple	*Acer negundo*	14	4	F	G	G	Preserve	
150	Basswood	*Tilia americana*	10	3	G	G	G	Preserve	
151	Manitoba Maple	*Acer negundo*	20	4	P	F	P	Preserve	Leaning over creek, dieback
152	Manitoba Maple	*Acer negundo*	14	3	F	G	F	Preserve	Slight lean over creek
153	Manitoba Maple	*Acer negundo*	15	3	P	F	P	Preserve	Leaning over creek, dieback
154	Manitoba Maple	*Acer negundo*	18	4	F	F	F	Preserve	Slight lean to creek
155	Manitoba Maple	*Acer negundo*	14	4	P	F	P	Preserve	Leaning over creek, dieback
156	Manitoba Maple	*Acer negundo*	25	4	F	G	F	Preserve	Slight lean to creek
157	Manitoba Maple	*Acer negundo*	23	4	F	G	F	Preserve	Slight lean to creek
158	Manitoba Maple	*Acer negundo*	26	4	F	G	F	Preserve	Slight lean to creek
159	Basswood	*Tilia americana*	14	4	P	G	P	Remove	At edge of bank, leaning to creek
160	Manitoba Maple	*Acer negundo*	29	4	F	F	F	Remove	
161	Manitoba Maple	*Acer negundo*	38	4	F	G	F	Preserve	Slight lean to creek
162	Manitoba Maple	*Acer negundo*	48	5	G	G	G	Preserve	
163	Manitoba Maple	*Acer negundo*	33,38	5	F	F	F	Preserve	Broken stem, lean to creek
164	Manitoba Maple	*Acer negundo*	48,16	5	P	F	P	Preserve	Lean over creek
165	Manitoba Maple	*Acer negundo*	36	4	F	F	F	Preserve	Pruned, leaning away from creek
166	Basswood	*Tilia americana*	46	5	G	G	G	Preserve	
167	Manitoba Maple	*Acer negundo*	28,29	5	F	G	F	Preserve	Trunks leaning
168	Crack Willow	*Salix × fragilis*	75	4	F	F	F	Preserve	
169	Manitoba Maple	*Acer negundo*	34	5	F	G	F	Preserve	Leaning towards creek
170	Manitoba Maple	*Acer negundo*	13	3	F	G	F	Preserve	Leaning towards creek
171	Basswood	*Tilia americana*	21	3	F	F	F	Preserve	Leaning towards creek
172	Manitoba Maple	*Acer negundo*	18	4	F	G	F	Preserve	Leaning towards creek
173	Crack Willow	*Salix × fragilis*	140	5	P	F	F	Preserve	Main stem fine, but others dead
174	Manitoba Maple	*Acer negundo*	27	4	G	G	G	Preserve	
175	White Elm	*Ulmus americana*	34	0	D	D	D	Preserve	
176	Manitoba Maple	*Acer negundo*	23	4	P	F	P	Preserve	Lean over creek
177	Manitoba Maple	*Acer negundo*	21	4	P	F	P	Preserve	Leaning over creek
178	Manitoba Maple	*Acer negundo*	12	3	G	G	G	Preserve	
179	Siberian Elm	*Ulmus pumila*	26	4	G	F	G	Preserve	
180	Siberian Elm	*Ulmus pumila*	28	4	G	F	G	Preserve	
181	Basswood	*Tilia americana*	12	2	F	F	F	Preserve	Uneven crown
182	Basswood	*Tilia americana*	23,32	5	G	G	G	Preserve	
183	Black Walnut	*Juglans nigra*	20	4	G	G	G	Preserve	
184	Crack Willow	*Salix × fragilis*	19	2	G	G	G	Preserve	
185	Norway Maple	*Acer platanoides*	16	3	G	G	G	Preserve	
186	Green Ash	*Fraxinus pennsylvanica*	17	0	D	D	D	Preserve	
187	Green Ash	*Fraxinus pennsylvanica*	20	0	D	D	D	Preserve	
188	European Buckthorn	*Rhmanus cathartica*	18,11	4	G	G	G	Preserve	
189	Green Ash	*Fraxinus pennsylvanica*	12	1	F	F	F	Preserve	Dieback
190	Green Ash	*Fraxinus pennsylvanica*	15	0	D	D	D	Preserve	
191	Green Ash	*Fraxinus pennsylvanica*	11	0	D	D	D	Preserve	

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

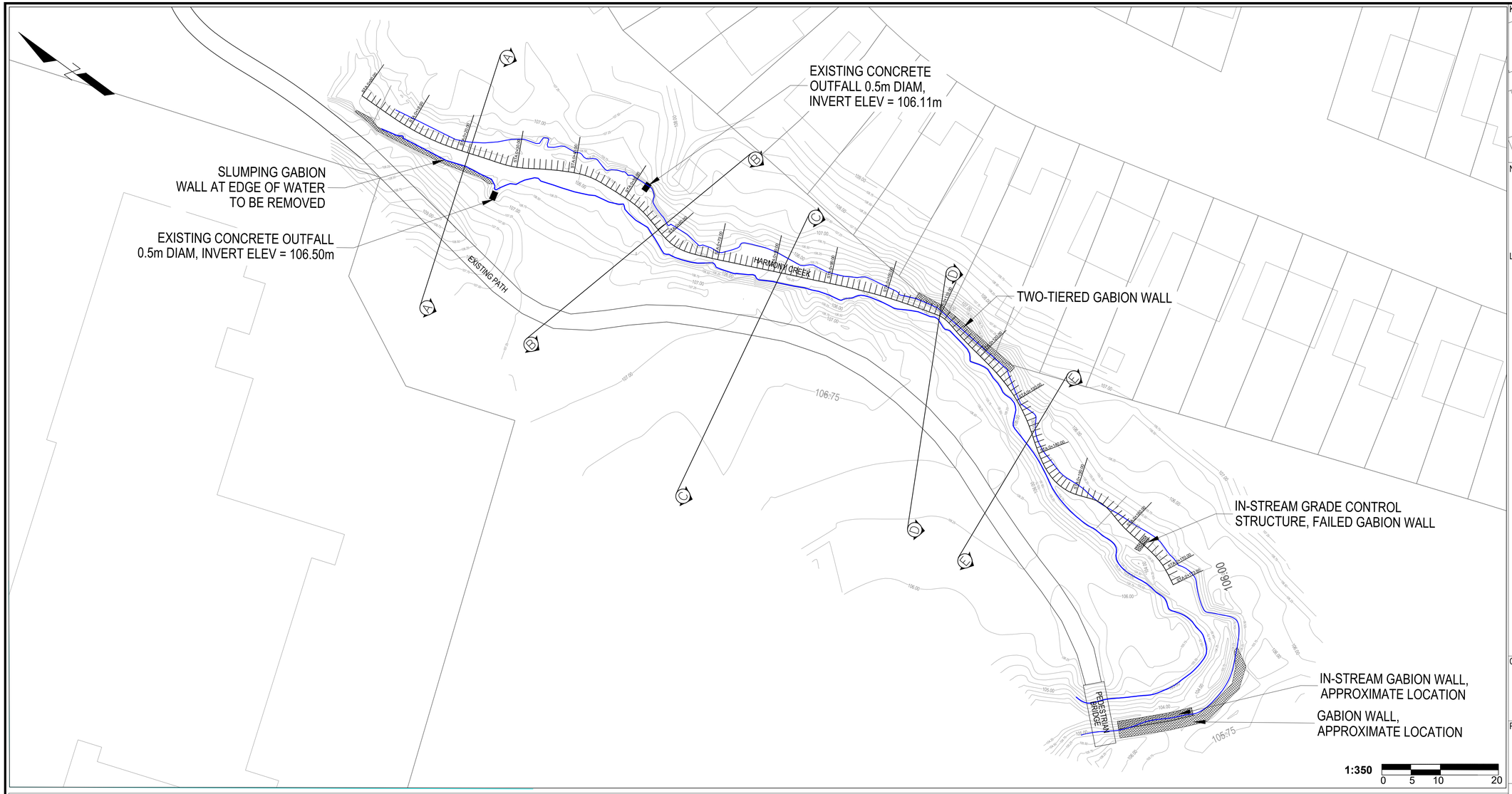
PROJECT:

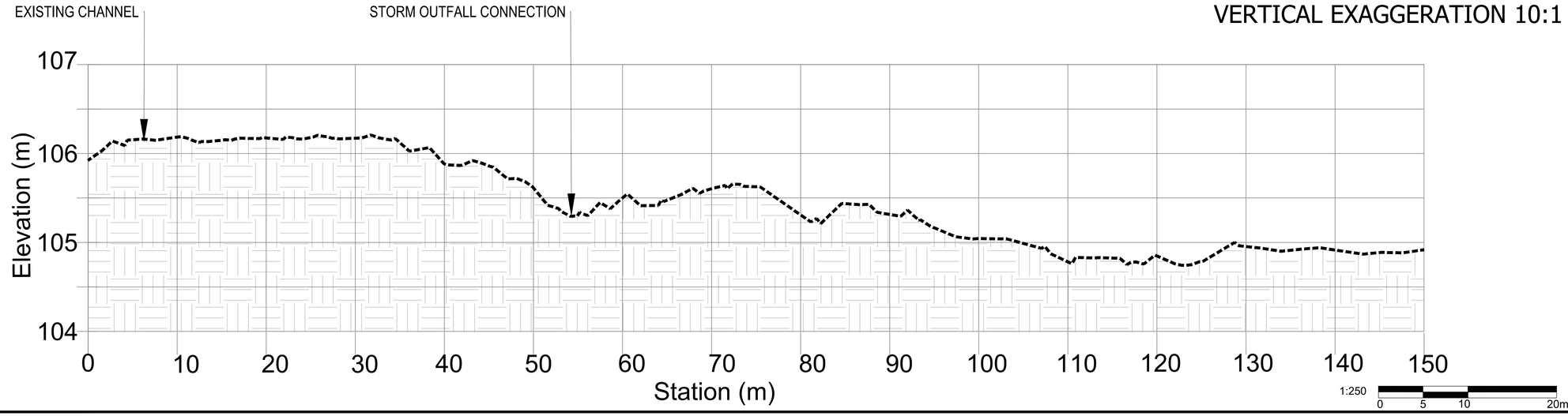
HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

TITLE:

GENERAL PLAN, REMOVALS AND NOTES

PROJECT NO: 1510208		DATE:	2022-08-12
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY:	RM/MO
DRAWING NO: GP	SHEET NO:	01	





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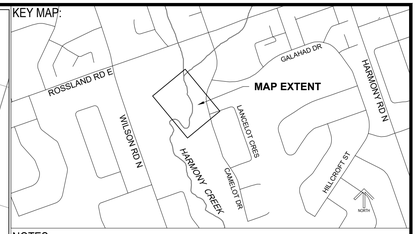


NOTES:

1. SURVEY PERFORMED BY CITY OF OSHAWA STAFF ON APRIL 7, 2022.
2. VERTICAL CONTROL IS IN METERS (CGVD28). ELEVATIONS HAVE BEEN DERIVED FROM CITY OF OSHAWA BENCHMARK #180. WILSON ROAD NORTH AT HILLCROFT STREET. CUT CROSS TO SOUTHWEST CORNER OF TOP OF BOTTOM STEP. HOUSE #453 WILSON ROAD NORTH. ELEVATION 107.460 m.
3. HORIZONTAL CONTROL IS NAD83 UTM17N. COORDINATES HAVE BEEN DERIVED FROM CITY OF OSHAWA HCM # 07119910188.
4. CONTOUR INTERVAL IS 0.25 METERS.

LEGEND:

SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS

EXISTING GABION WALLS

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

PROJECT:

HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

TITLE:

EXISTING PLAN AND PROFILE

PROJECT NO:	DATE:	
1510208	2022-08-12	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: GP	SHEET NO: 02	

PROPOSED RIFFLE

PROPOSED ARMOUR STONE WALL

PROPOSED POOL

EXISTING CONCRETE OUTFALL 0.5m DIAM, INVERT ELEV = 106.11m

PROPOSED STORM WATER OUTFALL RETROFIT

PROPOSED RIFFLE

SLUMPING GABION WALL AT EDGE OF WATER TO BE REMOVED

EXISTING CONCRETE OUTFALL 0.5m DIAM, INVERT ELEV = 106.50m

BACKFILL EXISTING CHANNEL WITH COMPACTED MATERIALS EXCAVATED FROM NEW CHANNEL

PROPOSED POOL

PROPOSED RIFFLE

EXISTING PATH

HARMONY CREEK

TWO-TIERED GABION WALL

PROPOSED CHANNEL

PROPOSED ARMOUR STONE WALL

PROPOSED POOL

PROPOSED RIFFLE

PROPOSED RIFFLE POOL MORPHOLOGY

PROPOSED TRAIL REALIGNMENT

IN-STREAM GRADE CONTROL STRUCTURE, FAILED GABION WALL

IN-STREAM GABION WALL, APPROXIMATE LOCATION

GABION WALL, APPROXIMATE LOCATION

PEDESTRIAN BRIDGE

Sta. 0+00.00
Sta. 0+10.00
Sta. 0+20.00
Sta. 0+30.00
Sta. 0+40.00
Sta. 0+50.00
Sta. 0+60.00
Sta. 0+70.00
Sta. 0+80.00
Sta. 0+90.00
Sta. 0+100.00
Sta. 0+110.00
Sta. 0+120.00
Sta. 0+130.00
Sta. 0+140.00
Sta. 0+150.00
Sta. 0+160.00

106.00
105.75

1:350
0 5 10 20

TIE INTO EXISTING CHANNEL

STORM OUTFALL CONNECTION

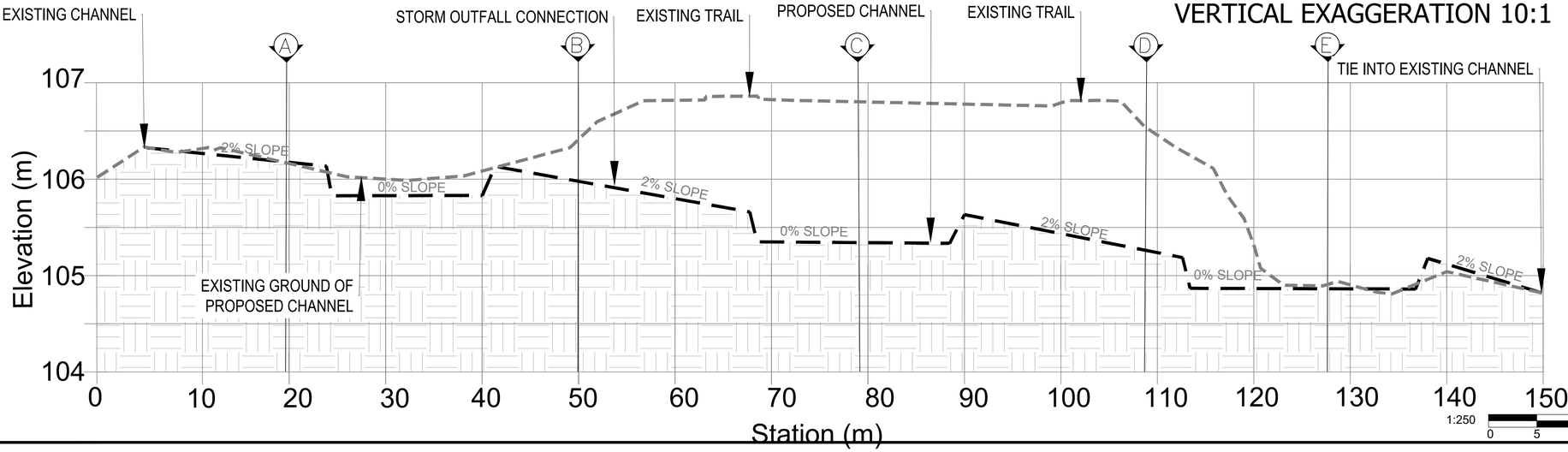
EXISTING TRAIL

PROPOSED CHANNEL

EXISTING TRAIL

TIE INTO EXISTING CHANNEL

VERTICAL EXAGGERATION 10:1



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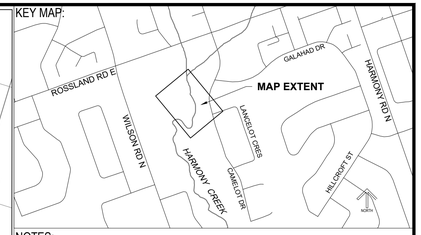
0 5 10 20m

KEY MAP:



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4. CONTOUR INTERVAL IS 0.25 METERS.

LEGEND:

- SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS
- EXISTING GABION WALLS
- PROPOSED ARMOUR STONE WALLS - 75 LIN M
- EXISTING CHANNEL TO BE FILLED

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

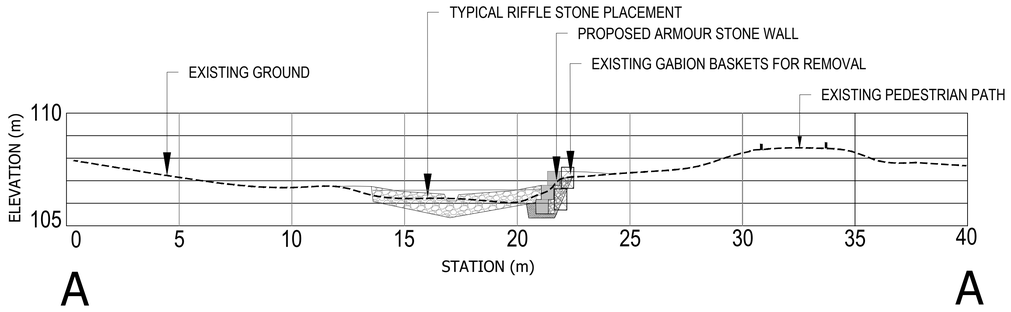
PROJECT:

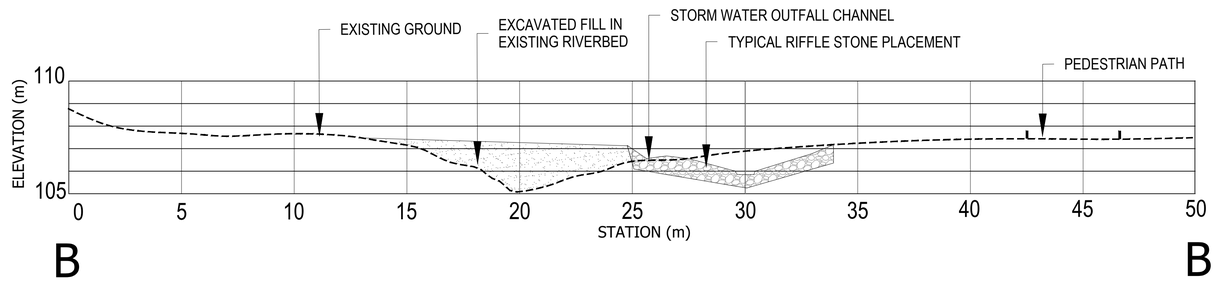
HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

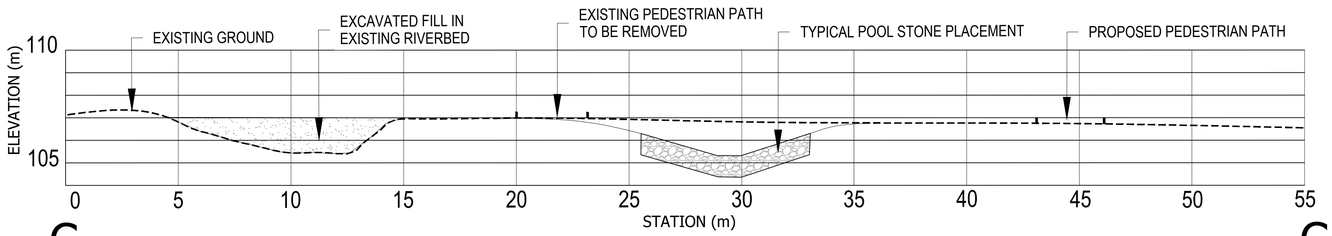
TITLE:

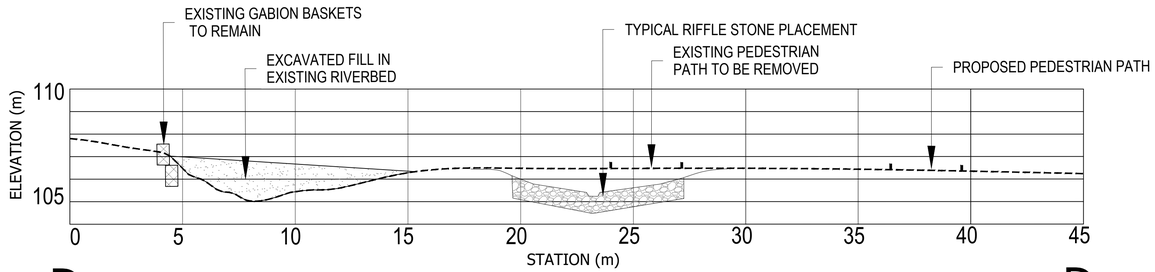
PROPOSED PLAN AND PROFILE

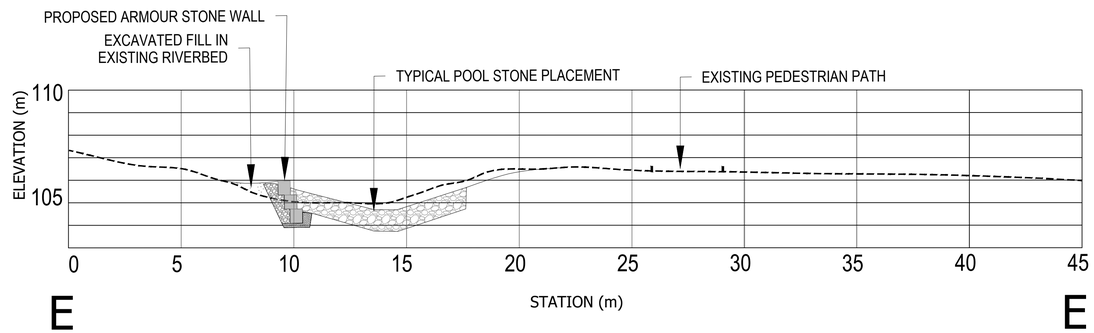
PROJECT NO:	DATE:	
1510208	2022-08-12	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: GP	SHEET NO: 03	











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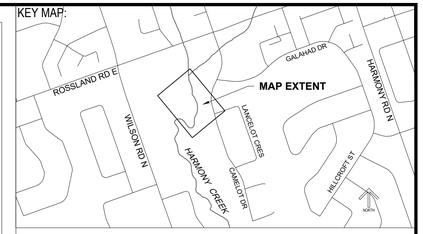

CLIENT:

CITY OF OSHAWA

PREPARED BY:

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DATE	REVISION	BY

DRAFT

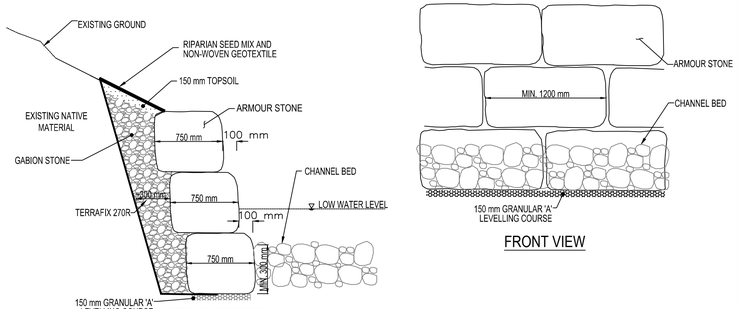
PROJECT:

HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

TITLE:

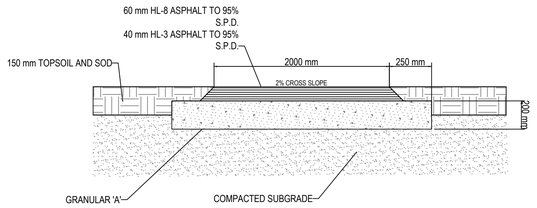
CROSS SECTIONS A-E

PROJECT NO:	DATE:	
1510208	2022-08-12	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: SP	SHEET NO: 04	



ARMOUR STONE RETAINING WALL

N.T.S.

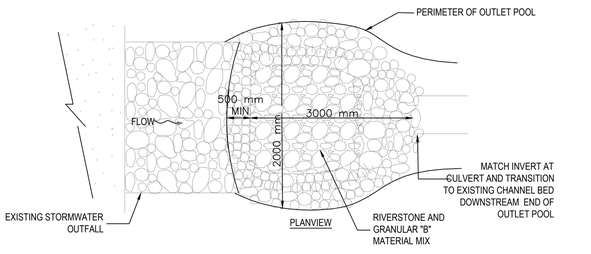


NOTES

1. PATHWAY SURFACE IS TO BE SMOOTH AND EVEN THROUGHOUT.
2. ALL COMPACTION TO BE 98% S.P.D. UNLESS OTHERWISE NOTED.
3. EDGE OF ASPHALT TO BE HAND TAMPED TO A 45° ANGLE.
4. COMPACTED SUBGRADE TO HAVE A 2% MIN. CROSS SLOPE.

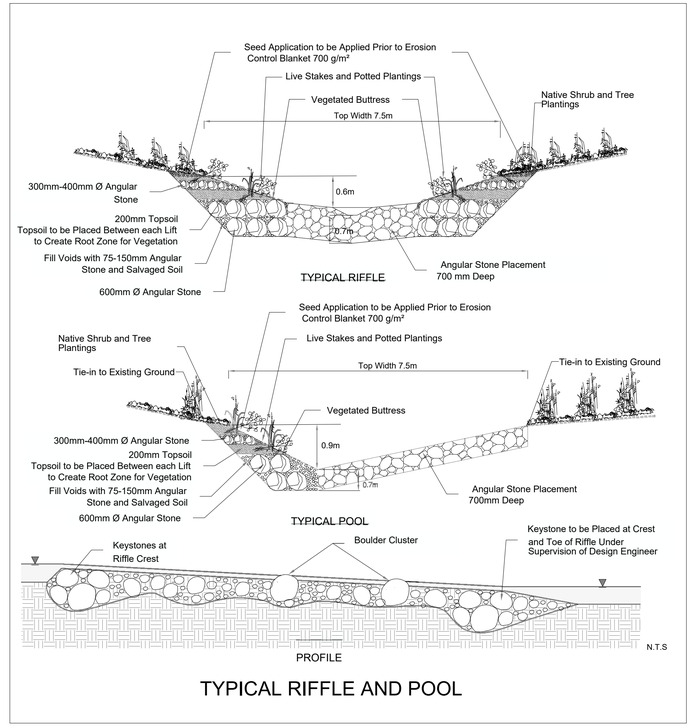
ASPHALT MULTI-USE TRAIL

N.T.S.

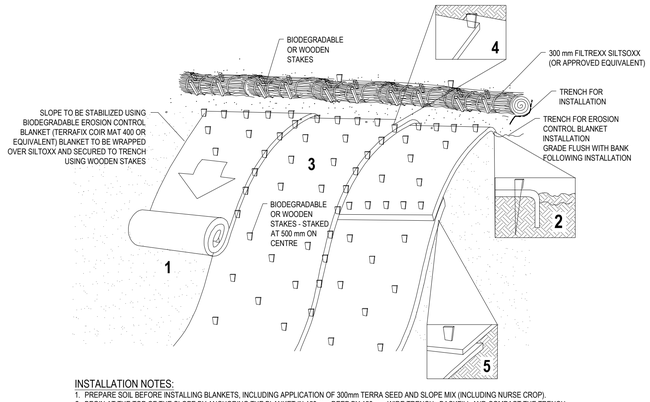


OUTLET POOL DETAIL

N.T.S.



TYPICAL RIFFLE AND POOL



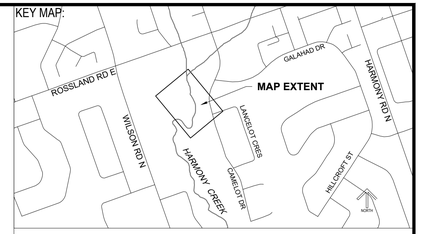
INSTALLATION NOTES:

1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING APPLICATION OF 300mm TERRA SEED AND SLOPE MIX (INCLUDING NURSE CROP).
2. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN 150 mm DEEP BY 150 mm WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER SECURING. TRENCH TO BE GRADED FLUSH WITH BANK AFTER BURYING AND STAKING.
3. ROLL THE BLANKETS (A) DOWN THE SLOPE.
4. THE EDGES OF PARALLEL BLANKETS MUST BE SECURED USING BIODEGRADABLE STAKES OR WOODEN STAKES WITH APPROXIMATELY 50 mm OVERLAP.
5. WHEN BLANKETS MUST BE SPLICED DOWN THE SLOPE, PLACE BLANKETS END OVER END (SHINGLE STYLE) WITH APPROXIMATELY 100 mm OVERLAP. STAKE THROUGH OVERLAPPED AREA APPROXIMATELY 50 mm APART.
6. STAKE AT 500 mm ON CENTRE

EROSION CONTROL BLANKET (TERRAFIX COIR MAT) SLOPE INSTALLATION

N.T.S.

KEY MAP:



CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

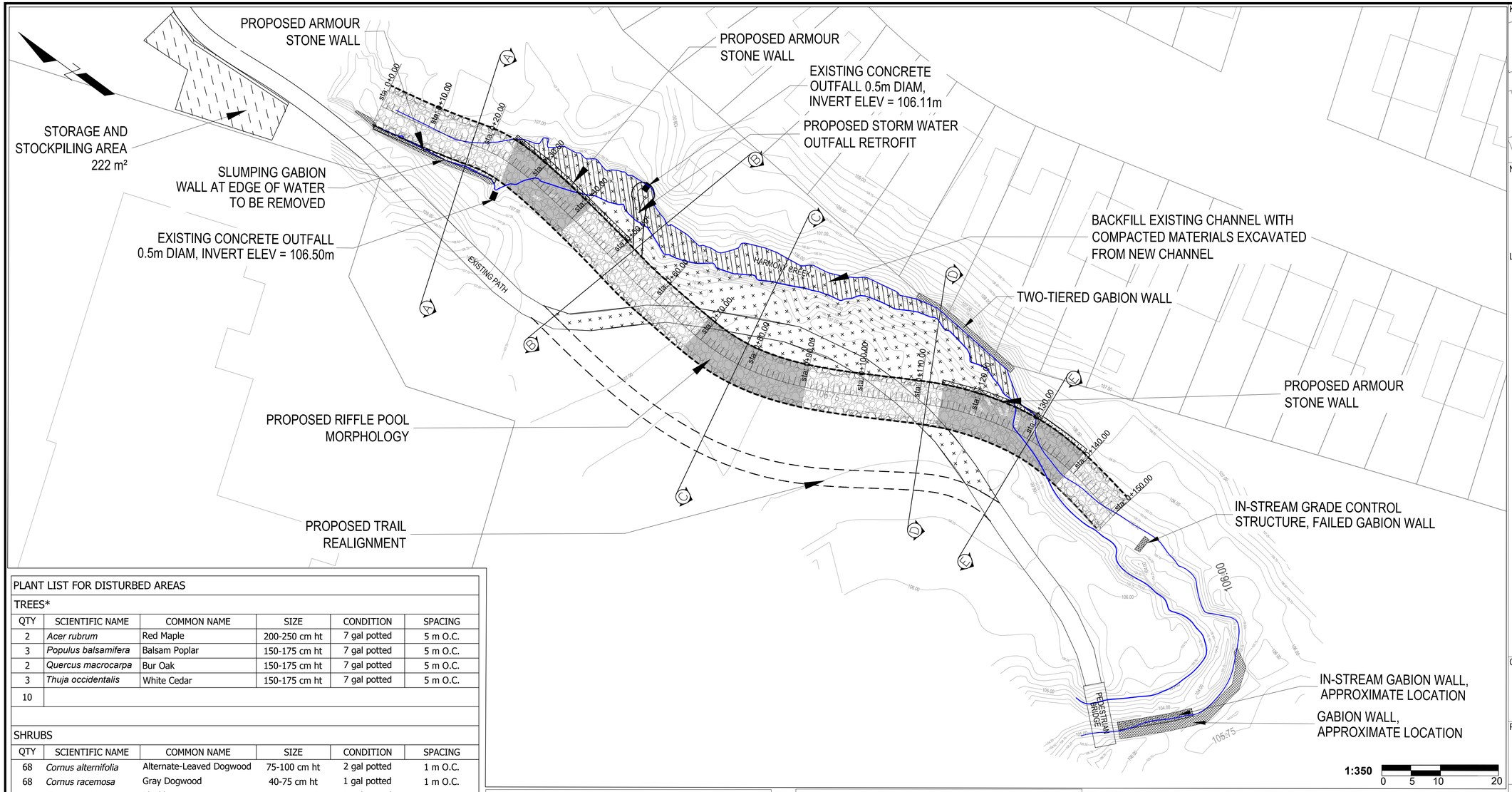
PROJECT:

HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

TITLE:

DETAIL DRAWINGS

PROJECT NO: 1510208		DATE: 2022-08-12	
DESIGN BY: MO	DRAWN BY: NC		APPROVED BY: RM/MO
DRAWING NO: GP		SHEET NO: 05	



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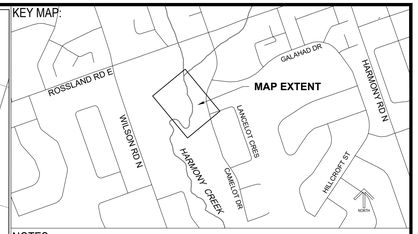

NOTES:

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LEGEND:

SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS

PLANTINGS OF TREES, SHRUBS, AND NATIVE SEED MIX IN DISTURBED AREAS - 1132m²

PLANTINGS OF NATIVE SEED MIX AND 0.5m STRIP OF SOD IN STORAGE AND STOCKPILE AREA
13m² OF SOD
209m² OF SEED

PLANT LIST FOR DISTURBED AREAS					
TREES*					
QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
2	*Acer rubrum*	Red Maple	200-250 cm ht	7 gal potted	5 m O.C.
3	*Populus balsamifera*	Balsam Poplar	150-175 cm ht	7 gal potted	5 m O.C.
2	*Quercus macrocarpa*	Bur Oak	150-175 cm ht	7 gal potted	5 m O.C.
3	*Thuja occidentalis*	White Cedar	150-175 cm ht	7 gal potted	5 m O.C.
10					
SHRUBS					
QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
68	*Cornus alternifolia*	Alternate-Leaved Dogwood	75-100 cm ht	2 gal potted	1 m O.C.
68	*Cornus racemosa*	Gray Dogwood	40-75 cm ht	1 gal potted	1 m O.C.
68	*Rubus occidentalis*	Blackberry	40-75 cm ht	1 gal potted	1 m O.C.
68	*Sambucus canadensis*	Elderberry	40-75 cm ht	1 gal potted	1 m O.C.
68	*Viburnum lentago*	Nannyberry Viburnum	75-100 cm ht	2 gal potted	1 m O.C.
340					

*TREES ARE NOT TO BE PLANTED DIRECTLY ADJACENT TO PROPOSED CHANNEL

SEED MIX FOR DISTURBED AREAS

SEED MIX TABLE (RIPARIAN)		
APPLICATION RATE 25 kg/ha at depth of 5 cm		
QTY (%)	SCIENTIFIC NAME	COMMON NAME
10%	*Rudbeckia hirta*	Black Eyed Susan
1%	*Anemone canadensis*	Canada Anemone
1%	*Symphyotrichum puniceum*	Swamp Aster
1%	*Symphyotrichum novae-angliae*	New England Aster
1%	*Monarda fistulosa*	Wild Bergamot
25%	*Oenothera biennis*	Evening Primrose
15%	*Carex vulpinoidea*	Fox Sedge
2%	*Asclepias syriaca*	Common Milkweed
2%	*Solidago canadensis*	Canada Goldenrod
1%	*Clematis virginiana*	Virgins Bower
1%	*Euthamia graminifolia*	Grass-leaved Goldenrod
40%	*Elymus riparius*	Riverbank Wild Rye
RESTORATION COVER CROP - 15 kg/ha at depth of 5 cm		
40%	*Avena Sativa*	Oat
45%	*Hordeum vulgare*	Barley
15%	*Elymus canadensis*	Canada Wild Rye

SEED MIX FOR STORAGE AND STOCKPILE AREA

UPLAND NATIVE SEED MIX		
SCIENTIFIC NAME	COMMON NAME	PROPORTION OF SEED MIX(%)
Anemone canadensis	Canada Anemone	10
Asclepias syriaca	Common Milkweed	5
Carex pensylvanica	Pennsylvania Sedge	10
Carex granularis	Limestone Meadow Sedge	15
Clematis virginiana	Virgin's Bower	1
Elymus virginicus var. virginicus	Virginia Wildrye	20
Juncus tenuis	Path Rush	10
Monarda fistrulosa var. fistulosa	Wild Bergamot	1
Rudbeckia hirta var. pulcherrima	Black-eyed Susan	5
Schizachyrium scoparium var. scoparium	Little Bluestem	20
Solidago nemoralis var. nemoralis	Gray-stemmed Goldenrod	2
Solidago bicolor	White Goldenrod	1

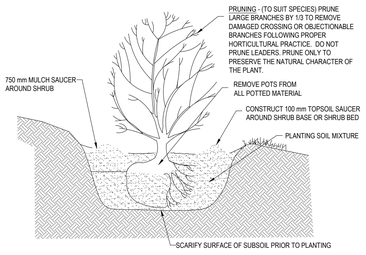
TO BE APPLIED AT 8-12 kg/ha. SOWN WITH NURSE CROP

NURSE CROP SEED MIX		
SCIENTIFIC NAME	COMMON NAME	PROPORTION OF SEED MIX(%)
Avena sativa	Oats	40
Elymus canadensis	Canada Wild Rye	15
Hordeum vulgare	Barley	45

TO BE APPLIED AT 15 kg/ha

SHRUB PLANTING DETAIL

N.T.S.

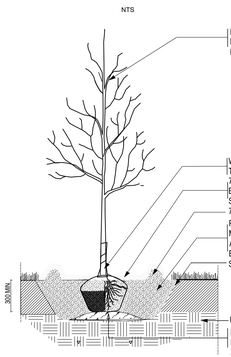


NOTES

- PLANTING METHOD ILLUSTRATED, SHALL APPLY EQUALLY TO BARE ROOT STOCK AND POTTED STOCK.
- SET SHRUBS 5 cm HIGHER THAN SURROUNDING GRADE TO ALLOW FOR SETTLEMENT.
- THE ABOVE DETAIL DOES NOT REPRESENT ANY PARTICULAR SPECIES.
- DEPTH OF PLANTING SHALL BE SUFFICIENT TO COVER ROOTS LAID IN A NATURAL POSITION.

DECIDUOUS TREE PLANTING TYPICAL DETAIL

NTS



NOTES:
1. ALL DIMENSIONS ARE IN MILLIMETRES.
2. NO TREE PITS SHALL BE LEFT OPEN OVERNIGHT.

RESTORATION NOTES

1. ANY IMPACT TO CITY OWNED TREES INCLUDING ANY DISRUPTION TO ROOTS, BEYOND THE TREES THAT HAVE BEEN IDENTIFIED FOR REMOVAL ON THE DRAWINGS, SHALL BE REVIEWED AND APPROVED ON SITE BY THE CITY'S FORESTRY SUPERVISOR. CONTRACTOR TO CONTACT THE CONTRACT ADMINISTRATOR TO MAKE ALL NECESSARY ARRANGEMENTS WITH THE CITY'S FORESTRY SUPERVISOR.
2. WOODY DEBRIS: ALL WOODY DEBRIS FROM REMOVED TREES DUE TO SITE DISTURBANCE SHOULD BE KEPT ON-SITE. SOME TREE TRUNKS CAN BE CUT INTO SMALLER SEGMENTS AND DISTRIBUTED THROUGHOUT THE SITE, OUTSIDE THE MAIN CHANNEL, AFTER THE COMPLETION OF RESTORATION PLANTINGS. INVASIVE SPECIES (I.E. COMMON BUCKTHORN AND MANITOBA MAPLE) SHALL NOT BE REUSED AS WOODY DEBRIS BUT SHALL BE MULCHED. THE REMAINING MATERIAL SHOULD BE MULCHED AND APPLIED AROUND THE BASED OF PLANTED TREES.
3. DO NOT STOCKPILE TOPSOIL CONSTRUCTION MATERIALS OR DEBRIS WITHIN THE DRIP LINE OF EXISTING TREES TO REMAIN ON SITE. CONTRACTOR TO PROTECT EXISTING TREES TO REMAIN. THE ENGINEER MAY DIRECT THE CONTRACTOR TO MARK AND FENCE PARTICULAR EXISTING TREES PRIOR TO STOCKPILING MATERIALS.
4. TREE REMOVAL - NO TREES SHALL BE REMOVED WITHOUT PRIOR APPROVAL FROM THE PROJECT COORDINATOR. ALL TREE REMOVALS TO BE COMPLETED IN ACCORDANCE WITH ACCEPTED FORESTRY PRACTICES AND WITHOUT IMPACT TO EXISTING TREES/VEGETATION TO REMAIN ON SITE.
5. ALL EXPOSED SOILS OR AREAS IMPACTED BY CONSTRUCTION ARE TO HAVE A MINIMUM 300mm DEPTH OF TOPSOIL AND TERRASEEDED WITH A NATIVE SEED MIX (SEE SEED MIX TABLE) AND COVERED WITH BIODEGRADABLE EROSION CONTROL MATTING - TERRAFIX COIR MAT 400, SEE DETAIL 3 ON DRAWING # CD.

PLANTING NOTES:

6. ALL NURSERY STOCK SHALL MEET STANDARDS OF THE CANADIAN NURSERY TRADES ASSOCIATION, LATEST EDITION. ALL PLANT MATERIAL SHALL BE STAKED FOR INSPECTION AND APPROVAL BY THE LANDSCAPE ARCHITECT.
7. CONTRACTOR SHALL MAINTAIN ALL AREAS OF PROJECT UNTIL SUBSTANTIAL COMPLETION OF PROJECT.
8. INSPECTION SHALL OCCUR ONCE THE 2 YEAR WARRANTY PERIOD IS UP. REPLACEMENTS MAY BE REQUIRED AT THIS TIME. REPLACEMENTS SHALL BE PLANTED WITHIN 30 DAYS FROM THE DATE OF INSPECTION, UNLESS OTHERWISE DIRECTED, IN ACCORDANCE WITH ACCEPTED HORTICULTURAL PRACTICES.
9. AT THE TIME OF FINAL INSPECTION, ALL PLANT MATERIAL SHALL BE IN A HEALTHY, VIGOROUS GROWING CONDITION. PLANTED IN FULL ACCORDANCE WITH DRAWINGS AND CONDITIONS.
10. LANDSCAPING CONTRACTOR TO PROVIDE 72 HOURS NOTICE TO THE ENGINEER AND LANDSCAPE ARCHITECT IF SPECIES, SIZE AND/OR QUANTITY IS NOT AVAILABLE AND SUBSTITUTIONS ARE NEEDED. ECOLOGIST TO IDENTIFY SUITABLE SUBSTITUTIONS AND HAVE THESE SUBSTITUTIONS APPROVED BY THE CITY AND CLOCA.
11. LANDSCAPING CONTRACTOR TO PROVIDE ENGINEER AND LANDSCAPE ARCHITECT WITH 48 HOURS NOTICE BEFORE AN AREA IS TO BE PLANTED, LAYOUT OF PLANT MATERIAL TO BE REVIEWED BY THE ENGINEER OR LANDSCAPE ARCHITECT PRIOR TO INSTALLATION.
12. WATERING IS REQUIRED TO PROMOTE HEALTHY GROWTH. FOR ALL PLANT MATERIAL, WATER THOROUGHLY IN LATE FALL PRIOR TO FREEZE UP TO SATURATE SOIL AROUND ROOT SYSTEM.
13. ALL MATERIAL SHALL BE WATERED AT THE TIME OF PLANTING.
14. ALL MATERIAL SHALL BE WATERED REGULARLY (WEEKLY BASIS IF CONDITIONS REQUIRE) DURING THE FIRST TWO YEARS OF ESTABLISHMENT. MORE FREQUENT WATERING WILL BE REQUIRED DURING PERIODS OF DROUGHT.
15. ALL TREES AND SHRUBS IN PLANTING MODULES ARE TO BE MULCHED INDIVIDUALLY.
16. MULCH SHALL BE TOPPED UP TO ENSURE THE SPECIFIED MINIMUM DEPTH IS MAINTAINED ON ALL PLANTING BEDS THROUGHOUT WARRANTY PERIOD.
17. GENERAL MAINTENANCE REQUIREMENTS FOR TREES, SHRUBS AND PERENNIALS SHALL BE PERFORMED A MINIMUM OF ONCE PER MONTH DURING THE GROWING SEASON.
18. THE CONTRACTOR SHALL BE RESPONSIBLE FOR THE REPLACEMENT OF UNACCEPTABLE OR DEAD MATERIAL. STRAIGHTENING TREES THAT LEAN, AND ANY OTHER PROCEDURE CONSISTENT WITH GOOD HORTICULTURAL PRACTICE NECESSARY TO ENSURE NORMAL, HEALTHY GROWING CONDITION OF PLANT MATERIAL.
19. ALL TREES ARE TO RECEIVE A WHITE SPIRAL PLASTIC TREE GUARD. THE LANDSCAPE CONTRACTOR IS RESPONSIBLE FOR MONITORING GROWTH OF TREES WITH TREE GUARDS AND REMOVING AND PROPERLY DISPOSING OF EVERY TREE GUARD WITHIN THE RESTORATION. A TREE GUARD IS READY TO BE REMOVED WHEN AN INDIVIDUAL TREE HAS REACHED FREE TO GROW STAGE AND /OR THE TREE GUARD IS VISIBLY CONSTRAINING TREE GROWTH.

TERRASEEDING NOTES:

20. HERBACEOUS SPECIES: RIPARIAN SEED MIX APPLIED AT 25 kg/ha AT DEPTH OF 5cm WITH A DRY SEED COVER (NURSE) CROP APPLIED AT 15 kg/ha AT DEPTH OF 5cm FOR THE WORK AREA, EXCLUDING VEGETATED STONE REVETMENT.
21. TERRASEEDING IS TO BE EXECUTED FOLLOWING COMPLETION OF THE TREE AND SHRUB PLANTING OPERATIONS.
22. AT THE TIME OF TERRASEEDING ALL SURFACE DESIGNATED FOR THIS OPERATION SHALL BE FRIABLE AND FINE GRADED TO A RELATIVE UNIFORM SURFACE. THE SURFACE SHALL HAVE BEEN CULTIVATED TO A MINIMUM DEPTH OF 50MM (2") AND A MAXIMUM DEPTH OF 75MM (3"). 300MM OF TOPSOIL WILL HAVE BEEN APPLIED PRIOR TO PLANTING AND SEEDING WORKS BEGINNING.
23. SEEDING AND OR RESEEDING SHALL NOT BE CARRIED OUT UNDER ADVERSE FIELD CONDITIONS SUCH AS HIGH WIND, FROZEN GROUND OR GROUND COVERED WITH SNOW, ICE OR STANDING WATER.
24. THE SITE AND EROSION CONTROL MEASURES SHALL BE MAINTAINED UNTIL VEGETATIVE COVER IS ESTABLISHED.
25. NO SEEDING OR COVER APPLICATION SHALL COME IN CONTACT WITH THE FOLIAGE OF EXISTING VEGETATION. NO SEED OR COVER SHALL COME IN CONTACT WITH EXISTING WATER BODIES.
26. SPECIFIED NURSE CROPS ARE TO BE APPLIED ALONG WITH THE NATIVE SEED MIX.

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

PROJECT:

HARMONY CREEK SITE 2 & 3
PRELIMINARY DESIGN

TITLE:

RESTORATION PLANTING PLAN

PROJECT NO:	DATE:
1510208	2022-08-12

DESIGN BY:	DRAWN BY:	APPROVED BY:
MO	NC	RM/MO

DRAWING NO:	SHEET NO:
GP	06

Appendix G

ROM Construction Cost Estimate

Rough Order-of-Magnitude Construction Cost Estimate
Channel Realignment and Erosion Control Works

Client: Oshawa® Prepare To Be Amazed

Palmer™

Project No.: 1510207
Date: 03-Aug-22
Prepared By: Max Osburn, P.Eng.
Checked By: Robin McKillop, M.Sc. P.Geo.
Project Description: Harmony Creek Site 2-3 Preliminary Design
Location: Oshawa, Ontario

				HARMONY CREEK SITE 2-3 PRELIMINARY DESIGN ROM COST ESTIMATE	
Project Phase	**Project Task**	**Units**	**Unit Cost**	**Quantity**	**Total Cost**
Mob/Demob/Access	*Mobilization/Demobilization*	LS	$ 20,000	1	$ 20,000
	Bond and Insurance	LS	$ 10,000	1	$ 10,000
	Field Office	LS	$ 10,000	1	$ 10,000
	Traffic Control and Project Signs	LS	$ 5,000	1	$ 5,000
	Construction Layout and Utility Locates	LS	$ 10,000	1	$ 10,000
	Site Access & Staging Area	LS	$ 15,000	1	$ 15,000
Environmental	*Erosion & Sediment Controls (i.e., Heavy Duty Silt Fence)*	m	$ 20	400	$ 8,000
	Fish Rescue and MNRF Fish Collection Permit	LS	$ 5,000	2	$ 10,000
	Flow Management & Silt Curtain (bypass pumping with cofferdam)	LS	$ 25,000	1	$ 25,000
Earthworks	*Clearing and Grubbing*	m^2	$ 15	920	$ 13,800
	Mature Tree Removal	LS	$ 1	15000	$ 15,000
	Cut Volume and Fill Volume	m^3	$ 50	800	$ 40,000
	Offsite Material Disposal	m^3	$ 20	250	$ 5,000
Removals	*Gabion Baskets & Debris*	m	$ 100	40	$ 4,000
	Asphalt Trail Removal	m^2	$ 30	150	$ 4,500
Channel Works	*Armourstone Retaining Wall*	m	$ 3,000	60	$ 180,000
	Channel Realignment (Riffle-Pool Stone 700mm Depth)	m	$ 1,250	150	$ 187,500
	Stormwater Outfall Retrofit	LS	$ 7,500	1	$ 7,500
Additional Site Restoration	*Existing Channel Infill and Grading*	m	$ 250	100	$ 25,000
	Plantings and Site Restoration (trees, shrubs, seeding, top soil)	m^2	$ 80	710	$ 56,800
	Asphalt Trail	m	$ 100	150	$ 15,000
	Task Subtotal (excl. HST)	$	-	-	$ 667,100
	Contingency (20%)	$	-	-	$ 133,420
	Project Subtotal (excl. HST)	$	-	-	$ 800,520
	Detailed Design Engineering and Tendering (15%)	$	-	-	$ 100,065
Assumptions:	*Contract Administration (10%)*	$	-	-	$ 66,710
	Construction Inspections (5%)	$	-	-	$ 33,355
	Project Total (excl. HST), rounded to near '000	$	-	-	$ 968,000

Unit rates are based on recently tendered projects of a similar nature.
The items and quantities are based on preliminary design drawings and are for estimation purposes only.
Inflation and pandemic related supply chain issues have resulted in substantial price volatility in 2021. Assumed rates may vary from actual rates at the time of construction
Works will be completed by an experienced third party contractor.
Flow management in work areas are based on a meterbag cofferdam and pump bypass system.
50% of the work area and 100% of access and laydown areas will require clearing and grubbing of trees and shrubs.
Offsite soil disposal can be completed within a 2-hour round trip.
The assumed D_{50} stone size is 250 mm.