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Preliminary Design and Municipal Class Environmental Assessment Schedule A+ Report

Oshawa Creek Site 6 & 8

Palmer Project #
1510207

Prepared For
City of Oshawa

June 15, 2022

June 15, 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 A+ Report
Project #: 1510207

Palmer is pleased to provide the City of Oshawa with our Preliminary Design and Class Environmental Assessment Schedule A+ Report to address erosion risk posed to private property and municipal infrastructure at Oshawa Creek Sites 6 and 8, immediately upstream of Thomas Street, in Oshawa. 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, in addition to the 'do nothing' option, were developed and evaluated. The preferred alternative, which is recommended for implementation at Sites 6 & 8, 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 preliminary designs for erosion mitigation measures to protect at-risk infrastructure and private property at Oshawa Creek Sites 6 and 8, upstream of Thomas Street (**Figure 1**). The associated study is meant to satisfy the conditions of the Schedule A+ Municipal Class Environmental Assessment (EA) process. This document includes project objectives (Section 2); 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

Erosion Sites 6 and 8 were initially prioritized during Palmer’s (2020) completion of a detailed fluvial geomorphic analysis and erosion hazard assessment along Oshawa Creek between Thomas Street and Wentworth Street West. The assessment was completed in support of the City’s objective of identifying and evaluating erosion hazards and developing strategies to mitigate corresponding unacceptable risks at prioritized sites. The assessment identified 11 hazard sites where infrastructure and private property are at risk due to ongoing fluvial adjustment. Conceptual erosion mitigation strategies were evaluated for each site, and preferred alternatives were identified.

Site 6 was identified along the outer (west) bank of a meander, approximately 50 m upstream of Thomas Street, where severe erosion is posing a risk to private property at the edge of the tableland. At Site 8 immediately downstream, local concentration of surface runoff has started to erode an existing boulder revetment along the east bank that protects the Thomas Street bridge abutment.

The preferred mitigation option determined through Palmer’s multi-criteria evaluation involved the creation of a low floodplain bench protected by a vegetated boulder revetment along the outer bank of the meander to create separation and mitigate continued fluvial erosion along the toe of the western valley wall. The existing deteriorated bank protection at Site 8 would also be replaced with a vegetated boulder revetment and small slope drain to intercept and control local runoff. Following Palmer’s assessment in 2020, the City requested consultation to advance the preferred conceptual option at Site 6/8 through preliminary design.

LEGEND:

- 3 Erosion Hazard Site
- 2 Photo Location and Direction
- Flow Direction
- 2020 Channel Centreline
- Study Corridor Limit

Existing Erosion Control Structures

- Rip-Rap Bank Revetment

TITLE:

Study Site

METRE SCALE: 0 2 4 8 12 16 20	NORTH:	CLIENT: City of Oshawa
PRINT SCALE: 1:600	PRINT SIZE: 11 x 17 "	TITLE: Oshawa Creek Geomorphological Assessment and Erosion Mitigation
DATUM: NAD 1983	PROJECTION: UTM Zone 17	
DATE: Jun 10, 2022	DRAWN: CV CHECKED: AS	
PREPARED BY: Palmer™		FIGURE NO. 1 REVISION: 1 PROJECT NO. 1510207

Document Path: G:\Shared drives\Projects 2015\15102 - City of Oshawa\1510207 - Oshawa Creek - Site 6-8 Preliminary Design\GIS\1_Workspace\Task 2 - Reporting\1510207_1-1_Prioritized Erosion Hazard Sites.mxd

Imagery (2020) provided by the City of Oshawa

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.

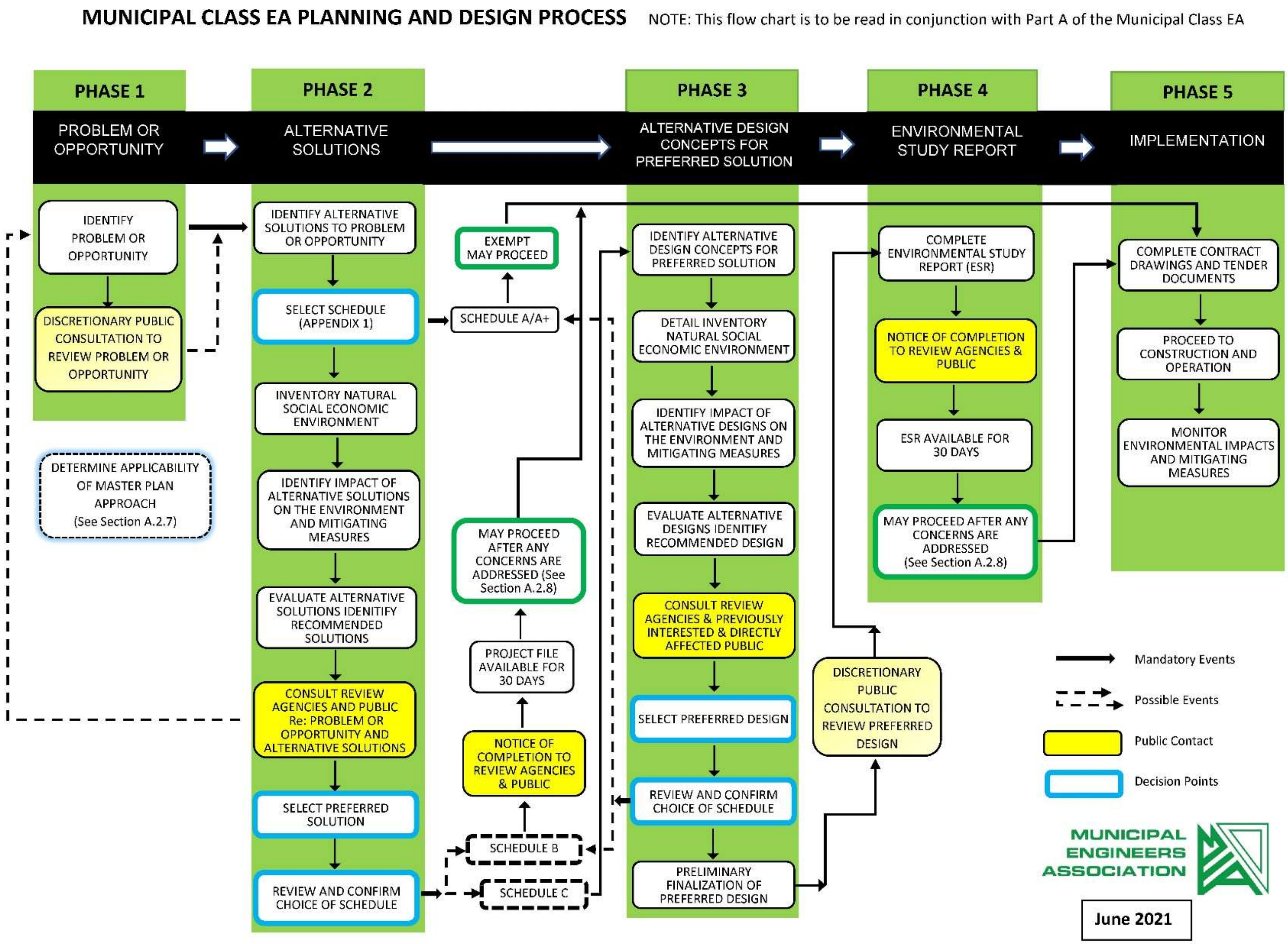


Figure 2. MEA Class EA Process

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 12, Schedule 'A' of the Municipal Water and Wastewater Projects section within Appendix 1 of the document, states:

> "[The proposed project will] replace traditional materials in an existing watercourse or in slope stability works with material of equal or better properties, at substantially the same location and for the same purpose."

The preferred works at Oshawa Creek Site 6 and 8 involves the replacement of existing erosion protection along the channel banks with vegetated riverstone and woody debris in substantially the same location, so they align closely with Item 12. Therefore, the project is considered to be a Schedule A undertaking. The City of Oshawa has elected to include a discretionary public outreach step, thereby elevating the project as a Schedule A+. Schedule A+ projects include identification of the problem or opportunity, public outreach, identification of alternative solutions, and selection of a preferred alternative. These projects are pre-approved and may proceed to implementation without following the full Class EA planning process.

2. Identification of Problems and Opportunities

2.1 Problem Statement

Severe erosion along the outer (west) bank of Oshawa Creek, approximately 50 m upstream of Thomas Street, is posing a risk to private property at the edge of tableland (Site 6). Slope recession initiated by fluvial scour and subsequent oversteepening of the valley wall may encroach into tableland, toward 204 Thomas Street and the properties along Valley Court, until toe erosion is mitigated, or a stable slope is achieved.

Immediately downstream, channel migration and local concentration of surface runoff has started to erode an existing boulder revetment along the east bank that protects the Thomas Street bridge abutment and the Joseph Kolodzie Oshawa Creek Bike Path (hereafter, the Bike Path) (Site 8). Ongoing erosion will eventually undermine the existing revetment, causing it to collapse and exposing the Thomas Street bridge abutment to direct scour.

2.2 Opportunities and Objective

The purpose of this study is to develop a preliminary mitigation strategy to address erosion and valley wall instability along Oshawa Creek at Sites 6 and 8. Rehabilitation objectives include the following:

- Protection of private property at the edge of tableland adjacent to Site 6.
- Protection of municipal infrastructure (e.g., the Bike Path and Thomas Street Bridge) at Site 8.
- 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

Oshawa Creek originates in agricultural lands on the southern flank of the Oak Ridges Moraine and flows generally southward over the till plains of the South Slope and the former Glacial Lake Iroquois Plain before entering Lake Ontario (Chapman and Putnam, 1984). The entire Oshawa Creek watershed has a drainage area of 120 km^2 (CLOCA, 2013). The southern portion of the Oshawa Creek watershed, especially south of Highway 407, is fully built-out with mostly residential and commercial development. As of 2007, the entire watershed had a recorded rural land use of 60% (CLOCA, 2007); however, this proportion is likely now smaller, based on changes observed in recent orthophotography provided by CLOCA. Land use directly upstream of, and adjacent to, the study corridor has been residential since 1954 before which the area was mixed residential and agricultural. Much of this development dates back to the mid-1900s, well before the incorporation of stormwater management (SWM) practices. Urbanization has altered the natural hydrology of the lower reaches of Oshawa Creek by accelerating surface runoff and flood routing, thereby increasing peak flows. Channel morphology has not fully adapted to the urbanized hydrologic regime, and the upcoming northward expansion of development in response to continued population growth, and recent eastward extension of Highway 407 will only further stress the system.

Within the Oshawa Main subwatershed, Oshawa Creek has a moderate gradient (average of 0.5%; CLOCA, 2007). Within the study corridor, along which the creek has a slightly gentler gradient of 0.44% as it approaches its mouth at Lake Ontario, Oshawa Creek meanders along the bottom of a well-defined valley. Surficial deposits of adjacent tableland consist of sandy silt to silty sand-textured till locally overlain by glaciolacustrine clay, silt, and sand deposits (OGS, 2010a, b). The valley bottom is generally filled with silty to cobbly alluvium, underlain by till, reflecting a history of lateral and vertical channel adjustment. Erosion-resistant till is commonly exposed along the bed and banks where the channel is in contact with the valley walls. Erosion protection measures (i.e., boulder revetments and armourstone walls) occur locally along the study corridor, typically adjacent to infrastructure.

3.2 Topographic Survey

A detailed topographic survey of Oshawa Creek encompassing Sites 6 and 8 was undertaken by the City of Oshawa with direction provided by Palmer staff in April of 2022. The survey was completed in sufficient detail to complete geomorphic analyses, hydraulic modeling, and detailed design. The survey captured the following details:

- Longitudinal profile of Oshawa Creek from upstream of the project limits to downstream of the Thomas Street bridge;
- Cross sections of the bankfull channel at 10-15 m spacing;
- Municipal infrastructure including the Thomas Street bridge, pedestrian trail and Bike Path Parking Lot;
- Mature vegetation (>10cm diameter at breast height potentially impacted as a result of the proposed works;
- Potential construction access and staging areas.

The horizontal reference plane used in the survey is NAD83(CSRS), Epoch 2010. The vertical datum used is the Canadian Geodetic Vertical Datum 1928 (CGVD28). All topographic data, maps, flood elevations and all other references are made to the above noted standards.

3.3 Channel Morphology

3.3.1 Historical Assessment

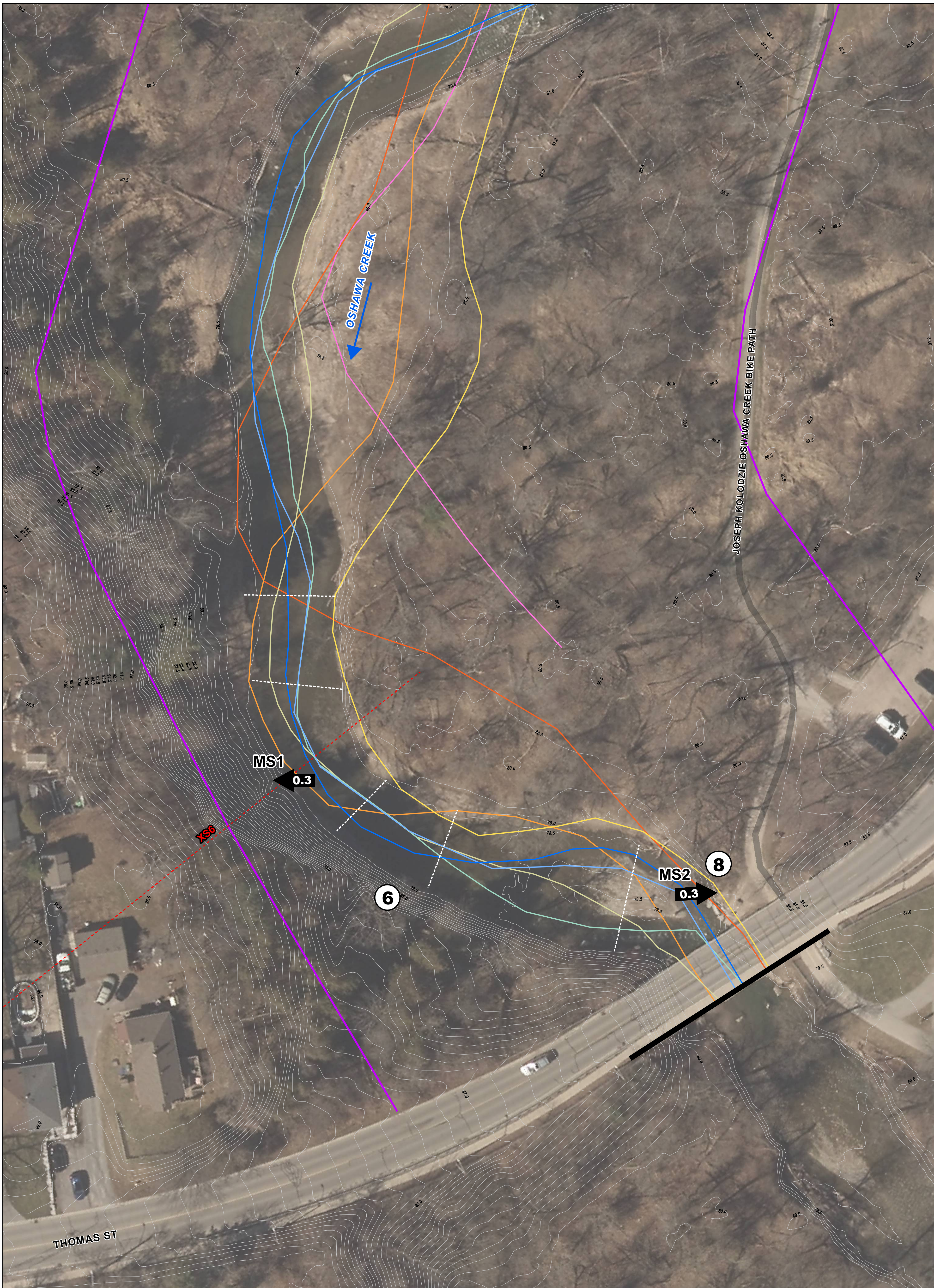
In 1927, the study corridor of Oshawa Creek was surrounded by undeveloped, agricultural land to the west, rural land use to the east, and a small urban development to the north. The valley walls were sparsely vegetated with young trees and shrubs.

The Wentworth Street and Thomas Street bridge crossings define the upstream and downstream extent of the study corridor, respectively (**Figure 3**). The Thomas Street crossing was constructed before 1927 but was moved approximately 250 m downstream sometime between 1927 and 1954. The Wentworth Street crossing was constructed sometime between 1954 and 1967. Additionally, a pedestrian bridge, constructed in the 1990s or early 2000s, crosses the channel approximately 150 m downstream of the Wentworth Street bridge crossing. A sanitary main, constructed before 1954, crosses beneath the watercourse immediately downstream of the pedestrian crossing.

Natural recolonization of the valley bottom by a variety of shrub and tree species in recent decades has re-established a functional riparian zone. Once dominated by meadow landscapes (e.g., 1927), the valley has since been colonized by a dense deciduous tree canopy.

Residential development within the Oshawa Creek watershed intensified in 1967, continuing through the early 2000s. Ongoing urbanization in the upper portions of the Oshawa Creek watershed continues to modify the hydrological response (‘flashiness’), which is inferred to be contributing to recent channel and planform adjustment. These adjustments pose a risk to development that has encroached to the valley edge and to infrastructure that crosses beneath the channel.

Between 2005 and 2010, the outer bank of Oshawa Creek, just upstream of the Thomas Street crossing and pedestrian crossing, was reinforced with boulder and armourstone revetments to prevent lateral erosion and subsequent outflanking of bridge footings.



LEGEND:

- 3 Erosion Hazard Site
- 0.2 Migration Site (MS) *rate in m/year*
- Meander Belt
- Cross Section Location
- LiDAR Cross Section Location
- Study Corridor Limits
- Contours (50 cm)
- Flow Direction

Channel Centre Line (Year)

- 2020
- 2018
- 2012
- 2005
- 1974
- 1967
- 1954
- 1927

TITLE:

Historic Changes and Meander Belt

METRE SCALE: 0 2 4 8 12 16 20

NORTH:

CLIENT: City of Oshawa

PRINT SCALE: 1:600 | PRINT SIZE: 11 x 17 "

DATUM: NAD 1983 | PROJECTION: UTM Zone 17

DATE: Jun 10, 2022 | DRAWN: CV | CHECKED: AS

PROJECT: Oshawa Creek Geomorphological Assessment and Erosion Mitigation

PREPARED BY: Palmer™

FIGURE NO. 3 | REVISION: 1 | PROJECT NO. 1510207

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Imagery (2020) provided by the City of Oshawa

3.3.2 Study Corridor

Oshawa Creek exhibits evidence of historical modification along the study corridor. Dynamic planform adjustment along the valley bottom suggests that channel morphology has not fully adopted to the urbanized hydrologic regime. The channel generally exhibits broad, irregularly shaped meanders that have increased in sinuosity and gradually migrated downstream, as indicated by the presence of inner-bank scroll (point) bars (**Photo 1**). The construction of Wentworth Street and Thomas Street on high, valley-spanning road embankments has locally fixed the channel planform in place, limiting planform departures within, and immediately upstream and downstream of, the study corridor. Average bed gradient is 0.44% along the entire study corridor, with no overall concavity/convexity in the longitudinal profile. Bed gradient is steeper than average from Site 6 to the downstream end of the study corridor (0.6%). Channel gradient along the study corridor is consistent with those typically associated with pool-riffle morphology (e.g., Montgomery and Buffington, 1997). Riffles are typically situated at the inflection points between successive meanders, and pools generally occur at and immediately downstream of meander apices.

Photo 1. Upstream view of channel approaching Site 6. A low, gentle eastern bank maintains good floodplain connectivity and helps attenuate flood energy.

Bed materials within Oshawa Creek are relatively well sorted, ranging from coarse sand to cobbles, and are dominated by gravels and small cobbles (**Figure 4**). Extensive fine-grained deposits blanket pool bottoms and a thin veneer of sand embeds larger particles in pools and riffles. The representative median grain size (D_{50}) of Oshawa Creek, within the study corridor, is approximately 50 mm (5 cm). There are several locations along the study corridor where underlying till is exposed on the bed (e.g., downstream of Site 6). Conspicuous traces of organic matter in overbank areas demarcate the limits of recent flood inundation.

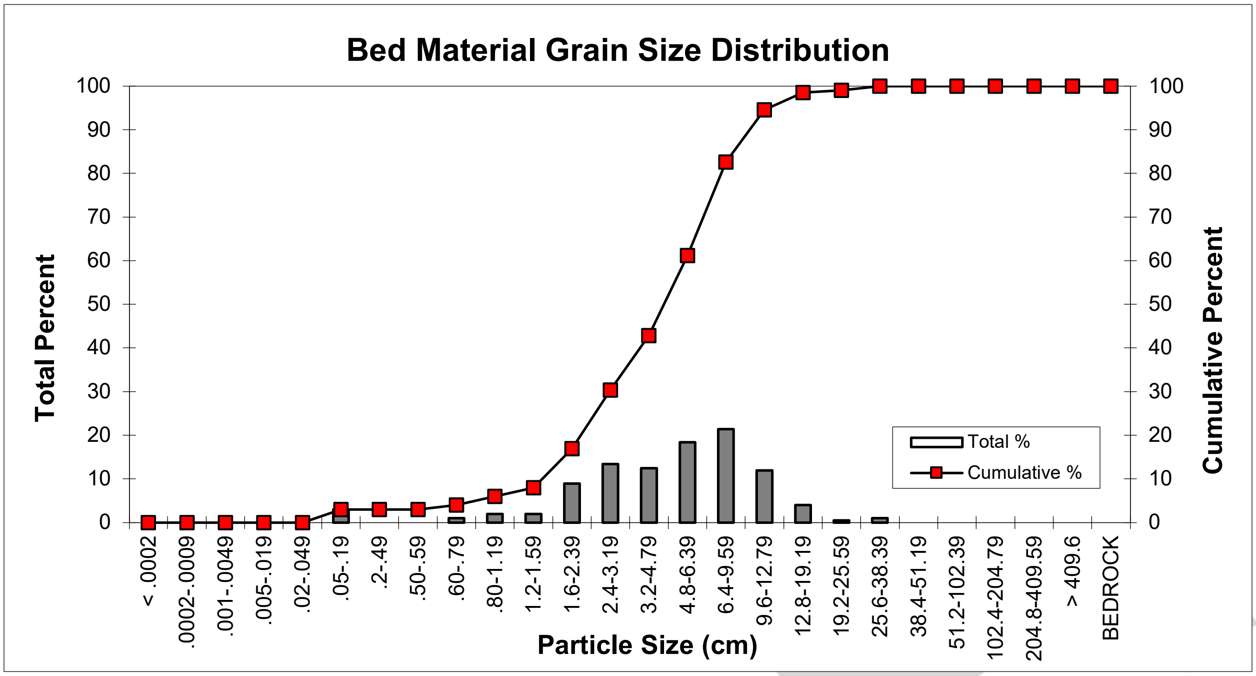

Figure 4. *Integrated grain size distribution of bed material from pebble counts (200 from Thomas Street tot Wentworth Street) conducted along Oshawa Creek.*

The results of the RGA suggest the study corridor is currently "transitional" with dominant modes of adjustment being aggradation and channel widening (**Table 2**). The results of the RSAT indicate the study corridor has 'Fair' quality based on good in-stream and riparian habitat conditions, fair channel stability and sediment scouring/deposition, and poor water quality (**Table 3**).

Table 2. *Summary results of RGA for Oshawa Creek between Thomas Street and Wentworth Street.*

Form/Process	Index
Aggradation	0.43
Degradation	0.17
Widening	0.44
Planimetric Form Adjustment	0.17
Stability Index	**0.30**
Classification	**Transitional**

Table 3. Summary results of RSAT for Oshawa Creek between Thomas Street and Wentworth Street.

Evaluation Category	Index
Channel Stability	5
Channel Scouring/Sediment Deposition	4
Physical In-stream Habitat	5
Water Quality*	2
Riparian Habitat Conditions	5
Biological Indicators	4
Total:	**25**
Verbal Ranking:	**Fair**

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

3.3.3 Meander Belt and Migration Rate

The meander belt was delineated by considering historical meander migration and the local confinement by valley walls. The existing meander belt is 90 m where it is unconfined, then widens to 110 m for the final version to account for a 20% factor of safety. The final meander belt was further refined (narrowed) to the midpoints of valley walls to better reflect localized confinements (**Figure 3**). Near Site 6 and 8, systematic migration was documented between 1974 and 2020 (i.e., migration measurement locations 1 and 2 in **Figure 3**) (**Table 4**). The migration rate at both locations was 0.3 m/year. Such rapid rates of migration largely reflect the erodible (alluvial) banks and valley walls and flashy peak flows that typify this study corridor.

Table 4. Meander migration rate calculation table based on comparative analysis of historical channel bank delineation.

Migration Measurement Location	Start (Year)	End (Year)	Period (Years)	Cardinal Direction	Distance (m)	Rate (m/year)
1	1974	2020	46	SW	12	0.3
2	2005	2020	15	ENE	5	0.3

3.3.4 Identification of Erosion Hazard Sites

Erosion along the study corridor is most pronounced along unprotected meanders where the channel is eroding its banks and/or the toe of a valley wall. A total of eight erosion hazard sites were identified and characterized during Palmer's detailed geomorphic analysis (2020). Site 6 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 8 was incorporated into the detailed assessment and mitigative concepts for Site 6, due to its proximity.

3.3.5 Oshawa Creek Site 6 & 8

Site 6 is located along the outer bank of a meander in contact with the western valley wall of Oshawa Creek (**Figure 1**). Channel contact with the valley wall has lengthened from about 75 m to 150 m between 1927 and 2020. The base of the valley wall has receded at a rate of approximately 0.3 m/year through an ongoing cycle of fluvial scour, oversteepening, and repeated mass movements (**Photo 2**). The valley wall has been unable to self-stabilize due to the repeated entrainment of sloughed material that temporarily accumulates along its toe during floods. Valley wall erosion at Site 6 was noted as a "high priority" for "erosion control or bank stabilization works" in the City's *Oshawa Creek Watershed Master Drainage* (Totten Sims Hubicki Associates, 1995) (**Figure 5)**. LiDAR data acquired in 2019 indicates the eroded valley wall is approximately 39^{o} steep along its unvegetated, eroded face, although only 23^{o} steep along its forested upper slope (**Figure 6**). Groundwater seepage, emerging part way down the erosion scar, may also be contributing to instability. The crest of the valley wall is approximately coincident with the edge of private property, with a dwelling and outbuildings setback approximately 10 m on adjacent tableland. Private property is located within the stable slope allowance (3H:1V, as defined by MNR, 2002) plus the toe erosion allowance (6 m, based on dense till exposed along the slope toe and MNR (2002). Continued slope recession and subsequent oversteepening of the valley wall may encroach into the tableland, toward 204 Thomas Street, until toe erosion is mitigated, or a stable slope is achieved. An overview of the erosion hazards and associated risks at Site 6 are provided in **Appendix A**.

Photo 2. An actively eroding scarp, approximately 100 m long and up to 17 m high, along the western valley wall at Site 6. Downstream view.

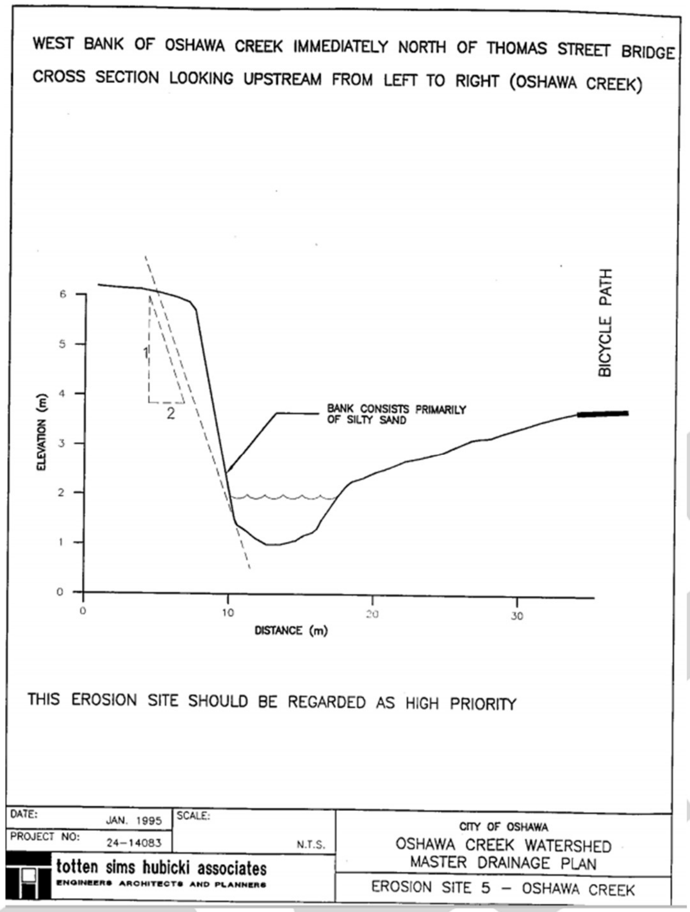

Figure 5. ***Upstream view of cross-section used by Totten Sims Hubicki Associates to identify the erosion hazard at Site 6 in 1995.***

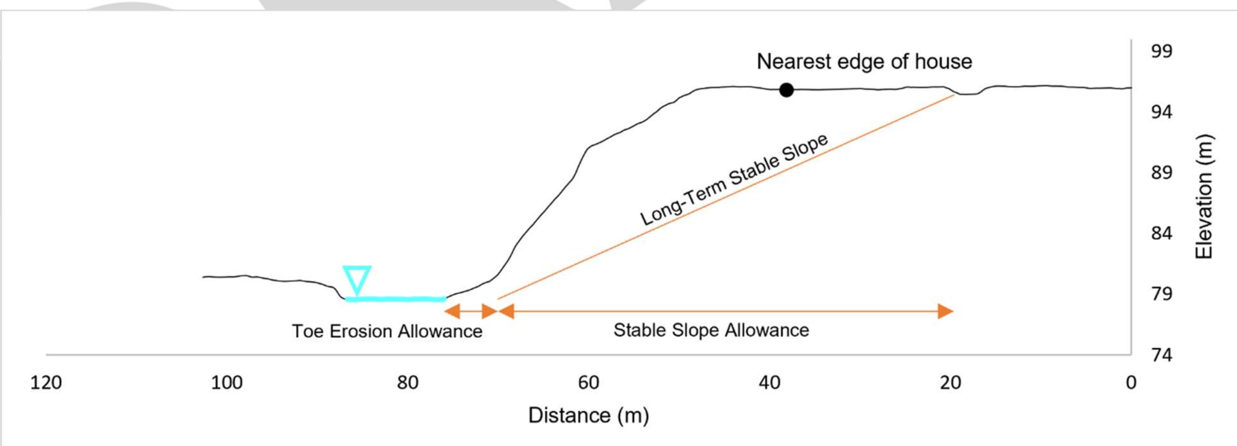

Figure 6. ***Downstream view of LiDAR-derived cross-section of west side of valley at Site 6, showing the toe erosion allowance (6 m) and the stable slope allowance (51 m) projected into tableland with private residences.***

Channel planform adjustment upstream of Thomas Street bridge (Site 8) has started to erode the upstream extent of the left bank boulder revetment protecting the bridge footing and Bike Path (**Photo 3**).

Overtopping flood flows have also resulted in the outflanking and winnowing of fines underlying and behind the boulder revetment. Surface runoff along the Bike Path, from the parking lot, cascades over the boulder revetment into the creek, and acts as a secondary erosion mechanism. An overview of the erosion hazards and associated risks at Site 8 are provided in **Appendix A.**

Photo 3. ***Riprap bank revetment at Site 8 that protects the Bike Path and left abutment of the Thomas Street bridge. Upstream view.***

Average bankfull width at Site 6 and 8 is 15.9 m, average bankfull depth is 0.8 m, and average bankfull discharge is 31.7 m^3/s (**Table 5**). Local bed scouring has resulted in a maximum pool bankfull depth of 1.8 m. The critical discharge to mobilize bed materials, averaged across cross-sections, is approximately 67.7% of the bankfull discharge (21.1 m^3/s). Higher critical discharge required to move coarser bed material (D_{50}) has resulted in lateral adjustments due to preferential erosion of the finer-grained channel banks when flows are contained within the channel. The energy that facilitates sediment mobilization is dispersed into the floodplain when depth is sufficient for channel water to overtop the banks (**Photo 1**).

Table 5. Estimated bankfull flow conditions and erosion thresholds 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)
Site 6/8	6-1	Riffle	24.9	16.3	0.7	1.0	22.9	1.4	23.6
	6-2	Riffle	31.5	15.6	0.8	1.2	19.2	1.6	22.3
	6-3	Pool	26.1	13.5	0.7	1.4	18.3	1.5	10.1
	6-4	Riffle	21.1	15.3	0.6	1.2	24.3	1.2	18.0
	6-5	Pool	55.1	19.0	1.1	1.8	17.4	2.1	26.7
Average			**31.7**	**15.9**	**0.8**	**1.3**	**20.4**	**1.6**	**20.1**

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, D_{cr}: critical depth.
2. Width-to-depth ratio (e.g., 34.6) calculated simply as the bankfull width (e.g., 20.9 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 range of 15 – 20 are common for in-regime channels with morphologies similar to Oshawa 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.
5. Based on surveyed cross-sections, local water surface slopes, and Manning's n values of 0.035.
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 Oshawa Creek Sites 6 and 8 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 Oshawa Creek HEC-RAS model (_Aug11_14_HEC-RAS.prj) was provided by CLOCA. The 2-Year, 5-Year, 10-Year, 25-Year, 50-Year, 100-Year and Regional (Hurricane Hazel) Storm Events were modelled with no revisions to the design flows. Flows for these storms through the study site are shown in **Table 6.** Locations of cross sections in the project area are shown in **Figure 7** (stations 2550 through 2262.023).

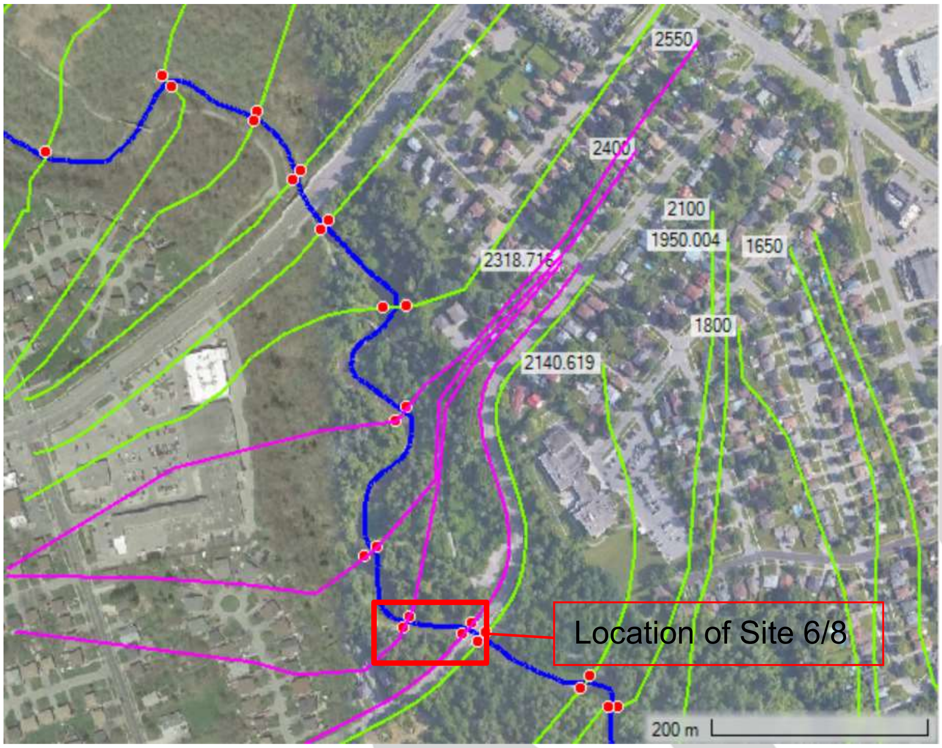

Figure 7. Location of cross sections through Oshawa Creek study site (HEC-RAS 6.2 Geometry Schematic per CLOCA)

Table 6. Oshawa 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	39.13
5 Year	69.18
10 Year	91.35
25 Year	124.35
50 Year	150.1
100 Year	177.77
Regional	672.49

3.4.2 Updated Existing Hydraulic Conditions

Using topographic survey data collected by the City of Oshawa in April 2022, 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 Oshawa Creek is provided in **Table 7**.

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

Cross Section	Storm Event	Total Flow	Min. Chnl Elev	W.S. Elev	E.G. Slope	Vel Chnl	Shear Chnl	Flow Area	Top Width Chnl	Froude #
		(m^3/s)	(m)	(m)	(m)	(m/s)	(N/m^2)	(m^2)	(m)	
2550	2 Year	39.13	79.68	80.77	0.00748	2.15	73.43	20.16	24.98	0.68
	5 Year	69.18	79.68	81.17	0.00737	2.63	100.86	31.3	41.84	0.71
	10 Year	91.35	79.68	81.38	0.00738	2.88	116.15	44.75	74.61	0.72
	25 Year	124.35	79.68	81.68	0.00655	3.03	122.17	71.55	113.38	0.7
	50 Year	150.1	79.68	81.94	0.00478	2.82	101.43	105.38	134.76	0.61
	100 Year	177.77	79.68	82.3	0.00277	2.37	68.71	156.51	143.94	0.48
	Regional	672.49	79.68	84.67	0.00138	2.58	65.99	522.33	163.3	0.37
2400	2 Year	39.13	78.65	80.29	0.00214	1.76	32.14	36.01	46.95	0.45
	5 Year	69.18	78.65	80.86	0.00161	1.87	32.93	74.09	104.85	0.41
	10 Year	91.35	78.65	81.11	0.00159	2	36.37	102.46	122.35	0.42
	25 Year	124.35	78.65	81.41	0.00162	2.19	41.71	140.28	124.94	0.43
	50 Year	150.1	78.65	81.75	0.00118	2.03	34.32	183.25	127.29	0.37
	100 Year	177.77	78.65	82.16	0.00083	1.85	27.36	236.5	134.42	0.32
	Regional	672.49	78.65	84.54	0.00081	2.6	45.4	689.72	213.02	0.34
2318.716 (Site 6)	2 Year	39.13	78.58	79.79	0.00706	2.53	74.7	16.28	18.51	0.77
	5 Year	69.18	78.58	80.4	0.0046	2.73	75.48	33.46	52.78	0.67
	10 Year	91.35	78.58	80.76	0.00325	2.6	64.42	73.45	147.35	0.58
	25 Year	124.35	78.58	81.31	0.00133	1.95	33.37	156.28	150.22	0.38
	50 Year	150.1	78.58	81.69	0.00087	1.73	25.08	213.66	152.23	0.32
	100 Year	177.77	78.58	82.13	0.00058	1.55	19.2	281.04	160.32	0.27
	Regional	672.49	78.58	84.5	0.00062	2.27	34.72	761.43	226.12	0.3
2262.023 (Site 8)	2 Year	39.13	77.34	79.9	0.00049	1.13	12.24	37.46	24.12	0.23
	5 Year	69.18	77.34	80.49	0.0007	1.56	21.61	51.31	25.52	0.28
	10 Year	91.35	77.34	80.76	0.00089	1.85	29.7	57.73	25.88	0.32
	25 Year	124.35	77.34	81.12	0.0011	2.21	40.94	66.45	27.92	0.36
	50 Year	150.1	77.34	81.43	0.00119	2.41	47.59	73.75	32.91	0.38
	100 Year	177.77	77.34	81.82	0.00117	2.54	51.22	83.14	73.72	0.38
	Regional	672.49	77.34	84.15	0.00129	3.53	86.01	328.61	138.3	0.43

Oshawa Creek in the project vicinity is a relatively natural system with unobstructed access to its floodplain. Upstream of Thomas Street at Site 6, the 2-year flow is fully contained within the channel, while greater magnitude flood events spill onto the floodplain and are dissipated by the well vegetated riparian area. The flow velocities during the 2-year and Regional storm events are 2.53 m/s and 2.27 m/s, respectively, demonstrating the energy dissipation provided by floodplain roughness. Flow narrows and accelerates as it approaches Site 8 and the Thomas Street bridge. The maximum velocity at Site 8, just upstream of the bridge, is 3.53 m/s during the Regional event. For reference, critical velocities capable of mobilizing typical stone materials used in erosion mitigation works are summarized below in Table 8.

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 6.1

3.5 Terrestrial and Aquatic Ecology

3.5.1 Terrestrial Ecology and Ecological Land Classification (ELC)

The study corridor is located within a naturalized system, which predominantly exhibits a deciduous tree canopy with small areas of thicket and meadow (CLOCA, 2007). The presence of small open meadow areas within the deciduous forest community indicates that this area has been subject to environmental disturbances in the past. The restriction of development from the main portion of 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 NHIC, no wetland communities of significant size have been mapped in the area (CLOCA, 2019). The MNRF's Land Information Ontario (LIO) database identifies several polygons of Oshawa Creek Coastal Wetland complex along the banks of Oshawa Creek, downstream of Thomas Street, but none of these features occurs within the study corridor.

CLOCA's ELC data is high-level and indicates two community types occurring within the study corridor: Fresh-Moist Hemlock Mixed Forest and Fresh-Moist Lowland Deciduous Forest. The study area is dominated primarily by two forest types, upland and lowland deciduous forest, divided primarily by topographic position within the valley (**Figure 8**). Eastern Hemlock *(Tsuga canadensis)* is present within the upland forest, but such coniferous species are uncommon within the canopy. No wetlands were identified within the study area, corroborating information from LIO, but some small inclusion wetland vegetation communities are associated with the riparian area of Oshawa Creek. The following ELC communities were identified within the study area:

<u>Dry – Fresh Sugar Maple Hemlock Deciduous Forest (FOD5)</u>
This forest type occupies the upper valley walls of Oshawa Creek, and is dominated by Sugar Maple *(Acer saccharum)*, with other upland hardwood species including Black Cherry *(Prunus serotina)*, White Ash *(Fraxinus americana)*, Basswood *(Tilia americana)* and occasional White Pine *(Pinus strobus)* and Eastern Hemlock in the canopy. The subcanopy includes younger individuals of the canopy species and Ironwood *(Ostrya virginiana)*. The understory, which is primarily sparse due to dense hardwood canopy cover, includes Trout Lily *(Erythronium americanum),* Long-stalked Sedge *(Carex pedunculata)*, sapling Sugar Maple, and Intermediate Wood Fern *(Dryopteris intermedia)*.

<u>Fresh – Moist Willow Lowland Deciduous Forest (FOD7-3)</u>
This forest type primarily occurs on the lowlands along the valley bottom of Oshawa Creek, with a canopy that is primarily dominated by non-native Willow species, indicating historical clearing or disturbance. Canopy trees include Crack Willow *(Salix fragilis)*, Weeping Willow *(Salix babylonica)* and Manitoba Maple *(Acer negundo)*, with an understory of Urban Avens *(Geum urbanum)*, Broad-leaved Dock *(Rumex crispus)*, Common Self-heal *(Prunella vulgaris)*, Creeping Bellflower *(Campanula rapunculoides)* and Great Willlow-herb *(Epilobium hirsutum)*.

ELC DESCRIPTION:

FOD5: Dry-Fresh Sugar Maple Hemlock Deciduous Forest
FOD7-3: Fresh-Moist Willow Lowland Deciduous Forest

LEGEND:

- Ecological Land Classification (ELC)
- Flow Direction

Imagery (2020) provided by the City of Oshawa

TITLE: **Existing Environmental Conditions**

METRE SCALE: 0 5 10 20 30 40	NORTH:	CLIENT: City of Oshawa	
PRINT SCALE: 1:1400	PRINT SIZE: 11 x 17 "	PROJECT: Oshawa Creek Geomorphological Assessment and Erosion Mitigation	
DATUM: NAD 1983	PROJECTION: UTM Zone 17		
DATE: Aug 23, 2021	DRAWN: KG CHECKED: AS		
PREPARED BY: Palmer™			
FIGURE NO. 8	REVISION: 1-1	PROJECT NO. 1510206	

Document Path: G:\Shared drives\Projects 2015\15102 - City of Oshawa\1510206 - Oshawa Creek - Thomas to Wentworth\Mapping\Figures\5_ArcGIS\1510204_2-1_Existing Environmental Conditions.mxd

3.5.2 Tree Inventory

The tree inventory was conducted by Palmer's certified arborist on April 7, 2022, for all trees greater than 10 cm Diameter at Breast Height (DBH). A total of 46 trees were inventoried. Information collected during the inventory is provided in **Appendix B,** and includes species name, tree tag number, tree size, dripline, general tree health, and location.

3.5.3 Aquatic Habitat

The corridor of Oshawa Creek between Thomas Street and Wentworth Street is classified as a fifth-order stream, as characterized by the Strahler method (CLOCA, 2007). It contains no impediments (partial or complete barriers) to fish passage entering from Lake Ontario. Oshawa Creek is predominantly a cold- and cool-water system, with warm-water sites found in the lower reaches of the main branch, as indicated by temperature loggers (CLOCA, 2007). The study area occurs within this warm-water reach. The warm water timing window for construction is July 1 to March 31 (DFO, CLOCA 2007). Oshawa Creek is a migratory corridor for spring and fall spawning runs of anadromous trout and Pacific Salmon from Lake Ontario. As such, any works must not block fish passage as migratory species are usually staging early in the lower parts of Oshawa Creek. The construction timing window should be confirmed with the local Ontario Ministry of Natural Resources and Forestry (MNRF) office before any in-water works are scheduled.

The following aquatic habitat descriptions interpret the aquatic habitat mapping provided in **Appendix C.** Along the study corridor, the creek is characterized by well-developed riffle-run-pool stream morphology. Undercut banks and overhanging woody debris are found throughout the reach and provide in-stream cover. The area around Erosion Sites 6 & 8 is primarily a straight run with limited available fish refuge through this area. Substrates within the watercourse vary among morphological habitat units, with pools primarily featuring silt and sands, and gravel and cobbles predominant within riffles and runs. Through the area of the proposed works in Erosion Sites 6 & 8, the substrates are primarily sorted cobbles through the run.

The riparian area is densely vegetated and includes overhanging woody plants and grasses. In some areas, large Willow *(Salix spp.)* trees 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. This section of the reach offers minimal fish habitat value as it is a run with limited riparian area or refuge. Despite the densely vegetated riparian area throughout the majority of the reach, vegetation is mostly absent from the wetted width of the creek, limited to some Creeping Bentgrass *(Agrostis stolonifera)* and Reed Canary Grass *(Phalaris arundinacaea)* emerging from sandy bars at the edges of pools. This section of the watercourse features significant erosion and steep slopes, primarily along the outer banks of the pools at the apices of meanders, currently providing limited fish habitat due to the lack of riparian cover and high-velocity runs within the study corridor. A small gravel bar occurs within the stream immediately upstream from Thomas Street, potentially providing habitat for small fish or fry in portions of the side channels.

3.5.4 Fisheries Communities

Data from the MNRF indicates an extensive list of fish species that are known to occur within Oshawa Creek: Bluegill *(Lepomis macrochirus)*, Bowfin *(Amia calva)*, Brook Trout *(Salvelinus fontinalis)*, Brown Bullhead *(Ameiurus nebulosus)*, Brown Trout *(Salmo trutta)*, Common Carp *(Cyprinus carpio)*, Largemouth Bass *(Micropterus salmoides)*, Northern Pike *(Esox lucius)*, Pumpkinseed*(Lepomis gibbosus)*, Rainbow Trout *(Onchorynchis mykiss)*, Rock Bass *(Ambloplites rupestris)*, Smallmouth Bass *(Micropterus dolomieu)*, White Sucker *(Catostomus commersonii)* and Yellow Perch *(Perca flavescens)*. A community of baitfish would also be expected to occur. This list of fish species includes those which would be expected closer to the confluence with Lake Ontario (i.e Rock Bass, Yellow Perch), with some only occurring in the higher reaches where thermal regimes are colder and habitat is more suitable (i.e. Brook Trout, Brown Trout).

The Study Area for this project occurs within a warmwater reach near the confluence with Lake Ontario. Headwater species such as Brook Trout would not be expected to occur within this reach. Being a warmwater reach, this area would support warmwater spawning species, thus the application of the warmwater timing window for Southern Ontario for avoiding spawning times is recommended. This would indicate no in-water work should occur between **March 15 to June 15** of the calendar year. No work should impede migratory routes for fish, particularly in the fall during the salmon run.

3.5.5 Species-at-Risk Screening

The field work undertaken by Palmer did not confirm any Species at Risk within the study area, however several are known to occur in Durham Region which could potentially find habitat within the Oshawa Valley corridor. Butternut *(Juglans cinerea)*, is an endangered tree species that could occur and commonly be detected on single site surveys. This species, or other SAR vegetation species were not detected during field investigations.

As with much of the province, the forested area has the potential to provide maternity roosting habitat for Endangered species of Bats. Roosting bats could be present from April 1st to September 30th in Southern Ontario. During this time period trees should not be removed as roosting bats may be present. If this is not avoidable based on project requirements, exist surveys can be undertaken by a qualified biologist to confirm presence / absence of roosting bats.

Several species of SAR birds can occur in mature forests in Durham Region. While no direct habitat was observed or previously reported, all birds and bird nests could be present during the breeding bird season. The timing window is similar to the potential presence of roosting bats, in which tree removal should not occur, but extends to all vegetation removal for birds during this window as nests could be present in shrubs and understory habitats.

Screening for any SAR will be required through Ontario Ministry of the Environment, Conservation and Parks in advance of, and to inform, any proposed works along the Oshawa Creek valley. Butternut (*Juglans cinerea*) and certain species of bats are at risk and may be present, for example, although neither was observed during Palmer's ecological field reconnaissance.

4. Evaluation of Alternative Solutions

4.1 Site 6 & 8

Two conceptual mitigation alternatives were evaluated, in addition to the 'do nothing' alternative, for Sites 6 and 8. The alternatives aim to protect the edge-of-tableland property adjacent to Site 6 from instability driven by fluvial scour. Planform adjustment and concentrated surface runoff have also begun to outflank and winnow fine-grained sediments from a deteriorated boulder revetment protecting the Bike Path and Thomas Street bridge. Schematic illustrations of each alternative are presented in **Appendix D.**

4.1.1 Do Nothing Alternative

This alternative represents the 'do nothing' strategy (**Table 9**). Without intervention, the property at 204 Thomas Street will remain at risk from a cycle of fluvial scour and mass movements along the base of the adjacent valley wall. The channel has been in contact with the valley for a period that predates the earliest available historical aerial photography (1927) and was already identified as a high-risk site by the City in 1995 (Totten Sims Hubicki Associates, 1995). The length of eroded valley wall has increased over this historical record as the meander broadens and extends its contact upstream. The expanding length of valley wall contact has the potential to impact properties along Valley Court if erosion mitigation is not implemented. For the sake of the evaluation of alternatives, it is assumed that emergency works may be required to mitigate risk, with little consideration given to ecological impacts or future, evolving risks. As such, repeated emergency works and associated disturbance may be warranted over time.

4.1.2 Concept 1: Boulder-protected Slope Toe Bench and Surface Runoff Control

Photo 4. Example of boulder-protected, slope-toe bench constructed along Wilket Creek, Toronto.

This conceptual alternative aims to eliminate fluvial/valley wall interaction with the construction and protection of a low floodplain bench projecting slightly into the channel from the toe of the valley wall (**Table 9**). **Photo 4** provides an example of a similar boulder (riprap) protected slope-toe bench for illustrative purposes. Embedded large wood would be integrated into a protective revetment for additional roughness and aquatic habitat benefits. To accommodate 'fill' associated with the bench and vegetated boulder revetment, a compensatory cut of the inner bank would be required to maintain bankfull geometry and flood conveyance/storage. The top of the bench and boulder revetment would be approximately coincident with the water surface elevation of the 2-year flow. Boulders would be keyed well into the bank, slightly beyond the upstream limit of scour, in order to inhibit future outflanking. In addition, boulders would smoothly tie-in with existing boulder toe protection that defines the downstream limit of scour. A vegetated boulder revetment is proposed to replace an existing and deteriorated boulder revetment that extends approximately 20 m from the eastern footing of the Thomas Street bridge. Existing boulders would be reused in the new structure. Secondary erosion from concentrated surface runoff from the adjacent trailhead parking lot and paved Bike Path would be intercepted by a slope drain integrated with the proposed boulder revetment.

4.1.3 Concept 2 – Meander Mirroring

Concept 2 involves local realignment of the meander away from the western valley wall (**Table 9**). Meander geometry and channel length would be maintained by mirroring the existing alignment. The existing channel would be backfilled with clean fill and compacted to prevent the reoccupation during overbank flood events. Realignment would start upstream of the valley wall contact to allow for a smooth transition into the new alignment and accommodate a straighter approach before the Thomas Street crossing. A vegetated boulder revetment with embedded large wood would be constructed along the new outer banks to help maintain the intended planform approaching the bridge. Secondary erosion from concentrated surface runoff from the adjacent trailhead parking lot and paved Bike Path would be intercepted by a slope drain integrated within the proposed boulder revetment.

4.1.4 Evaluation of Concept Alternatives

A basic evaluation of each alternative 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 (**Table 9**).

[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 6 & 8

Objective	Criteria	Comment	(Do Nothing)	**Concept 1** (Boulder-protected Slope Toe Bench and Surface Runoff Control)	**Concept 2** (Channel Mirroring)	Notes
Physical and Natural Environment	Flooding	Impact on surface drainage, flooding; meet legislated criteria for flooding and water	3	3	4	In-stream works would maintain cross-sectional area, so there should be little to no effect on flood levels. Concept 2 may improve flood conveyance/storage.
	Erosion	Impacts on soils, geology, rate of erosion	1	4	5	Do Nothing would allow erosional processes to continue, increasing risk to private property and downstream infrastructure. Concepts 1 and 2 would address existing erosion and would not impact erosional processes downstream. Concept 2 would eliminate fluvial/valley wall interaction.
	Terrestrial Habitat	Impact on connectivity, diversity and sustainability	3	4	3	Concept 1 would require removal of riparian vegetation through compensatory inner-bank cut. Concept 2 would have substantial short-term impacts following the removal of mature riparian trees. Riparian vegetation, including trees, would be planted following construction to restore the area disturbed for floodplain cut. Extensive removal of existing vegetation allows for the removal of non-native species.
	Aquatic Habitat	Impact on connectivity, spawning and sustainability	3	4	5	Both concepts involve stone placement along the outer bank(s), although integrated plantings and embedded wood would help offset the armouring effects. Concept 2 offers the opportunity to increase fish habitat in the form of a new riffle and run.
Social/Cultural Environment	Aesthetic Value	Impact on existing and proposed development aesthetic value	1	4	5	Construction of a vegetated boulder revetment, especially with embedded wood (Concepts 1 and 2), would improve the aesthetic of the erosion mitigation structure.
	Benefit to Community	Access to trails, enjoyment of valley	3	2	2	Temporary closure of the trailhead parking lot and Bike Path may be required to accommodate construction activities.
	Archaeological Features	Impacts on existing archaeological features	n/a	n/a	n/a	n/a
Environmental Approvals and Permitting	Regulatory Agency Acceptance	Satisfy CLOCA, DFO and MECP mandates	3	3	3	Do Nothing alternative can lead to agency involvement if emergency works are required. Concept 1 and 2 would require in-channel works, which would trigger a need for DFO and CLOCA review.
Financial Criteria	Capital Costs	ROM costs for implementation of the proposed concept (including engineering & environmental, mobilization & demobilization (access), earthworks, channel works)	2	5	3	Do Nothing would not address erosion risk and may result in emergency works and/or additional construction costs in the long-term (e.g., infrastructure repair). Concept 1 would require continuous armoring of the long erosion scar with vegetated boulder revetment. Concept 2 would necessitate significant cut/fill to maintain existing flood conveyance/storage as well as bank protection at new channel bends.
	Maintenance Costs	ROM costs to maintain the proposed structure, considering regular or periodic structural/vegetation maintenance expectations	1	4	5	Do Nothing may necessitate emergency works and/or increased maintenance frequency if not robustly designed or implemented; Concepts 1 and 2 would minimize maintenance requirements. Sloughing material from the valley wall may lead to additional maintenance costs for Concept 1.
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; Concepts 1 and 2 would require implementation by those experienced in natural channel works
Risks	Potential Risks to Existing Infrastructure	Protection or potential exposure of infrastructure (fence, wall, building, etc.)	1	4	5	Do Nothing would not alleviate erosion risks to infrastructure, unless emergency works are implemented. Concepts 1 and 2 would mitigate existing erosion risk and future impacts to infrastructure (e.g., Thomas Street bridge).
	Potential Risks to Public	Impact on public safety and requirement for safety features (e.g., safety fences)	1	5	5	Concepts 1 and 2 would address erosion concerns in close proximity to the Bike Path and private properties, thereby improving public safety.
	Potential Risks to Private Property	Potential for loss of private property due to bank recession	1	4	5	Without intervention, the private property at 204 Thomas Street appears to be at risk from a continued cycle of fluvial scour and mass movements. Properties on Valley Ct may become at risk in the future as well. Concepts 1 and 2 would provide long-term toe protection and slow or stop further recession of the erosion scar up the valley wall. Concept 2 eliminates fluvial/valley wall interaction.
Total Score:			**28**	**49**	**45**	
Combined Rank:			3	1	2	Concept 1 is the preferred alternative. It is recommended that a targeted geotechnical investigation first be completed by the City in the immediate future. Results would inform the urgency for mitigation and determine if actual slope stabilization measures are additionally required.

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 has been used: 1 = unfavourable, 2 = less favourable 3 = acceptable, 4 = more favourable 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 Selection of Preferred Alternative

At Site 6, severe erosion along the outer bank of a slowly migrating meander is responsible for decades of undercutting and mass movements along the lower half of the western valley wall. Private property (204 Thomas Street) at the edge of adjacent tableland is located within the stable slope allowance and may be at risk from continued slope recession. At Site 8, the upstream extent of boulder revetment that protects the Bike Path and left abutment of the Thomas Street bridge exhibits precursory signs of failure due to channel planform adjustment and local concentration of surface runoff from the adjacent parking lot and Bike Path. Concept 1 (Boulder-protected Slope Toe Bench and Surface Runoff Control) is the preferred option based on the reduced area of disturbance, Rough Order of Magnitude (ROM) costs and elimination of fluvial/valley wall interaction.

5. Public Consultation

5.1 Project Announcement

This Study is being carried out under *Schedule A+* in accordance with the requirements of the MEA's *Municipal Class Environmental Assessment for Municipal Projects*. The Study process includes identification of measures to mitigate adverse impacts and discretionary public outreach. 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 announcement and list of stakeholders is included in **Appendix E.**

6. Preliminary Design of Preferred Alternative

Appendix F includes the preliminary design drawings for the preferred Alternative (Concept 1) at Site 6/8.

6.1 Hydrology and Hydraulics

The proposed works require local 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 vegetated revetments, flood bench and inner bank cut geometry were incorporated into cross sections within Oshawa Creek Reach 1 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 10.**

Table 10. Hydraulic changes between existing and proposed conditions

Cross Section	Storm Event	Total Flow	Flood Elevation			Channel Velocity			Channel Shear Stress		
			Existing	Proposed	Change in Flood Elevation	Existing	Proposed	Change in Velocity	Existing	Proposed	Change in Shear
		(m^3/s)	(m)	(m)	(m)	(m/s)	(m/s)	(m/s)	(N/m^2)	(N/m^2)	(N/m^2)
2550	2 Year	39.13	80.77	80.77	0	2.15	2.16	0.01	73.43	74.65	1.22
	5 Year	69.18	81.17	81.17	0	2.63	2.63	0	100.86	100.85	-0.01
	10 Year	91.35	81.38	81.38	0	2.88	2.89	0.01	116.15	116.76	0.61
	25 Year	124.35	81.68	81.68	0	3.03	3.03	0	122.17	122	-0.17
	50 Year	150.1	81.94	81.94	0	2.82	2.81	-0.01	101.43	101.25	-0.18
	100 Year	177.77	82.3	82.31	0.01	2.37	2.37	0	68.71	68.68	-0.03
	Regional	672.49	84.67	84.67	0	2.58	2.58	0	65.99	66.05	0.06
2400	2 Year	39.13	80.29	80.37	0.08	1.76	1.64	-0.12	32.14	27.51	-4.63
	5 Year	69.18	80.86	80.86	0	1.87	1.87	0	32.93	32.91	-0.02
	10 Year	91.35	81.11	81.08	-0.03	2	2.05	0.05	36.37	38.29	1.92
	25 Year	124.35	81.41	81.42	0.01	2.19	2.18	-0.01	41.71	41.44	-0.27
	50 Year	150.1	81.75	81.75	0	2.03	2.02	-0.01	34.32	34.25	-0.07
	100 Year	177.77	82.16	82.16	0	1.85	1.85	0	27.36	27.35	-0.01
	Regional	672.49	84.54	84.54	0	2.6	2.6	0	45.4	45.45	0.05
2318.716 (Site 6)	2 Year	39.13	79.79	79.75	-0.04	2.53	2.81	0.28	74.7	101.21	26.51
	5 Year	69.18	80.4	80.42	0.02	2.73	2.62	-0.11	75.48	72.71	-2.77
	10 Year	91.35	80.76	80.79	0.03	2.6	2.37	-0.23	64.42	55.09	-9.33
	25 Year	124.35	81.31	81.33	0.02	1.95	1.82	-0.13	33.37	30.01	-3.36
	50 Year	150.1	81.69	81.7	0.01	1.73	1.63	-0.1	25.08	22.84	-2.24
	100 Year	177.77	82.13	82.13	0	1.55	1.46	-0.09	19.2	17.59	-1.61
	Regional	672.49	84.5	84.5	0	2.27	2.17	-0.1	34.72	32.3	-2.42

Cross Section	***Storm Event***	***Total Flow***	***Flood Elevation***			***Channel Velocity***			***Channel Shear Stress***		
			Existing	**Proposed**	**Change in Flood Elevation**	**Existing**	**Proposed**	**Change in Velocity**	**Existing**	**Proposed**	**Change in Shear**
		(m^3/s)	**(m)**	**(m)**	**(m)**	**(m/s)**	**(m/s)**	**(m/s)**	**(N/m^2)**	**(N/m^2)**	**(N/m^2)**
2262.023 (Site 8)	2 Year	39.13	79.9	79.9	0	1.13	1.13	0	12.24	12.24	0
	5 Year	69.18	80.49	80.49	0	1.56	1.56	0	21.61	21.61	0
	10 Year	91.35	80.76	80.76	0	1.85	1.85	0	29.7	29.7	0
	25 Year	124.35	81.12	81.12	0	2.21	2.21	0	40.94	40.94	0
	50 Year	150.1	81.43	81.43	0	2.41	2.41	0	47.59	47.59	0
	100 Year	177.77	81.82	81.82	0	2.54	2.54	0	51.22	51.22	0
	Regional	672.49	84.15	84.15	0	3.53	3.53	0	86.01	86.01	0

The hydraulic analysis demonstrates that proposed works do not change Regional Flood elevations. Water surface elevation reductions of up to 0.04 m are observed during the 2-Year flood event at Section 2318.716, while increases of up to 0.08 m are observed during the 2-Year event immediately upstream at Section 2400, with no significant increase in flood risk to public safety, adjacent property, or infrastructure. Any increases in flood elevation do not extend beyond the vegetated floodplain of Oshawa Creek. Considering these factors, the proposed works are unlikely to result in adverse flooding impacts.

The analyses reveal minor increases in velocity and shear stress between existing and proposed conditions near Site 6 at Section 2318.716. These increases are related to the corresponding decreases in water surface elevation at this location and have been incorporated into the Scour Analysis and Stone Sizing described in Section 6.2.

6.2 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 flow rates (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, 1977), the MTO Drainage Design Standards (2010), and the USACE Maynord Method (USACE, 1994).

Table 11 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 50 mm, as determined during the geomorphic field assessment. The median grain size is mobilized by the 2-year storm event.

Table 11. Storm event velocity and stable stone size

Flood Event Return Period	Channel Velocity* (m/s)	Stable Stone Size** (mm)
2 Year	1.13	50
5 Year	1.56	85
10 Year	1.85	125
25 Year	2.21	190
50 Year	2.41	230
100 Year	2.54	260
Regional	3.53	530

**Flow velocity observed at HEC-RAS cross section 2262.023.*
***Stable stone size based on the permissible velocity approach (Komar, 1987).*

In order to maintain stable channel banks that resist erosion over a wide range of return period events, the maximum velocity observed during the 100-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 100-year storm event is 2.54 m/s at cross-section 2262.023, immediately upstream of the Thomas Street bridge at Site 8.

Table 12 provides the recommended stone size gradation for the channel banks based on the permissible velocity approach, incorporating a safety factor of 1.5 for the D_{50}, and 2.3 for the D_{100}, relative to the stable stone for the 100-year event. The proposed stone type shall be sub-angular riverstone. Existing native material from the inner-bank cut 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 12. Proposed stone sizing gradation

% Finer	Proposed Stone Size	
	(mm)	**(in)**
D_{100}	600	24
D_{85}	500	20
D_{50}	400	16
D_{30}	250	10
D_{15}	150	**6**
Placed 600 mm Thick		

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

The boulders that protect the slope-toe bench will consist of a minimum 600 mm-thick layer of sub-angular riverstone placed up to the 2-year storm elevation, as shown in the design drawings. The inner bank opposite the slope-toe bench will be cut at 3H:1V, to better allow point bar formation. The riverstone works are to be embedded and keyed into the bed of the existing channel in order to accommodate minor toe scour.

A median (D_{50}) stone size of 400 mm should provide sufficient scour protection for flow events that yield the greatest potential for scour. Appropriately sized existing material can be recycled and incorporated into the proposed works at the discretion of the engineer. The proposed 600 mm thickness of stone cover will accommodate minor, localized settlement or displacement. The sub-angular riverstone revetment will provide immediate erosion protection to the bankfull channel where shear stresses are the greatest. 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 revetment and keying-in at its upstream tie-in will accommodate minor channel adjustments that occur naturally.

6.3 Vegetation Impacts and Restoration Plan

The proposed access route has specifically been configured to minimize the need for tree removals, by avoiding the densely treed section of floodplain north and east of the creek bank area. Based on the tree survey and the proposed work footprint and access route, only 3 'poor condition' trees require removal in association with the works (Tag ID: 824, 829, 742). Additional information specific to each tree is provided in **Appendix B**. A variety of native tree and shrub species have been specified to replace those identified for removal. The restoration planting plan is presented in **Appendix F**, and includes 5 trees and a total of 359 shrubs. All disturbed areas will be stabilized with 200 mm topsoil and 50 mm Terraseeding composed of a native riparian seed mix approved by CLOCA.

Once works are complete, vegetation should be established on the disturbed land and newly graded slopes as quickly as possible. Plant roots enhance bank stability by increasing soil shear strength and reducing river-edge flow velocities. All areas disturbed by erosion mitigation works will be planted with seed mix, shrubs, and trees. The vegetated revetment will be planted will potted stock, and the access route will be planted with shrubs and trees.

6.4 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 estimated cost to implement erosion control works at Oshawa Creek Sites 6 and 8 is $402,000 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 permit issued prior to any construction activities taking place.

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. vegetated boulder revetment along banks). 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 warm water timing window between July 1 and March 31st. 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 will occur during the first year, 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 for comparison to subsequent monitoring efforts. 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: ______________________________

Alex Scott, B.Sc.
Fluvial Processes Specialist

Prepared By: ______________________________

Ryan Morin, B.Sc.
Ecologist

Prepared By: ______________________________

Michael Brierley, M.Sc.
Fluvial Processes Specialist

Reviewed By: ______________________________

Max Osburn, P.Eng.

Water Resources Engineer

Approved By:

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

9. References

Central Lake Ontario Conservation Authority, 2007:
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Appendix A

Standard Overviews of Erosion Hazard Sites

Description:
Erosion along the outer bank of a broad meander in contact with the valley wall has initiated and maintained slope instability. A point bar exhibiting a scroll pattern has developed along the inner bank, a testament to the history of lateral and down-valley migration of the meander apex. Private property is approximately coincident with the crest of the valley wall, which comprises till locally capped by glaciolacustrine sand. A dwelling and outbuilding is set 10 m back from the crest of the valley wall and is at risk if recession of the valley wall were to continue. Flow: top to bottom.

	Feature at Risk:	Distance to Feature	Condition of Bank and/or Existing Erosion Protection:	Mechanism(s) of Failure:	Risk	Recommended Action(s):
Site 6	Property at edge of adjacent tableland	10 m	Approximately 18 m high, 150 m long erosion scar along lower valley wall	Repeated fluvial scour and mass movements	High	Design and implement measures to protect valley wall from continued fluvial interaction

Description:
Boulder riprap revetments installed along the left bank immediately upstream of the Thomas Street bridge protect the bridge footings. A medial bar locally concentrates flow along the left bank, which could eventually undermine or outflank the revetment and pose a risk to the adjacent Joseph Kolodzie Oshawa Creek Bike Path and eastern bridge footing. Additionally, concentration of surface runoff from the parking lot northwest of the creek winnows fine material from behind the revetments and forms small collapse areas. Flow: top to bottom.

	Feature at Risk:	Distance to Feature	Condition of Bank and/or Existing Erosion Protection:	Mechanism(s) of Failure:	Risk	Recommended Action(s):
Site 8	Joseph Kolodzie Bike Path and bridge footing	0 m (contact)	Functional	Outflanking and/or undermining	Moderate	Design and implement measures to protect trail and bridge abutment (based on assumed works to be completed at Site 6)

Appendix B

Tree Inventory

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
815	Manitoba Maple	*Acer negundo*	51	4	F	F	F	
816	Willow	*Salix* sp.	72	5	F	F	F	
817	Willow	*Salix* sp.	52	4	P	F	F	Small woodpecker cavities present
818	Manitoba Maple	*Acer negundo*	41	3	F	G	F	Slight lean from creek
819	Norway Maple	*Acer platanoides*	10	2	G	G	G	
820	Eastern White Pine	*Pinus strobus*	20	3	G	G	G	
815	Manitoba Maple	*Acer negundo*	51	4	F	F	F	
821	Ash	*Fraxinus* sp.	24,8,30	1	VP	VP	VP	Almost dead. Only small stem still alive. Main leaders both broken.
822	Manitoba Maple	*Acer negundo*	46	6	P	P	P	One remaining stem in fair health, but both other leaders are down.
823	Manitoba Maple	*Acer negundo*	40	6	P	F	P	Leaning towards watercourse
824	Manitoba Maple	*Acer negundo*	39	7	P	F	P	Leaning towards watercourse
825	Manitoba Maple	*Acer negundo*	39,15	5	P	F	P	Leaning towards watercourse
826	Manitoba Maple	*Acer negundo*	36	5	F	F	F	
827	Manitoba Maple	*Acer negundo*	16	4	P	F	P	Leaning
828	Manitoba Maple	*Acer negundo*	31,29	4	P	F	P	One leader broken at top, the other leaning and curving downwards
829	Manitoba Maple	*Acer negundo*	50	7	P	G	P	Leaning towards watercourse
830	Norway Maple	*Acer platanoides*	24	3	G	G	G	
831	Manitoba Maple	*Acer negundo*	40,41	8	P	G	P	Leaning towards watercourse
832	Willow	*Salix* sp.	80	5	P	P	P	Leaning towards creek. One leader down
833	Manitoba Maple	*Acer negundo*	15	2	VP	F	VP	Stem broken
834	Manitoba Maple	*Acer negundo*	19	3	P	G	P	Leader between adjacent willow stems
835	Manitoba Maple	*Acer negundo*	21	4	F	G	F	Leaning towards watercourse
836	Manitoba Maple	*Acer negundo*	28	5	F	G	F	Slight lean to watercourse
837	Manitoba Maple	*Acer negundo*	37	6	P	G	P	Leaning over pedestrian path
838	Willow	*Salix* sp.	49	5	P	P	P	Only one stem still alive
839	Manitoba Maple	*Acer negundo*	19,17	4	F	G	F	Smaller stem leaning towards creek, main leader straight
840	Manitoba Maple	*Acer negundo*	65	8	P	F	P	Stem crack 4 m high. Tree leaning towards watercourse

Tag #	Common Name	Scientific Name	DBH (m)	Dripline (m)	Condition*			Notes
					Structure	*Vigour*	*Overall*	
841	Manitoba Maple	*Acer negundo*	34	5	P	F	P	Leaning towards creek
842	Manitoba Maple	*Acer negundo*	34	5	P	F	P	Leaning towards creek
843	Red Maple	*Acer rubrum*	19	4	G	G	G	
844	Manitoba Maple	*Acer negundo*	26	5	G	G	G	
845	Manitoba Maple	*Acer negundo*	19	4	G	G	G	
846	Manitoba Maple	*Acer negundo*	12	2	P	P	P	Broken top
847	Black Walnut	*Juglans nigra*	10	2	G	G	G	
848	Manitoba Maple	*Acer negundo*	13,18	4	F	G	F	
849	Silver Maple	*Acer saccharinum*	30	3	G	G	G	
850	Silver Maple	*Acer saccharinum*	36	4	G	F	G	
851	Silver Maple	*Acer saccharinum*	28	3	G	G	G	
852	Manitoba Maple	*Acer negundo*	22	3	G	G	G	
853	Manitoba Maple	*Acer negundo*	22	4	F	F	F	Leaning towards road
854	Manitoba Maple	*Acer negundo*	22	4	F	F	F	Leaning towards road
855	Silver Maple	*Acer saccharinum*	34	5	G	G	G	
856	Silver Maple	*Acer saccharinum*	34	5	G	G	G	

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

Appendix C

Fish Habitat Mapping

LEGEND:

TITLE:

Fish Habitat Mapping

METRE SCALE: 0 5 10 20 30 40 50

NORTH:

CLIENT: City of Oshawa

PRINT SCALE:	1:1750	PRINT SIZE:	11 x 17 "
DATUM:	NAD 1983	PROJECTION:	UTM Zone 17
DATE:	Jul 09, 2021	DRAWN:	CHECKED:

PREPARED BY: Palmer™

PROJECT: Preliminary Design and Municipal Class Environmental Assessment Schedule A Report

APPENDIX: C

REVISION:

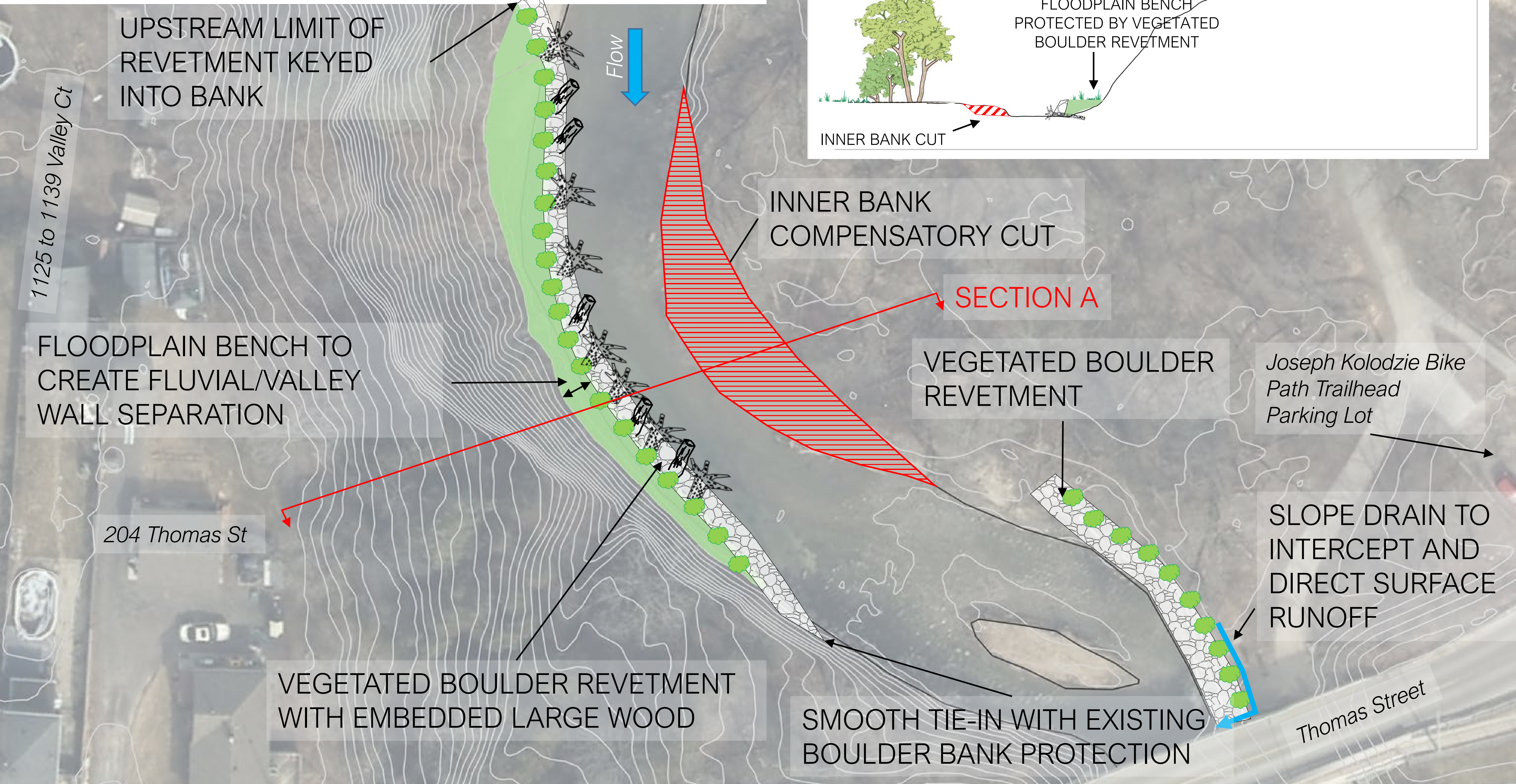
PROJECT NO. 1510207

Imagery (2020) provided by the City of Oshawa

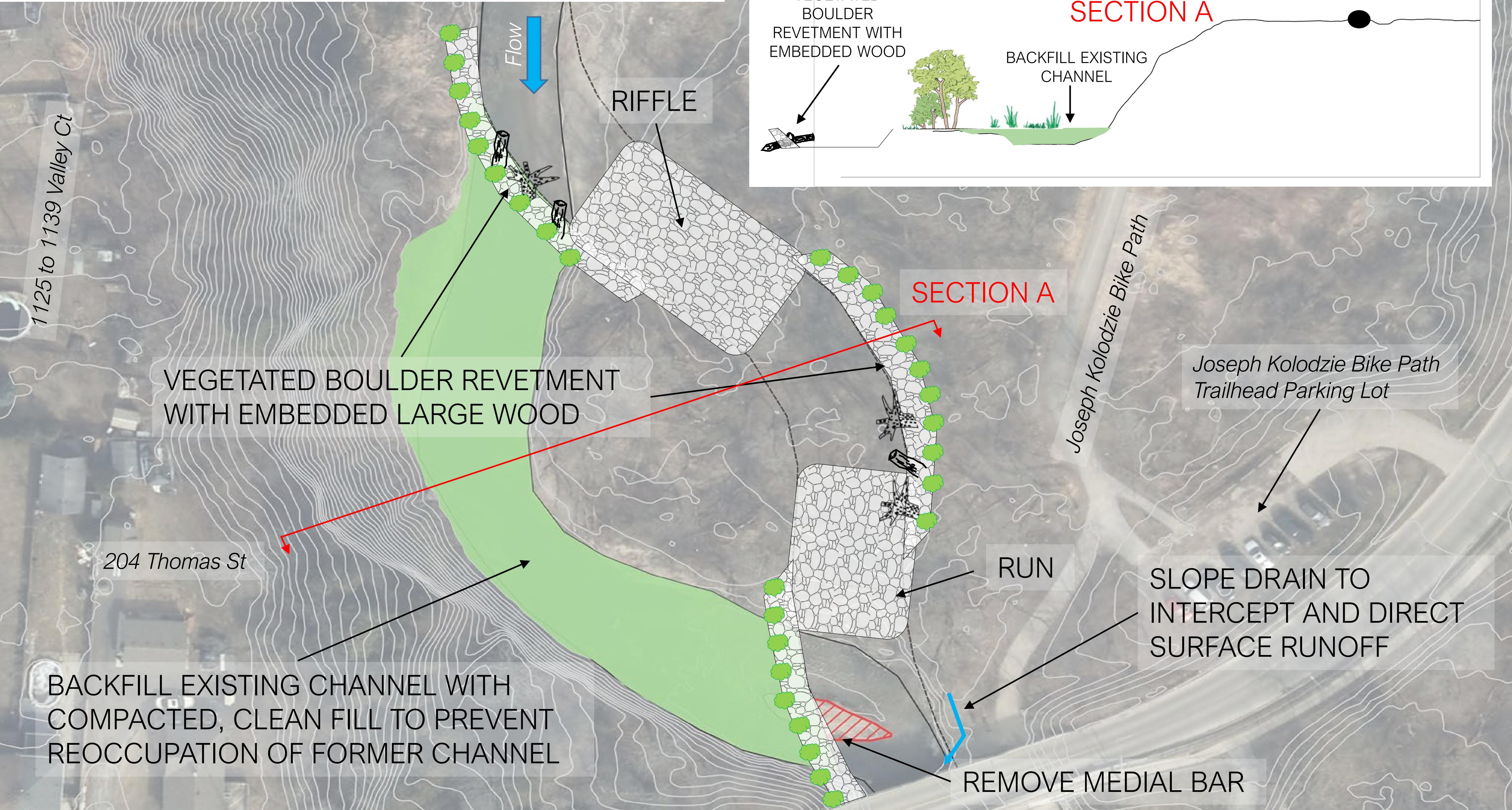
Appendix D

Concept Sketches

Site 6 – Concept 1 – Boulder Protected Slope Toe Bench and Surface Runoff Control



Site 6 – Concept 2 – Meander Mirroring



Appendix E

Public Consultation

PROJECT ANNOUNCEMENT

Municipal Class Environmental Assessment

Oshawa Creek Site 6 – 8 Preliminary Design

The Study

The City of Oshawa (the City), through their consultant Palmer Environmental Consulting Group is undertaking a Municipal Class A+ Environmental Assessment to address significant erosion concerns on Oshawa Creek, just upstream of Thomas Street in the City of Oshawa. The attached map shows the location of the study area.

The Process

The Study will be carried out under *Schedule 'A+'* in accordance with the requirements of the Municipal Engineers Association (MEA), *Municipal Class Environmental Assessment for Municipal Projects*. The Study process includes identification of measures to mitigate adverse impacts and public outreach. The Project Team invites public input and comments and will incorporate them into the planning and design of this project. Project information, studies and mitigation options will be posted online on the City's website to provide an opportunity for the public to review the study findings.

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, M.Sc., P.Geo., CAN-CISEC** Vice President, Principal Geomorphologist **Palmer Environmental Consulting Group** 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									

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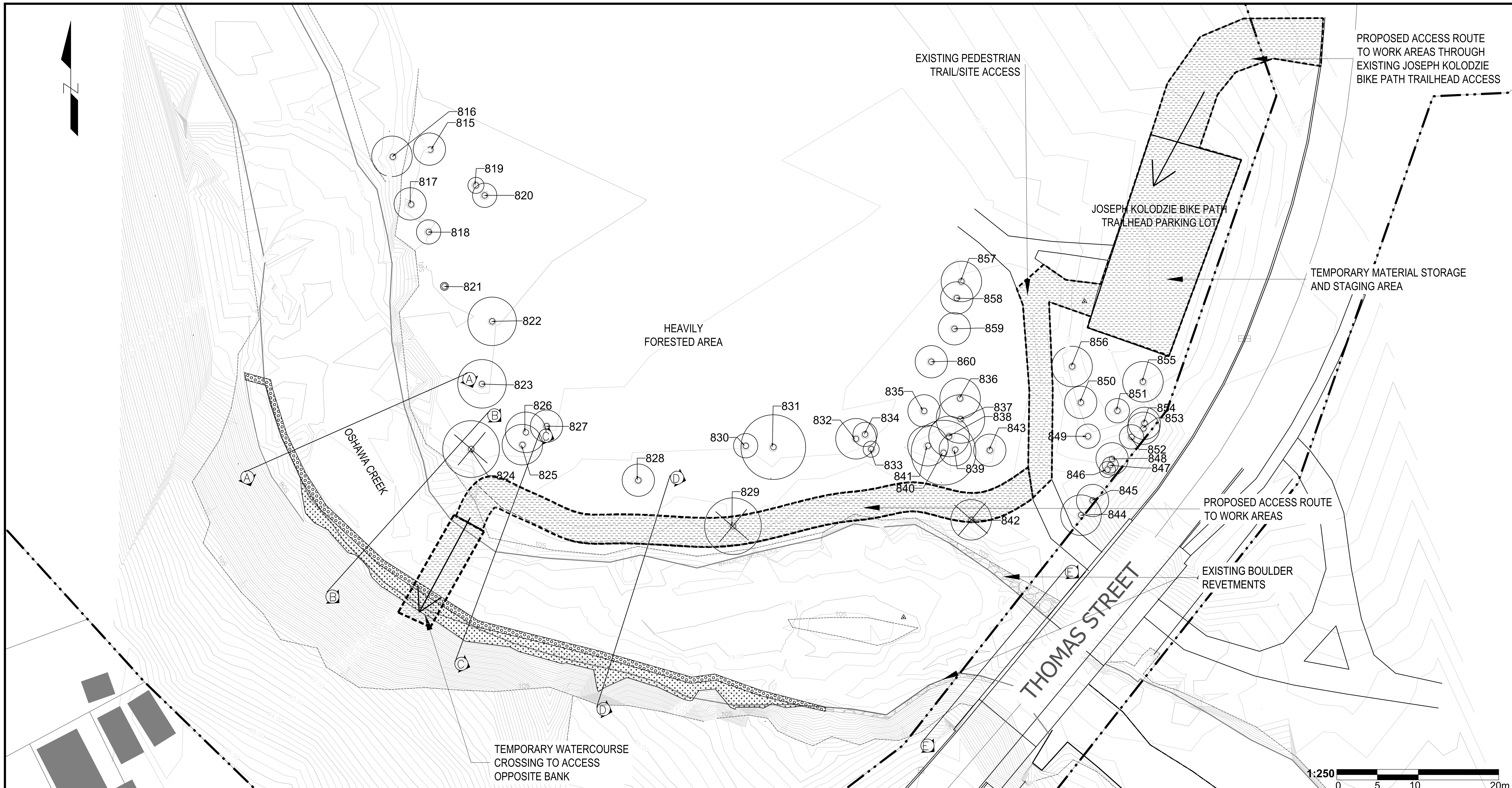
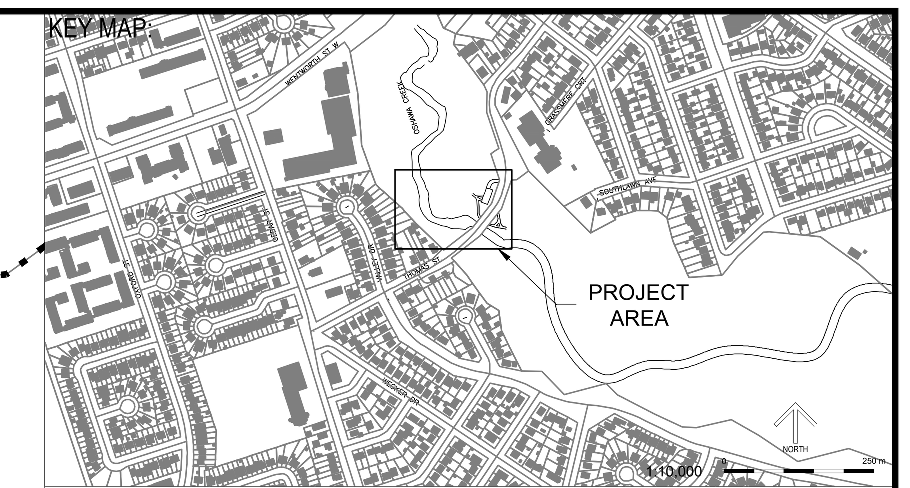
Appendix F

Site 6/8 Preliminary Design and Restoration Plan



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:

- PROPERTY BOUNDARY
- SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS
- 1678 TREE TAG NUMBER
- TREE CROWN
- TREE LOCATION
- TREE FOR PRESERVATION
- TREE FOR REMOVAL
- EXISTING BOULDER REVETMENTS
- PROPOSED CONSTRUCTION ACCESS ROUTE
- PROPOSED VEGETATED BOULDER REVETMENT SEE DETAIL 1
- PROPOSED CUT BANK
- PROPOSED FLOODPLAIN BENCH

TREE INVENTORY

Tag #	Common Name	Scientific Name	DBH (cm)	Dripline (m)	Condition** Structure	Condition** Vigour	Condition** Overall	Recommendation	Notes:
815	Manitoba Maple	*Acer negundo*	51	4	F	F	F	Preserve	
816	Willow	Salix sp.	72	5	F	F	F	Preserve	
817	Willow	Salix sp.	52	4	P	F	F	Preserve	Small woodpecker cavities present
818	Manitoba Maple	*Acer negundo*	41	3	F	G	F	Preserve	Slight lean from creek
819	Norway Maple	*Acer platanoides*	10	2	G	G	G	Preserve	
820	Eastern White Pine	*Pinus strobus*	20	3	G	G	G	Preserve	
821	Ash	Fraxinus sp.	24,8,30	1	VP	VP	VP	Preserve	Almost dead. Only small stem still alive. Main leaders both broken.
822	Manitoba Maple	*Acer negundo*	46	6	P	P	P	Preserve	One remaining stem in fair health, but both other leaders are down.
823	Manitoba Maple	*Acer negundo*	40	6	P	F	P	Preserve	Leaning towards watercourse
824	**Manitoba Maple**	***Acer negundo***	**39**	**7**	**P**	**F**	**P**	**Remove***	**Leaning towards watercourse**
825	Manitoba Maple	*Acer negundo*	39,15	5	P	F	P	Preserve	Leaning towards watercourse
826	Manitoba Maple	*Acer negundo*	36	5	F	F	F	Preserve	
827	Manitoba Maple	*Acer negundo*	16	4	P	F	P	Preserve	Leaning
828	Manitoba Maple	*Acer negundo*	31,29	4	P	F	P	Preserve	One leader broken at top, the other leaning and curving downwards
829	**Manitoba Maple**	***Acer negundo***	**50**	**7**	**P**	**G**	**P**	**Remove***	**Leaning towards watercourse**
830	Norway Maple	*Acer platanoides*	24	3	G	G	G	Preserve	
831	Manitoba Maple	*Acer negundo*	40,41	8	P	G	P	Preserve	Leaning towards watercourse
832	Willow	Salix sp.	80	5	P	P	P	Preserve	Leaning towards creek. One leader down
833	Manitoba Maple	*Acer negundo*	15	2	VP	F	VP	Preserve	Stem broken
834	Manitoba Maple	*Acer negundo*	19	3	P	G	P	Preserve	Leader between adjacent willow stems
835	Manitoba Maple	*Acer negundo*	21	4	F	G	F	Preserve	Leaning towards watercourse
836	Manitoba Maple	*Acer negundo*	28	5	F	G	F	Preserve	Slight lean to watercourse
837	Manitoba Maple	*Acer negundo*	37	6	P	G	P	Preserve	Leaning over pedestrian path
838	Willow	Salix sp.	49	5	P	P	P	Preserve	Only one stem still alive
839	Manitoba Maple	*Acer negundo*	19,17	4	F	G	F	Preserve	Smaller stem leaning towards creek, main leader straight
840	Manitoba Maple	*Acer negundo*	65	8	P	F	P	Preserve	Stem crack 4 m high. Tree leaning towards watercourse
841	Manitoba Maple	*Acer negundo*	34	5	P	F	P	Preserve	Leaning towards creek
842	**Manitoba Maple**	***Acer negundo***	**34**	**5**	**P**	**F**	**P**	**Remove***	**Leaning towards creek**
843	Red Maple	*Acer rubrum*	19	4	G	G	G	Preserve	
844	Manitoba Maple	*Acer negundo*	26	5	G	G	G	Preserve	
845	Manitoba Maple	*Acer negundo*	19	4	G	G	G	Preserve	
846	Manitoba Maple	*Acer negundo*	12	2	P	P	P	Preserve	Broken top
847	Black Walnut	*Juglans nigra*	10	2	G	G	G	Preserve	
848	Manitoba Maple	*Acer negundo*	13,18	4	F	G	F	Preserve	
849	Silver Maple	*Acer saccharinum*	30	3	G	G	G	Preserve	
850	Silver Maple	*Acer saccharinum*	36	4	G	F	G	Preserve	
851	Silver Maple	*Acer saccharinum*	28	3	G	G	G	Preserve	
852	Manitoba Maple	*Acer negundo*	22	3	G	G	G	Preserve	
853	Manitoba Maple	*Acer negundo*	22	4	F	F	F	Preserve	Leaning towards road
854	Manitoba Maple	*Acer negundo*	22	4	F	F	F	Preserve	Leaning towards road
855	Silver Maple	*Acer saccharinum*	34	5	G	G	G	Preserve	
856	Silver Maple	*Acer saccharinum*	34	5	G	G	G	Preserve	
857	Willow	Salix sp.	84	5	P	F	P	Preserve	
858	Manitoba Maple	*Acer negundo*	35	4	F	F	F	Preserve	Curving main leader
859	Manitoba Maple	*Acer negundo*	37	4	F	F	F	Preserve	
860	Manitoba Maple	*Acer negundo*	26	4	F	F	F	Preserve	

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

*Tree compensations shall be determined in consultation with the City of Oshawa

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.

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

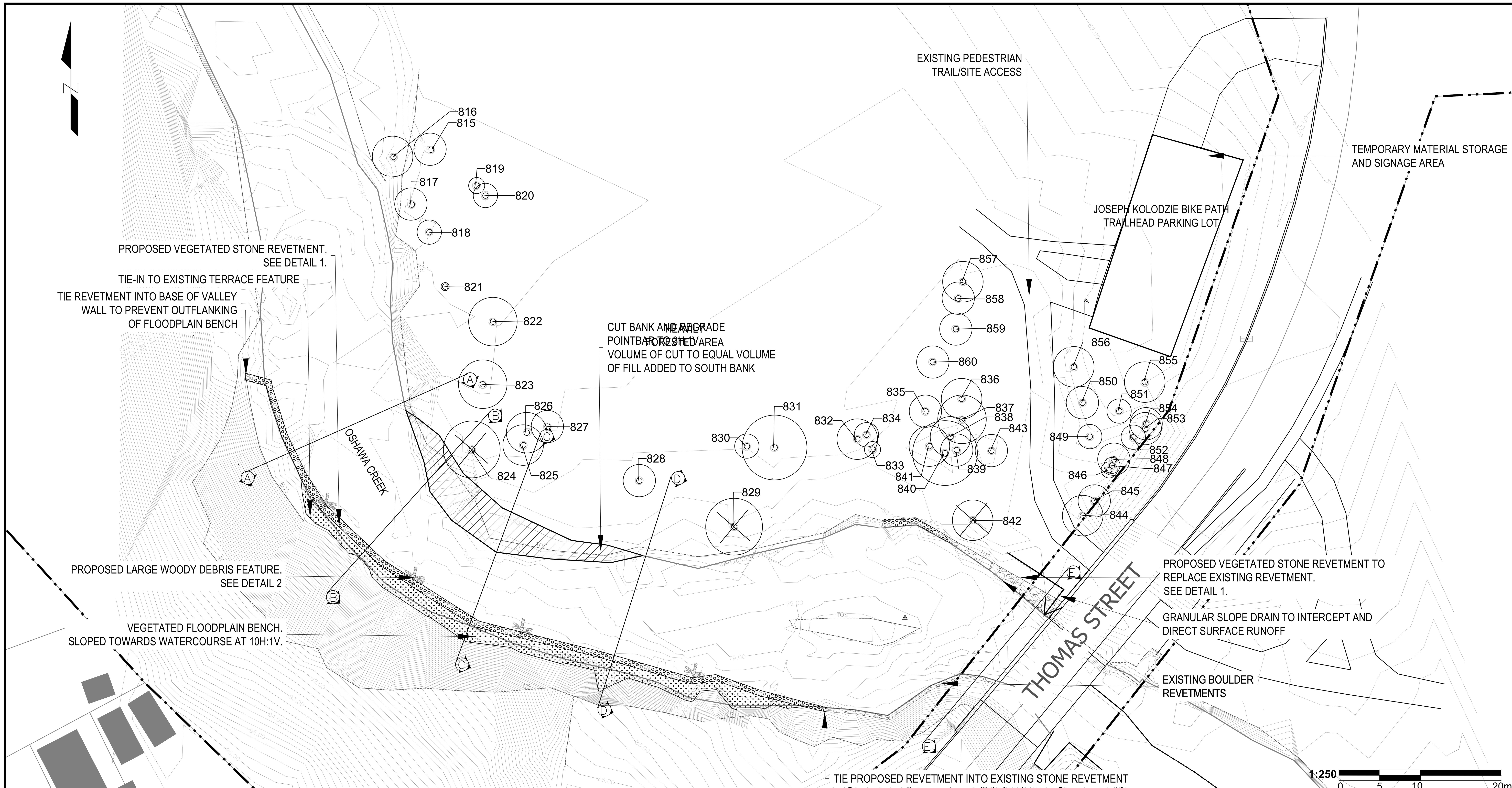
PROJECT:

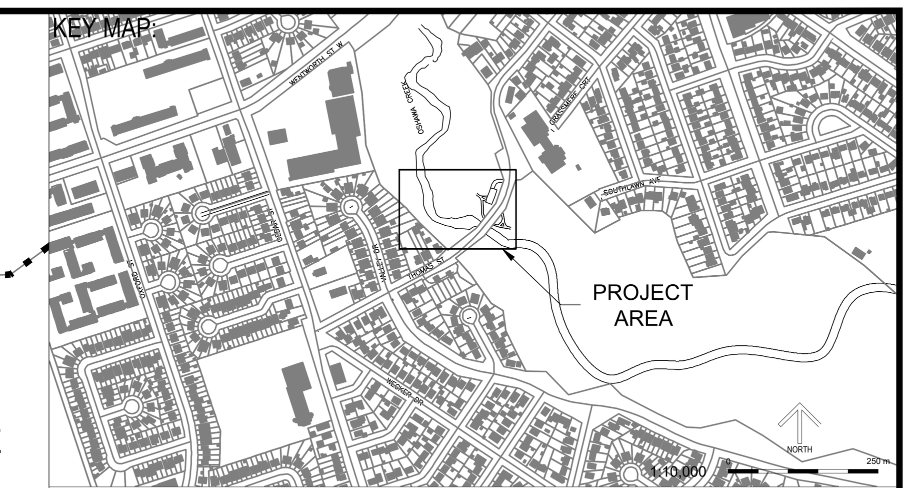
OSHAWA CREEK SITE 6 & 8 EROSION MITIGATION PRELIMINARY DESIGN

TITLE:

GENERAL PLAN, REMOVALS AND NOTES

PROJECT NO: 1510206	DATE: 2022-06-14	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: GP	SHEET NO: 01	



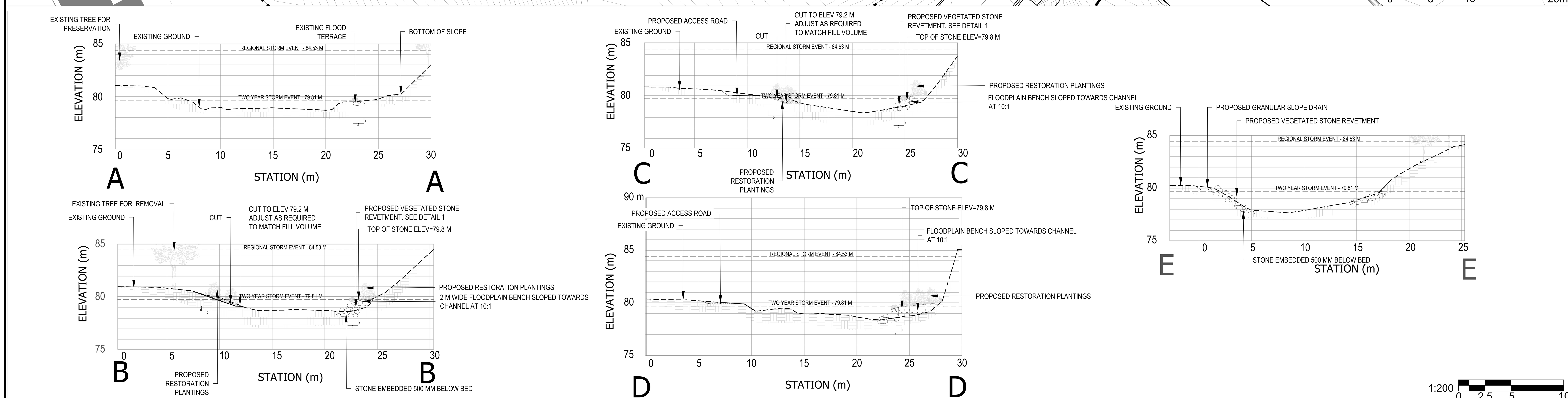


NOTES:

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:

- PROPERTY BOUNDARY
- SURROUNDING LOT FABRIC AND BUILDING FOOTPRINTS
- TREE TAG NUMBER
- TREE CROWN
- TREE LOCATION
- TREE FOR PRESERVATION
- TREE FOR REMOVAL
- EXISTING BOULDER REVETMENTS
- PROPOSED VEGETATED BOULDER REVETMENT SEE DETAIL 1
- PROPOSED CUT BANK
- PROPOSED FLOODPLAIN BENCH
- PROPOSED LARGE WOODY DEBRIS FEATURE SEE DETAIL 2



CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer™

DATE	REVISION	BY

DRAFT

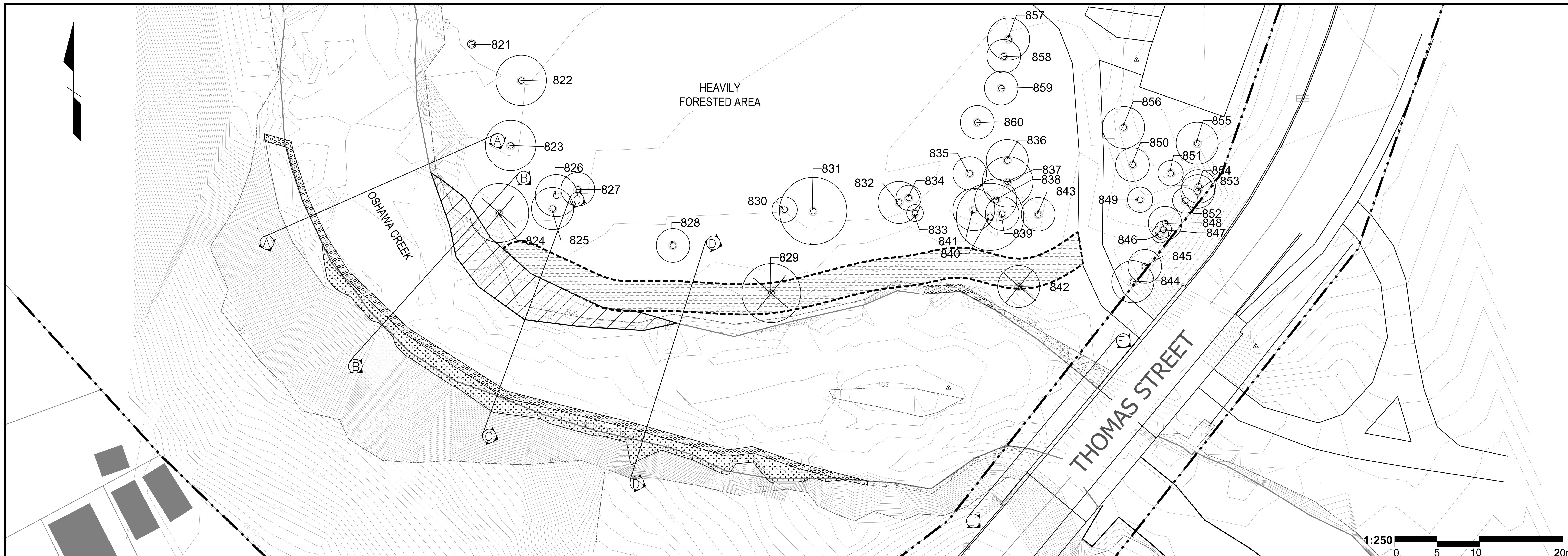
PROJECT:

OSHAWA CREEK SITE 6 & 8 EROSION MITIGATION PRELIMINARY DESIGN

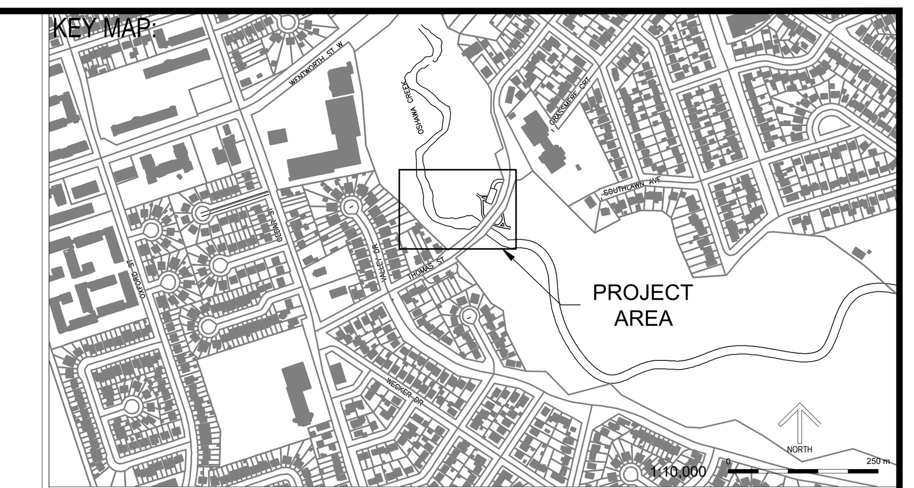
TITLE:

SITE PLAN, CROSS SECTIONS AND DETAILS

PROJECT NO: 1510206	DATE: 2022-06-14		
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO	
DRAWING NO: SP	SHEET NO: 02		



KEY MAP



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4. CONTOUR INTERVAL IS 0.25 METERS.

LEGEND:

- 1678 — TREE TAG NUMBER
- TREE CROWN
- TREE LOCATION
- TREE FOR PRESERVATION
- TREE FOR REMOVAL
- EXISTING BOULDER REVETMENTS
- SHRUB PLANTINGS WITHIN VEGETATED BOULDER REVETMENT AREA: North Bank: 7 m² - South Bank: 68 m² - Total: 75 m²
- SHRUBS AND SEED MIX TO RESTORE CUT BANK AREA: 124 m²
- SHRUBS AND SEED MIX TO RESTORE FLOODPLAIN BENCH AREA: 120 m²
- TREE, SHRUB, AND SEED MIX TO RESTORE CONSTRUCTION ACCESS ROUTE AREA: 245 m²

PLANT LIST FOR RESTORATION OF ACCESS ROUTE

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.
1	*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.
5					

SHRUBS

QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
10	*Cornus alternifolia*	Alternate-Leaved Dogwood	75-100 cm ht	2 gal potted	1 m O.C.
10	*Cornus racemosa*	Gray Dogwood	40-75 cm ht	1 gal potted	1 m O.C.
10	*Rubus occidentalis*	Blackberry	40-75 cm ht	1 gal potted	1 m O.C.
10	*Sambucus canadensis*	Elderberry	40-75 cm ht	1 gal potted	1 m O.C.
10	*Viburnum lentago*	Nannyberry Viburnum	75-100 cm ht	2 gal potted	1 m O.C.
50					

PLANT LIST FOR FLOODPLAIN BENCH

SHRUBS

QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
20	*Cephalanthus occidentalis*	Common Buttonbush	40-75 cm ht	1 gal potted	1 m O.C.
30	*Cornus racemosa*	Gray Dogwood	40-75 cm ht	1 gal potted	1 m O.C.
30	*Rubus occidentalis*	Blackberry	40-75 cm ht	1 gal potted	1 m O.C.
20	*Sambucus canadensis*	Elderberry	40-75 cm ht	1 gal potted	1 m O.C.
20	*Viburnum lentago*	Nannyberry Viburnum	75-100 cm ht	2 gal potted	1 m O.C.
120					

PLANT LIST FOR VEGETATED BOULDER REVETMENT

SHRUBS

QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
27	*Cornus stolonifera*	Red Osier Dogwood	40-75 cm ht	1 gal potted	1 pot per square metre
15	*Ribes americanum*	Wild Black Currant	40-75 cm ht	1 gal potted	1 pot per square metre
17	*Salix discolor*	Pussy Willow	40-75 cm ht	1 gal potted	1 pot per square metre
16	*Salix exigua*	Sandbar Willow	40-75 cm ht	1 gal potted	1 pot per square metre
75					

PLANT LIST FOR CUT BANK

SHRUBS

QTY	SCIENTIFIC NAME	COMMON NAME	SIZE	CONDITION	SPACING
10	*Cornus racemosa*	Gray Dogwood	40-75 cm ht	1 gal potted	1 m O.C.
38	*Cornus stolonifera*	Red Osier Dogwood	40-75 cm ht	1 gal potted	1 m O.C.
10	*Ribes americanum*	Wild Black Currant	40-75 cm ht	1 gal potted	1 m O.C.
10	*Rubus occidentalis*	Blackberry	40-75 cm ht	1 gal potted	1 m O.C.
15	*Sambucus canadensis*	Elderberry	40-75 cm ht	1 gal potted	1 m O.C.
13	*Salix discolor*	Pussy Willow	40-75 cm ht	1 gal potted	1 m O.C.
13	*Salix exigua*	Sandbar Willow	40-75 cm ht	1 gal potted	1 m O.C.
15	*Viburnum lentago*	Nannyberry Viburnum	75-100 cm ht	2 gal potted	1 m O.C.
124					

SEED MIX TABLE (RIPARIAN)

QTY (%)	SCIENTIFIC NAME	COMMON NAME
APPLICATION RATE 25 kg/ha at depth of 5 cm		
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

TOTAL SEED MIX AREA: 489 m²

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:

OSHAWA CREEK SITE 6 & 8 EROSION MITIGATION PRELIMINARY DESIGN

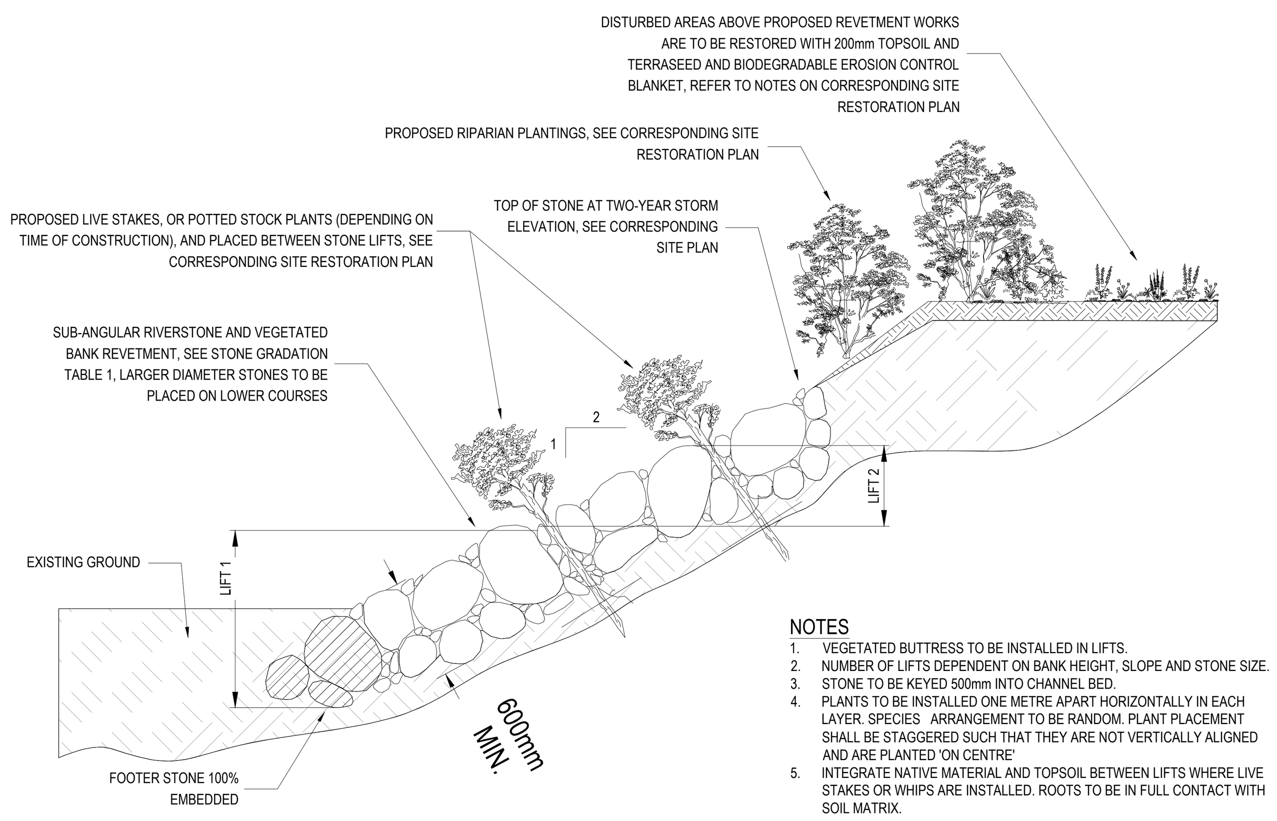
TITLE:

SITE RESTORATION PLAN

PROJECT NO: 1510206	DATE: 2022-06-14	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: SP	SHEET NO: 03	

DETAIL 1 - VEGETATED BOULDER REVETMENT

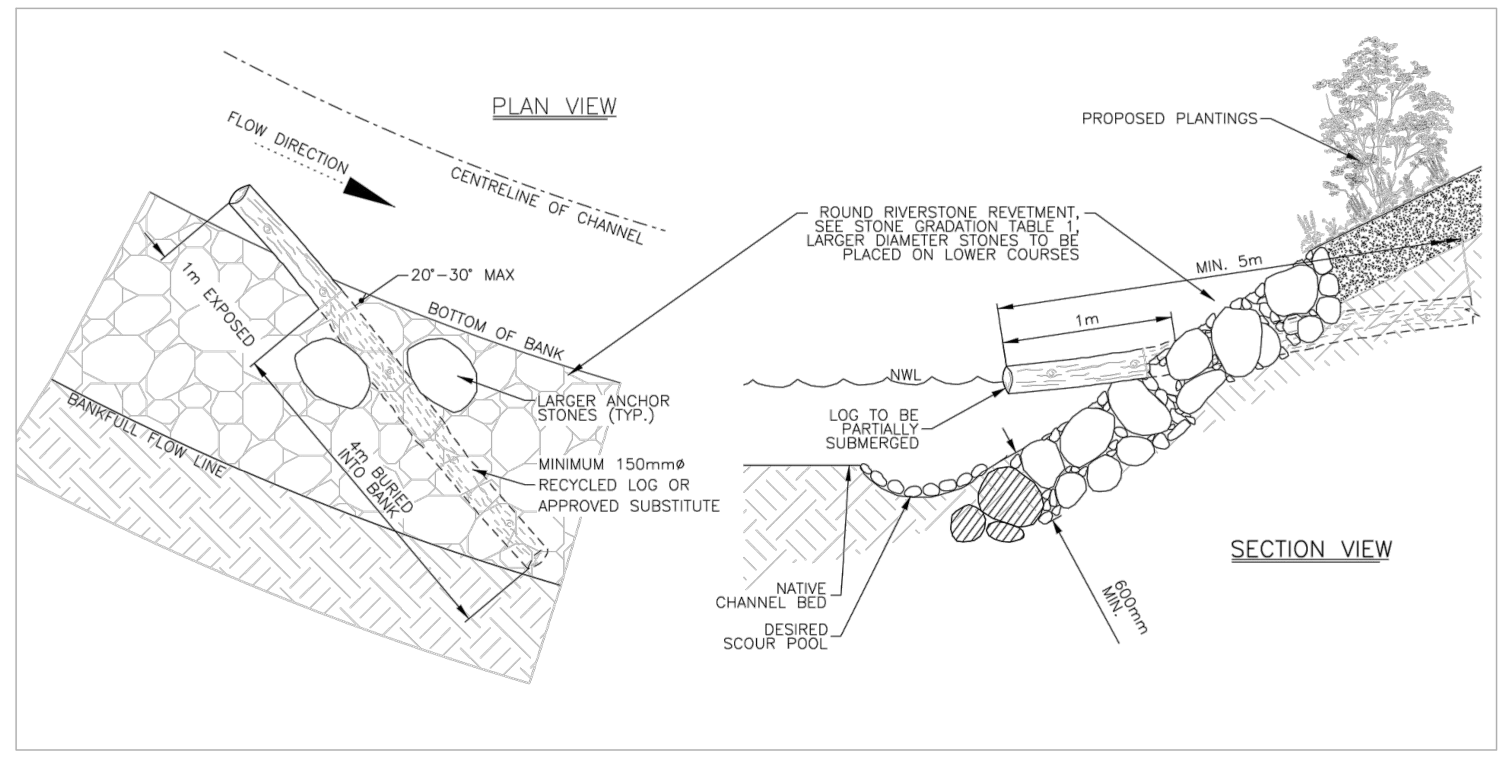
N.T.S.



NOTES
1. VEGETATED BUTTRESS TO BE INSTALLED IN LIFTS.
2. NUMBER OF LIFTS DEPENDENT ON BANK HEIGHT, SLOPE AND STONE SIZE.
3. STONE TO BE KEYED 500mm INTO CHANNEL BED.
4. PLANTS TO BE INSTALLED ONE METRE APART HORIZONTALLY IN EACH LAYER. SPECIES ARRANGEMENT TO BE RANDOM. PLANT PLACEMENT SHALL BE STAGGERED SUCH THAT THEY ARE NOT VERTICALLY ALIGNED AND ARE PLANTED 'ON CENTRE'
5. INTEGRATE NATIVE MATERIAL AND TOPSOIL BETWEEN LIFTS WHERE LIVE STAKES OR WHIPS ARE INSTALLED. ROOTS TO BE IN FULL CONTACT WITH SOIL MATRIX.

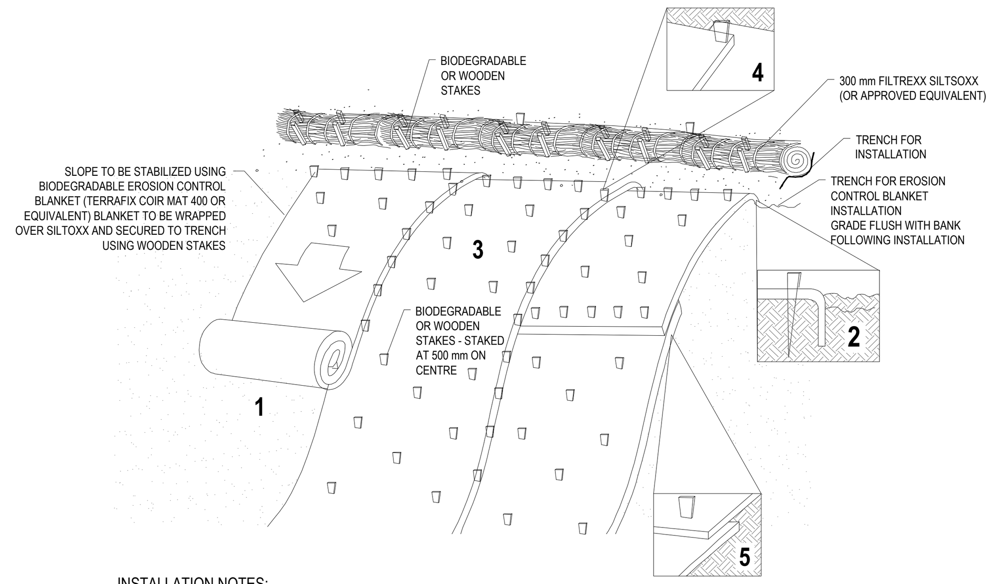
DETAIL 2 - LARGE WOODY DEBRIS FEATURE/LOG

N.T.S.



DETAIL 3 - EROSION CONTROL BLANKET (TERRAFIX COIR MAT) SLOPE INSTALLATION

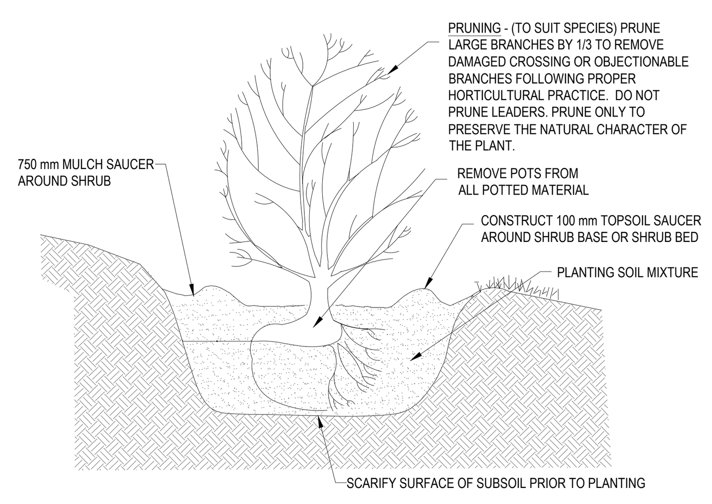
N.T.S.



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

DETAIL 4 - SHRUB PLANTING DETAIL

N.T.S.

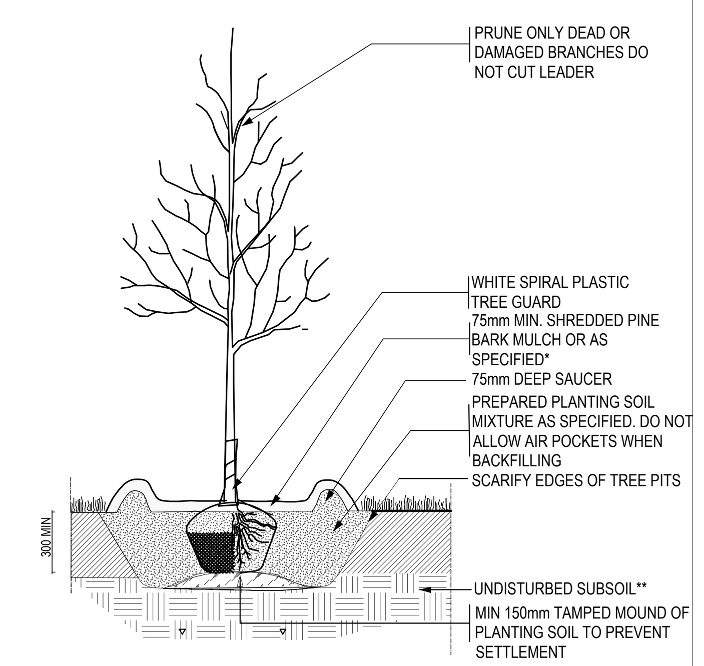


SPACING = 1000 mm o/c

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.

DETAIL 5 - DECIDUOUS TREE PLANTING TYPICAL DETAIL

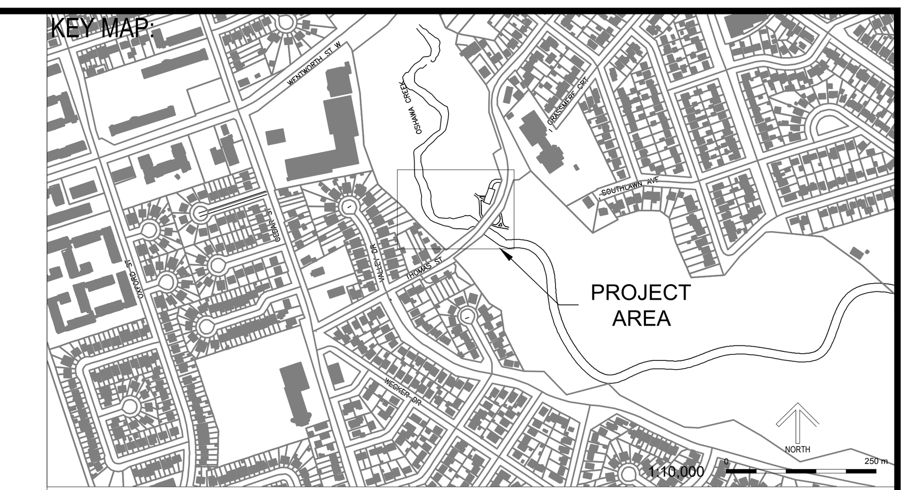
NTS



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

STONE GRADATION TABLE 1 (ROUNDED STONE)	
STONE SIZE (mm)	PERCENT BY VOLUME
250	20
400	60
600	20
STONE THICKNESS OF 600mm	

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:

CLIENT:

CITY OF OSHAWA

PREPARED BY:

Palmer TM

DATE	REVISION	BY

DRAFT

PROJECT:

OSHAWA CREEK SITE 6 & 8 EROSION MITIGATION PRELIMINARY DESIGN

TITLE:

CONSTRUCTION DETAILS

PROJECT NO: 1510206	DATE: 2022-06-14	
DESIGN BY: MO	DRAWN BY: NC	APPROVED BY: RM/MO
DRAWING NO: CD	SHEET NO: 04	

Palmer™

Appendix G

ROM Cost Estimate

Rough Order-of-Magnitude Construction Cost Estimate

In-Stream and Channel Bank Restoration Works

Palmer™

Client: Oshawa® Prepare To Be Amazed

Project No.:	1510207
Date:	09-Jun-22
Prepared By:	Max Osburn, P.Eng.
Checked By:	Robin McKillop, M.Sc. P.Geo.
Project Description:	Oshawa Creek Site 6-8 Preliminary Design
Location:	Oshawa, Ontario

				OSHAWA CREEK SITE 6-8 PRELIMINARY DESIGN	
				ROM COST ESTIMATE	
Project Phase	**Project Task**	**Units**	**Unit Cost**	**Quantity**	**Total Cost**
Mob/Demob/Access	*Mobilization/Demobilization*	LS	$ 15,000	1	$ 15,000
	Site Access/Egress & Restoration of Trail/Parking Lot/Signs	m	$ 100	842	$ 84,200
Environmental	*Erosion and Sediment Control and Site Perimeter Fencing*	LS	$ 5,000	1	$ 5,000
	Fish Rescue	LS	$ 5,000	2	$ 10,000
	Flow Management & Silt Curtain	LS	$ 10,000	1	$ 10,000
Earthworks	*Clearing, Grubbing, Tree and Debris Removal*	m^2	$ 15	386	$ 5,790
	Cut Volume	m^3	$ 30	123	$ 3,690
	Fill Volume	m^3	$ 30	383	$ 11,490
Bank/Channel Works	*One Bank (i.e., Vegetated Stone, LWD, Revetment, Landscaping, etc.)*	m	$ 1,500	82	$ 123,000
Site Restoration	*Landscaping / Site Restoration*	m^2	$ 15	554	$ 8,310
	Task Subtotal (excl. HST)	$	-	-	$ 268,170
	Contingency (20%)	$	-	-	$ 53,634
	Project Subtotal (excl. HST)	$	-	-	$ 321,804
	Engineering and Permitting (15%)	$	-	-	$ 48,271
	Contract Administration (10%)	$	-	-	$ 32,180
	Project Total (excl. HST), rounded to near '000	$	-	-	$ 402,000

Assumptions:

Unit rates are based on recently tendered projects of a similar nature.

The items and quantities are based on preliminary construction engineering drawings and are for estimation purposes only.

Inflation and pandemic related supply chain issues have resulted in substantial price volatility in 2022. Assumed rates may vary from actual rates at the time of construction.

Works will be completed by an experienced third party contractor.

50% of the work area and 100% of access and laydown areas will require clearing and grubbing of trees and shrubs.

The assumed D_{50} stone size is 400 mm.