PALMER
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In association with
Greck

West Don River at E.T. Seton Park – Detailed Fluvial Geomorphic Analysis and Erosion Risk Assessment

Contract # 10009019

Palmer Project #
1504416

Prepared For
Toronto and Region Conservation Authority

October 2, 2019

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October 2, 2019

Carrie Smith
Project Manager
Toronto and Region Conservation Authority (TRCA)
5 Shoreham Drive,
Downsview, Ontario MEN 1S4

Dear Carrie Smith:

Re: **West Don River at E.T. Seton Park – Detailed Fluvial Geomorphic Analysis and Erosion Risk Assessment**
Project #: **1504416**

Palmer Environmental Consulting Group Inc., in association with Greck and Associates Limited, is pleased to provide Toronto and Region Conservation Authority with the results of our detailed fluvial geomorphic analysis of West Don River at E.T. Seton Park, in Toronto, as a basis for inventorying, evaluating and recommending actions to address erosion risks posed to public and private infrastructure.

Through geomorphic field investigations and desktop analyses, we identified 48 sites with infrastructure at risk from continued lateral (channel migration) or vertical (down-cutting) erosion. Erosion control structures at 40 of these sites offer varying degrees of protection due to their condition, original design and ongoing fluvial adjustments. Recommended actions for each site include a new, repaired, replaced or enhanced erosion control structure (21 sites); the abandonment or removal of an existing erosion control structure (6 sites); or 'do nothing' apart from monitoring (in some cases subject to the findings of a site-specific survey) (21 sites). Opportunities for coordinated design and implementation of erosion mitigation efforts are identified.

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

Yours truly,
Palmer Environmental Consulting Group Inc.

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

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

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1. Introduction

Palmer Environmental Consulting Group Inc. (Palmer), in association with Greck and Associates Limited (Greck), is pleased to provide Toronto and Region Conservation Authority (TRCA) with our fluvial geomorphic study and erosion risk evaluation to prioritize erosion mitigation efforts along West Don River, between Eglinton Avenue East and its confluence with East Don River, in E.T. Seton Park, in the City of Toronto (the City). The study conducted a comprehensive evaluation of erosion-related risk posed to existing private and public infrastructure and assets, in order to inform preliminary recommendations for the maintenance, decommissioning or construction of erosion control structures along West Don River.

An overview of the physical setting and historical changes of West Don River (Section 2) is followed by a summary of methods (Section 3); a description of channel morphology and characterization of erosional processes (Section 4); an inventory and evaluation of erosion risks, based in part on an assessment of the condition of existing erosion control structures (Section 5); recommendations for erosion mitigation (Section 6); and our conclusions and recommended next steps (Section 7).

Results of rapid assessments, applied to each of three reaches, are provided in **Appendix A**. Standardized, half-page summary characterizations of each of the 48 inventoried erosion hazard sites and erosion control structures, including hazard, risk and recommended actions, are provided in **Appendix B**. An assessment of the condition of existing erosion control structures is included in **Appendix C**. Complete erosion risk evaluation and prioritization results, considering both likelihood and anticipated consequence of impact without mitigation, are provided in **Appendix D**.

2. Physical Setting and Historical Changes

E.T Seton Park is situated within the West Don River valley between Eglington Avenue and the confluence with East Don River (**Figure 1**). It is within the Iroquois Plain physiographic region (Ontario Geological Survey (OGS), 2019a). Since deglaciation, West Don River has incised through coarse- to fine-grained glaciolacustrine deposits into underlying sandy silt to silty sand till. The level bottom of the West Don River valley is predominantly modern alluvial deposits comprising stratified silt, sand and gravel with localized organics (OGS, 2019b).

West Don River exhibits a history of channel realignment, most of which occurred between 1965 and 1978. West Don River has been progressively realigned along the toe of the western valley wall (**Figure 1**) through a series of anthropogenic meander cut-offs. A series of meander scars and oxbows in an anomalously wide section of valley bottom behind the Ontario Science Centre reveal the former, natural channel planform (**Figure 2**).

The study area encompasses three distinct reaches of West Don River (**Figure 1**). Reach 1 has remained largely unchanged despite the channel being realigned near its downstream end in 2005. Over the period of record, the channel has been shortened slightly from 677 m in 1939 to 663 m in 2018. A large meander was cut-off between 1965 and 1978 immediately upstream of the defined study area. Reach 2 has been straightened and realigned in a few locations to protect to toe of the valley wall, including a large meander cut-off beneath the hydro corridor between 1954 and 1965. Channel length has decreased only 95 m between 1939 (1,226 m) and 2018 (1,131 m). Sometime prior to 1910 (based on historical mapping), approximately 1 km of channel was cut off based on oxbows clearly visible in the vicinity of what is now a constructed wetland on the valley bottom behind the Ontario Science Centre (**Figures 1** and **2**). Evidence of channel realignment is most pronounced along Reach 3, where channel length decreased by approximately 270 m between 1939 (1,319 m) and 2018 (1,051 m). Straightening and realignment of the channel to protect the toe of the valley wall and Don Valley Parkway has increased channel gradient compared to that along reaches 1 and 2.

Toronto and Region Conservation Authority

PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

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PROJECT:	Geomorphic Analysis and Erosion Risk Assessment at E.T. Seton Park		
PROJECT NO.	1504416	REVISION:	0
DATE:	Jul 31, 2019	SCALE:	1:5000
DRAWN:	CV	DATUM:	NAD 1983
CHECKED:	MB	PROJECTION:	UTM zone 17

LEGEND:

- Meander Belt
- Flow Direction
- Reach Break
- Contour (2m)

Historic Channel Centrelines

- 2018
- 2005
- 1993
- 1978
- 1965
- 1954
- 1939

Note: 2018 Imagery provided by City of Toronto (WMS)

Historical Changes and Meander Belt

FIGURE 1

Figure 2. Relic Meander Features in Valley Bottom alongside the Upper Portion of Contemporary, Straightened Reach 2 (1939 Aerial Photograph Base)

3. Methods

3.1 Desktop- and Field-based Geomorphic Analysis

The fluvial geomorphology of West Don River was assessed through a combination of desktop analysis and field investigations. Data were collected to enable application of the *Erosion Risk Evaluation Tool* (Palmer, 2016) (Section 3.3). We reviewed a number of important background information sources for the study area, including TRCA's *Don River Watershed Report: Fluvial Geomorphology – Report on Current Conditions* (TRCA, 2009), *West Don River Slope Stabilization and Channel Realignment Report (Aquafor Beech, 2005)*; as-built drawings of West Don River Sanitary Trunk Sewer *(R.V. Anderson and Associates, 1957);* LiDAR-derived elevation data and 0.25 m contour topographic data provided by TRCA; existing bedrock and surficial geology mapping (OGS, 2019a,b); and HEC-RAS modelling and associated floodplain mapping provided by TRCA. Historic and recent aerial photography (1939, 1954, 1965, 1978, 1993, 2005, 2018) from TRCA was studied to characterize historical channel conditions and previous anthropogenic disturbances. Historic mapping from 1910 extended the period of river planform record, at least approximately. Aerial photography also supported the establishment of erosion hazard zones.

Erosion hazard zones, depicting river migration potential within immediate (<5 years), short-term (5-10 years) and long-term (10-25 years) timeframes, were delineated for sections of the channel that exhibited systematic, progressive bank erosion over the period of record (1939 to 2018). Time-averaged migration rates and trajectories were estimated from the comparative overlay of historical channel planforms. The erosion hazard zones were then delineated based on extrapolation of these rates and trajectories from the applicable top of bank in the 2018 orthophotography. The meander belt was delineated for each of the three reaches in accordance with TRCA's *Belt Width Delineation Procedures* (Parish Geomorphic, 2004). The existing meander belt for each reach was established by delineating and then buffering the meander belt axis until the boundary lines encompassed all meanders. The final meander belt includes a reach-specific factor of safety based on an average 100-year erosion rate. Locally confined portions of the belt boundaries were modified to roughly follow the midpoint of the valley wall.

Initial field reconnaissance along West Don River at Seton Park was completed by Palmer's Principal Fluvial Geomorphologist and fluvial processes specialist on April 10, 2019. The purpose of this visit was to inventory existing erosion control structures and unprotected infrastructure. Follow-up field work was completed by Palmer's staff specializing in fluvial geomorphology on July 12, 2019 to examine patterns and processes of local erosion, verify bankfull measurements, observe bed and bank materials, and ground truth aerial photograph-based interpretations in order to inform geomorphic analysis. Thalweg configuration and erosional hollows were mapped to support follow-up desktop interpretation. Site-specific data collection included six bankfull cross-sections (a representative riffle and pool along each reach); substrate characteristics; and a description of bank composition and structure[1]. Bankfull dimensions were based on field indicators defining the principal limit of scour, including abrupt changes in bank vegetation, material and steepness (Harrelson et al., 1994), which is assumed to represent the 'channel-forming' discharge. The grain size distribution of alluvial material comprising representative riffles in each reach was determined through modified Wolman (1954) pebbles counts.

[1] *Banks are denoted based on a downstream view throughout the report.*

A Rapid Geomorphic Assessment (RGA; Ontario Ministry of the Environment, 2003) was completed along the study corridor to document evidence of channel aggradation, degradation, widening and planimetric form adjustment. The RGA tool provides a useful checklist of evidence to consider, but its results are dependent on the presence or absence of a set number of specific features within a reach and thus must be interpreted carefully to ensure accuracy (McKillop, 2016). A Rapid Stream Assessment Technique (RSAT; Galli, 1996) was also completed.

A reach-scale longitudinal profile was generated from TRCA's high-resolution, LiDAR-derived, digital elevation data, which represents the approximate water surface along the channel centerline. Bankfull geometry and hydraulics were estimated based on the field survey data and the slope generated from the LiDAR-derived longitudinal profile. Erosion threshold analyses were completed based on a Shields (1936) approach as outlined by Church (2006), as it is a semi-empirical approach (as opposed to completely empirical) and is well-suited for gravel-bed watercourses. A bed erosion threshold is the hydraulic condition at which the channel bed is in a state of incipient motion, and the critical discharge is the flow that produces that threshold condition at a particular location along the channel. The median grain size (D_{50}) and a grain size representative of the coarse fraction (D_{84}) were applied to erosion threshold calculations. A hiding function (Wilcock & Crowe, 2003) was applied to the critical shear stress calculations of the D_{84} because the presence of fine particles results in coarser particles protruding further into the water column, increasing the mobility of coarse particles relative to a uniform bed surface.

Erosion thresholds were compared to hydraulic conditions at bankfull flows (established from the field survey) as well as modelled shear stresses at 48 HECRAS riverstations for the 2-year return flow (53.6 m^3/s) to better understand the propensity for scour along the study corridor and any reach-to-reach differences. Excess shear stress was calculated at each riverstation for both the D_{50} and D_{84}. Exceedance of the D_{84} erosion threshold represents periods of high bed load transport and morphological restructuring (Mackenzie and Eaton, 2017). As well, 'full bed mobility' (i.e. all fractions are mobile), a condition that is met when the modelled shear stress is 2x greater than critical shear stress of the D_{50} (Wilcock and McArdell, 1993), was assessed at each riverstation for the 2-year return flow.

3.2 Assessment of Existing Erosion Control Structures

Existing erosion control structure assessments were completed during the initial field reconnaissance on April 10, 2019. A total of 40 structures were identified, 17 of which are maintained by TRCA. The apparent original purpose of revetments, retaining walls and slope treatments was noted. Gabion revetments were characterized according to their original and current number and posture of tiers, proportion of released stone, and condition of wire cages. Retaining walls, slope treatments and any grade control structures were characterized according to their material(s), height, form and overall structural integrity, as well as their current condition. Specific attention was given to characterizing the dominant mode(s) of failure of erosion control structures, such as undermining, outflanking and/or deterioration of wire cages, in order to inform understanding of site-specific erosional processes and unmitigated timeframes until infrastructure impact.

3.3 Evaluation of Site-specific Erosion Risk to Infrastructure

Risk of erosion to the West Don River Sanitary Trunk Sewer (the sanitary sewer) and other public and private infrastructure was largely evaluated by adapting and applying Palmer's (2016) *Erosion Risk Evaluation Tool* for both lateral and vertical erosion processes. The *Erosion Risk Evaluation Tool* establishes indices that indicate the relative likelihood (risk) of continued erosion along a channel impacting adjacent (lateral erosion) or buried (vertical erosion) infrastructure. It is particularly helpful where reliable lateral erosion rates cannot be determined based on comparative overlay analysis of historic channel planforms (e.g. dense tree canopy, small photograph scale, poor temporal coverage, anthropogenic disturbance) and where depth of cover to buried infrastructure is unknown, out of date, or unreliable. To accommodate sites already at least partly protected by erosion control structures, we allowed for assignment of 0 (not applicable) values to certain risk parameters in addition to the standard 1 (Low), 2 (Moderate) and 3 (High) values. For example, allowing the "Grain Size (GS)" and "Vegetative Cover (VC)" parameters to be assigned values of 0 in relation to the "Bank Erodibility" category appropriately lowered the Lateral Erosion Risk (LER) Index.

An evaluation of the likelihood (risk) of erosional impact at each of the 17 sites identified by TRCA, plus an additional 31 sites, required consideration of site-specific channel conditions and erosional processes. The likelihoods (risks) of lateral (Section 3.3.1) and vertical (Section 3.3.2) erosion impacting infrastructure were assessed separately before an overall erosion risk rating (Section 3.3.4) could be established based on additional consideration of the consequence of unmitigated erosion (Section 3.3.3). In the rare cases where both banks were included in the characterization, the evaluation was always conducted conservatively based on the outer bank of a meander or where the potential for impact was greatest (e.g. steel sheet piling lining both banks at Site 2). Reference to outflanking potential (e.g. "outflanking of sanitary sewer") in the site-specific characterizations of at-risk, buried linear infrastructure crossings is made in the context of outflanking of the concrete encasement and/or bank stabilization measures designed to maintain the crossing location.

3.3.1 Lateral Erosion Risk (Likelihood of Impact)

Palmer's (2016) *Erosion Risk Evaluation Tool* was modified slightly[2] to include eight evaluation parameters representing three categories in relation to lateral erosion risk (LER), or likelihood of impact (**Table 1**). A brief rationale for the inclusion of each parameter is provided below:

[2] *Stratigraphy (ST) was removed due to unreliable characterization behind the many existing erosion control structures along West Don River in E.T. Seton Park.*

Table 1. Lateral Erosion Risk Evaluation Parameter Ranks and Weights

Category	Parameter	Low (1)	Moderate (2)	High (3)	Weight
BANK DISTANCE	Distance from Top-of-Bank (DB)	>5 m	2 – 5 m	<2 m	0.200
BANK STRESS	Planform Position (PL)	Inner bank of meander	Straight	Outer bank of meander	0.150
	Thalweg Position (TH)	Inside	Centre/flat	Outside	0.100
	Radius of Curvature (RC)	>50 m	10 – 50 m	<10 m	0.100
BANK ERODIBILITY	Grain Size (GS)	Silt/sand dominated	Sand/gravel dominated	Cobble or till dominated	0.075
	Bank Angle (BA)	<45º	45 – 55º	>55º	0.075
	Vegetative Cover (VC)	Low (<30% of area)	Medium (30-70% of area)	High (>70% of area)	0.200
	Bank Height-to-Bankfull Depth (HD)	<1.6	1.6 – 2.5	>2.5	0.100

Bank distance:

- *Distance from Top-of-Bank* (**DB**) – The lateral separation between the at-risk infrastructure largely determines how much material would need to be eroded before it is intercepted by the channel; risk increases with decreasing separation distance.

Bank stress

- *Planform Position* (**PL**) – The position of the at-risk infrastructure relative to channel meanders partially determines whether lateral channel adjustments are likely to increase or decrease channel-infrastructure separation; risk is greatest if the infrastructure is situated alongside the outer bank of a meander.
- *Thalweg Position* (**TH**) – The position of the thalweg within the channel affects the amount of shear stress exerted on the bank adjacent to the at-risk infrastructure; risk is greatest if the thalweg is on the near side of the channel, relative to the at-risk infrastructure.
- *Radius of Curvature* (**RC**) – The shape of a meander, in particular its sharpness (radius), affects the amount and distribution of shear stress along the outer bank; risk for adjacent infrastructure increases with decreasing radius of curvature.

Bank erodibility

- *Grain Size* (**GS**) – The size and cohesiveness of materials comprising the bank influence how readily they are eroded; risk increases with decreasing grain size and cohesiveness.
- *Bank Angle* (**BA**) – The steepness of a bank strongly influences its susceptibility to failure through sloughing and slumping; risk increases with increasing angle.

- *Vegetative Cover* (**VC**) – The distribution and density of riparian vegetation along the bank influence its stability and susceptibility to erosion through rooting effects; risk increases with decreasing vegetative cover.
- *Bank Height-to-Bankfull Depth* (**HD**) – How much higher a bank is than the bankfull depth determines how much bank material is unsupported and subject to failure during bankfull flow events; risk increases with an increasing bank height-to-bankfull depth ratio.

Each evaluation parameter was given a *Low*, *Moderate* or *High* rating, or a *Not Applicable* value (**Table 1**). The purpose was to establish the relative likelihood (risk) contribution of the different parameters for each risk site. Some of these parameters were assigned physically meaningful thresholds based on professional experience or references, while others had ranks assigned to ensure representation of subsets in the populations of results of that parameter for all the sites.

The relative evaluation of LER was achieved by developing and applying to each site a parametric equation that yields an LER Index. The LER Index is a number that represents the relative likelihood (risk) of erosion impacting infrastructure through lateral channel adjustments (i.e., bank erosion). Evaluations using the LER Index approach have several important benefits:

- ***Comparability*** – The single, resultant number (LER Index) allows direct comparisons to be made among different sites.
- ***Transparency*** – Evaluations are transparent, with all steps systematic and traceable.
- ***Flexibility*** – The assignment of weights to each evaluation parameter provides TRCA with the flexibility to vary their relative importance (weight) for different project circumstances.

The parametric equation yielding the LER Index for a given site is expressed as,

Lateral Erosion Index = $DB*w_{DB} + PL*w_{PL} + TH*w_{TH} + RC*w_{RC} + GS*w_{GS} + BA*w_{BA} + VC*w_{VC} + HD*w_{HD}$

where, for each term in the equation (e.g., $DB*w_{DB}$), the first factor in each product (e.g., DB) represents the rank value (0 (*N/A*), 1 (*Low*), 2 (*Moderate*) or 3 (*High*)) of one of eight evaluation parameters (in this example, Distance from Top-of-bank); and the second factor in each product (e.g., w_{DB}) represents the weight (between 0 and 1) of that evaluation parameter. The sum of each of the eight products results in a single, positive number, referred to as the LER Index. For the ultimate purpose of deriving an overall erosion risk rating, the LER Index values were subsequently assigned LER ratings of Low (L), Moderate (M) or High (H) based on natural breaks at 1.75 (L/M threshold) and 2.30 (M/H threshold) in a plot of the LER Index results.

3.3.2 Vertical Erosion Risk

Palmer's (2016) *Erosion Risk Evaluation Tool* includes three evaluation parameters within a single category in relation to vertical erosion risk (VER), or likelihood of impact (**Table 2**). The depth of cover between the creek bed and the buried infrastructure (e.g. sewer pipe) is not explicitly included as an evaluation parameter, because its accuracy is commonly unknown, but it was considered in the final overall rating, where possible. A brief rationale for the inclusion of each parameter is provided below:

Table 2. Vertical Erosion Risk Evaluation Parameter Ranks and Weights

Category	Parameter	Low (1)	Moderate (2)	High (3)	Weight
BED ERODIBILITY	Reach-scale Process (RP)	Aggradation	Widening or Planform Adjustment	Degradation	0.200
	Site-scale Process (SP)	Erosion (e.g., scour pool)	Neutral (e.g., shallow pool, low riffle)	Deposition (e.g., bar)	0.500
	Bed Material (BM)	Till, large cobbles or riprap	Small to medium cobbles	Silt, sand and/or gravel	0.300

***Bed erodibility*[3]**

- *Reach-scale Process* (**RP**) – The dominant mode of geomorphic adjustment, at a reach scale, influences long-term trends in bed erodibility; risk is greater along reaches exhibiting degradation.
- *Site-scale Process* (**SP**) – The trend of erosion or deposition at a particular site affects its susceptibility to degradation; risk is greater for existing erosion sites.
- *Bed Material* (**BM**) – The size and cohesiveness of materials comprising the bed influence how readily they are eroded; risk increases with decreasing grain size and cohesiveness.

The evaluation of the VER was completed following a similar approach to that used in the evaluation of lateral erosion risk. Each parameter was given a *Low*, *Moderate* or *High* rank, or *Not Applicable* value (**Table 2**). The relative evaluation of VER was achieved by developing and applying a parametric equation to each site that yields a VER Index. The VER Index is a number that represents the relative likelihood (risk) of erosion impacting buried infrastructure through vertical channel adjustments (i.e., down-cutting).

The parametric equation yielding the VER Index for a given site is expressed as,

$$\text{Vertical Erosion Index} = RP*w_{RP} + SP*w_{SP} + BM*w_{BM}$$

where, for each term in the equation (e.g., $RP*w_{RP}$), the first factor in each product (e.g., RP) represents the rank value (0 (*N/A*), 1 (*Low*), 2 (*Moderate*) or 3 (*High*)) of one of three evaluation parameters (in this example, Reach-scale Process); and the second factor in each product (e.g., w_{RP}) represents the weight (between 0 and 1) of that evaluation parameter. The sum of each of the three products results in a single, positive number, referred to as the VER Index. For the ultimate purpose of deriving an overall erosion risk rating, the VER Index values were subsequently assigned VER ratings of Low (L), Moderate (M) or High (H) that reflect the spread in VER Index results.

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[3] The depth of cover between the creek bed and the buried sewer pipe was not explicitly included as an evaluation parameter, because its accuracy is unknown at several sites due to historical channel realignment, but it was considered in the final overall rating (described below), where possible.

3.3.3 Consequence of Unmitigated Erosion

Risk to infrastructure depends on both the likelihood and consequence of impact from erosion. The anticipated consequence of impact was interpreted and classified relatively – Low (L), Moderate (M) or High (H) – based on consideration of the implications of impact (e.g. public safety, environment, recreation, cost) and professional judgment. For example, exposure of a sanitary main by erosion was considered a High consequence, given the potential for damage to the pipe, potential environmental effects and the complexity, cost and urgency of mitigative solutions. In contrast, the undermining of an informal mountain bike trail was considered a Low consequence, because a localized closure or realignment of the trail would be ample mitigation.

3.3.4 Overall Erosion Risk Rating

For each of the 48 risk sites, an overall erosion risk (OER) rating from Very High to Very Low was assigned based on a combination of the likelihood of erosional impact (as determined by the H/M/L classification of the LER and VER indices) and the anticipated consequence of unmitigated erosion (H/M/L classification) (**Table 3**). All other things being equal, the rating essentially constitutes a prioritization for erosion mitigation efforts. In general, sites with Very High or High ratings warrant attention within 5 years, sites with Moderate ratings warrant attention in 5 to 10 years, and sites with Low or Very Low ratings warrant attention in 10 to 25 years (if at all).

Table 3. Overall Erosion Risk Rating Matrix

		Consequence		
		Low (L)	**Moderate (M)**	**High (H)**
Likelihood (Lateral and Vertical Risk Rating)	**High (H)**	Moderate	High	Very High
	Moderate (M)	Low	Moderate	High
	Low (L)	Very Low	Low	Moderate

3.4 Recommendations for Erosion Mitigation

Recommendations for erosion mitigation were provided based on the generalized prioritization established by the OER rating, additional site-specific considerations (e.g. estimated timeframe until impact, effectiveness of existing erosion control), and the ecological implications of disturbance. An OER rating of High or Very High did not necessarily translate into recommended actions involving channel works, although this was generally the case. One of six standardized recommended actions was assigned to each site:

- *Do Nothing* – still allows for monitoring of site conditions and/of follow-up survey or investigation;
- *Repair Existing Structure* – minor maintenance or rehabilitation of existing erosion control structure;
- *Replace or Enhance Existing Structure* – major change to existing erosion control structure to improve its effectiveness;

- *Construct New Structure* – implementation of erosion control measures where none are currently present;
- *Abandon Existing Structure* – leave existing erosion control structure to deteriorate where removal would likely cause greater disturbance or harm to aquatic/riparian habitat; or
- *Remove Existing Structure and Restore Channel* – remove existing erosion control structure and then restore channel to improve aquatic/riparian habitat and avoid exacerbating erosion.

For sites where erosion mitigation works are recommended, we also identified opportunities to optimize efforts along a given section of reach by coordinating the design and implementation of multiple sites. The intention was to highlight coordination that avoids repeated disturbance to a section of channel and reduces costs through a single mobilization/demobilization of equipment and economies of scale. Each site that would logically be coordinated with another was assigned the same letter code (e.g., A, B, C), implying the grouping not a prioritization, in the summary data table.

4. Description of Channel Morphology

The study corridor for this project extends along West Don River for 2.8 km from approximately 100 m upstream of Eglington Avenue to the confluence with East Don River (**Figure 1**). The study corridor consists of three distinct reaches, which exhibit a history anthropogenic modification (Section 2). **Figure 3** depicts a longitudinal profile along all three reaches.

4.1 Reach 1

Reach 1 actually beings approximately 600 m upstream of Eglinton Avenue East at the confluence with Wilket Creek, a major contributor of flow, and extends downstream to the valley wall contact immediately downstream of the second pedestrian bridge (**Figure 1**). In accordance with TRCA's requirements for this study, Reach 1 was truncated at the point bar approximately 100 m upstream of Eglinton Avenue. Reach 1 exhibits a partly confined, sinuous to irregularly meandering channel pattern within a relatively narrow valley. Its upstream limit roughly coincides with the northern (inland) limit of the Iroquois Plain. The channel is slightly entrenched below the floodplain, such that only flows exceeding the 10-year flood spill overbank (as per TRCA's HEC-RAS model). Fine sediment (sand) deposition is widespread along mid to upper banks of the channel.

Bed materials within Reach 1 are dominated by gravels but range from silt to cobble-sized (~10 cm diameter) stone released from deteriorated gabion baskets (**Photo 1**). A thin veneer of sand embeds gravels in pools, whereas gravels and cobbles form the riffles. The representative median grain size (D_{50}) along the reach was estimated to be 33 mm.

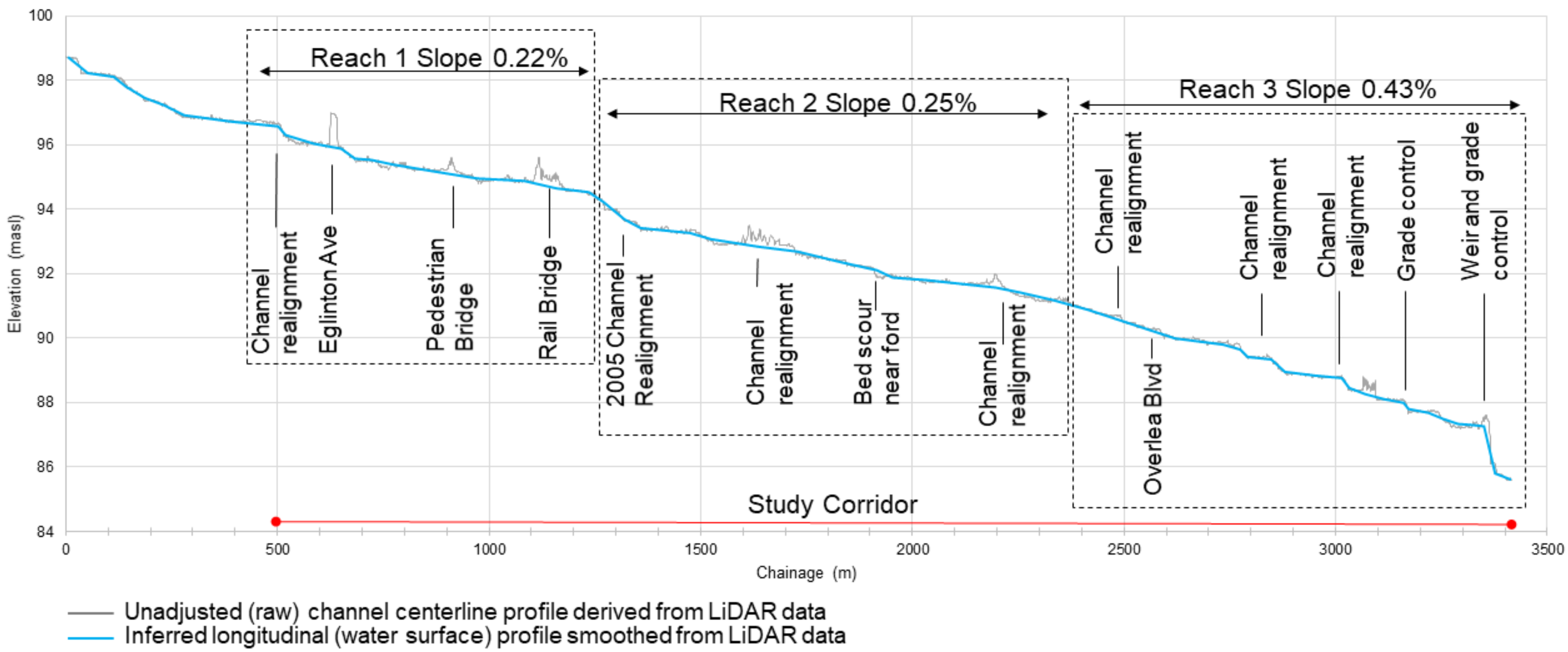


Figure 3. West Don River longitudinal profile derived from LiDAR data provided by TRCA

Photo 1. Looking upstream at a riffle with its natural stone composition augmented by stone released from deteriorated gabion baskets upstream

Pool-riffle morphology is generally well developed along the study corridor. Average bed gradient is 0.22% (**Figure 3**). The longitudinal profile exhibits local convexities and knickpoints that reflect past realignment (shortening and steepening) near Eglington Avenue East. The channel exhibits a roughly trapezoidal to rectangular cross-section along its riffles. Pool cross-sections are generally asymmetric, deepest along the base of the outer banks of meanders. Riffles tend to have the coarsest material based on field observations. Sand veneers overlie the bed in pools and runs. Sand and gravel point bars are located along the inner banks of most meanders. Mid-channel bars occur at anomalously wide sections of channel (**Photo 2**).

The average bankfull width and depth of the surveyed cross-sections are approximately 13.9 m and 1.06 m, respectively. Maximum depth at bankfull stage averages 1.8 m. The bankfull discharge for the study corridor was estimated as 24.9 m^3/s (**Table 4**). The bed erosion threshold was estimated as 20.0 m^3/s, demonstrating that the alluvial bed material is mobilized during flows slightly below the physical tops of bank. Comparison of modelled shear stresses during the 2-year return flow in Reach 1 to erosion thresholds suggest the D_{50} and D_{84} are entrained at 10 of 15 HEC-RAS riverstations (67%). The average excess shear stress during the 2-year return flow at the 15 HEC-RAS riverstations is 22.3 N/m^2. Furthermore, 6 of the 15 riverstations (40%) experience total bed mobility, a condition that occurs when the shear stress is at least two times greater than the erosion threshold, during the 2-year return flow.

Photo 2. Looking upstream at mid-channel bar at the upstream end of Reach 1

Table 4. Bankfull Dimensions and Hydraulics at Surveyed Cross-sections

Reach	XS	Type	Bankfull Hydraulics						Critical Discharge
			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)
1	1	Pool	31.5	14.9	1.2	2.5	12.0	1.4	19.6
	2	Riffle	18.3	12.9	0.9	1.2	14.5	1.1	20.5
	Average		**24.9**	**13.9**	**1.1**	**1.8**	**13.3**	**1.2**	**20.0**
2	1	Riffle	17.2	15.0	0.8	1.0	19.2	1.1	12.5
	2	Pool	20.9	11.1	1.1	1.5	10.4	1.4	6.4
	Average		**19.1**	**13.0**	**0.9**	**1.3**	**14.8**	**1.3**	**9.5**
3	1	Pool	43.9	22.6	1.0	1.7	23.5	1.7	6.1
	2	Riffle	30.0	16.0	0.9	1.2	17.4	1.7	7.7
	Average		**36.9**	**19.3**	**0.9**	**1.5**	**20.4**	**1.7**	**6.9**

Notes:

1. *Abbreviations: XS: cross-section, Q_{bfl}: bankfull discharge, W_{bfl}: bankfull width, D_{bflA}: bankfull depth (average), D_{bflM}: bankfull depth (maximum), V_{bfl}: bankfull velocity (average).*
2. V_{bfl} and Q_{bfl} values are estimated using a Manning's 'n' of 0.035 (Hicks and Mason, 1998) and an energy gradient of 0.22% (Reach 1), 0.25% (Reach 2) and 0.43% (Reach 3).

Banks are generally composed of loose alluvial silts and sands with an elevated gravel armour layer visible (**Photo 3**). The channel has incised by approximately 0.5 m into underlying laminated, fine-grained glaciolacustrine sediments along the straight section that parallels the southern valley wall. Eroded banks are nearly vertical with a slight undercut along unprotected outer banks of meanders. The outer banks of meanders are generally armoured with gabion basket retaining walls, which transfer energy and promote erosion downstream. Most gabion basket retaining walls have released a portion of the stone from their bottom tier, following deterioration of their wire cages, or have partly failed structurally and exposed loose alluvial material in behind. Cobble rip-rap revetments generally do not extend to the tops of bank; scour is common above. Erosional hollows are present where the thalweg is in contact with a bank in straightened sections (**Photo 4**). Riparian vegetation is a mix of grasses, shrubs and trees. Mature trees are present along the channel banks at the upstream extent of the reach. Mature trees are discontinuously scattered along the left bank (park side) likely due to historic clearing and realignment. Large wood was observed locally along channel banks, but no channel-spanning jams were present at the time of survey. Leaning trees with undercut roots are at risk of collapsing into the channel along the reach.

Photo 3. Left bank with stratified glaciolacustrine sediments overlain by alluvial gravels and cobbles (active channel deposits) and silt and sand (flood deposits)

Photo 4. Erosion hollow and severely undercut tree roots along right bank immediately downstream of a gabion basket retaining wall

Reach 1 is classified as transitional based on the RGA score (**Table 5**, **Appendix A**). Indicators of degradation (down-cutting) and widening, as well as a few indicators of aggradation, were noted. Some of these indicators are more reflective of normal erosional and depositional processes along a meandering watercourse. Widening is interpreted to be the dominant mode of adjustment along the reach. The RSAT score identified the channel as being in 'fair' condition with water quality and riparian habitat conditions as the limiting factors (**Table 6**, **Appendix A**).

Reach 1 flows along relatively narrow valley and is partly confined along the southern valley wall, which results in an abrupt change in meander belt axis. The existing meander belt is 88 m, based on historic and current channel planforms (**Figure 1**). The final meander belt rangers from 112 to 140 m based on local confinement of valley walls and addition of the 100-year erosion rate (factor of safety).

Table 5. Summary Results of Rapid Geomorphic Assessment (RGA) for West Don River

Form/Process	**Index**		
	Reach 1	**Reach 3**	**Reach 3**
Aggradation	0.43	0.29	0.29
Degradation	0.44	0.38	0.30
Widening	0.56	0.56	0.44
Planimetric Form Adjustment	0.14	0.14	0.14
Stability Index	**0.39**	**0.33**	**0.29**
Classification	**Transitional**	**Transitional**	**Transitional**

Table 6. Summary Results of Rapid Stream Assessment Technique (RSAT) for West Don River

Evaluation Category	Score		
	Reach 1	**Reach 2**	**Reach 3**
Channel Stability	6	5	7
Channel Scouring/Sediment Deposition	4	4	4
Physical In-stream Habitat	4	5	3
Water Quality[4]	2	2	2
Riparian Habitat Conditions	3	4	3
Biological Indicators	4	4	3
Total:	**23**	**24**	**22**
Verbal Ranking:	**Fair**	**Fair**	**Fair**

4.2 Reach 2

Reach 2 mainly follows along the base of the western valley from its initial contact near the second pedestrian bridge downstream to the confluence with Walmsley Brook. The near-continuous confinement of this reach by the western valley wall influences sediment sources, channel morphology and erosion patterns (**Photo 5**). Several slope failures along the valley wall have been initiated or exacerbated by fluvial undercutting. The channel is slightly entrenched, such that only flows exceeding the 10-year flood spill overbank onto the floodplain (as per TRCA's HEC-RAS model). Several instances of channel realignment (**Figure 1**) have formed anomalously narrow sections of channel, creating pinch-points with unnaturally deep flow and heightened erosion potential.

[4] *Water quality score is based off TRCA's watershed report card*

Photo 5. Upstream view toward severe bank erosion adjacent to an active seepage site protecting into the channel from the western valley wall

Bed materials along Reach 2 are dominated by gravels but range from silt to cobble-sized stone (~10 cm diameter) released from deteriorated gabion baskets. A thin veneer of sand embeds gravels in pools, whereas gravels and cobbles form the riffles. The representative median grain size (D_{50}) along the reach was estimated to be 28 mm.

Pool-riffle morphology is generally well developed along the reach, with notably deeper pools compared to along reaches 1 and 3. Average bed gradient along Reach 2 is 0.25% (**Figure 3**), slightly steeper than that of Reach 1, due to a history of channel realignment and meander cut-offs. Like Reach 1, Reach 2 exhibits local convexities and knickpoints that reflect past realignment (shortening and steepening). The longitudinal profile is anomalously steep along the recent (2005) realignment at the upstream end of the reach (**Photo 6**). Localized steepening of the channel and erosion control revetments have transferred energy downstream and severely eroded the outer bank of the next downstream meander (**Figure 1**). The channel exhibits a roughly trapezoidal to rectangular cross-section along its riffles. Pool cross-sections are generally asymmetric, deepest along the base of the outer banks of meanders. Riffles tend to have the coarsest material based on field observations. Sand veneers the bed in pools and runs. Sand and gravel point bars are located along the inner banks of most meanders. Point bar development is generally poor due to past realignment.

The average bankfull width and depth of the surveyed cross-sections are approximately 13.0 m and 0.9 m, respectively. Maximum depth at bankfull stage averages 1.3 m. The bankfull discharge for the study corridor was estimated as 19.1 m^3/s (**Table 4**). The bed erosion threshold was estimated as 9.5 m^3/s, demonstrating that the alluvial bed material is mobilized during flows that are roughly half of bankfull discharge. Comparison of modelled shear stresses during the 2-year return flow in Reach 2 to erosion thresholds suggest the D_{50} is entrained at all 7 HEC-RAS riverstations and the D_{84} is entrained at 5 of 7 HEC-RAS riverstations (71%). The average excess shear stress during the 2-year return flow at the 7 HEC-RAS riverstations is 21.6 N/m^2, which is comparable to Reach 1. Furthermore, 3 of 7 riverstations (43%) experience total bed mobility during the 2-year return flow, which is also comparable to Reach 1.

Photo 6. Looking downstream at steepened realigned meander at upstream end of Reach 2

Banks are generally composed of loose alluvial silts and sands along the left (park side) bank. Eroded banks are nearly vertical, with a slight undercut along unprotected outer banks of meanders. The outer banks of meanders are generally armoured with gabion basket retaining walls, which transfer energy downstream. Most gabion basket retaining walls have released a portion of the stone from their bottom tier, following deterioration of their wire cages, or have partly failed structurally and exposed loose alluvial material in behind (**Photo 7**). Cobble rip-rap revetments do not extend to the top of bank and are commonly scoured above. Riparian vegetation is a mix of grasses, shrubs and trees. Mature trees are present along the channel banks. Large wood was observed locally along channel banks, but no channel-spanning jams were present at the time of survey. Leaning trees with undercut roots are at risk of collapsing into the channel along the reach.

Photo 7. Downstream view of stone released from deteriorated wire basket

The reach is classified as transitional based on the RGA score (**Table 5**, **Appendix A**). Indicators of degradation (down-cutting) and widening were noted. Some of these indicators are more reflective of normal erosional and depositional processes along a modified watercourse. Overall, the channel exhibits signs of widening and slight degradation, with deterioration of erosion control structures. The RSAT score identified the channel as being in 'fair' condition with water quality and riparian habitat conditions as the limiting factors (**Table 6**, **Appendix A**).

Reach 2 is partly confined along the western valley wall, following a series of channel realignments and meander cut-offs. The existing meander belt is 145 m, based on historic and current channel planforms (**Figure 1**). The final meander belt ranges from 156 to 170 m based on local confinement of the valley wall and addition of the 100-year erosion rate (factor of safety).

4.3 Reach 3

Reach 3 extends from Walmsley Brook, which contributes storm flows from a broader drainage area than was naturally present at its confluence, downstream to the confluence with East Don River. Historically, this section of river exhibited a partly confined, regular meander pattern. It has since been partly straightened to accommodate road infrastructure and recreational land uses in the valley bottom. The channel is slightly entrenched, such that only flows exceeding the 5-year flood spill overbank onto the floodplain (as per TRCA's HEC-RAS model). Fine sediment (sand) deposition is widespread along mid to upper banks of the channel.

Bed materials along Reach 3 are dominated by gravels but range from silt to cobble-sized (~10 cm diameter) stone released from deteriorated gabion baskets. A thin veneer of sand embeds gravels in pools, whereas gravels and cobbles form the riffles. Cobbles released from deteriorated gabion baskets are discontinuous along the bed. A concrete weir near the downstream end of the reach slightly impounds low flows and has accumulated a wedge of silt and sand immediately upstream. The representative median grain size (D_{50}) along the reach was estimated to be 26 mm.

Pool-riffle morphology is generally poorly developed along the reach. Average bed gradient is 0.45% (**Figure 3**). The longitudinal profile exhibits local convexities and knickpoints that reflect past realignment (shortening and steepening) along its entire length, similarly to those noted along reaches 1 and 2. The channel exhibits a roughly trapezoidal to rectangular cross-section along its riffles. Pool/run cross-sections are generally asymmetric, deepest along the base of the outer banks of meanders. Riffles tend to have the coarsest material. Sand veneers overlie the bed in pools and runs. Some sand and gravel point bars occur mid-reach. Mid-channel bars occur along anomalously wide sections of channel (**Photo 8**).

The average bankfull width and depth of the surveyed cross-sections are approximately 19.3 m and 0.9 m, respectively. Maximum depth at bankfull stage averages 1.5 m. The bankfull discharge for the study corridor was estimated as 36.9 m^3/s (**Table 4**). The bed erosion threshold was estimated as 6.9 m^3/s, demonstrating that the alluvial bed material is mobilized during flows well below bankfull. Comparison of modelled shear stresses during the 2-year return flow in Reach 3 to erosion thresholds suggest the D_{50} and the D_{84} are entrained at all 21 HEC-RAS riverstations (**Appendix A**). The average excess shear stress during the 2-year return flow at the 21 HEC-RAS riverstations is 34.4 N/m^2, which is notably higher than along Reach 1 and Reach 2. Furthermore, 13 of 21 riverstations (62%) experience total bed mobility during the 2-year return flow. The steeper gradient in Reach 3 (0.43%) relative to Reach 1 (0.22%) and Reach 2 (0.25%) has contributed to the high erosion potential in Reach 3.

Photo 8. Upstream view of mid-channel bar at an anomalously wide section of channel

Banks are generally composed of loose alluvial silts and sands with an elevated gravel armour layer visible. Eroded banks are nearly vertical with a slight undercut along unprotected outer banks of meanders. The outer banks of meanders are generally armoured with gabion basket retaining walls, which transfer energy downstream. Most gabion basket retaining walls have released a portion of the stone from their bottom tier, following deterioration of their wire cages, or have partly failed structurally and exposed loose alluvial material in behind (**Photo 9**). Rip-rap cobble revetments do not extend to the tops of bank and are commonly scoured above. Erosional hollows are present where the thalweg is in contact with a bank in straightened sections. Riparian vegetation is a mix of grasses, shrubs and trees. Mature trees are present along the channel banks at the upstream extent of the reach. Mature trees are discontinuously scattered along the left bank, likely due to historic clearing and realignment. Large wood was observed locally along channel banks, but no channel-spanning jams were present at the time of survey. Leaning trees with undercut roots are at risk of collapsing into the channel along the reach.

Photo 9. View of outflanked and failed gabion basket along the outer (right) bank of a meander

Reach 3 is classified as transitional based on the RGA score (**Table 5**, **Appendix A**). Indicators of degradation (down-cutting) and widening were noted. Some of these indicators are more reflective of normal erosional and depositional processes along a modified watercourse. Overall, the channel exhibits signs of widening and slight degradation, with deterioration of erosion control structures. The RSAT score identified the channel as being in ‘fair’ condition with water quality and riparian habitat conditions as the limiting factors (**Table 6**, **Appendix A**).

The existing meander belt is 145 m, based on historic and current channel planforms (**Figure 1**). The final meander belt ranges from to 150 to 170 m based on local confinement of the valley wall and addition of the 100-year erosion rate (factor of safety).

4.4 Erosion Hazard Areas

4.4.1 Vertical Erosion

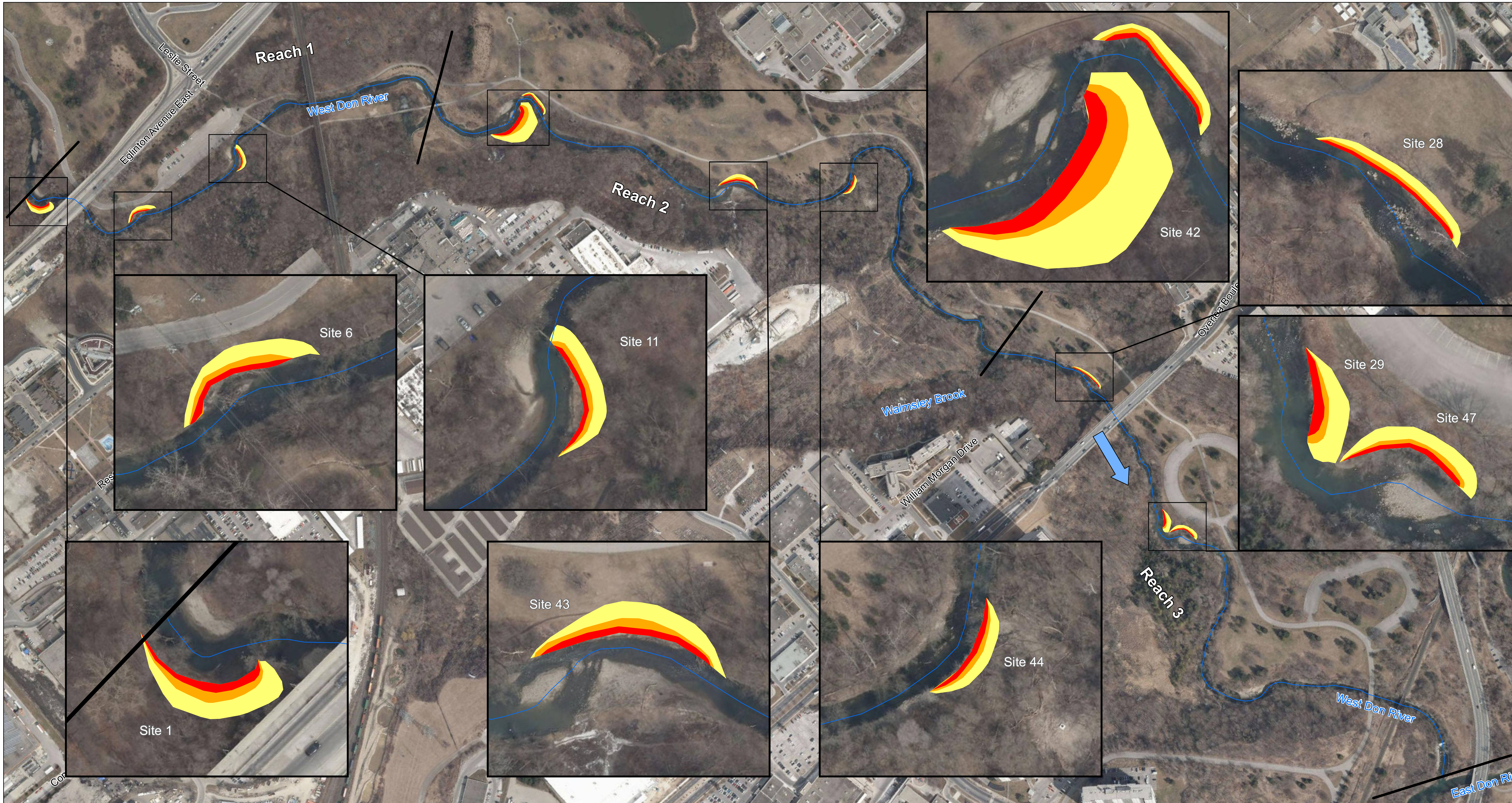
Historical aerial photographs and mapping reveal that channel realignment (straightening and steepening) along the study corridor has occurred for more than a century. Significant shortening (by approximately 1 km) and straightening of West Don River occurred sometime before 1910 (**Figure 2**). The watercourse was further shortened by 380 m in the mid-1900s. Vertical scour is a response to observed planform changes and has affected geomorphic processes within the study area.

The longitudinal profile highlights knickpoints and convexities, which are an indication of past channel realignment (**Figure 3**). Lateral erosion has been limited by the extent of armoured banks, whereas vertical erosion is only locally moderated by grade control structures. According to as-built drawings, original depth of cover over the buried sanitary sewer ranged from approximately 0.5 to 1.5 m (R.V. Anderson and Associates, 1957). Depths of cover have likely changed over the past half century, so these values may no longer be representative. The sewer was constructed (1957) prior to most recent channel realignments (between 1965 and 1978), which suggests that depth of cover may be a key planning consideration in the long-term.

4.4.2 Lateral Erosion

Erosion hazard areas are shown in **Figure 4**. Thalweg position and the most conspicuous erosion hollows are delineated in **Figure 5**. Natural meander adjustment within the study area has been limited due to the abundance and extent of erosion control structures along the banks. In addition, areas once migrating laterally have since been straightened and realigned (**Figure 1**). Systematic lateral erosion is limited to areas without bank stabilization measures. In addition, rapid outer bank erosion and erosional hollows have developed immediately downstream of erosion control structures or where structures have failed. The recent development of erosional hollows has typically occurred over the past 13 years (2005 to 2018) in responses to changes in thalweg configuration.

Areas of systematic bank erosion, which allow establishment of erosion hazard zones, are evenly distributed along each reach. Reach 1 has three mappable erosion hazard zones (**Figure 4**), which have the potential to impact infrastructure and are currently outflanking existing erosion control structures. Migration rates range from 0.20 to 0.25 m/year along Reach 1 where banks are unprotected (**Table 7**). The migration rate at Site 1 appears to have recently accelerated, resulting in the exposure of a pipe (now elevated above the water surface) and outflanking of a gabion basket retaining wall. Migration rates along reaches 2 and 3 highlight a similar trend of accelerated lateral erosion between 2005 and 2018. A changing hydrologic regime (watershed urbanization), increased flood peaks and continued deterioration of existing erosion control structures are contributing to an increase erosion risk within the study area. Most existing erosion control structures are still reasonably effective, despite nearing or exceeding their expected lifespan. Continued deterioration of gabion baskets, in particular, may result in rapid erosion once they fail (e.g. Site 6).



Toronto and Region Conservation Authority

PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

0 50 100 150
metres

N

PROJECT:	Geomorphic Analysis and Erosion Risk Assessment at E.T. Seton Park

PROJECT NO.	1504416	REVISION:	0
DATE:	Jul 31, 2019	SCALE:	1:5000
DRAWN:	CV	DATUM:	NAD 1983
CHECKED:	MB	PROJECTION:	UTM zone 17

LEGEND:

- Flow Direction
- Reach Break
- Channel Centerline (2018)

Erosion Hazard Zones

- 5 year
- 10 year
- 25 year

Note: 2018 Imagery provided by City of Toronto (WMS)

Erosion Hazard Areas

FIGURE 4

Toronto and Region Conservation Authority

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0 50 100 150 metres

N

PROJECT:	Geomorphic Analysis and Erosion Risk Assessment at E.T. Seton Park		
PROJECT NO.	1504416	REVISION:	0
DATE:	Jul 31, 2019	SCALE:	1:5000
DRAWN:	CV	DATUM:	NAD 1983
CHECKED:	MB	PROJECTION:	UTM zone 17

LEGEND:

- Thalweg
- Flow Direction
- Reach Break
- Erosion Hollow

Note: 2018 Imagery provided by City of Toronto (WMS)

Thalweg Position and Erosion Hollows

FIGURE 5

Table 7. Average Lateral River Migration Rates along West Don River

Reach	Site	Average Lateral River Migration Rate (m/yr)	
		1965 - 2018	2005 - 2018
Reach 1	Site 1	0.2	0.6
	Site 6	N/A	0.3
	Site 11	0.25	N/A
Reach 2	Site 42	N/A	1.2
	Site 43	0.2	0.5
Reach 3	Site 28	0.15	N/A
	Site 29	0.4	N/A
	Site 47	0.15	0.3

Overall, channel sinuosity has markedly decreased over the historical record. West Don River would likely readopt its meandering planform in the absence of physical constraints and human intervention, based on local documentation of continued lateral adjustment. The locally confining effect of the western valley wall limits lateral migration and biases erosion into the adjacent park areas, some with infrastructure.

5. Inventory and Evaluation of Site-specific Erosion Risks

5.1 Inventory of Erosion Hazard Sites and Associated Control Structures

A total of 48 erosion hazard sites were identified and inventoried (**Figure 6**) through desktop review and field reconnaissance. Standardized characterizations of each erosion hazard site, including a field photograph and descriptive paragraph of site conditions and erosional processes, are provided in **Appendix B**. Of the 48 sites, 17 have retaining walls (e.g. gabion baskets), 15 have bank revetments (e.g. rip-rap), five have grade controls (e.g. constructed riffle) and 11 are unprotected (i.e. no erosion control structure). At-risk infrastructure includes bridges, a sanitary sewer (including maintenance holes), a gas line, stormwater outfalls, and recreational trails. The characteristics of all existing erosion control structures, including their type, purpose, condition and effectiveness, are tabulated in **Appendix C**.

Toronto and Region Conservation Authority

PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

0 50 100 150 metres

N

PROJECT:	Geomorphic Analysis and Erosion Risk Assessment at E.T. Seton Park
PROJECT NO. 1504416	REVISION: 0
DATE: Aug 01, 2019	SCALE: 1:5000
DRAWN: CV	DATUM: NAD 1983
CHECKED: MB	PROJECTION: UTM zone 17

LEGEND:

- 11 Inventoried Site
- Flow Direction
- Reach Break
- Approximate Sanitary Sewer Alignment

Note: 2018 Imagery provided by City of Toronto (WMS)

Inventoried Erosion Hazard Sites

FIGURE 6

5.2 Evaluation of Site-specific Erosion Risks

The standardized one-page characterizations of each site in **Appendix B** also report the likelihood (risk) of impact, anticipated consequence of impact and overall erosion risk rating. **Table 8** provides a succinct summary of the results of the evaluation. Of the 48 sites, seven rate as Very High (VH) and 16 rate as High (H). Two-thirds of the Very High and High risk sites are associated with potential impact to the sanitary sewer.

Table 8. Summary of Erosion Risk Evaluation

TRCA ID	Site	Erosion Risk Rating (Lateral or Vertical)	Consequence Rating	Overall Erosion Risk Rating
	1	H	H	VH
	2	M	H	H
	3	H	H	VH
	4	M	L	L
5.21	5	H	H	VH
5.20	6	H	M	H
5.19	7	M	H	H
	8	L	H	M
5.18	9	M	H	H
DRR18-12	10	L	H	M
5.17	11	L	H	M
5.16	12	M	M	M
	13	M	H	H
5.14	14	L	L	VL
	15	L	M	L
DRR220-02	16	L	H	M
5.13	17	M	H	H
5.12	18	L	L	VL
5.11	19	L	M	L
5.10	20	L	L	VL
	21	M	L	L
DRR221-01	22	H	H	VH
Gas Crossing	23	L	H	M
5.9	24	H	M	H
5.9	25	H	M	H
DRR221-03	26	H	H	VH
	27	M	L	L
	28	H	H	VH
DRR224-06	29	M	M	M
	30	M	H	H
	31	M	M	M
5.5	32	L	M	L
5.4	33	M	H	H
DRR224-02	34	L	H	M
Grade control	35	L	M	L
5.3	36	M	M	M
5.2	37	M	M	M
5.1	38	L	H	M
Grade control	39	L	M	L
	40	H	M	H
	41	M	H	H
	42	H	M	H
	43	H	L	M
	44	M	H	H
	45	M	H	H
	46	M	H	H
	47	H	H	VH
	48	L	H	M

6. Recommendations for Erosion Mitigation

Based on field observations and subsequent erosion risk evaluation, recommended actions for each erosion hazard site have been provided (**Table 9**, **Appendices B** and **D**). The recommendations are based on the overarching assumption that reach-scale reconstruction is an unrealistic option due to current land use and infrastructure constraints, the potential extent and duration of ecological disturbance, and cost. Deterioration of existing erosion control structures is widespread along the study corridor, which is not surprising given their similar age and expected lifespans, although many still provide adequate erosion protection. A new, repaired, replaced or enhanced erosion control structure is recommended at 21 of the 48 sites (in some cases subject to the findings of a site-specific survey). Abandonment or removal of structures is recommended at six of the 48 sites where infrastructure is not at risk in their absence. A 'do nothing' option, which still allows for monitoring or site-specific survey (e.g. depth of cover), is appropriate at 21 of the 48 sites. Opportunities for coordination of design and implementation of risk mitigation, largely based on the close proximity of multiple sites, are identified in **Table 9**.

Table 9. Recommended Actions and Coordination of Implementation of Risk Mitigation

TRCA ID	Site	Recommended Action(s)	Coordination of Implementation of Risk Mitigation
	1	Replace or Enhance Existing Structure	A
	2	Do Nothing	
	3	Construct New Structure	A
	4	Do Nothing	
5.21	5	Construct New Structure	B
5.20	6	Construct New Structure	B
5.19	7	Replace or Enhance Existing Structure	B
	8	Replace or Enhance Existing Structure	B
5.18	9	Replace or Enhance Existing Structure	
DRR18-12	10	Do Nothing	
5.17	11	Do Nothing	
5.16	12	Do Nothing	
	13	Replace or Enhance Existing Structure	
5.14	14	Abandon Existing Structure	
	15	Do Nothing	
DRR220-02	16	Do Nothing	
5.13	17	Replace or Enhance Existing Structure	C
5.12	18	Do Nothing	
5.11	19	Do Nothing	
5.10	20	Abandon Existing Structure	
	21	Abandon Existing Structure	D
DRR221-01	22	Construct New Structure	D
Gas Crossing	23	Construct New Structure	
5.9	24	Remove Existing Structure and Restore Channel	D
5.9	25	Construct New Structure	D
DRR221-03	26	Construct New Structure	D
	27	Abandon Existing Structure	
	28	Repair Existing Structure	
DRR224-06	29	Construct New Structure	E
	30	Construct New Structure	
	31	Do Nothing	
5.5	32	Do Nothing	
5.4	33	Abandon Existing Structure	
DRR224-02	34	Do Nothing	
Grade control	35	Repair Existing Structure	
5.3	36	Do Nothing	
5.2	37	Do Nothing	
5.1	38	Do Nothing	
Grade control	39	Do Nothing	
	40	Do Nothing	
	41	Construct New Structure	B
	42	Do Nothing	C
	43	Do Nothing	
	44	Construct New Structure	D
	45	Do Nothing	
	46	Do Nothing	
	47	Construct New Structure	E
	48	Do Nothing	

7. Conclusions and Next Steps

A fluvial geomorphic assessment and erosion risk evaluation was completed along West Don River, within E.T. Seton Park between Eglington Avenue East and its confluence with East Don River, to help TRCA prioritize erosion mitigation efforts. The study corridor comprises three distinct reaches, the characteristics of which reflect a long history of anthropogenic modification in the form of realignments (straightening and meander cut-offs) and extensive bed and bank erosion control.

A total of 48 erosion hazard sites was inventoried through field investigation and desktop analysis. Forty of these sites have erosion control structures with conditions that range from intact and fully effective to completely failed and ineffective. The structures are predominantly gabion basket retaining walls and cobble-sized rip-rap revetments, with grade controls and other structures being less common.

An evaluation of risk to private and public infrastructure at all 48 erosion hazard sites was completed based on consideration of the likelihood of impact and anticipated consequence without mitigation. The likelihood of impact, due to lateral or vertical erosion (as applicable), was determined based on application of Palmer's (2016) *Erosion Risk Evaluation Tool*, modified slightly for this study corridor and project. Thirteen sites have High likelihoods, 19 sites have Moderate likelihoods and 16 sites have Low likelihoods, based on a simplified classification to which the lateral and vertical erosion risk indices were assigned. The anticipated consequence to infrastructure without mitigation was forecasted based on professional judgment and a variety of criteria. Without intervention, twenty-six sites would have High consequences, 16 sites would have Moderate consequences and 8 sites would have Low consequences. The overall risk at each site was assigned based on the combination of the likelihood and consequence through a standardized matrix, yielding the following risks: 7 Very High, 16 High, 14 Moderate, 8 Low and 3 Very Low.

Recommendations for erosion control structures at each site were provided based on the prioritization established by the overall erosion risk rating, additional site-specific considerations (e.g. estimated timeframe until impact), and the ecological implications of disturbance. Twenty-one erosion control structures are recommended for repair, replacement, enhancement or new construction. Optimization of the design and implementation of erosion mitigation efforts can be achieved by coordinating works at nearby sites.

Several recommended next steps warrant TRCA's consideration, based on the results of this study:

- *Refinement of vertical (scour) risks* – The risk of exposure of buried linear infrastructure (e.g. sanitary mains) can be markedly improved based on up-to-date information on the depth of cover at each site. A subsurface utility survey may be needed in addition to a site-specific, existing conditions topographic survey to verify as-built pipe obvert/encasement elevation. A site-specific scour assessment, which would account for local bed morphology, sediment transport dynamics and any grade control influences, would allow further refinement.
- *Site-specific geotechnical investigation* – If not already completed, a geotechnical investigation is required to assess the risk posed by active valley wall instability (i.e. mass movement failures) to the hydro towers set back just 6 m from the crest of slope at Site 45. A slope stability analysis would enable determination of the tableland position of the long-term stable slope and the need for any slope stabilization measures.

- *Development of erosion mitigation concepts* – The sections of channel where multiple erosion hazard sites are concentrated, including those with High or Very High risks, are logical candidates for the development of erosion mitigation concepts. The close proximity of multiple sites may, in some cases, enable TRCA to implement a natural channel design solution that allows for the use of surplus fill it is interested in redistributing from upstream sources.

8. Certification

This report was prepared and reviewed by the undersigned:

Prepared By:

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Reviewed By:

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Appendix A

Results of Rapid Geomorphic Assessment and Rapid Stream Assessment Technique

Summary of Rapid Stream Assessment Technique (RSAT)

Project #: 1504416
Crew: **MB/RM**
Date:
Weather:
Stream: REACH 1

Evaluation Category	Excellent	Good	Fair	Poor	Score
1. Channel Stability	9 - 11	6 - 8	3 - 5	0 - 2	6
2. Channel Scouring/Sediment Deposition	7 - 8	5 - 6	3 - 4	0 - 2	4
3. Physical Instream Habitat	7 - 8	5 - 6	3 - 4	0 - 2	4
4. Water Quality	7 - 8	5 - 6	3 - 4	0 - 2	2
5. Riparian Habitat Conditions	6 - 7	4 - 5	2 - 3	0 - 2	3
6. Biological Indicators	7 - 8	5 - 6	3 - 4	0 - 2	4
				Total:	23
				Verbal Ranking:	Fair

Score	Verbal Stream Quality Ranking
42 - 50	Excellent Condition
30 - 41	Good Condition
16 - 29	Fair Condition
<16	Poor Condition

Planform Sketch:

Summary of Rapid Geomorphic Assessment (RGA) Classification

Reach 1

FORM / PROCESS	GEOMORPHIC INDICATOR Num	Description	PRESENT? (√) No	Yes	FACTOR VALUE
2 **Evidence of Aggradation (AI)**	1	Lobate Bar	✓		
	2	Coarse materials in riffles embedded		✓	
	3	Siltation in pools		✓	
	4	Medial Bars	✓		
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone	✓		
		Sum of Indicies:	4	3	0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			NA
	2	Exposed sanitary / storm sewer / pipeline / etc.	✓		
	3	Elevated sorm sewer oufalls		✓	
	4	Undermined gabion baskets / concrete aprons / etc.		✓	
	5	Scour pools d/s of culverts / storm sewer outlets		✓	
	6	Cut face on bar forms	✓		
	7	Head cutting due to knick point migration	✓		
	8	Terrace cut through older bar material	✓		
	9	Suspended armour alyer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock	✓		
		Sum of Indicies:	5	4	0.44
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends	✓		
	5	Basal scour on both sides of channel through riffle		✓	
	6	Gabion baskets / concrete walls / etc. out flanked		✓	
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.	✓		
	9	Fracture lines along top of bank	✓		
	10	Exposed building foundation			NA
		Sum of Indicies:	4	5	0.56
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		
	2	Single thread channel to multiple channel	✓		
	3	Evolution of pool-riffle form to low bed relief form	✓		
	4	Cut-off channel(s)	✓		
	5	Formation of island(s)	✓		
	6	Thalweg alignment out of phase meander form	✓		
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of Indicies:	6	1	0.14

STABILITY INDEX: 0.39286

Condition: Transitional

Summary of Rapid Stream Assessment Technique (RSAT)

Project #: 1504416
Crew: **MB/RM**
Date:
Weather:
Stream: REACH 2

Evaluation Category	Excellent	Good	Fair	Poor	Score
1. Channel Stability	9 - 11	6 - 8	3 - 5	0 - 2	5
2. Channel Scouring/Sediment Deposition	7 - 8	5 - 6	3 - 4	0 - 2	4
3. Physical Instream Habitat	7 - 8	5 - 6	3 - 4	0 - 2	5
4. Water Quality	7 - 8	5 - 6	3 - 4	0 - 2	2
5. Riparian Habitat Conditions	6 - 7	4 - 5	2 - 3	0 - 2	4
6. Biological Indicators	7 - 8	5 - 6	3 - 4	0 - 2	4
				Total:	24
				Verbal Ranking:	Fair

Score	Verbal Stream Quality Ranking
42 - 50	Excellent Condition
30 - 41	Good Condition
16 - 29	Fair Condition
<16	Poor Condition

Planform Sketch:

Summary of Rapid Geomorphic Assessment (RGA) Classification

Reach 2

FORM / PROCESS	Num	Description	PRESENT? (√) No	PRESENT? (√) Yes	FACTOR VALUE
2	1	Lobate Bar	✓		
Evidence of Aggradation (AI)	2	Coarse materials in riffles embedded	✓		
	3	Siltation in pools		✓	
	4	Medial Bars		✓	
	5	Accretion on point bars	✓		
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone	✓		
		Sum of Indicies:	5	2	0.29

FORM / PROCESS	Num	Description	No	Yes	FACTOR VALUE
Evidence of Degradation (DI)	1	Exposed bridge footing(s)			NA
	2	Exposed sanitary / storm sewer / pipeline / etc.	✓		
	3	Elevated sorm sewer oufalls		✓	
	4	Undermined gabion baskets / concrete aprons / etc.		✓	
	5	Scour pools d/s of culverts / storm sewer outlets			NA
	6	Cut face on bar forms	✓		
	7	Head cutting due to knick point migration	✓		
	8	Terrace cut through older bar material	✓		
	9	Suspended armour alyer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock	✓		
		Sum of Indicies:	5	3	0.38

FORM / PROCESS	Num	Description	No	Yes	FACTOR VALUE
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends		✓	
	5	Basal scour on both sides of channel through riffle		✓	
	6	Gabion baskets / concrete walls / etc. out flanked	✓		
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.	✓		
	9	Fracture lines along top of bank	✓		
	10	Exposed building foundation			NA
		Sum of Indicies:	4	5	0.56

FORM / PROCESS	Num	Description	No	Yes	FACTOR VALUE
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		
	2	Single thread channel to multiple channel	✓		
	3	Evolution of pool-riffle form to low bed relief form	✓		
	4	Cut-off channel(s)	✓		
	5	Formation of island(s)	✓		
	6	Thalweg alignment out of phase meander form	✓		
	7	Bar forms poorly formed / reworked / removed		✓	
		Sum of Indicies:	6	1	0.14

STABILITY INDEX: 0.33978

Condition: Transitional

Summary of Rapid Stream Assessment Technique (RSAT)

Project #: 1504416
Crew: **MB/RM**
Date:
Weather:
Stream: REACH 3

Evaluation Category	Excellent	Good	Fair	Poor	Score
1. Channel Stability	9 - 11	6 - 8	3 - 5	0 - 2	7
2. Channel Scouring/Sediment Deposition	7 - 8	5 - 6	3 - 4	0 - 2	4
3. Physical Instream Habitat	7 - 8	5 - 6	3 - 4	0 - 2	3
4. Water Quality	7 - 8	5 - 6	3 - 4	0 - 2	2
5. Riparian Habitat Conditions	6 - 7	4 - 5	2 - 3	0 - 2	2
6. Biological Indicators	7 - 8	5 - 6	3 - 4	0 - 2	3
				Total:	21
				Verbal Ranking:	Fair

Score	Verbal Stream Quality Ranking
42 - 50	Excellent Condition
30 - 41	Good Condition
16 - 29	Fair Condition
<16	Poor Condition

Planform Sketch:

Summary of Rapid Geomorphic Assessment (RGA) Classification

Reach 3

FORM / PROCESS	GEOMORPHIC INDICATOR		PRESENT? (√)		FACTOR VALUE
	Num	Description	No	Yes	
2	1	Lobate Bar	✓		
Evidence of Aggradation (AI)	2	Coarse materials in riffles embedded	✓		
	3	Siltation in pools		✓	
	4	Medial Bars	✓		
	5	Accretion on point bars		✓	
	6	Poor longitudinal sorting of bed materials	✓		
	7	Deposition in the overbank zone	✓		
		Sum of Indicies:	5	2	0.29
Evidence of Degradation (DI)	1	Exposed bridge footing(s)		✓	
	2	Exposed sanitary / storm sewer / pipeline / etc.		✓	
	3	Elevated sorm sewer oufalls	✓		
	4	Undermined gabion baskets / concrete aprons / etc.	✓		
	5	Scour pools d/s of culverts / storm sewer outlets	✓		
	6	Cut face on bar forms	✓		
	7	Head cutting due to knick point migration	✓		
	8	Terrace cut through older bar material	✓		
	9	Suspended armour alyer visible in bank		✓	
	10	Channel worn into undisturbed overburden / bedrock	✓		
		Sum of Indicies:	7	3	0.30
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.		✓	
	2	Occurrence of large organic debris		✓	
	3	Exposed tree roots		✓	
	4	Basal scour on inside meander bends	✓		
	5	Basal scour on both sides of channel through riffle	✓		
	6	Gabion baskets / concrete walls / etc. out flanked		✓	
	7	Length of basal scour >50% through subject reach	✓		
	8	Exposed length of previously buried pipe / cable / etc.	✓		
	9	Fracture lines along top of bank	✓		
	10	Exposed building foundation			NA
		Sum of Indicies:	5	4	0.44
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)	✓		
	2	Single thread channel to multiple channel	✓		
	3	Evolution of pool-riffle form to low bed relief form	✓		
	4	Cut-off channel(s)	✓		
	5	Formation of island(s)	✓		
	6	Thalweg alignment out of phase meander form		✓	
	7	Bar forms poorly formed / reworked / removed	✓		
		Sum of Indicies:	6	1	0.14

STABILITY INDEX: 0.29325

Condition: Transitional

Appendix B

Standardized Summary Characterization of Inventoried Erosion Hazard Sites

Description:
A gabion basket retaining wall that protects an Eglington Avenue bridge pier at the downstream limit of a sharp meander is outflanked and partly undermined. The bottom tier has failed with stone released into the channel. The upstream portion of the retaining wall, which slightly projects into the channel, has collapsed where erosion is concentrated behind the retaining wall. The gabion basket is functioning normally along the downstream extent where a point bar has developed. The structure no longer provides its intended erosion protection. Flow: right to left.

Site 1	**TRCA ID:** n/a	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Replace or Enhance Existing Structure – Replace with vegetated boulder revetment along outer bank of meander. Coordinate with Site 3.

Description:
Steel sheet pile protects Eglington Avenue bridge piers. Sheet pile along the outer bank extends upstream and ties in with a stormwater outfall and rip-rap protection, preventing outflanking. The thalweg and deep pool are in contact with the sheet pile along the outer bank. Erosion along the outer bank immediately downstream of the sheet pile has resulted in a slight projection of the structure into the channel. However, there is no immediate risk. Sheet pile also protects bridge piers along the inner bank, where a point bar has developed. Flow: background to foreground.

Site 2	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Do Nothing – Sheet pile is intact and should just be monitored.

Description:
A pipe has been exposed by erosion along the bed and outer bank of a sharp meander immediately upstream of Eglington Avenue. A section of the pipe is now suspended above the bed and even water surface. Systematic lateral erosion and extension of the meander has occurred following realignment in 1954 (construction of Eglington Avenue). Erosion accelerated between 2005 and 2018 along the outer bank (and likely bed), possibly exposing the pipe during this timeframe. Without intervention, erosive energy will be further concentrated along the outer bank, increasing risk to the pipe. Flow: right to left.

Site 3	**TRCA ID:** n/a	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Once purpose/ownership of pipe are known, a constructed riffle and/or channel realignment may be appropriate. Coordinate with Site 1.

Description:
A stormwater outfall discharges perpendicular to flow along the outer bank of a meander. An anomalously wide cross-section moderates erosive energy at the recessed outfall. Thalweg position is along the opposite (inner) bank, and the meander apex is positioned further downstream. The widened cross-sectional width is a result of past channel realignment in association with Eglington Avenue. Rip-rap and armourstone protect the outfall from being outflanked with only minor displacement of stone observed. Minor scour was observed along the bed. Flow: right to left.

Site 4	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** Low **Risk:** Low **Recommended Action(s):** Do Nothing.

Description:
A gabion basket retaining wall protecting a sanitary main along the outer bank of a meander has failed mid-way along its length, such that it no longer provides erosion protection for an adjacent sanitary main. The bottom tier is deteriorated and stone has been released upstream of the failed mid-section. The channel axis abruptly changes direction upon impingement along the southern valley wall, such that erosive energy is concentrated along the outer bank and bed. Scour along the toe and deterioration of the bottom baskets resulted in the eventual collapse of the retaining wall. Flow: right to left.

Site 5	**TRCA ID: DR05.21**	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Construct New Structure – Vegetated boulder revetment to replace deteriorated gabion basket. Coordinate with Sites 6, 7, 8 and 41.

Description:
A gabion basket retaining wall protecting a corrugated steel pipe (CSP) outfall and park access road along the outer bank of a slight meander has failed (white arrow) along its entire length and no longer provides erosion protection. The downstream extent of a separate failed gabion basket (DR05.21) projects into the channel, along the opposite bank, and deflects flow across the channel. The subject gabion basket has been outflanked, allowing erosion of loose alluvial material and undermining of the CSP. An armour layer exposed in the bank indicates bed degradation along this straight and slightly entrenched section also contributed to the failure of erosion protection. Flow: background to foreground (photo on left) and left to right (photo on right).

Site 6	**TRCA ID: DR05.20**	**Likelihood:** High **Consequence:** Moderate **Risk:** High **Recommended Action(s):** Construct New Structure – The urgency of this work can be reduced by removing the gabion on the opposite bank. Coordinate with Sites 5, 7, 8 and 41.

Description:
A boulder rip-rap revetment protects a sanitary main, including a maintenance hole (white arrow), and the downstream tie-in of gabion basket retaining wall along right bank of a straight section of channel. The channel is straight and slightly entrenched along this section, indicating that bed degradation is the dominant erosional process. The top of the boulder rip-rap revetment is slightly below bankfull elevation, limiting erosion protection during high flows. Some stone has been displaced along its entire length, but the erosion control structure still provides adequate protection with only minor scour above the feature. Flow: right to left.

Site 7	**TRCA ID: DR05.19**	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Replace or Enhance Existing Structure – Existing revetment to be enhanced and tied in with new vegetated revetment at Site 5.

Description:
Cobble sized rip-rap placed along the toe of the right bank protects the approach to an unused ford. The ford and associated access road were likely used in conjunction with construction of the sanitary main that parallels the channel. The low right bank angle locally increases channel cross-sectional width and lowers shear stress and erosive potential at the ford. The rip-rap has been slightly displaced along its length but remains effective. Flow: right to left.

Site 8	**TRCA ID:** n/a	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Replace or Enhance Existing Structure – Existing revetment to be enhanced and tied in with new vegetated revetment at Site 5.

Description:
A cobble and boulder rip-rap revetment protects a parking lot, pedestrian bridge abutment and sanitary maintenance hole along the outer bank of a meander. The channel is slightly entrenched, with its bankfull depth below the adjacent parking lot. Upper bank scour (white arrow) near the upstream end of the revetment has displaced some stone. Systematic, down-valley migration of an upstream meander has shifted the thalweg and bend apex such that erosive energy is concentrated mid-way along the revetment. Flow: foreground to background.

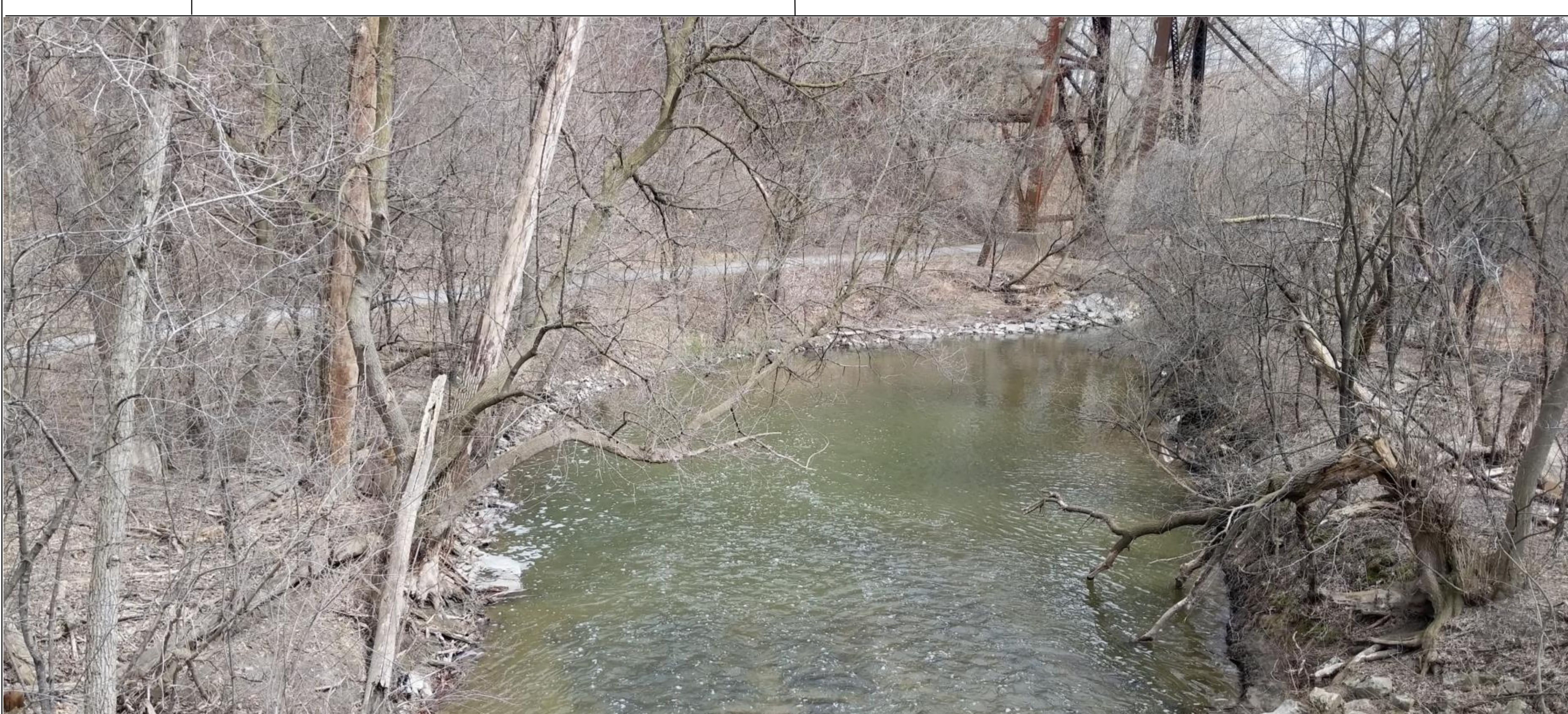
Site 9	**TRCA ID: DR05.18**	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Replace or Enhance Existing Structure – Raise the crest of the revetment at least to bankfull elevation or install live stakes or brush layers above existing rip-rap.

Description:
Cobble rip-rap along the bed protects a sanitary main crossing beneath the channel. Systematic, down-valley migration of an upstream meander has shifted downstream the pool and the point at which the thalweg contacts the outer bank, which now coincides with the sanitary crossing. The depth of cover was approximately 0.5 m in 1957. A point bar has formed along the inner (right) bank of the meander. Deep pools immediately upstream and downstream of the riffle may pose a long-term risk to sanitary pipe exposure through bed degradation (down-cutting). Pool depths immediately upstream and downstream represent an approximation of maximum scour potential along this straight section. Flow: foreground to background.

Site 10	**TRCA ID: DRR18-12**	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – An existing conditions survey should be completed to confirm depth of cover remains acceptable, and upstream planform adjustment should be monitored.

Description:
A cobble and boulder rip-rap revetment protects a pedestrian bridge abutment and sanitary maintenance hole along the inner bank of a meander. The crest of the revetment is below bankfull elevation. Upper-bank scour along its entire length has displaced some stone. Systematic, down-valley migration of an upstream meander has the potential to outflank the revetment at its upstream end. Flow: background to foreground.

Site 11	TRCA ID: DR05.17	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor planform adjustment upstream.



Description:
A cobble and boulder rip-rap revetment protects West Don River Trail along the outer bank of a meander. The top of the revetment is roughly coincident with or slightly below bankfull elevation. The outer (left) bank is well vegetated above bankfull depth with no scour observed above the revetment. Erosional energy is concentrated along the bed, with a large and deep pool formed along the toe of the revetment, where minor displacement of stone has occurred. Flow: foreground to background.

Site 12	TRCA ID: DR05.16	**Likelihood:** Moderate **Consequence:** Moderate **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor scour along the toe of structure.

Description:
Armourstone blocks protect the CN rail bridge piers along both banks. Armourstone blocks tie in with a cobble-boulder revetment (DR05.16) along the outer (right) bank of an upstream meander, to prevent outflanking, and also protect the opposite bank. The erosion control structure creates a pinch-point, which locally increases flow depth and shear stress. The narrowing and acceleration of flow beneath the rail bridge has undermined the retaining wall such that armourstone along its entire length has been dislodged or displaced. Flow: background to foreground.

Site 13	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Replace or Enhance Existing Structure – Replace structure along both banks and include constructed riffle to protect bed from scour along this narrowed section.

Description:
Channel realignment in 2005 resulted in the abandonment of the gabion basket retaining wall along the right bank of a relic meander (white arrow). The gabion wall used to protect the channel from outflanking an old concrete pedestrian bridge. The retaining wall is set back from the new channel bank and no longer needed for erosion protection. Flow: right to left

Site 14	**TRCA ID:** DR05.14	**Likelihood:** Low **Consequence:** Low **Risk:** Very Low **Recommended Action(s):** Abandon Existing Structure.

Description:
A vegetated cobble revetment along the outer banks of a realigned meander protects against lateral migration of the channel toward the West Don River Trail and toes of the valley walls. Minor settling of stone has occurred near the downstream extent of the realignment. Flow: foreground to background.

Site 15	**TRCA ID:** n/a	**Likelihood:** Low **Consequence:** Moderate **Risk:** Low **Recommended Action(s):** Do Nothing – Continue to monitor integrity of revetment.

Description:
A cobble and boulder riffle constructed mid-way along a realigned meander protects a sanitary main that crosses beneath the channel. Minor erosion along the inner (right) bank was observed. No displacement of riffle stone or degradation over the pipe was identified. The depth of cover is approximately 1.1 m (2005). Flow: background to foreground.

Site 16	**TRCA ID: DRR220-02**	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – Monitor for signs of bed degradation.

Description:
A gabion basket retaining wall along the outer bank of a sharp meander protects a stormwater outfall, sanitary maintenance hole and West Don River Trail. The bottom tier of gabion baskets has deteriorated and released its stone alone its upstream extent (upstream of the outfall). Downstream of the outfall, the gabion basket has failed and collapsed into the channel. Collapsed gabion basket retaining wall acts as toe protection during low flow conditions. The stormwater outfall has been undermined and collapsed. Released stone has created a riffle at the downstream extent of the erosion control structure. Severe erosion along the opposite bank of the upstream meander has the potential to change long-term channel geometry near the outfall. Flow: right to left

Site 17	TRCA ID: DR05.13	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Replace or Enhance Existing Structure – Vegetated boulder revetment to prevent continued outflanking/undermining; outfall rehabilitation. Coordinate with Site 42.

Description:
Earth fill and bioengineering have been applied in an effort to stabilize the valley wall. Abundant groundwater seepage and a surface water channel (gully) were observed during leaf-off conditions, with deterioration of the slope observed. The feature projects slightly into the channel, perhaps exacerbating erosion along the opposite bank (Site 43). No fluvial scour was observed along the toe of the stabilized slope. Fluvial processes make a negligible contribution to risk at this site. Flow: right to left.

Site 18	TRCA ID: DR05.12	**Likelihood:** Low **Consequence:** Low **Risk:** Very Low **Recommended Action(s):** Do Nothing – Continue to monitor slope/channel interaction; consider the need for a geotechnical assessment if tableland property/infrastructure may be at risk.

Description:
A cobble revetment along the outer bank of a broad meander protects West Don River Trail. The top of the revetment is approximately coincident with bankfull elevation and exhibits minor displacement of stone along its length. Tree roots exposed along the bank slope indicate winnowing of rip-rap and fill material. The bank is well vegetated above bankfull elevation helps resist erosion and maintain stability. Minor undermining of the revetment toe was observed as erosion is concentrated along the bed. Flow: background to foreground.

Site 19	**TRCA ID: DR05.11**	**Likelihood:** Low **Consequence:** Moderate **Risk:** Low **Recommended Action(s):** Do Nothing – Continue to monitor.

Description:
A gabion basket retaining wall along the outer (right) bank of a broad meander is protecting the toe of the western valley wall. The channel was realigned away from the valley wall between 1965 and 1978 to mitigate channel encroachment. The channel cross-section is slightly narrowed, increasing flow depth and shear stress, resulting in bed degradation and undermining of the retaining wall. The bottom tier of gabion baskets has deteriorated and released its stone along nearly its entire length. Deterioration of the bottom tier has caused the upper two tiers to 'slip' down the bank toward the channel. The existing erosion control structure only appears to protect an informal mountain bike trail. Flow: right to left.

Site 20	**TRCA ID: DR05.10**	**Likelihood:** Low **Consequence:** Low **Risk:** Very Low **Recommended Action(s):** Abandon Existing Structure – no infrastructure at risk.

Description:
A long gabion basket retaining wall along the outer (right) bank of a broad meander inhibits down-valley migration and maintains existing meander geometry. The intended purpose of the retaining wall is unclear (perhaps part of historical 'river training' works), but the structure has helped mitigate outflanking of an inactive gas line (Site 23). The bottom tier has deteriorated and released stone along its entire length**.** Tree roots exposed along the bank indicate winnowing of fill material and entrainment of rip-rap. The bank is well vegetated above bankfull elevation, providing long-term stability and added resistance to erosion. Minor undermining of the revetment toe was observed as erosion is concentrated along the bed. Flow: background to foreground.

Site 21	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** Low **Risk:** Low **Recommended Action(s):** Abandon Existing Structure – subject to any necessary protection of the inactive gas line crossing being achieved through works at neighbouring sites.

Description:
A sanitary crossing is located at the downstream extent of a long gabion basket retaining wall, at an old ford (as defined by bank cuts along both approaches). A constructed riffle protects the underlying sanitary pipe. It is unknown if the retaining wall's purpose was for the protection of the sanitary crossing; regardless, it has prevented the lateral migration of the channel over the pipe. The constructed riffle has mitigated bed degradation (down-cutting) over the sanitary pipe, maintaining depth of cover. Recent enlargement of an erosional hollow and scour along the toe of the outer (right) bank directly over the pipe has increased risk to the sanitary crossing. The depth of cover ranged from approximately 0.5 m to 1 m in 1957. Flow: right to left.

Site 22	**TRCA ID: DRR221-01**	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Construct New Structure – Constructed riffle over pipe/bank to prevent scour if unacceptable surveyed depth of cover. Coordinate with Sites 21, 25, 26 and 44.

Description:
An inactive petroleum gas line crosses beneath the channel near the downstream extent of a gabion basket retain wall (DR05.21) along the outer (right) bank of a broad meander. The retaining wall inhibits systematic lateral migration and maintains existing meander geometry. The purpose of the retaining wall is unknown; regardless, the structure has prevented the channel from outflanking the sanitary (Site 22) and gas line crossings. Stone released from the deteriorated bottom tier of gabion baskets has been redistributed across the bed. The gabion-sized rip-rap now acts as partial bed protection, with minor scour along the toe of the opposite (left) bank creating a relatively shallow pool over the pipe. The depth of cover is unknown. Flow: right to left.

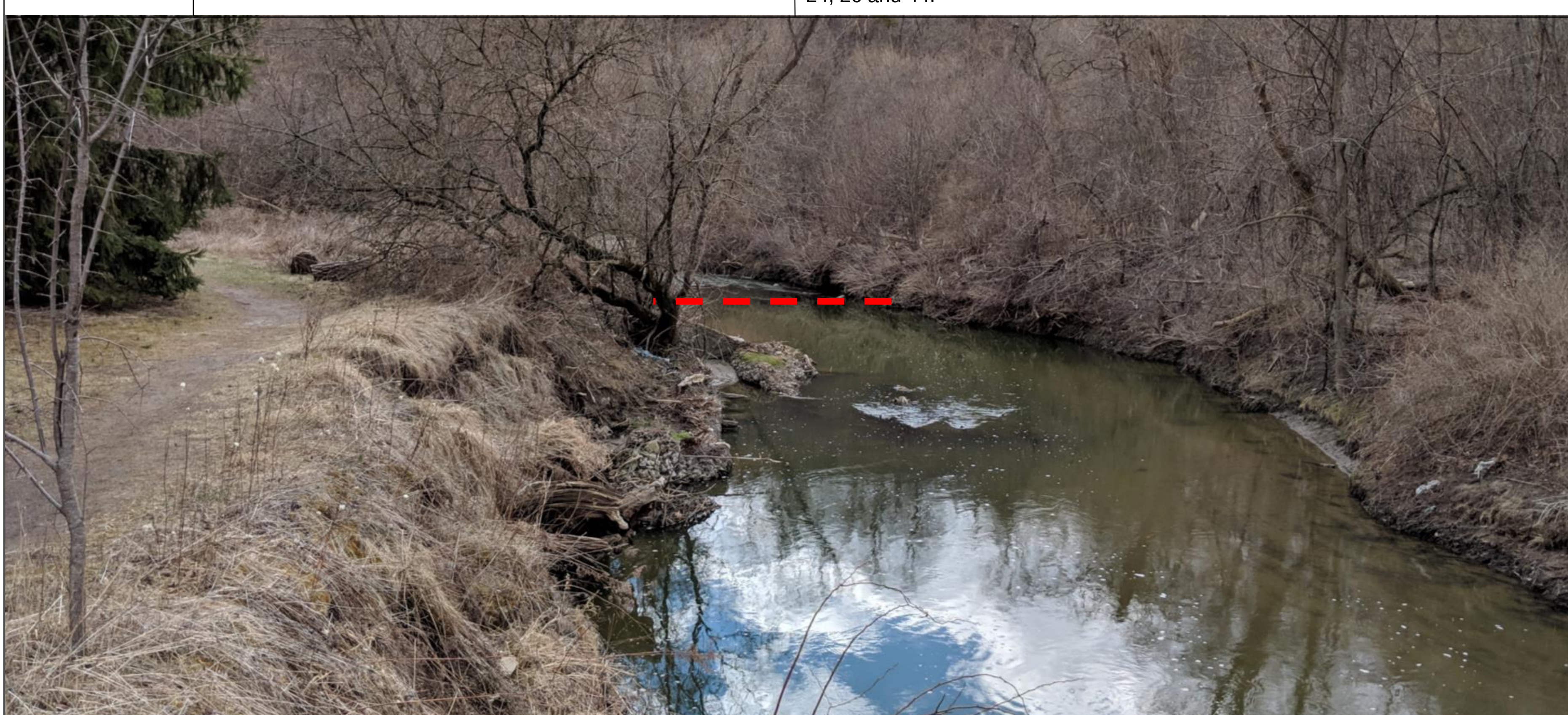
Site 23	**TRCA ID: Gas Crossing**	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Construct New Structure – An existing conditions survey should be completed to determine depth of cover, and the bed elevation should be monitored for signs of degradation. New grade control to be installed if cover insufficient.

Description:
Erosion control structure DR05.9 consists of a gabion basket retaining wall (Site 25) set back from a wood sheet pile (Site 24). The wood sheet pile is discontinuous along the outer (left) bank of a sharp meander to protect an elevated stormwater outfall and maintain existing meander geometry. Sections of sheet pile have been undermined and outflanked, with rafted sections observed approximately 350 m downstream. The sheet pile no longer provides effective erosion control. Flow: foreground to background.

Site 24	**TRCA ID: DR05.9**	**Likelihood:** High **Consequence:** Moderate **Risk:** High **Recommended Action(s):** Remove Existing Structure and Restore Channel – Sheet pile erosion protection ineffective and redundant. Coordinate with Sites 21, 22, 25, 26 and 44.

Description:
Erosion control structure DR05.9 consists of a gabion basket retaining wall (Site 25) set back from a wood sheet pile (Site 24). A gabion basket retaining wall along the outer (left) bank of a sharp meander provides additional protection for a stormwater outfall and West Don River Trail. Upstream of the stormwater outfall, the bottom tier of gabion basket has deteriorated and released stone. The top of the retaining wall is approximately coincident with bankfull elevation, with a well vegetated slope above. Along the downstream arm of the meander, gabion basket extends to the top of bank, with rootwads suspended above water surface and a localized concrete apron along the toe. A large, deep pool along the downstream arm has undermined the retaining wall, resulting in its slippage over the rootwads. The retaining wall still helps mitigate erosion. Flow: background to foreground.

Site 25	**TRCA ID: DR05.9**	**Likelihood:** High **Consequence:** Moderate **Risk:** High **Recommended Action(s):** Construct New Structure – Vegetated boulder revetment. Coordinate with Sites 21, 24, 26 and 44.



Description:
A sanitary pipe crosses beneath the channel with no erosion protection along the bed or banks. The high outer (left) bank of the sharp meander contains flow greater than bankfull flow, concentrating erosive energy within the channel. In addition, the upstream bank protection has concentrated erosive energy along the bed, creating a long and deep pool that extends over the crossing. The depth of cover ranged from 1 m to 1.5 m in 1957. Flow: foreground to background.

Site 26	**TRCA ID: DRR221-03**	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Construct New Structure – Construct a riffle over the pipe crossing, subject to an existing conditions survey confirming unacceptable depth of cover.

Description:
A gabion basket retaining wall along the outer (right) bank of a meander, immediately downstream of the Walmsley Brook confluence, has begun to deteriorate and collapse. The original purpose of the erosion control structure is unclear; it may have been installed to protect an adjacent access path. The upstream extent of the gabion basket, from the mouth of Walmsley Brook, has collapsed and released its stone, which has created a riffle mid-way along its length. The bottom tier has deteriorated and released stone along its entire length. Flow: right to left.

Site 27	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** Low **Risk:** Low **Recommended Action(s):** Abandon Existing Structure – no infrastructure at risk.

Description:
Boulder revetments along both banks of a realigned broad meander (virtually straightened) section of channel protect a sanitary main, stormwater outfall and bridge piers along the outer (left) bank and bridge piers along the inner bank. The upstream section, along the left bank, has been outflanked with boulders displaced and deposited beneath Overlea Bouvard bridge. A large erosion hollow is now exposed during bankfull flows, and the sanitary sewer is setback approximately 5 m from the top of bank. Minor boulder displacement was observed along the rest of the structures' length. Flow: foreground to background (left photo); background to foreground (right photo).

Site 28	**TRCA ID:** n/a	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Repair Existing Structure – Rehabilitate upstream extent of boulder revetment.

Description:
A gabion basket retaining wall along the outer bank of a meander has failed along its entire length, driving the collapse of a CSP outfall into the channel. The retaining wall has been undermined and outflanked, resulting in failure of the structure. The retaining wall was constructed to protect the toe of the valley wall following minor realignment and straightening of the channel. The site is a point of erosion concentration following additional realignment beneath Overlea Boulevard. Flow: right to left.

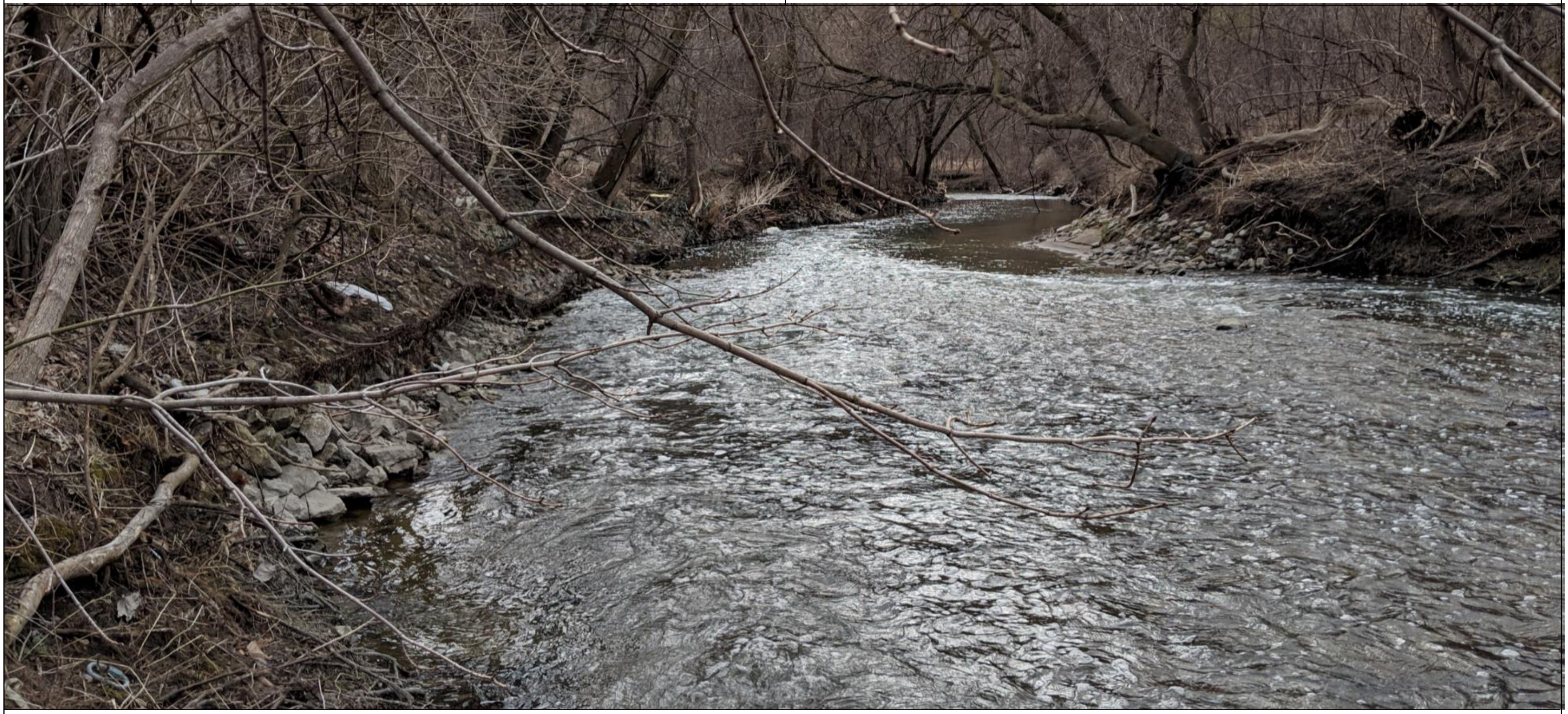
Site 29	**TRCA ID: DRR224-06**	**Likelihood:** Moderate **Consequence:** Moderate **Risk:** Moderate **Recommended Action(s):** Construct New Structure – Vegetated boulder revetment. Additional investigation to assess broken pipe. Recessed pipe (non-flexible concrete pipe) now at-risk from head-cut and undermining due to change in outlet position.

Description:
A sanitary pipe crosses beneath the channel with no erosion protection structures along the bed or banks. The river is slightly entrenched upstream of the crossing, concentrating erosional forces within the channel. The floodplain is assessible immediately downstream of the crossing along the inner (right) bank. Severe erosion along both banks has created an anomalously wide 'blow-out' at the crossing. Erosion is concentrated laterally, with only minor scour along the bed. The depth of cover of the crossing was approximately 0.5 m in 1957. Flow: background to foreground.

Site 30	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Construct New Structure – Construct a riffle over the pipe crossing if an existing conditions survey confirms an unacceptably shallow depth of cover.

Description:
A gabion basket retaining wall along the outer (left) bank of a meander protects a gated access road to a parking lot along the West Don River Trail. The retaining wall extends to the top of the bank at an engineered angle, with fill placed overtop to naturalize its appearance. Deterioration of the bottom tier and scour along the toe has released stone along the upstream extent. Vegetation along the upper bank (above bankfull elevation) resists erosion and improves stability. The structure is still functioning effectively with only minor deterioration. Flow: foreground to background.

Site 31	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** Moderate **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor for structure deterioration.



Description:
A long gabion basket retaining wall along the outer (right) bank of a meander inhibits down-valley migration and maintains existing meander geometry. The original purpose of the retaining wall is unclear, but the structure has prevented the straight section of channel from outflanking the grade control riffle at its downstream extent. The top of the retaining wall is coincident with bankfull elevation and well vegetated above. The bottom tier of gabion baskets has deteriorated and released stone along its entire length. Although exhibiting signs of deterioration, the retaining wall still provides effective erosion control. Flow: foreground to background.

Site 32	**TRCA ID: DR05.5**	**Likelihood:** Low **Consequence:** Moderate **Risk:** Low **Recommended Action(s):** Do Nothing – Continue to monitor for structure deterioration.

Description:
A gabion basket retaining wall along the outer (right) bank of a meander inhibits lateral extension, maintains existing meander geometry and helps protect a sanitary crossing near its upstream extent. The original purpose of the retaining wall appears to have been protection of the toe of the valley wall following realignment of the channel. The upstream extent of the gabion basket, over the sanitary crossing, has deteriorated and released stone from both of its tiers. The retaining wall has failed and is discontinuous. The retaining wall has been undermined and outflanked, resulting in section of gabion basket being transported approximately 50 m downstream. Downstream of the sanitary crossing, the retaining wall does not protect infrastructure. Flow: right to left.

Site 33	**TRCA ID: DR05.4**	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Abandon Existing Structure (downstream of Site 34) – Structure no longer provides erosion control. Wire mesh can be manually cut away with stone left in place.

Description:
A sanitary crossing beneath the channel is protected along the bed and banks. A boulder riffle recently constructed over the crossing inhibits bed degradation (down-cutting) over the pipe. Outer bank protection shows signs of deterioration, but it has maintained bank position and the crossing location. Erosion control structures are largely effective, with only minor erosion and displacement of riffle stone over the crossing. The depth of cover over the sanitary sewer ranged from approximately 0.5 m to 1 m in 1957. The recent construction of a riffle over the crossing indicates that the depth of cover may now be greater. Flow: foreground to background.

Site 34	**TRCA ID: DRR224-02**	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor for bed degradation following an existing conditions survey to confirm acceptable depth of cover.

Description:
A boulder riffle acts as a grade control following several channel shortening realignments along Reach 3. The purpose of the riffle appears to be prevention of long-term bed degradation (down-cutting) and knickpoint migration upstream, which could otherwise undermine existing erosion control structures. The riffle currently acts as a pinch-point, slightly narrowing the channel cross-section, and has led to localized bank erosion and outflanking. A change in the channel longitudinal profile could compromise upstream erosion control structures. Flow: right to left.

Site 35	**TRCA ID: Grade control**	**Likelihood:** Low **Consequence:** Moderate **Risk:** Low **Recommended Action(s):** Repair Existing Structure – Slight channel widening or embedment of stone to be included in repair to minimize potential for outflanking.

Description:
A boulder revetment has been placed along the toe of the gently sloping bank to protect gated park access road bridge abutments along this straightened section of channel (white arrow). The low bank angle and vegetated slope increase resistance to erosion, and the top of bank is well below bankfull elevation. Small erosional hollows and displacement of stone were observed along the length of the boulder revetment. The revetment does not fully protect the bridge abutments during bankfull flows. Flow: background to foreground.

Site 36	**TRCA ID: DR05.3**	**Likelihood:** Moderate **Consequence:** Moderate **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor for deterioration and scour above protection.

Description:
A boulder revetment has been placed along the toe of the gently sloping bank to protect gated park access road bridge abutments along this straightened section of channel (white arrow). The low bank angle and vegetated slope increase resistance to erosion, and the top of bank is well below bankfull elevation. Small erosional hollows and displacement of stone were observed along the length of the boulder revetment. The revetment does not fully protect bridge abutments during bankfull flows. Flow: background to foreground.

Site 37	TRCA ID: DR05.2	**Likelihood:** Moderate **Consequence:** Moderate **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor for deterioration and scour above protection.

Description:
A concrete slab revetment along outer bank of a broad meander inhibits systematic lateral extension, maintains existing meander geometry and helps protect the northern rail bridge abutment. A short section of concrete slabs also protects the bridge abutment along the inner bank. The channel was significantly realigned and shortened by approximately 90 m, creating a long and gradual meander to its confluence with Don River. Scour along the toe of the revetment has undermined the concrete slabs, some of which have 'slipped' into the channel. Some of the slabs near the downstream end have been displaced downstream. Tree roots have contributed to deterioration of the revetment by displacing slabs, allowing water penetration and winnowing of fines. The revetment ties in with a similar, armourstone revetment that extends downstream to the Don River confluence. Flow: background to foreground.

Site 38	TRCA ID: DR05.1	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor for outflanking and scour around concrete slabs.

Description:
The construction of a concrete weir inhibits bed degradation (down-cutting) by acting as a grade control and controlling river base level downstream of the rail crossing. The channel was significantly realigned and shortened by approximately 90 m, creating a long and gradual meander to its confluence with Don River. Grade control was required due to the local increase in bed gradient along the realigned section, to prevent the upstream migration of a knickpoint. Sediment has deposited to the crest of the weir allowing for bed material transport over the structure. A plunge pool has developed immediately downstream, with bed-protecting armourstone slabs displaced slightly downstream. Flow: background to foreground.

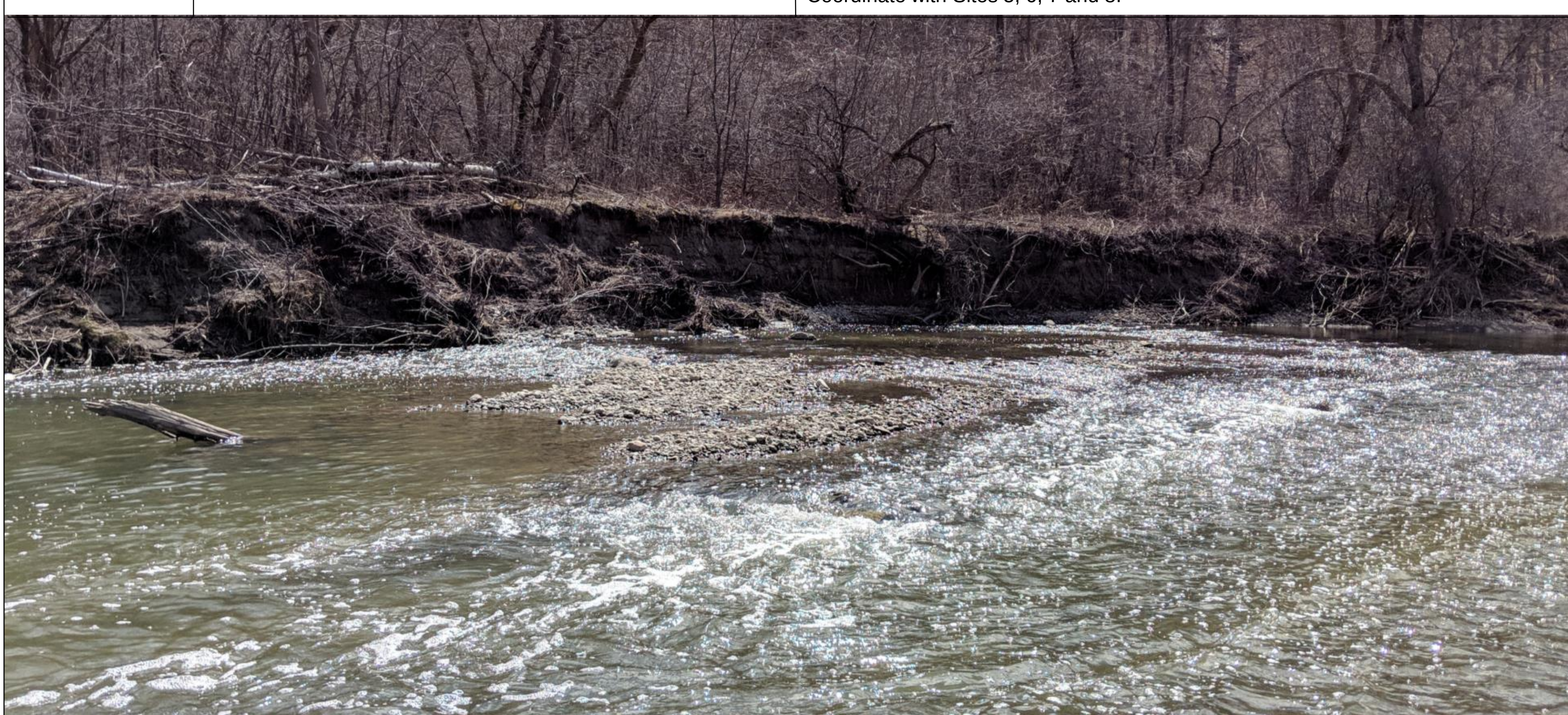
Site 39	**TRCA ID:** n/a	**Likelihood:** Low **Consequence:** Moderate **Risk:** Low **Recommended Action(s):** Do Nothing – Continue to monitor for bed degradation within plunge pool.

Description:
An armourstone slab revetment along the outer (left) bank of a broad meander extends the entire length of the realigned channel from the railway crossing to the confluence with Don River. Downstream of the weir, an armourstone slab revetment also protects the inner bank. Along the outer bank, the armourstone revetment ties in with TRCA's concrete slab revetment (DR05.01). The revetment inhibits lateral adjustment, maintains existing meander geometry and prevents outflanking of the concrete weir. Grouting between the armourstone slabs has deteriorated along its entire length, allowing water to undermine the slabs and winnow fine sediments. Discrete sections of armourstone slabs are missing. Although deterioration was observed, the revetment still provides effective erosion control and prevents outflanking of the weir. Flow: foreground to background.

Site 40	**TRCA ID: DR05.1**	**Likelihood:** High **Consequence:** Moderate **Risk:** High **Recommended Action(s):** Do Nothing – Continue to monitor for outflanking and scour around armourstone slabs.

Description:
Downstream of DR05.20, scour along the toe of the right bank has undermined a large network of tree roots and formed a scallop-shaped failure. The sanitary sewer and maintenance hole are set back approximately 5 m from the active erosion scar. An armour layer exposed in the bank documents bed degradation (down-cutting) along this straight and slightly entrenched section. Energy transfer along the armoured outer bank immediately upstream has also contributed to erosion. Flow: right to left.

Site 41	TRCA ID: n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Construct New Structure – Vegetated boulder revetment in association with Site 5. Coordinate with Sites 5, 6, 7 and 8.



Description:
Severe erosion immediately downstream of the recently (2005) realigned channel (Site 15) has resulted in rapid and systematic lateral migration along the outer (right) bank of the meander. Downstream energy transfer from the armoured outer bank immediately upstream has exacerbated the erosion of loose alluvial material. Erosion has started to outflank the downstream extent of Site 15 as the length of erosion extends upstream. Rapid planform adjustment and the presence of loose alluvial material indicate that continued erosion is likely going to affect conditions immediately downstream at Site 17 (DR05.13). Flow: right to left.

Site 42	TRCA ID: n/a	**Likelihood:** High **Consequence:** Moderate **Risk:** High **Recommended Action(s):** Do Nothing – Continue to monitor planform geometry and its implications for erosion control works immediately downstream at Site 17.

Description:
Debris from gullying and mass movements on the steep valley wall has accumulated at the slope toe such that it projects slightly into the river, deflecting flow toward the opposite bank. This deflection has formed a small, new meander. The channel is slightly entrenched, which contributes to the erosion of loose alluvial material. A mountain bike trail along the top of bank is at risk of being undermined, with corresponding risk to park users. The West Don River Trail is setback approximately 25 m with the sanitary further behind the trail. Flow: Background to foreground.

Site 43	**TRCA ID:** n/a	**Likelihood:** High **Consequence:** Low **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor planform adjustment and consider riparian planting along outer bank to create natural buffer and increase erosion resistance.

Description:
Downstream of Site 21, scour along the bed and toe of the right bank has formed a scallop-shaped erosional hollow. Bed scour and outer bank erosion is directly over a sanitary crossing (DRR221.01), increasing the risk of outflanking and exposure of the sanitary pipe. The depth of the sanitary pipe is unknown. Downstream energy transfer from the armoured outer bank (Site 21) immediately upstream has also contributed to erosion. Flow: right to left.

Site 44	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Construct New Structure – Grade control riffle and vegetated boulder revetment. Coordinate with Sites 21, 22, 24, 25 and 26.

Description:
Fluvial scour along the toe of the valley wall has resulted in undercut banks and contributed to slumping failures on the valley wall beneath the hydro corridor. Hydro towers are located in close proximity (approximately 6 m) to the crest of the valley wall, which exhibits active and recurrent mass movements. Recent failures have deposited material in the channel. Flow: background to foreground.

Site 45	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Do Nothing – Continue to monitor planform adjustment and consider conducting a geotechnical/slope stability investigation to evaluate risk to the hydro towers.

Description:
Scour and undermining along the outer (left) bank of a sharp meander has resulted in the exposure of tree roots and toppling of trees. The outer bank has become a point of erosion concentration downstream of a channel realignment and meander cut-off immediately upstream. A well vegetated bank has limited the down-valley migration of the meander; however, continued undermining, outflanking and toppling of trees will allow for lateral migration toward the sanitary sewer and West Don River Trail, both of which are more than 25 m away. Flow: foreground to background.

Site 46	**TRCA ID:** n/a	**Likelihood:** Moderate **Consequence:** High **Risk:** High **Recommended Action(s):** Do Nothing – Continue to monitor planform adjustment.

Description:
Severe erosion along both the outer and inner bank of a sharp mender has resulted in rapid and systematic lateral migration at a sanitary sewer crossing. The channel has an anomalously wide 'blow-out' where flow splits around a large cobble-boulder, mid-channel bar. Erosion along the outer bank has resulted in the failure of an erosion control structure (Site 29). Erosion along the inner bank is migrating toward a circular parking lot. A sanitary sewer crossing beneath the channel (Site 30) is at risk of being outflanked on one or both sides. The depth of sewer is unknown. Flow: background to foreground.

Site 47	**TRCA ID:** n/a	**Likelihood:** High **Consequence:** High **Risk:** Very High **Recommended Action(s):** Construct New Structure – Vegetated boulder revetment and determine current depth of cover over sanitary sewer.

Description:
A scallop-shaped erosional hollow along the inner bank of a meander is coincident with thalweg contact. An anomalously wide 'blow-out' along the channel has formed where the thalweg is out of phase with meander geometry. A previous large woody debris accumulation could have deflected flow toward the inner bank and initiated anomalous scour. A bare slope is prone to further instability as a result of fluvial interaction. The sanitary sewer is set back approximately 25 m from the top of the erosional hollow. Flow: foreground to background.

Site 48	**TRCA ID:** n/a	**Likelihood:** Low **Consequence:** High **Risk:** Moderate **Recommended Action(s):** Do Nothing – Continue to monitor planform adjustment.

Appendix C

Existing Erosion Control Structures Conditions Assessment

Appendix C. Existing Erosion Control Structures Conditions Assessment

TRCA ID	Site No.	Ownership	Basic Characteristics				Gabion Basket				Effectiveness	
			Erosion Control Type	Purpose	Material	Height	Number of Tiers	Posture	Released Stone (%)	Condition of Wire	Dominant Mode(s) of failure	Conditon
	1	City	Retaining Wall	Bridge pier	Gabion	1.5	2	Straight	20%	Deteriorated	Outflanking	Deteriorated/Failed
	2	City	Retaining Wall	Bridge pier	Sheet Pile	2					Stable	Good
	3	Private	Retaining Wall	Pipe	n/a	n/a					n/a	n/a
	4	TRCA/City	Revetment	Stormwater outfall	Rip-rap	1.5					Stable	Good
5.21	5	TRCA	Retaining Wall	Sanitary main	Gabion	2.5	3	Straight/leaning	50%	Deteriorated/Failed	Undermining	Deteriorated/Failed
5.20	6	TRCA/City	Revetment	Stormwater outfall, access road	Rip-rap	1.5					Outflanking	Failed
5.19	7	TRCA/City	Revetment	Sanitary main	Boulder	1					Deterioration	Deteriorated
	8	City	Revetment	Sanitary main (ford)	Rip-rap	1					Deterioration	Good
5.18	9	TRCA	Revetment	Parking lot, sanitary MH	Rip-rap	1					Deterioration	Displaced
DRR18-12	10	City	Bed	Sanitary main	Rip-rap	n/a					Deterioration	Displaced
5.17	11	TRCA	Revetment	Bridge pier, sanitary MH	Rip-rap	1.5					Deterioration	Displaced
5.16	12	TRCA	Revetment	Trail	Rip-rap	2					Deterioration	Displaced
	13	Private	Retaining Wall	Rail bridge abutment	Rip-rap	1.5					Plucking/Outflanking	Displaced
5.15	14	TRCA	Retaining Wall	Unknown	Gabion	2	2	Straight	n/a	n/a	n/a	n/a
	15	City	Revetment	Trail	Stone	1.5					Stable	Displaced
DRR220-02	16	City	Bed	Sanitary main	Stone	n/a					Stable	Good
5.13	17	TRCA/City	Retaining Wall	Stormwater outfall, sanitary MH and trail	Gabion	2.5	3	Flat	50%	Deteriorated/Failed	Undermining	Deteriorated/Failed
5.12	18	TRCA	Slope Treatment	Slope protection	Earth fill	n/a					Gullying	n/a
5.11	19	TRCA	Revetment	Trail	Rip-rap	1.5					Deterioration	Displaced
5.10	20	TRCA	Retaining Wall	Slope protection, trail	Gabion	2	3	Leaning/collapsed	33%	Deteriorated/Failed	Undermining	Deteriorated/Failed
	21	City	Retaining Wall	Inactive gas line	Gabion	2.5	3	Collapased	33%	Deteriorated/Failed	Undermining	Deteriorated/Failed
DRR221-01	22	City	Revetment	Sanitary main	Rip-rap	n/a					Deterioration	Displaced
	23	Private	n/a	Gas pipeline		n/a						
5.9	24	TRCA/City	Retaining Wall	Stormwater outfall, trail	Gabion	3	4	Collapased	20%	Deteriorated/Failed	Undermining	Deteriorated/Failed
5.9	25	TRCA/City	Retaining Wall	Trail	Sheet Pile	1					Outflanking	Deteriorated/Failed
DRR221-03	26	City	n/a	n/a	n/a	n/a						
	27	City	Retaining Wall	Slope protection, trail	Gabion	2	3	Collapased	33%	Deteriorated/Failed	Undermining	Deteriorated/Failed
	28	City	Revetment	Sanitary main, bridge piers	Stone	1.5					Outflanking	Displaced
	29	City	Retaining Wall	Stormwater outfall	Gabion	1.5	2	Collapased	33%	Deteriorated/Failed	Undermining	Deteriorated
DRR224-02	30	City	N/A	Sanitary main	n/a	n/a					n/a	n/a
5.5	31	City	Retaining Wall	Park access road	Gabion	3	3	Straight	33%	Displaced	Undermining	Deteriorated
5.5	32	TRCA	Retaining Wall	Grade control	Gabion	1	2	Collapased	75%	Deteriorated/Failed	Undermining	Deteriorated
5.4	33	TRCA	Retaining Wall	Sanitary main, trail	Gabion	1.5	2 to 3	Collapased	60%	Deteriorated/Failed	Undermining/Outflanking	Deteriorated/Failed
	34	City	Bed	Sanitary main	Boulder	n/a					Stable	Displaced
	35	TRCA	Bed	Grade control	Boulder	n/a					Stable	Displaced
5.3	36	TRCA	Revetment	Access road bridge abutment	Boulder	1					Outflanking	Displaced
5.2	37	TRCA	Revetment	Access road bridge abutment	Boulder	1					Outflanking	Displaced
5.1	38	TRCA	Revetment	Rail bridge abutment	Boulder	1					Outflanking	Displaced
	39	City	Bed	Grade control	Concrete	n/a					Undermining	Intact
	40	City	Retaining Wall	Concrete weir grade control	Armourstone	2.5					Outflanking	Deteriorated/Mostly stable

Appendix D

Erosion Risk Evaluation and Recommendations

LATERAL EROSION RISK / **Lateral Erosion Risk Implications**

TRCA ID	Site	Bank Distance: Distance from Top-of-Bank (DB) (m) — Measure	Rank Value	Bank Stress: Planform Position (PL) — Measure	Rank Value	Bank Stress: Thalweg Position (TH) — Measure	Rank Value	Bank Stress: Radius of Curvature (RC) (m) — Measure	Rank Value	Bank Erodibility: Grain Size (GS) — Measure	Rank Value	Bank Erodibility: Bank Angle (BA) (º) — Measure	Rank Value	Bank Erodibility: Vegetative Cover Above Bankfull — Measure	Rank Value	Bank Erodibility: Bank Height-to-Bankfull Depth (HD) — Measure	Rank Value	Lateral Erosion Risk Index	Lateral Erosion Risk Rating (Likelihood)	Estimated Years to Contact (comparative overlay)	Consequence of Unmitigated Erosion: Rating	Consequence of Unmitigated Erosion: Description	Overall Erosion Risk Rating	Recommended Action(s)	Coordination of Implementation of Risk Mitigation
Weight =>		0.2		0.15		0.1		0.1		0.075		0.075		0.2		0.1									
	1	5	3	outer bank of meander	3	near	3	27	2	silt/sand	3	35-90	2	low	3	1.4	1	2.63	H	0	H	Outflanking of bridge pier	VH	Replace or Enhance Existing Structure	A
	2	0	3	outer bank of meander	3	opposite	1	42	2	engineered materia	0	35-90	2	low	3	1.1	1	2.20	M		H	Scour of bridge pier	H	Do Nothing	
	4	0	3	outer bank of meander	3	opposite	1	47	2	engineered materia	0	35-90	2	low	3	1.1	1	2.20	M		L	Outflanking and undermining of stormwater outfall	L	Do Nothing	
5.21	5	5	3	inner bank of meander	1	near	3	41	2	silt/sand	3	35-90	2	low	3	1.9	2	2.43	H		H	Exposure of sanitary mair	VH	Construct New Structure	B
5.20	6	0	3	outer bank of meander	3	near	3	20	2	silt/sand	3	>90	3	low	3	1.7	2	2.80	H	0	M	Further collapse of stormwater outfall and undermining of park access road	H	Construct New Structure	B
5.19	7	6.5	2	straight	2	near	3	41	2	cobble/boulder	1	<35	1	low	3	1.7	2	2.15	M		H	Exposure of sanitary main	H	Replace or Enhance Existing Structure	B
	8	8	1	straight	2	centre	2	straight	1	cobble/boulder	1	<35	1	med	2	1.1	1	1.45	L		H	Exposure of sanitary main	M	Replace or Enhance Existing Structure	B
5.18	9	1	3	outer bank of meander	3	near	3	25	2	cobble/boulder	1	35-90	2	high	1	1.7	2	2.18	M		H	Undermining of parking lot and exposure of sanitary maintenance hole	H	Replace or Enhance Existing Structure	
5.17	11	0	3	inner bank of meander	1	centre	2	25	2	cobble/boulder	1	35-90	2	high	1	1.4	1	1.68	L	5	H	Impact to bridge pier and exposure of sanitary maintenance hole	M	Do Nothing	
5.16	12	4	3	outer bank of meander	3	near	3	25	2	cobble/boulder	1	35-90	2	high	1	1.4	1	2.08	M		M	Undermining and temporary closure or realignment of paved tra	M	Do Nothing	
	13	1	3	straight	2	centre	2	straight	1	silt/sand	3	35-90	2	low	3	1.4	1	2.28	M		H	Outflanking and undermining of CN railway bridge abutment	H	Replace or Enhance Existing Structure	
5.14	14	n/a	0	inner bank of meander	1	centre	2	straight	1	engineered materia	0	<35	1	low	3	1.1	1	1.23	L		L	None - channel realigned away from erosion control structure	VL	Abandon Existing Structure	
	15	15	1	outer bank of meander	3	near	3	30	2	cobble/boulder	1	<35	1	high	1	1.4	1	1.60	L		M	Undermining and temporary closure or realignment of paved tra	L	Do Nothing	
5.13	17	0	3	outer bank of meander	3	near	3	28	2	sand/gravel	2	35-90	2	high	1	1.9	2	2.25	M	10	H	Undermining/exposure of stormwater outfall, maintenance hole and paved tra	H	Replace or Enhance Existing Structure	C
5.12	18	n/a		valley wal	n/a	n/a		n/a		n/a		n/a		n/a		n/a		n/a	L		L	Risk to tableland property/infrastructure not driven by fluvial processe	VL	Do Nothing	
5.11	19	12	2	inner bank of meander	1	near	3	>50	1	engineered materia	0	<35	1	high	1	1.5	1	1.33	L		M	Undermining and temporary closure or realignment of paved tra	L	Do Nothing	
5.10	20	≥25	1	outer bank of meander	3	opposite	1	>50	1	cobble/boulder	1	>90	3	low	3	1.5	1	1.85	L		L	Undermining and realignment of informal mountain bike trai	VL	Abandon Existing Structure	
	21	25	1	outer bank of meander	3	near	3	49	2	cobble/boulder	1	35-90	2	med	2	1.9	2	1.98	M		L	Outflanking of inactive gas line	L	Abandon Existing Structure	D
5.9	24	0	3	outer bank of meander	3	near	3	48	2	silt/sand	3	35-90	2	high	1	2.3	2	2.33	H		M	Outflanking of outfall and undermining and temporary closure or realignment of paved trai	H	Remove Existing Structure and Restore Channe	D
5.9	25	0	3	outer bank of meander	3	near	3	48	2	silt/sand	3	35-90	2	high	1	2.3	2	2.33	H		M	Undermining and temporary closure or realignment of paved tra	H	Construct New Structure	D
	27	≥25	1	outer bank of meander	3	near	3	>50	1	sand/gravel	2	35-90	2	med	2	1.9	2	1.95	M		L	Undermining and temporary closure or realignment of informal mountain bike trai	L	Abandon Existing Structure	
	28	5	3	outer bank of meander	3	near	3	>50	1	silt/sand	3	35-90	2	med	2	2.1	2	2.43	H		H	Exposure of sanitary main and bridge piers	VH	Repair Existing Structure	
DRR224-06	29	5	3	outer bank of meander	3	near	3	32	2	cobble/boulder	1	35-90	2	high	1	2.9	3	2.28	M		M	Continued collapse of stormwater outfall pipe	M	Construct New Structure	E
	31	5	3	outer bank of meander	3	near	3	41	2	engineered materia	0	<35	1	high	1	2.5	2	2.03	M		M	Undermining and temporary closure of gated park access roac	M	Do Nothing	
5.5	32	15	1	straight	2	near	3	41	2	cobble/boulder	1	35-90	2	high	1	1.7	2	1.63	L	50	M	Outflanking of grade control riffle at downstream exten	L	Do Nothing	
5.4	33	≥25	1	outer bank of meander	3	near	3	>50	1	silt/sand	3	>90	3	high	1	1.3	1	1.80	M		H	Outflanking of sanitary main and undermining and closure/realignment of informal mountain bike tra	H	Abandon Existing Structure	
5.3	36	1	3	straight	2	centre	2	straight	1	sand/gravel	2	<35	1	high	1	2.1	2	1.83	M		M	Outflanking of gated park access road bridge abutment	M	Do Nothing	
5.2	37	1	3	straight	2	centre	2	straight	1	sand/gravel	2	<35	1	high	1	1.7	2	1.83	M		M	Outflanking of gated park access road bridge abutment	M	Do Nothing	
5.1	38	1	3	straight	2	centre	2	straight	1	engineered materia	0	<35	1	high	1	1.7	2	1.68	L		H	Outflanking of railway bridge abutment	M	Do Nothing	
	40	0	3	outer bank of meander	3	near	3	>50	1	engineered materia	0	<35	1	low	3	2.1	2	2.33	H		M	Outflanking of concrete weir grade control	H	Do Nothing	
	41	4	3	straight	1	centre	2	straight	1	sand/gravel	2	35-90	2	low	3	1.7	2	2.15	M		H	Exposure of sanitary main and maintenance hole	H	Construct New Structure	B
	42	≥25	1	outer bank of meander	3	near	3	47	2	sand/gravel	2	>90	3	low	3	1.9	2	2.33	H		M	Alteration of channel planform such that energy may be directed at stormwater outfall (Site 17	H	Do Nothing	C
	43	20	1	outer bank of meander	3	near	3	25	2	sand/gravel	2	>90	3	low	3	2.3	2	2.33	H	70	L	Undermining and temporary closure or realignment of mountain bike tra	M	Do Nothing	
	44	5	1	outer bank of meander	3	near	3	>50	1	silt/sand	3	>90	3	med	2	1.5	1	2.00	M		H	Outflanking of sanitary main crossing	H	Construct New Structure	D
	45	7	1	outer bank of meander	3	near	3	>50	1	silt/sand	3	35-90	2	low	3	2.3	2	2.23	M		H	Undermining and destabilization of hydro towers	H	Do Nothing	
	46	≥25	1	outer bank of meander	3	near	3	15	2	sand/gravel	2	35-90	2	med	2	1.5	1	1.95	M		H	Exposure of sanitary mair	H	Do Nothing	
	47	10	2	outer bank of meander	3	near	3	32	2	silt/sand	3	35-90	2	low	3	2.5	3	2.63	H	5	H	Outflanking of sanitary main crossing	VH	Construct New Structure	E
	48	24	1	outer bank of meander	1	centre	2	>50	1	sand/gravel	2	>90	3	med	2	2.1	2	1.63	L		H	Exposure of sanitary mair	M	Do Nothing	

VERTICAL EROSION RISK / **Vertical Erosion Risk Implications**

TRCA ID	Site	Bed Erodibility: Reach-scale Process — Measure	Rank Value	Bed Erodibility: Site-scale Process — Measure	Rank Value	Bed Erodibility: Bed Material — Measure	Rank Value	Vertical Erosion Risk Index	Vertical Erosion Risk Rating (Likelihood)	Consequence of Unmitigated Erosion: Rating	Consequence of Unmitigated Erosion: Description	Overall Erosion Risk Rating: Rating	Recommended Action(s)	Coordination of Implementation of Risk Mitigation
Weight =>		0.15		0.5		0.35								
	3	Wide/Plan Adj	2	Erosion	3	Sand/Gravel	3	2.85	H	H	Damage to exposed pipe	VH	Construct New Structure	A
DRR18-12	10	Wide/Plan Adj	2	Neutral	2	Cobble/rip-rap	1	1.65	L	H	Exposure of sanitary main	M	Do Nothing	
DRR220-02	16	Wide/Plan Adj	2	Neutral	2	Engineered	0	1.30	L	H	Exposure of sanitary main	M	Do Nothing	
DRR221-01	22	Wide/Plan Adj	2	Erosion	3	Sand/Gravel	3	2.85	H	H	Exposure of sanitary main	VH	Construct New Structure	D
Gas Crossing	23	Wide/Plan Adj	2	Neutral	2	Cobble/rip-rap	1	1.65	L	H	Exposure of gas pipeline	M	Construct New Structure	
DRR221-03	26	Wide/Plan Adj	2	Erosion	3	Sand/Gravel	3	2.85	H	H	Exposure of sanitary main	VH	Construct New Structure	D
	30	Wide/Plan Adj	2	Neutral	2	Gravel/Cobble	2	2.00	M	H	Exposure of sanitary mair	H	Construct New Structure	
DRR224-02	34	Wide/Plan Adj	2	Neutral	2	Large Cobble	1	1.65	L	H	Exposure of sanitary main	M	Do Nothing	
Grade control	35	Wide/Plan Adj	2	Neutral	2	Large Cobble	1	1.65	L	M	Change in channel gradient	L	Repair Existing Structure	
Grade control	39	Wide/Plan Adj	2	Neutral	2	Engineered	0	1.30	L	M	Change in channel gradient	L	Do Nothing	