Appendix C

Bank Condition and Flow Capacity Assessment

Flow Capacity and Bank Condition Assessment Memorandum

08 April 2024

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From	Jeff Doucette	**Project No.**	11209954-MEM-4
Project Name	City of Toronto-Yellow Creek MP		
Subject	Flow Capacity and Bank Condition Assessment		

Dear Mr. McCreery

1. Introduction

1.1 Purpose of this report

The Yellow Creek Geomorphic Systems Master Plan (YCGSMP) project comprises a comprehensive investigation of the factors that have contributed to substantial stream bed, bank and erosion control infrastructure damage within the Yellow Creek channel. The study area for this project included the aboveground reach of Yellow Creek within the Vale of Avoca between Mount Pleasant Cemetery and the crossing near Mount Pleasant Road (**Figure 1**). The investigation guides the development of a long-term rehabilitation plan for Yellow Creek that will protect Toronto Water infrastructure while minimizing riparian ecosystem impacts and enhancing aquatic habitat. The YCGSMP takes into consideration past and concurrent erosion control projects, assessments, and designs within the stream corridor. The study followed the framework of the Municipal Class Environmental Assessment process for Schedule B projects, with the integration of methodologies from the MNR *Adaptive Management of Stream Corridors* (2002) protocol.

The following tasks were completed to provided supplemental information on the condition of Yellow Creek to aid in future prioritization of works within the valley: (1) a flow capacity assessment, and (2) a bank condition assessment. The following technical memo presents the results of both assessments. The purpose of the flow capacity analysis was to determine the size of storm events that could be conveyed through the upstream source culverts and the downstream outlet structure within the study area to better understand the hydrology and hydraulics of the system as requested by the City. The purpose of the bank condition assessment was to identify the type of bank protection (if present) and the condition of the structure or natural slope within the study area, to prioritize future bank protection repairs or replacements. GHD completed the bank condition assessment on November 20th, 2023.

1.2 Limitations

This report: has been prepared by GHD for City of Toronto and may only be used and relied on by City of Toronto for the purpose agreed between GHD and City of Toronto as set out in section 1.1 of this report.

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The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

Accessibility of documents

If this report is required to be accessible in any other format, this can be provided by GHD upon request and at an additional cost if necessary.

2. Culvert Capacity Assessment

2.1 Methodology

Yellow Creek originates at a large box culvert to the south of Mount Pleasant Cemetery. The creek is an open channel for 1256 m before going back underground in an inlet south of the rail crossing.

The flow capacities of the source culvert and downstream inlet (catch basin) were calculated using Bently FlowMaster.

The upstream source culvert outlet consists of a 1,800 mm diameter concrete pipe outletting to a flared box culvert. Dimensions of the pipe and gradient approaching the outlet were obtained from the City of Toronto DCAD 2.0 online ESRI database.

The dimensions of the downstream inlet or catch basin where the creek continues underground were obtained from an as-built drawing (P-116, Dated December 1946) and the gradient was obtained from the City of Toronto DCAD 2.0 online ESRI database which closely matched the information on as-built P-116. Note that the gradient and dimensions of the first section of the box culvert were used in the flow estimation. It is possible that different restrictions and gradients further downstream in the system could reduce the maximum flow rate.

2.2 Flow Capacity Results

The stormsewer parameters obtained from the as-built drawings are indicated in Table 1 along with the results of the hydraulic calculations.

Table 1 Stormsewer Flow Capacity Calculations

Stormsewer ID	Diameter (mm)	Material	Slope (m/m)	Flow Capacity (m^3/s)
Upstream Source Culvert Outlet (OF3882413570)	1,800	Concrete	0.04	27.2
Yellow Creek Downstream Catch basin (CB3786114151)	2,700mm x 2,550mm	Concrete	0.018	61.6

Table 1 indicates the estimated maximum flow which can enter Yellow Creek from the upstream source culvert based upon a maximum flow capacity analysis. The maximum flow entering Yellow Creek from the source culvert is 27.2 m^3/s and the estimated maximum flow for the culver inlet at the downstream end of Yellow Creek is 61.6 m^3/s. There are 4 additional stormwater outlets within the system ranging from 300 mm diameter to 1350 mm diameter.

2.3 Flow Comparison

The Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic modelling software has been used by the TRCA for conducting one-dimensional steady flow analysis for a range of flow events at the Site. The existing Yellow Creek HEC-RAS model (YellowCreekUpdate.prj) was provided by the TRCA on September 16th, 2022. This model indicates the flows within Yellow Creek at the inlet and outlet are as indicated in Table 2.

Table 2 HEC-RAS Flow Data

Design Storm Event	Upstream Source Flow (m^3/s)	Downstream Model end Flow (m^3/s)
2-year	7.99	8.19
5-year	17.16	17.76
10-year	22.91	23.78
25-year	29.71	30.99
50-year	39.97	38.49
100-year	43.67	45.4
Regional	134.41	139.97

As shown in Table 2, the flow capacity of the main source storm outlet at the upstream end of Yellow Creek is equivalent to between the 10-year and 25-year flow event. The flow capacity of the downstream inlet structure is sufficient to convey greater than the 100-year flow event without causing additional backwater effects.

3. Bank Condition Assessment

3.1 Methodology

The bank type and condition were assessed every 20 m along the centerline of the channel (**Note:** Due to channel sinuosity the bank length in each section varies slightly from 20 m). There were five bank types found within the study area: gabion baskets, quarry block walls, vegetated buttresses, rip rap revetments, and natural banks. The channel bank conditions were scored from 1 to 5, where 1 is Good, 2 is Fair, 3 is Poor, 4 is Failing, and 5 is Failed. A detailed breakdown of how each structure type was assessed can be found in **Table 2.1**.

Bank treatments did not always perfectly align with the 20 m interval sections. When this occurred, the bank type that covered most (>50%) of the section was recorded and assessed. When scoring the conditions of bank treatments, 3 major criteria were considered: undermining of the structure, loss/displacement of material, and slumping of the structure. For natural banks, the 3 major criteria were: undercutting of the banks, degree of scouring, and degree of slumping/overhanging. Natural banks were only scored as 1,3, or 5. Photos of each bank section were taken during the assessment (**Appendix A**).

Table 2.1 Detailed bank assessment scoring

	Gabion Basket	Quarried Block Wall	Vegetated Rock Buttress/ Rip Rap Revetment[1]	Natural Bank
1 – Good	Less than 10% of structure exhibits undermining. No slumping or outflanking. No loss of material.	Less than 10% of structure exhibits undermining. No slumping or outflanking. No loss of material, stones in tight formation.	Less than 10% of rip rap displaced. Consistent slope. Good vegetation growth contributing to structural stability.	Less than 10% of bank experiencing undercutting. No exposed parent material. Good vegetation growth securing the bank.
2 – Fair	10-20% of structure exhibits undermining. No slumping or outflanking. Minor loss of material.	10-20% of structure exhibits undermining. No outflanking or slumping.	10-20% of rip rap displaced. Consistent slope. Good vegetation growth contributing to structural stability.	N/A.

	Gabion Basket	Quarried Block Wall	Vegetated Rock Buttress/ Rip Rap Revetment[1]	Natural Bank
		No loss of material, stones slightly misaligned.		
3 – Poor	20%-50%undermining of structure. No outflanking. Moderate loss of material OR slightly slumping/bulging.	20%-50% undermining of structure. Misaligned/cracked stones OR slight slumping/bulging. No outflanking.	20-30% of rip rap displaced. Slightly inconsistent slope. Some vegetation growth contributing to structural stability.	Moderately scoured bank. Some exposed roots. Minimal exposed parent material. Slight overhanging top of bank OR slumping.
4 – Failing	> 50% undermining of structure AND slumping/bulging. Minor outflanking. Actively emptying basket.	> 50% undermining of structure AND moderate slumping/bulging. Major stone misalignment. Minor outflanking.	30-40% of rip rap displaced. Inconsistent slope. Little to no vegetation growth contributing to structural stability.	N/A.
5 - Failed	Overturned baskets. Major slumping. Major outflanking. Gabions completely emptied at bottom tier.[2]	Severe undermining. Blocks displaced in the channel. Major outflanking.	More than 50% of rip rap displaced. Detached from slope. Little to no vegetation growth contributing to structural stability.	Severely scoured bank. Exposed roots. Exposed parent material. Suspended armour layer. Overhanging top of bank. Major slumping.

Notes
[1] – Descriptors about vegetation do not apply to rip rap revetment.
[2] – If a gabion structure was completely emptied at the bottom, it was considered failed (5).

3.2 Results

The bank type and condition for each section of Yellow Creek in the study area are shown in **Figures 2-1** to **2-4**. An ESRI shapefile has also been provided as requested.

Gabion baskets, quarry blocks walls, vegetated rock buttresses, rip rap revetments, and natural banks composed approximately 19.4%, 61.3%, 4.8%, 1.6%, and 12.9% of the creek, respectively. The prominent bank type in reach 1 was gabion baskets, covering 60.7% of the reach. In reaches 2 and 3, quarry block walls were the prominent bank type, covering 58% and 80% of their sections, respectively. Reach 4 was composed only of quarried block walls on the banks of the whole reach.

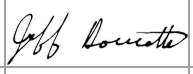
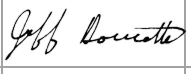
Most gabion baskets in the study area had failed, with major loss of material, severe slumping, and severe undermining. Quarried block walls were generally in less than fair condition. Vegetated rock buttresses were frequently in fair condition, featuring 10-20% of the material displaced, consistent slope, and good vegetation growth securing the structure. Rip rap revetments were the least common bank type with only two occurrences, one in poor condition, and the other failed. Lastly, natural banks were primarily in moderate condition featuring moderate scouring, some exposed roots and parent material, and slight overhanging or slumping.

Approximately 54.0% of all banks suffered from severe erosion and were failing or had failed. Approximately 29.0% of all banks were in moderate condition, while 16.9% of banks were in good or fair condition. The percentage of gabion baskets, quarry block walls, vegetated rock buttresses, and rip rap revetments in critical condition (failed or failing) were 79.2%, 51.3%, 33.3%, and 50%, respectively. Most of reach 1 and 2 were failing or had failed (71% and 60%, respectively), while less than half of the banks assessed in reach 3 and 4 were failing or had failed (37% and 38%, respectively).

4. Conclusions

The flow capacity of the existing North Inlet structure is 27.2 m^3/s, which was sufficient to convey between the 10 and 25-year flow events. The Yellow Creek Outlet structure capacity was 61.6 m^3/s, which will convey greater than the 100-year event without backwater impacts.

The bank condition assessment revealed that most of the gabion basket and many of the quarry block wall bank treatments were failing (4) or have failed (5). Reaches 1 and 2 had the highest percentage of failed and failing banks as 71% and 60% of the banks, respectively, were failing or had failed. This corresponds to approximately 400 m and 600 m of failing or failed banks in reaches 1 and 2, respectively.

Project name		City of Toronto-Yellow Creek MP					
Document title		Flow Capacity and Bank Condition Assessment Memorandum | Bank Condition Assessment					
Project number		11209954-MEM-4					
File name		11209954-MEM-4-Bank Condition Assessment					
Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S3	A	Yusef-Karim Lakhani	Jeff Doucette		Jeff Doucette		20/02/24

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Paper Size ANSI A

0 30 60 90 120

Metres

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

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CITY OF TORONTO
YELLOW CREEK GEOMORPHIC SYSTEMS
MASTER PLAN SHORT-TERM EROSION MONITORING

Project No. **11209954**
Revision No. **-**
Date **Aug 15, 2023**

PROJECT LOCATION

FIGURE 1

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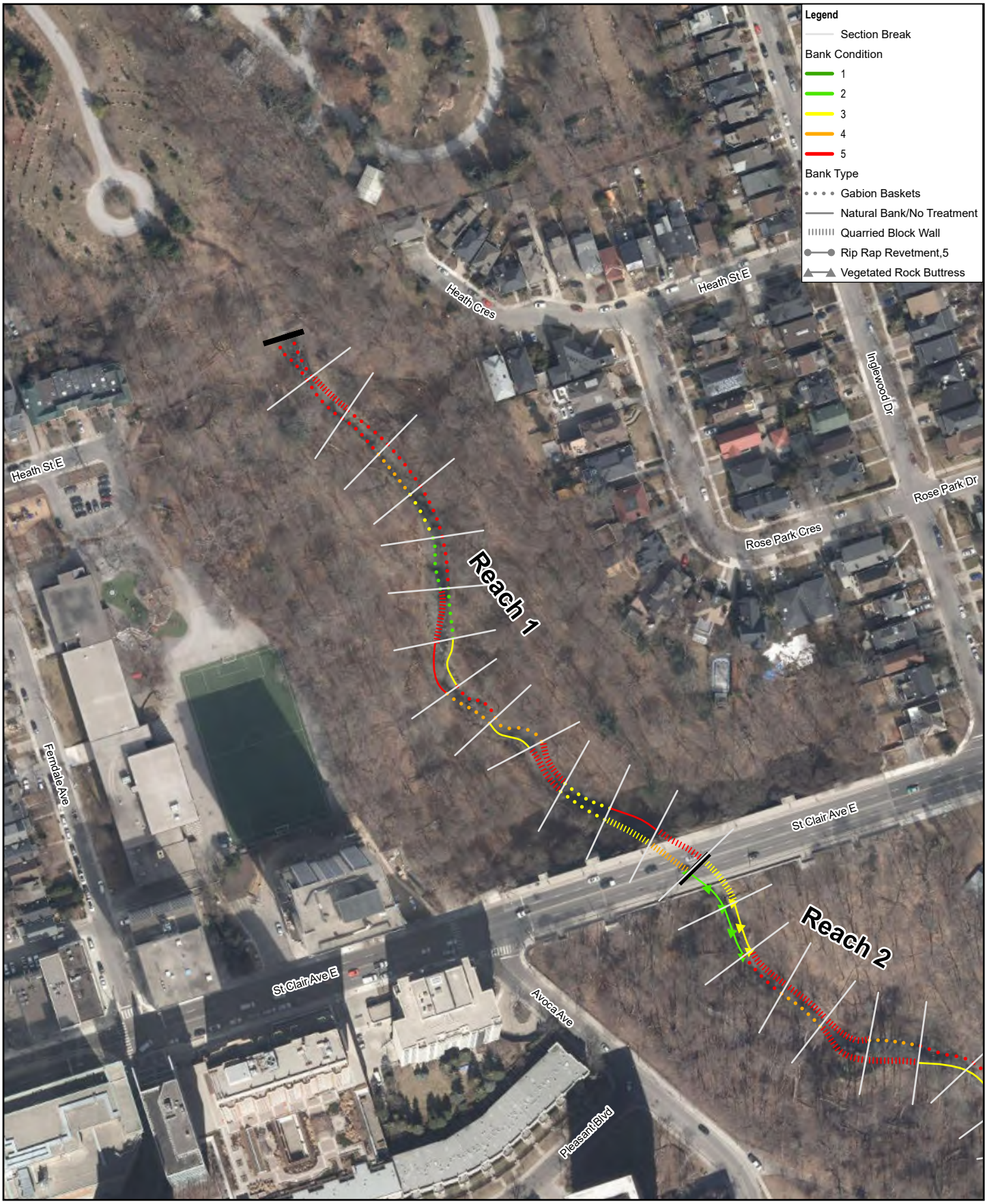

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Grid: NAD 1983 UTM Zone 17N

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CITY OF TORONTO
YELLOW CREEK GEOMORPHIC SYSTEMS
MASTER PLAN SHORT-TERM EROSION MONITORING

YELLOW CREEK
REACH 1
BANK CONDITION ASSESSMENT

Project No. **11209954**
Revision No. **-**
Date **Apr 2, 2024**

FIGURE 2-1

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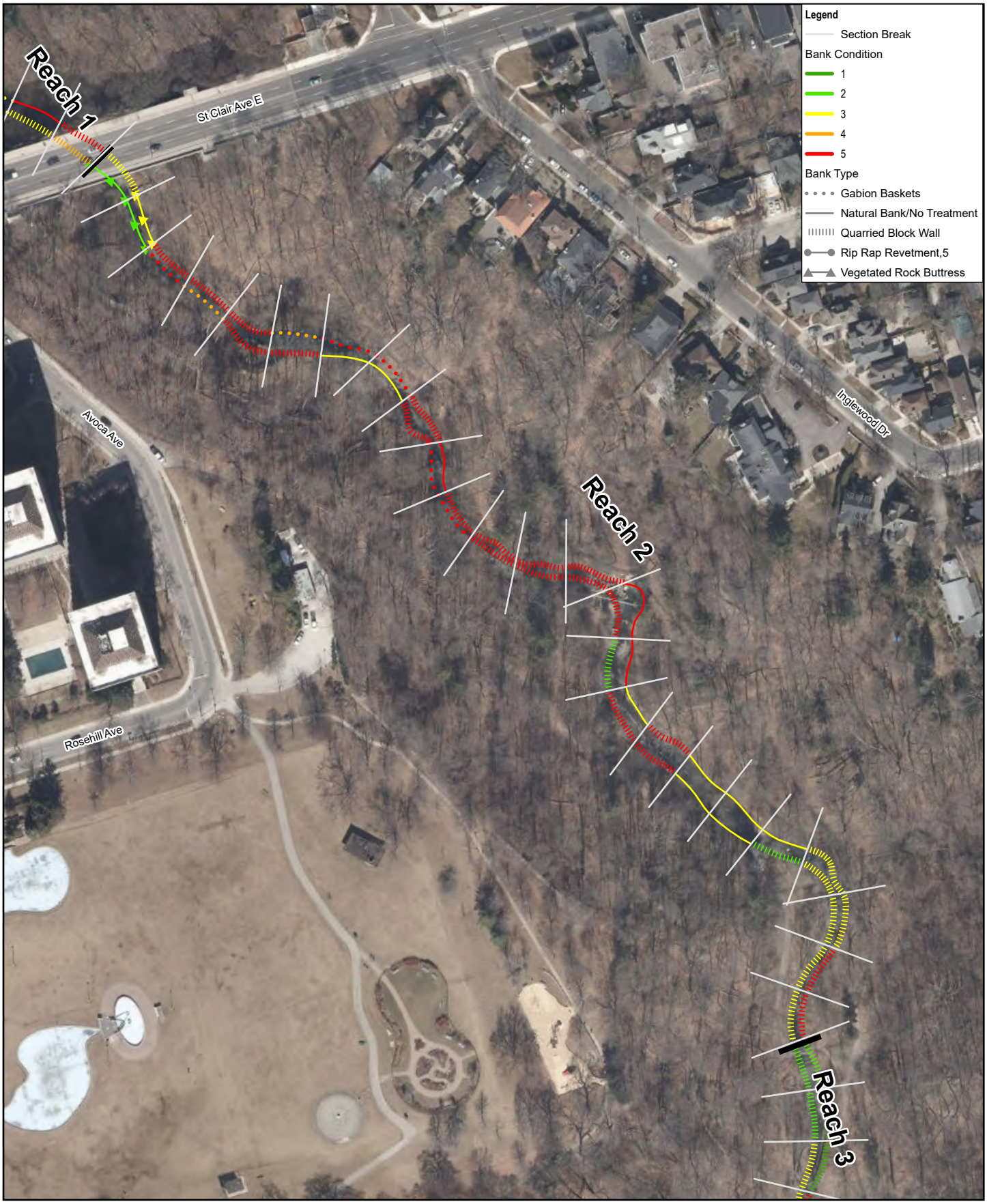

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Map Projection: Transverse Mercator
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CITY OF TORONTO
YELLOW CREEK GEOMORPHIC SYSTEMS
MASTER PLAN SHORT-TERM EROSION MONITORING

YELLOW CREEK
REACH 2
BANK CONDITION ASSESSMENT

Project No. **11209954**
Revision No. **-**
Date **Apr 2, 2024**

FIGURE 2-2

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Paper Size ANSI A

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: North American 1983
Grid: NAD 1983 UTM Zone 17N

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CITY OF TORONTO
YELLOW CREEK GEOMORPHIC SYSTEMS
MASTER PLAN SHORT-TERM EROSION MONITORING

YELLOW CREEK
REACH 3
BANK CONDITION ASSESSMENT

Project No. **11209954**
Revision No. **-**
Date **Apr 2, 2024**

FIGURE 2-3

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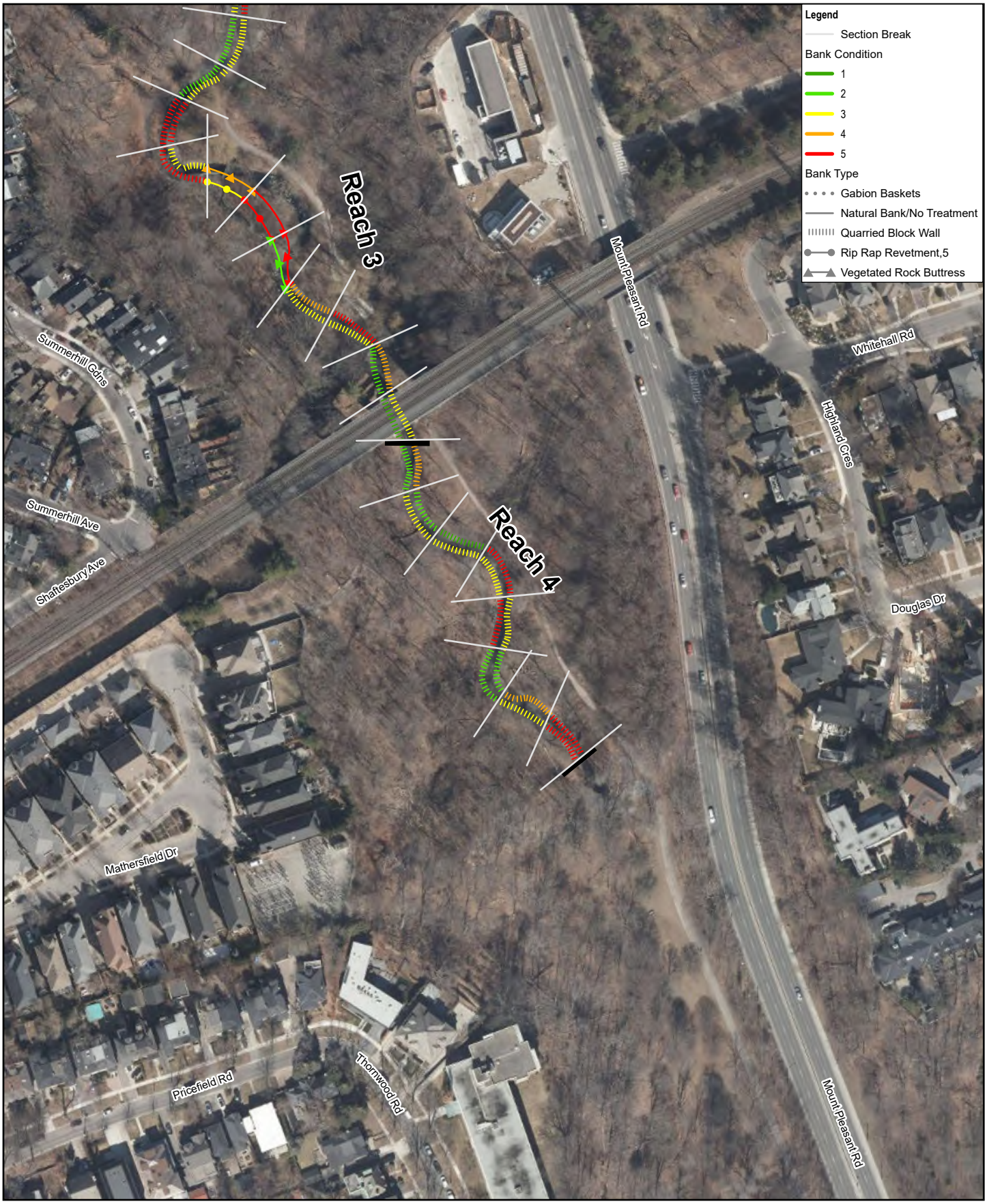

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Grid: NAD 1983 UTM Zone 17N

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CITY OF TORONTO
YELLOW CREEK GEOMORPHIC SYSTEMS
MASTER PLAN SHORT-TERM EROSION MONITORING

YELLOW CREEK
REACH 4
BANK CONDITION ASSESSMENT

Project No. **11209954**
Revision No. **-**
Date **Apr 2, 2024**

FIGURE 2-4

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Data source: basemap/cot_ortho_2018_color_8cm: City of Toronto.

Appendix A

Photographic Inventory

Photographic Inventory

Photo 1 - November 20th, 2023 – Example of fair (2) gabion baskets. Some undermining visible.

Photo 2 - November 20th, 2023 – Example of poor (3) gabion baskets. Slightly slumping and undermining visible.

Photo 3 - November 20th, 2023 – Example of failed (5) gabion baskets.

Photo 4 - November 20th, 2023 – Example of good (1) quarried block wall.

Photo 5 - November 20th, 2023 – Example of poor (3) quarried block wall. Misaligned and cracked stones visible.

Photo 6 - November 20th, 2023 – Example of failed (5) quarried block wall.

Photo 7 - November 20th, 2023 – Example of poor (3) rip rap revetment. Displaced rip-rap visible in the channel.

Photo 8 - November 20th, 2023 – Example of fair (2) vegetated rock buttress.

Photo 9 - November 20th, 2023 – Example of failed (5) vegetated rock buttress. Most of the rip rap is displaced.

Photo 10 - November 20th, 2023 – Example of poor (3) natural bank. Evidence of scour visible.

Photo 11 - November 20th, 2023 – Example of failed (5) natural bank. Severe scour visible.