Fluvial Geomorphological and Erosion Threshold Assessment, Tributary of Cardinal Creek

1296 and 1400 Old Montreal Road City of Ottawa, Ontario



Prepared for: Tamarack Developments 3187 Albion Road South Ottawa, Ontario K1V 8Y3

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GEO Morphix Project No. 23076



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2.0	Updated erosion threshold assessment Amendments to address reviewer comments	Kelsey Serviss Jan Franssen Kelly MacGillivray	Paul Villard	November 11, 2024

Disclaimer

This report presents professional opinions and findings of a scientific and technical nature based on the knowledge and information available at the time of preparation. This document is prepared solely for the Client, and the data, interpretations, suggestions, recommendations, and opinions expressed in the report pertain only to the project being completed for the Client.

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1 Introduction

GEO Morphix Ltd. (GEO Morphix) was retained by Tamarack Developments to complete a fluvial geomorphology assessment in support of the Cardinal Creek Village South development at 1296 and 1400 Old Montreal Road Draft Plan of Subdivision in Ottawa, Ontario. The proposed development site, referred to as the 'subject lands', is bounded by Old Montreal Road to the north, Cox Country Road to the east, a tributary to Cardinal Creek aligned perpendicular to Cox Country Road to the south, and existing low-density residential properties to the west. The subject lands have a development area of approximately 46.30 ha.

The tributary to Cardinal Creek, comprising the southern border to the subject lands and aligned perpendicular to Cox Country Road, is known as the South Tributary. The South Tributary corridor is a forested, confined valley that flows towards the southwest and outlets to Cardinal Creek approximately 350 m south of the Old Montreal Road crossing over Cardinal Creek. The majority of contributing drainage to the South Tributary originates from the south and the east. A map of the subject lands is provided in **Appendix A**.

Following a review of the Cardinal Creek Village South Draft Plan of Subdivision and Zoning By-Law Amendment applications, the City of Ottawa outlined concerns regarding a specific slope failure location downstream of the proposed development area and apparent instability and deforestation/erosion impacts to the South Cardinal Creek Tributary valley. The City of Ottawa suggests that the slope failure has resulted in a change to the environmental setting compared to the conditions under which the Cardinal Creek Village Master Services Study (MSS) was completed approximately ten years ago. The City has indicated that the potential change in the environmental setting requires an addendum to the Cardinal Creek Village Master Servicing Study (MSS) and an Environmental Management Plan (EMP). Specifically, there is a need for further detailed geotechnical and geomorphological investigations.

It is noted that although the original geomorphological assessments completed are dated, they are reasonably detailed in scope. The concerns brought forward by the City are geotechnical and geomorphological in nature, and thus, the present assessment is limited to specific concerns about erosion and slope adjustment. The geomorphological study of the tributary focused on updating existing condition characterization, updating/confirming erosion hazard delineation, reviewing erosion mitigation strategies, identifying remedial measures required to stabilize the slope, and confirming and updating (where required) the stormwater management criteria. The City has stated that this work is required before the Cardinal Creek Village South development can proceed.

The work plan outlined below conforms to the Terms of Reference previously submitted to Tamarack Developments and was specifically developed to provide information that addresses the City's comments and concerns. In summary, we would complete the following activities as part of our work:

- Review available background reports and mapping (i.e., watershed/subwatershed studies, geology, topography, conceptual development plans) to inform watershed and drainage network characterization. Specific reports to be reviewed include the following:
 - Cardinal Creek Geomorphic Assessment, City of Ottawa (Geomorphic Solutions April 2007)
 - Cardinal Creek Village Erosion Threshold Assessment of South Tributary (Parish Geomorphic Limited – January 2013)
 - Cardinal Creek Village Meander Belt Width Delineation Memo (Parish Geomorphic Limited – April 4, 2013)
 - Cardinal Creek Village Erosion Threshold Assessment of Cardinal Creek Main Branch (Parish Geomorphic Limited – May 2013)

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- Preliminary Geotechnical Review for Proposed SWMP (Paterson Group December 2, 2020)
- Phase I Environmental Site Assessment Cardinal Creek Village South (Paterson Group May 20, 2022)
- Geotechnical Investigation Cardinal Creek Village South (Paterson Group November 19, 2021)
- Preliminary Stormwater Management Plan and Stormwater Management Facility Design (JFSA – December 21, 2021)
- Functional Servicing Report Cardinal Creek Village South (DSEL June 2022)
- Review watercourse reach delineation and confirm/update reach delineation completed through past studies to support the characterization of existing conditions
- Develop a Terms of Reference to ensure the geomorphological component of the study addresses all requirements of the City of Ottawa
- Update the original historical assessment to include more recent aerial photographs to identify any additional slope adjustments or feature changes
- Conduct LiDAR-based assessment based on available data to identify geomorphic units, including slips, landslides, and other erosion features, to bring the assessment up to the current period
- Review the previously completed rapid geomorphological field assessments, and, where required, complete updated rapid geomorphic field assessments to document any areas of significant erosion, collect instream measurements of bankfull channel dimensions, and characterize bed and bank material composition and structure
 - Compile an erosion inventory along the South Tributary to document evidence of dynamic adjustments along channel or adjacent valley slopes
- Complete a detailed geomorphic field assessment data and field observations in the context of erosion thresholds
- Review meander belt width delineation or erosion hazard for the watercourse using historical and recent aerial imagery, field observations, or empirical modelling approaches where required
- Develop and initiate a pre-development erosion monitoring program to establish baseline conditions for comparison during post-construction
- Specifically review the identified slope failure location at 1320 Grand-Chêne Court within reach **R3** and provide recommendations for dealing with erosion concerns in that area

2 Desktop Assessment

A review of pertinent background material was completed to inform and provide context regarding local hydrology, stream morphology, and previous erosion hazard studies. Material reviewed includes site plans, historical aerial photographs, publicly available surficial geological mapping, physiological region and landform mapping, watershed reports published by RVCA, and previous assessments and reports, which are listed above. Spatial terrain datasets were also analyzed to map and interpret channel and valley geomorphic features to provide insights into the nature and rate of geomorphic change within the subject lands.

2.1 Watershed Characteristics

The subject lands are located in the Orleans suburb in the Cardinal Creek Watershed, east of Ottawa. Cardinal Creek is eight kilometres long and drains approximately 35 km² of land (RVCA, 2022). The creek flows in a northwestern direction from the headwaters east of the intersection of Frank Kenny Road and Innes Road until it crosses Watters Road, where it changes direction to flow north towards the Ottawa River. Land use within the watershed is primarily agricultural, particularly within the headwaters, and transitions into residential and commercial land use at the downstream extent before reaching the

Ottawa River (RVCA, 2022). The section of Cardinal Creek where the South Tributary outlets meanders within a forested, confined valley surrounded by residential properties in the adjacent tablelands.

The South Tributary corridor is a forested, confined valley that flows towards the southwest and outlets to Cardinal Creek approximately 350 m south of the Old Montreal Road crossing over Cardinal Creek. The farthest upstream extent of the South Tributary is immediately west of the intersection of Cox Country Road and Jonquille Way. This portion of the watercourse is a straightened agricultural drain, which transitions into a forested corridor with decreasing elevation and increasing width, sinuosity, and valley confinement closer to the confluence with Cardinal Creek.

The majority of contributing drainage to the South Tributary originates from the south and the east. Land use to the south is comprised of agricultural fields with forested areas occupying some of the headwater channel corridors that discharge to the South Tributary. Portions of the headwater channel corridors to the south have been deforested and straightened as recently as the 2010s. Land use to the east is comprised of low-density residential properties and a fragmented forest block. Former land use towards the east appears to have been agricultural, and the drainage features in this area were previously straightened to accommodate prior farming activities.

2.2 Surficial Geology and Physiography

Surficial geology and physiography act as primary controls regarding channel development, as they greatly influence a given drainage system's hydrological and sediment characteristics. Channel morphodynamics are primarily governed by the flow regime and the availability and type of sediments within the stream corridor. These factors are explored as they offer insight into existing conditions and potential changes that could be expected in the future as they relate to proposed development within the streams catchment area. A map showing the surficial geology throughout the subject lands is provided in **Appendix C**.

The St. Lawrence-Ottawa Lowlands physiographic region, an area of low relief with elevations approaching sea level (approximately 200 feet asl or lower), encompasses the entirety of the subject lands (Chapman and Putnam, 1984). There are two minor physiographic regions throughout the subject lands: the Ottawa Valley Clay Plains (region 49), which encompass most of the South Tributary and it's contributing watercourses flowing from the south, and an area around the farthest upstream reaches with glacial till comprised of gravel to boulder-sized substrate that is likely part of the Glengarry Till Plain (region 46) (Chapman and Putnam, 1984). The Ottawa Valley Clay Plain region is characterized by deep, silty clay plains interrupted by occasional rock and sand ridges (Chapman and Putnam, 1984). The clay deposits originated in a glaciomarine context in the brackish waters of the Champlain Sea with sediments sourced from Canadian Shield granite (Alysworth and Lawrence, 2003; Hunter, Crow, and Brooks, 2011; Chapman and Putnam, 1984). Surficial geology throughout the subject lands is thus primarily comprised of a clay and silty clay layer derived from non-clay minerals (i.e., glacial rock flour) that is generally poorly drained and very plastic (Alysworth and Lawrence, 2003; Chapman and Putnam, 1984; OGS, 2010). The native sediments that compose the channel substrate within the South Tributary are dominated by cohesive clay materials. An ancient landslide scar comprised of the native sediments is present within the lower reaches of the South Tributary and a small area where the calciferous Paleozoic bedrock outcrops at the surface. The landslide scar also overlaps with the main channel of Cardinal Creek near the confluence with the South Tributary, and there are more extensive bedrock outcrops within the main channel along the reach downstream of the confluence.

2.3 Review of Previous Studies

Studies conducted for the Greater Cardinal Creek Subwatershed Study (SWS) were reviewed to confirm preliminary erosion threshold targets and other development constraints for the subject land. The

Greater Cardinal Creek SWS was initiated to document existing conditions within the watershed and provide recommendations for development and preservation. While the SWS was ongoing, an Urban Expansion Area, Area 11, was confirmed within the watershed. The reviewed SWS studies include the Geomorphic Assessment (Geomorphic Solutions, 2007) and the Existing Conditions report (AECOM, 2009).

Studies conducted as part of the Master Servicing Study (MSS) for Cardinal Creek Village were reviewed to confirm updated erosion threshold targets and erosion hazard setbacks. The MSS was initiated to investigate the provision of servicing infrastructure to support the proposed development of Cardinal Creek Village within the City of Ottawa. The Cardinal Creek Village development area comprises 208 hectares of the Area 11 Urban Expansion Area north of the South Tributary to Cardinal Creek. Studies reviewed include the Meander Belt Width (MBW) Delineation and Erosion Threshold Assessments for the Cardinal Creek main branch and South Tributary in three (3) separate reports (Parish Geomorphic Ltd., 2013). Erosion threshold methods and results from the respective geomorphic assessments are discussed in more detail in **Section 4** below.

Studies prepared for the Planning Act development application and the Functional Servicing Study (FSS) for Cardinal Creek Village were also reviewed to confirm erosion hazard setbacks and development constraints for the subject lands. Studies conducted to establish existing conditions, assess stormwater management, and identify erosion hazards and development constraints for the Cardinal Creek Village South development were reviewed. These include the Preliminary Geotechnical Review for the proposed SWMP (Paterson Group, 2020), the Phase 1 Environmental Site Assessment (Paterson Group, May 2022), the Geotechnical Investigation for Cardinal Creek Village South (Paterson Group, November 2021), and the Preliminary SWMP (JFSA, 2021). The Geotechnical Review for the proposed SWMP and the Geotechnical investigation completed by Paterson Group (Paterson) were revised in 2023, and the most up-to-date versions of these documents were reviewed. The Geotechnical Slope Stability Assessment for the recent slope failure within the rear yard of **1320 Grand-Chêne Court** was also reviewed (Paterson, 2023).

2.3.1 Geomorphic Assessment and Existing Conditions for Cardinal Creek

The Geomorphic Assessment report examined the Cardinal Creek watershed at a "planning level" to delineate reaches, develop an understanding of system health and sensitivity to change, and provide preliminary targets for planning and baseline data for future studies (Geomorphic Solutions, 2007). Rapid and detailed geomorphic assessments were conducted along the main branch of Cardinal Creek in October and November 2006. There was no access to the South Tributary during this time, and the Geomorphic Assessment did not delineate erosion hazards or estimate an erosion threshold for that watercourse. The results for reaches along the main channel are provided for reference. The Rapid Geomorphic Assessments (RGAs) conducted along the main branch found that reach C4 was 'In Regime' with an RGA score of 0.14, while reach C10 was found to be 'In Regime' with an RGA score of 0.11 (MOE, 2003; VANR, 2007). Erosion thresholds were modelled for reaches C4 and C10 along the main branch using the results of the rapid and detailed assessments. Reach C4 is located upstream of the South Tributary near the intersection of Frank Kenny Road and Cox Country Road, while reach C10 is the reach into which the South Tributary discharges. For reach C4, a critical discharge of 1.01 m³/s was modelled based on a permissible shear of 4.7 N/m^2 for the compact sandy clay observed along the channel bed. For reach C10, a critical discharge of 0.05 m³/s was modelled using a critical velocity of 0.30 m/s based on the flow competency for the median grain size of the bed substrate.

The Existing Conditions report identified sites requiring immediate slope stabilization and where toe erosion protection is recommended, all located along the main branch of Cardinal Creek (AECOM, 2009). The Subwatershed Management Plan phase built upon the Existing Conditions report and included identification, policies for protection, and potential habitat restoration opportunities of the natural

heritage system. The forested areas occupying the South Tributary corridor and its headwater channels to the south were all designated as Significant Woodland. According to the Cardinal Creek SMP, one of the headwater channel corridors near the eastern end of the South Tributary was deforested and straightened in 2009, and increased channel and bank instability were observed within the South Tributary following this deforestation.

2.3.2 Erosion and Meander Belt Width Assessments for Cardinal Creek Village and Cardinal Creek Village South

Erosion Assessment reports examined watercourses within the Cardinal Creek watershed in which the development of Cardinal Creek Village was proposed to support the associated stormwater management plan (Parish Geomorphic Ltd., 2013). Rapid and detailed assessments were conducted along the main branch of Cardinal Creek by Parish Geomorphic Ltd. (Parish) in April 2013. An erosion threshold was modelled for reach **C11-B** by Parish in May of 2013 based on the results of the rapid and detailed assessments. Reach **C11-B** is located downstream of the South Tributary, south of Old Montreal Road. The rapid assessments found that reach **C11-B** was 'In Adjustment', with a 0.44 RGA score, with widening being the dominant form of adjustment (MOE, 2003; VANR, 2007). Reach **C11** was assessed in 2007 by Geomorphic Solutions and was assessed as being 'In Transition' with an RGA score of 0.34 and widening being the dominant form of adjustment. In 2007, reach **C10** was found to be 'In Regime' with an RGA score of 0.11. The 2013 rapid assessments found reach **C10** was 'In Adjustment' with an RGA score of 0.33 with widening as the dominant form of adjustment. An erosion threshold, expressed as a critical discharge of 1.5 m³/s, was modelled for reach **C11-B** based on a permissible shear of 12.25 N/m² for the compact sandy clay observed along the channel bed.

Rapid and detailed assessments and erosion threshold modelling were also completed for reaches along the South Tributary to Cardinal Creek in 2012 and 2013 by Parish (Parish Geomorphic Ltd., January 2013). Three (3) reaches were delineated within the South Tributary, **R1**, **R2**, and **R3**. **R1** comprises the farthest upstream extent with a large proportion of its length straightened and traveling through agricultural fields. **R2** begins where the watercourse enters a confining, forested valley and continues until the downstream side of a wide southeastward bend in the valley and channel. **R3** continues from there until the confluence with the main channel of Cardinal Creek. The RGA found that all three (3) reaches, **R1**, **R2**, and **R3** were 'In Adjustment' with RGA scores of 0.485, 0.55, and 0.51, respectively. Widening was the dominant form of adjustment in all cases (MOE, 2003; VANR, 2007). The erosion threshold was modelled in reach **R2** based on the permissible shear of 20.3 N/m² for the silty-clay bed substrate observed throughout the reach, which resulted in a critical discharge of 0.43 m³/s (Dunn, 1959).

Meander Belt Width delineation was also completed for all reaches along the South Tributary to Cardinal Creek in 2013 (Parish Geomorphic Ltd., April 2013). An additional reach was delineated during this assessment that divided **R3** in two to create **R4**, which begins where a large contributing watercourse (reach **T4**, see **Section 3.1** below) meets the South Tributary and continues until the confluence with the main channel. MBWs were both measured and empirically derived, each with a 10% buffer applied, with the more conservative empirically derived MBWs ultimately being recommended due to the high RGA scores for the tributary. The empirical MBWs were calculated using methods outlined in Lorenz et al. (1985), Ward (2002), and Williams (1986) and then averaged to derive the final estimate. The MBWs for **R1**, **R2**, **R3**, and **R4** are 26.6 m, 26.6 m, 25.8 m, and 29.8 m, respectively. Reach **R2** was used as a surrogate for **R1**, as the latter was historically straightened.

2.3.3 Phase I Environmental Site Assessment Cardinal Creek Village South

The Phase I Environmental Site Assessment (ESA) aimed to review past land use within and adjacent to the subject lands to identify potential environmental concerns caused by previous activities (Paterson

Group, 2022). Land use within and adjacent to the subject lands was found to be historically agricultural or rural residential. A site inspection of contemporary land use within the subject lands identified a rock crushing and storage operation in the western portion of the development area, with the remainder of the development area being vacant. No environmental concerns were identified with respect to this ongoing operation within the subject lands or current land uses within properties adjacent to the subject lands. A Phase II ESA was not recommended.

2.3.4 Preliminary Stormwater Management Plan and Design

The Preliminary Stormwater Management Plan and Stormwater Management Facility Design for Cardinal Creek Village South evaluated the storage required for the proposed SWM facilities (JFSA, 2021). While two SWM facilities are proposed within Cardinal Creek South Village, only one is proposed to discharge to the South Tributary and is discussed herein. The SWMP proposed to discharge to the South Tributary would drain an area of 38.08 ha and provide quality, quantity, and erosion control up to the 100-year level. Target release rates for the pond were estimated using an XPSWMM model for the 24-hour SCS Type II design storm, and the proposed drainage area to the pond was simulated using a SWMHYMO model. The proposed pond design was determined to be of sufficient size, as quantity control requirements were met.

2.3.5 Preliminary Geotechnical Review of Proposed SWMP Cardinal Creek Village South

The geotechnical review of the proposed SWMP in Cardinal Creek Village South was undertaken to provide recommendations for construction based on the subsurface profile at the proposed pond location and slope stability adjacent to the proposed pond location (Paterson, 2023). The proposed pond location is located within the tablelands north of the South Tributary to Cardinal Creek along reach **R2**. Subsurface conditions were examined through test holes advanced at the proposed SWMP location. The subsurface was found to be comprised of a very stiff brown silty clay transitioning at 3 to 6 m below the existing surface to a stiff grey silty clay. A long-term groundwater depth of 3 to 4 m below the existing ground surface was estimated. The slope stability analysis incorporated results from the subsurface investigations to model the stable slope at two cross-sections along the north valley slope adjacent to the proposed location under a range of pond water levels. The minimum factors of safety of 1.5 under statics conditions and 1.1 under seismic conditions were met at both cross-sections and the slope was determined to be stable under long-term conditions.

2.3.6 Geotechnical Investigation for Cardinal Creek Village South

The Geotechnical Investigation for Cardinal Creek Village South examined subsurface conditions within the subject lands and slope stability along the slopes within the South Tributary valley to provide design recommendations for the development (Paterson Group, 2023). Subsurface conditions were observed using a combination of boreholes and test pits advanced throughout the subject lands between January 2009 and March 2021. Groundwater levels were monitored using piezometers fitted to boreholes. Overburden thickness within the subject lands was delineated through a probehole bedrock delineation program conducted in November 2019. The watercourse and slopes within the valley were observed between April 2012 and July 2023. Cross-sections along valley slopes derived from topographic surveys and LiDAR data were assessed as part of the slope stability analysis.

The surficial soil was found to be underlain by a weathered brown crust of stiff silty clay, which was underlain by an unweathered grey silty clay to depths greater than 9 m, with depth decreasing towards the eastern side of the subject lands. Glacial till comprised of silty clay with variable coarse contents ranging in size from sand up to boulders was also present below the unweathered grey silty clay. Depth to bedrock from the existing ground surface ranged from 0 to 25 m, decreasing in depth towards the eastern side of the subject lands. A long-term groundwater depth of 3 to 4 m below the existing ground

surface was estimated. Permissible grade raise restrictions ranging from 2 to 2.5 m were proposed for the site due to the silty clay subsurface layer.

Slopes ranging from 3 to 15 m in height and 5H:1V to 1H:1V in gradient were observed throughout the South Tributary valley. Slopes were comprised of a stiff brown silty clay underlain by firm grey silty clay. Toe erosion was observed where the watercourse was in contact with the valley wall. Undercutting and shallow slips were noted as the types of erosion observed. The channel bed was observed to be comprised of a combination of glacial till and grey silty clay in the farthest upstream portion of the South Tributary and grey silty clay in the downstream portion. The Limit of Hazard Lands setback along the top of the north valley slope was delineated based on the slope stability analysis, which incorporated results from all subsurface investigations described above and was carried out in accordance with the City of Ottawa's standard guidelines. The minimum factor of safety of 1.5 was met at all cross-sections analyzed except for two, where setbacks of 4.7 and 17 m were delineated. A toe erosion allowance of 5 m, delineated from the stable top of slope, was proposed based on the observed slope composition and toe erosion.

2.3.7 Geotechnical Slope Stability Assessment of Recent Slope Failure

A slope failure along the north valley slope of the South Tributary was previously identified within the rear yard of **1320 Grand-Chêne Court** and observed in a land surface model generated from remotely sensed data (Stantec, 2021). The City of Ottawa was made aware of this slope failure and expressed concern regarding slope stability throughout the proposed development of Cardinal Creek Village South through an engineering review letter dated June 2, 2023. Additional geotechnical and geomorphological studies were undertaken to address the slope stability concerns.

Paterson Group (Paterson) initiated and conducted a geotechnical slope stability assessment in 2023. Based on interviews with the property owner of **1320 Grand-Chêne Court** conducted by Paterson, the slope failure was initially observed in April 2014, shortly after they had taken possession, and annual slope movement has been observed since then. It was also noted that the ground surface adjacent to a retaining wall along the top of the valley slope within the neighbouring property had failed at an unknown time in the past (Paterson, 2023). Based on discussions with the contractor who constructed the homes along Grand-Chêne Court, the property owner learned that the ground surface throughout that development area had been raised using soil generated from building excavations. This soil was also dumped down the valley slope of the South Tributary.

A failure surface ranging from 0.40 to 1.2 m in height was observed along the top of the valley slope in the rear yard of **1320 Grand-Chêne Court** by Paterson in July 2023. Additional slip surfaces were also noted along the base of the slope. The subsurface profile consisted of a relatively thick layer of the aforementioned fill, overlying a relatively thin layer of brown silty clay, which was overlying a saturated layer of firm to stiff grey silty clay (Paterson, 2023). Depth to bedrock was estimated to be approximately 18.2 m based on public well records. The valley slope was 14 m in height with a 3.5H:1V profile with local sections up to 1.5H:1V (Paterson, 2023).

The slope stability analysis for the valley slope at **1320 Grand-Chêne Court** found that the factor of safety was 1.1 for slope conditions prior to in-filling (Paterson, 2023). The minimum factor of safety generally recommended where slope failure would endanger permanent structures is 1.5. The report concluded that a limit of hazard lands setback should have been applied to the lot, and fill placement in the tablelands and along the valley slope should have been avoided (Paterson, 2023). The slope failure was ultimately attributed to a combination of the fill placement and ongoing erosion at the toe of the valley slope by the watercourse. Additional geotechnical studies were recommended to verify undisturbed soil characteristics and depth of the failure plane and to delineate a stable slope setback with a minimum 1.5 factor of safety.

2.4 Historical Assessment

A series of historical aerial photographs were reviewed to determine changes to the South Tributary, the main channel of Cardinal Creek, where the tributary outlets, and surrounding land use and land cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics and is used to inform erosion hazard assessments. Aerial photographs for the years 1976, 1991, 2002, 2011, and 2021 from GEO Ottawa (https://maps.ottawa.ca/geoottawa/) were reviewed. Imagery is provided in **Appendix B** for reference.

1976

The subject property and portions of the surrounding area were actively cultivated prior to 1976. Old Montreal Road and Cox Country Road were established by this time. Land use within the tablelands surrounding the main channel of Cardinal Creek downstream of the South Tributary confluence was comprised of residential properties. Land use north and east of the South Tributary, which is visible on the 1976 imagery, consisted primarily of agricultural fields. At this time, there were few residential dwellings located south of Old Montreal Road between the road and reaches **R3** and **R4** of the subject tributary (updated reach delineation is detailed in **Section 3.1** below, and a reach map is provided in **Appendix A**). A forested buffer separates the agricultural fields to the north of the upstream reaches from the valley. Land use south of the South Tributary outside the subject lands is largely comprised of forest interspersed with agricultural fields. Evidence of the tributaries (reaches **T1**, **T2**, **T3**, and **T4**) draining the land south of the South Tributary is largely obscured by the forest cover. However, the westernmost tributary (**T4**) is observable where it transitions from straightened agricultural drainage to a forested valley.

The South Tributary channel pattern is largely obscured by forest cover in the 1976 imagery. However, a straightened section of the channel through agricultural fields perpendicular to and immediately downstream of Cox Country Road, reach **R1**, is discernable in the imagery. Downstream of this, a backwatered area is visible within reach **R1A** before the watercourse enters the forested valley, and the channel pattern is obscured where reach **R2** begins. Also visible is a vegetative buffer surrounding the area where a branching drainage channel is noted along the northern valley wall of reach **R2**. This drainage feature extends into a field immediately east of the lot where piled fill is currently stored. In the Geotechnical Investigation for Cardinal Creek Village South, this drainage feature is recommended for infilling (Paterson, 2023). Crossings over the watercourse and valley are visible within the middle extent of the South Tributary, where there is a wide southeastward bend, delineated as reach **R2A** in the present report. The land is cleared of vegetation along an embankment supporting the road, suggesting it may have been recently graded.

1991

Land use appears to remain largely unchanged between 1976 and 1991, with the exception of the area east of Cox Country Road, upstream of the South Tributary. The area that was formerly agricultural fields east of Cox Country Road has been cleared, and grading and road building are evident, with several residential lots already occupied by homes. The channel pattern of the South Tributary and its southern contributing channels (**T1** to **T4**) remains largely obscured. Backwatering previously observed at the upstream extent in reach **R1A** has receded, and the area previously occupied by water now appears to have herbaceous meadow cover. Vegetation surrounding the branching drainage channel observed encroaching to the north from **R2**, as well as the beginning of the channel itself, are visible in the 1991 imagery. Straightened ditches are evident, draining agricultural fields north of the valley into the South Tributary. The crossings observed in the 1976 imagery within the middle extents of the watercourse appear to remain in use. New houses were built along the edge of the northern valley wall

immediately downstream of the crossings in **R3** between 1976 and 1991. Construction and grading activities appear to have been recent in the 1991 imagery, as the land is cleared of vegetation.

2002

Land use within the subject lands and surrounding areas again appears largely unchanged between 1991 and 2002. Some planform change is observable within reach **C10** along the main channel, particularly in the downstream extent, where a meander bend appears to have migrated towards the Old Montreal Road embankment. An area of the embankment that was forested in 1991 is missing some tree cover in the 2002 imagery, exposed sediment is evident, and a form resembling a slump with a headscarp near the road is observable. The upstream extent of the channel in reach **R1** remains a straight ditch surrounded by agricultural fields. The channel pattern of the South Tributary and its southern contributing channels (**T1** to **T4**) remains largely obscured. Immediately downstream of the straight section, there is an irregularly meandering channel travelling through a wide floodplain vegetated with herbaceous meadow cover visible in the area, which was previously backwatered, delineated as reach **R1A** in the present report. The channel pattern is mostly obscured downstream of this as it enters the forested valley. Severe backwatering is evident upstream of the previously noted crossings in **R2A**.

2011

Land use within the subject lands again remains largely unchanged between 2002 and 2011. Additional planform changes are visible along **C10**, where changes were identified in the 2002 imagery. Substrate from the slope on the outside of the meander bend appears to have settled at the base of the slope, constricting the channel at that location. Cutoff chutes appear to have formed around mature, vegetated bars upstream of this, creating islands. A beaver dam is evident across the channel upstream of this, causing backwatering upstream. The outside of the meander bend immediately upstream of the beaver dam appears to have migrated, as the slope that was forested in the 2002 imagery is missing tree cover, and exposed sediment is evident. A second beaver dam is evident just downstream of the confluence with the South Tributary.

An area of forest has been removed in the tablelands south of the valley adjacent to the section from reach **R1** to **R2A**; reaches **T1** and **T2** are located in this area. There is evidence of **T1** and **T2** on the deforested landscape in approximately their current alignment. An area surrounding **T1**, where the channel bends westward, appears to be saturated, suggesting possible historic backwatering at that location. The area north of **T1** remained forested in the 2011 imagery. **T3** and **T4** remain largely obscured by forest cover, except **T4** is observable where it transitions from straightened agricultural drainage to a forested valley and remains in the same alignment as the 1976 imagery.

The upstream extent of the channel in **R1** remains straight, while the channel just downstream in **R1A** within the wide, vegetated floodplain no longer meanders. There is a small area with backwatering, then a relatively straight section with evidence of lateral scour beginning to form meanders. Observing the 2005 and 2008 imagery, the area is covered in a large volume of water, which likely lead to deposition over the former channel location and formation of a new channel through the freshly deposited sediments when the backwatered area drained. Vegetation surrounding the encroaching drainage channel previously observed along the north valley wall in **R2**, as well as the beginning of the channel itself, remain visible and appear to be in the same location. The formerly backwatered area upstream of the valley crossing in **R2A** has drained, and a narrow channel is visible, cutting a path through a wide floodplain likely created by sediments deposited while the area was backwatered. The crossing appears to remain in use, although part of the road has been abandoned, and a more direct path is visible, cutting across the landscape. Additional houses and pools were built along the edge of the north valley wall downstream of the crossing in **R3**. Parts of the channel are visible downstream of the crossing in

R3, meandering through a wide floodplain that lacks tree cover. Observing the 2007 imagery, this area is also backwatered, and there is extensive treefall along the margins of the valley. Thus, this area also underwent a cycle of backwatering, deposition, drainage, and new channel formation similar to the upstream section previously described.

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The slope along Old Montreal Road, where a headscarp was previously visible along reach **C10** in the 2002 imagery, appears to have undergone stabilization works. The location where the channel constriction occurred has adjusted, with the opposite bank having migrated away from the road. The cutoff chutes appear to have enlarged and the former main channel that flowed between the islands created by the cutoff chutes appears to be in the process of abandonment. The farthest downstream beaver dam noted in the 2011 imagery is no longer present in the 2021 imagery. The slope immediately upstream of this also appears to have undergone stabilization works. It is unclear whether the beaver dam just downstream of the confluence with the South Tributary is still present due to shadows on the aerial images.

Deforestation within the tablelands south of the valley adjacent to the section from reach **R1** to **R2A** continued between 2011 and 2021, with the previously forested area north of **T1** now cleared of trees and the fields being actively cultivated. The farthest upstream sections of **T1** and **T2** that were previously surrounded by forest are now realigned and straightened, with little buffering of **T2** from the agricultural fields, while **T1** appears to be buffered to the south. **T3** and **T4** remain largely obscured by forest cover, except **T4** is observable where it transitions from straightened agricultural drainage to a forested valley and remains in the same alignment as the 1976 imagery. The channel pattern within the upstream extent of the South Tributary in **R1** and **R1A** remains identical. Vegetation surrounding the encroaching drainage channel along **R2** remains visible and its footprint appears identical to earlier images. The storage piles of fill appeared on the tablelands north of the valley adjacent to **R2** between 2011 and 2014 and continued to expand to its current extent in the intervening period. The area upstream of the crossing in **R2A** maintains a wide floodplain with herbaceous vegetation cover. The crossing appears to have been abandoned, as vegetation along the road is overgrown. The area downstream of the crossing in **R3** is backwatered again.

2.5 Digital Terrain Analysis

Terrain analysis of two high-resolution spatial datasets was used to map, plot, and interpret channel and valley geomorphic features within the study area. Stream channels are inherently dynamic features of the natural landscape, and the detailed observation of channel and valley geomorphology using spatial datasets is useful to gain insight into how a given fluvial system has adjusted and is likely to adjust over time. In particular, the use of high-resolution bare-earth digital elevation models derived from airborne LiDAR surveys allows for detailed broad-scale mapping and analysis of geomorphic features. In cases where two or more elevation surveys are available, analyzing the detailed topographic data from these surveys can provide useful insights into the nature and rate of geomorphic adjustment during the intervening period.

2.5.1 Methods

For this study remote sensing data was used for detailed analysis of geomorphic features adjacent to and within the valley of the subject watercourse. Remote sensing data in the form of LiDAR-derived bare-earth digital elevation models (DEM) with a horizontal resolution of 1x1 m were provided by Stantec (2012 data) and also obtained from a publicly available dataset maintained by OMNRF (2019/2020 data). The bare-earth elevation raster datasets were used to generate hillshade models and longitudinal channel bed elevation profiles both useful for interpreting and analyzing geomorphic features. The

following specific geomorphic features and terrain metrics were mapped, plotted, and analyzed using the high-resolution elevation data:

- Land surface changes across the study area between 2012 and 2019/2020
- Gullies along the valley walls
- Slumps and landslides feature along the valley walls
- Slope gradients within the valley
- Channel bed longitudinal profile for 2012 and 2019/2020

The 2012 and 2019/2020 DEMs were used to generate a land surface change raster, or a DEM of Difference (DoD), which is used to highlight areas of significant elevation change between the two survey periods. The DoD was generated by subtracting the elevation values recorded in the more recent 2019/2020 elevation raster from the elevation values recorded in the earlier 2012 elevation raster. The DoD was overlayed on the 2019/2020 hillshade raster to show the spatial distribution and magnitude of land surface changes over the given time period. Ground control points (n=10) were used to evaluate and correct for any systematic elevation difference between the two elevations in the 2019/2020 dataset were all lower and ranged from -0.16 to -0.31 m of the 2012 elevations. To account for the elevation difference, an offset of 0.22 m was applied to the 2019/2020 elevation raster before generating the DoD.

Geomorphic features, including gullies, slumps, and landslides, were delineated using the hillshade model generated from the OMNRF bare-earth elevation raster. Delineation was generally accomplished by visually interpreting the morphological features and characteristics shown on the hillshade, slope gradient raster, and land surface change raster. Slumps were identifiable by their concave profile, with a steep, crescent-shaped headscarp and debris amassed at the base of the slope. More recent slumps were the most readily identifiable due to the contrast in slope gradient between the headscarp and the debris pile, while in older slumps the contrast was somewhat diminished likely due to ongoing erosion processes. Gullies were identifiable as relatively straight V-shaped features cut into the valley walls, approximately perpendicular to the length of the valley. The land surface change and geomorphic features map is provided in **Appendix D**.

The OMNRF 2019/2020 bare-earth elevation raster was also used to generate a slope raster with a slope classification scheme that highlights slopes with gradients of >3:1, >2:1, and >1:1. For reference, the minimum stable slope gradient recommended by OMNRF is 3:1 (horizontal:vertical) ratio (OMNRF, 2002). The resulting slope classification raster was overlayed on the 2019/2020 hillshade raster to show the spatial distribution of the relatively higher slope areas adjacent to the creek and within its valley. Areas shaded 'red' are those with slopes greater than 45 degrees (i.e., >1:1 slope). This analysis was undertaken to map the spatial distribution of the steepest slopes and to aid in identifying geomorphic features. The resulting slope raster and hillshade map is provided in **Appendix D**.

The 2012 and 2019/2020 DEMs were used to generate longitudinal profiles of the South Tributary channel. The longitudinal profiles were generated by sampling elevation values from both the 2012 (corrected) and 2019/2020 DEMs at intervals of 1 m along the channel flow path. The sampled elevations in meters for the respective years were then plotted with horizontal distance downstream. Reach breaks and other features along the South Tributary, including the historical crossings, beaver dams, underlying surficial geology, and the longitudinal extent of the recent slope failure, were overlayed on the plot to provide geomorphic context. The plot is presented below in **Figure 1**.

2.5.2 Slope and Land Surface Change Results

The active channel, floodplain, and valley walls are all clearly visible on the hillshade model generated from the 2019/2020 bare-earth DEM (OMNRF; 2020). Slumps, gullies, and areas of backwatering are discernable on the hillshade model as well as the land surface change and slope gradient distribution rasters. Historic landslides within tributary valleys, as mapped in Brooks (2019), are also identifiable on the hillshade model. The results of the analysis are discussed below, reach by reach. For reference, figures showing mapped geomorphic features and slope gradients are provided in **Appendix D**.

Reaches **R1** and **R1A**

Along reach **R1**, the hillshade model reveals that the watercourse is unconfined and the channel straightened. The banks in this reach have relatively steep, localized slope gradients up to approximately 50% on the slope gradient map. Here, channel banks range from 0.5 to 1.0 m in height. Minor evidence of lateral scour along the banks was observed during the field assessment (details provided in Section 3.2—General Reach Observations).

The channel planform in reach **R1A** is relatively straight with some isolated bends. A well defined valley emerges with distance downstream while the channel gradient increases, as shown on the longitudinal channel profile provided below (see **Figure 1**). As noted in the Historical Assessment provided above, the hillshade model shows evidence of historic beaver activity within this reach. Desktop terrain analysis indicates there are no locations within **R1A** where the watercourse is in contact with the valley slopes, a finding that is consistent with the results of the field assessment (see discussion below). The valley slope gradient appears to increase with distance downstream as valley walls increase in height, with maximum local slope gradients around 50%. Floodplain widths within the emerging valley range from approximately 4-18 m.

Reach R2

Downstream of this in **R2**, the watercourse becomes confined within a valley characterized by alternating scalloped valley wall headlands that encroach into a relatively narrow floodplain. The watercourse meanders somewhat irregularly within its confined valley setting, making frequent contact with the toe of the valley slope. The hillshade model reveals an evident connection between the valley form and channel form within this reach, as the scalloped valley form largely follows the pattern and wavelength of the meanders. Slump scarps and gullies are a frequent feature along the scalloped valley walls. The floodplain within this reach is discontinuous due to the narrow valley and encroaching headlands. Instead, there are isolated pocket floodplains (up to 15 m wide) and terraced features, which are observable in the hillshade model and were noted during the field assessment.

There is a sharp increase in the magnitude of valley wall slope gradients entering Reach **R2** and a higher density of gradient values greater than 33%. Terrain analysis revealed valley wall slope gradients of up to 140%. Terrain slopes tend to be greater within gullies, along the face of slumping valley wall headscarps, and where the outside of meander bends are in contact with the valley wall. There are several gullies and slumps along the valley walls along this reach where elevation decreases between 1 to 3 m were detected in localized and isolated locations (i.e., land surface areas with magnitudes in the order of 10^1 m^2). Most of the gullies and slumps present along **R2** were not associated with recent land surface changes detected through land surface change analysis (i.e., DoD raster). Localized elevation decreases of the magnitude of 1 to 3 m were detected along Reach **R2** (DoD raster; 2012 vs 2019/2020 elevation datasets) at the outside of several meander bends. The watercourse is in contact with the valley slopes on the outside of many of these meander bends, some of which have slope gradients of up to 125%.

The form of the branching drainage feature extending into the fields north of the valley that was noted in the Historical Assessment is revealed more clearly on the hillshade model. The lack of recent elevation changes along this feature indicates it formed and stabilized prior to 2012 (i.e., the year of the first DEM used in this terrain assessment).

Reach R2A

The watercourse continues to flow within the confined valley in reach **R2A**, although scalloping along the valley walls is no longer evident. A sculpted embankment along the north valley slope supports access paths to two watercourse crossings that may have historically impacted the valley planform. The valley wall, both upstream and downstream of the embankment, ties in with the valley wall above the embankment, suggesting the embankment was built out from the valley slope and interrupted the generally southwestward trajectory of the valley planform. The curve of the southeastward bend along the south valley wall also appears to match that of the embankment. The watercourse planform through this reach meanders irregularly through a wider floodplain (7 to 19 m) upstream of the first channel crossing. The planform between the first and second crossings is straighter through a narrower floodplain (width: 4 to 6 m). Channel planform was also likely historically impacted by the channel crossings and the aforementioned embankments. Distinct from Reach **R2**, here, multiple channel flow paths are visible in the hillshade model within the much wider floodplain area upstream of the first channel crossing. These channel features were also observed during the field assessment (see Section 3.2 below).

There is a lower density of valley slope gradients steeper than 33% along the north valley slope compared to adjacent reaches, where local gradients up to 75% are observed. Limited elevation changes were detected in **R2A** upstream of the first crossing, however, there is one location along the north slope where the watercourse is in contact with the toe of a slump where elevation decrease was detected. Slope gradients along the sculpted crossing embankment and the south valley slope opposite it are identical in steepness and density to those upstream. Some localized elevation decreases between 2012 and 2019/2020 were detected along the base of the valley wall along this section. These elevation decreases comprised relatively small patches with surface areas on the order of 10^1 m^2 . Valley wall slope gradients within this section increase relative to the upstream portion of this reach, with gradients up to 107% observed.

Reach R3

The watercourse continues to flow within a confined valley and the generally southwestward trajectory of the north valley wall continues in reach **R3**, while the south valley wall through this reach becomes more complex in its form. The south valley wall trajectory is interrupted by tributaries, relatively deep gullies, and the debris of a large landslide (Brooks, 2019). Slump scars are also present along both valley walls, and there are recent slope failures along both the north and south valley walls adjacent to the property at **1320 Grand-Chêne Court** across from the landslide debris where the watercourse is in contact with the valley slope toes. The channel planform meanders irregularly through a floodplain with variable width (2 to 26 m) along the reach. The variable floodplain widths are attributed to the channel flowing through unconsolidated sediment deposits on the upstream side of two beaver dams located within this reach, features that are visible in the hillshade model and were observed during the field assessment.

Valley wall slope gradients within the section upstream of the first beaver dam tend to be greater within gullies, along the face of slump headscarps, and where the outside of meander bends are in contact with the valley slope toe. Outside the slope failure at 1320 Grande-Chene, analysis of the LiDAR datasets indicates that the slopes of the northern valley wall along Reach **R3** have been relatively stable without slumping or the development of gully features during the period between 2012-2020. On the southern

valley wall, two relatively deep gullies had formed prior to 2012. Since 2012, areas with elevation increases of up to approximately 1 and elevation decreases of up to approximately 3 m were detected along the length of one of these two larger gully features. Along the channel two areas of relatively large elevation increases show the effect of backwatering caused by the first beaver dam. Note, here elevations shown on the DEM from 2019/2020 are that of an inferred water surface elevation rather than the bare-earth elevations shown on the DEM for areas outside the wetted channel. This is a known and important limitation of bare-earth elevation models derived from LiDAR data as the near-infrared lasers used for aerial LiDAR surveys do not effectively penetrate water. This area was no longer backwatered during field assessments conducted in July 2023, and both beaver dams appear to have been breached sometime between 2019/2020 and 2021 based on surface model and aerial imagery observations.

The recent slope failure at **1320 Grande-Chene** is located immediately downstream of the location of one of the two former beaver dams. At the location of the slope failure, changes in elevation were detected in the DoD along both valley slopes, channel banks, and within the floodplain. Elevation decreases up to 2 m were detected along the top of the north valley slope at the location of the recent failure, cumulatively comprising a land surface area on the order of 10^2 m^2 , and with slope gradients of up to 108% observed on the LiDAR-derived bare-earth DEM. At the toe of the slope below the recent failure, an area with elevation decreases was detected along the outside of a meander bend where local slope gradients up to 117% were measured. Elevation decreases at that location range from approximately 1 to 3 m and comprise a land surface area with a magnitude in the order of 10^1 m^2 . Opposite from this along the south valley slope, a crescent-shaped area of elevation decrease was detected where local slope gradients up to 102% were observed, indicating a recent slump. Elevation decreases at this location are up to approximately 3 m and comprise a land surface area with a magnitude on the order of 10^2 m^2 .

Downstream of **1320 Grande-Chene Court**, valley wall slope gradient decreases along the north valley wall, with gradients up to 57% observed, as does the density of slopes greater than 33%. There are two slumps along the south valley slope within this section with gradients up to 70% measured on the headscarp; recent and significant elevation changes were not detected at this location. Significant elevation increases in the area upstream of the second beaver dam were detected on the DoD and are likely representative of backwatering caused by the beaver dam. Evidence that this area had recently drained was observed during field assessments conducted in July 2023. This was confirmed by observing imagery dated to May 8, 2023, using Google Earth Pro, which showed that the area remained backwatered as of that date, indicating the beaver pond drained sometime between May and July 2023.

Reach R4

The watercourse continues to flow in a confined valley setting in reach **R4** while the general valley trajectory turns southwards. The South Tributary valley walls at the upstream end of the reach tie into the Cardinal Creek valley walls; several slumps and gullies are in this transition zone. The channel planform meanders tortuously through a floodplain. Here floodplain widths range from 2 to 15 m, with the channel making frequent contact with the toe of the valley slope along the outside of meander bends. There is evidence of recent slumping in the lower end of the reach. Elevation decreases up to approximately 2.5 m were detected in multiple slump headscarps along the valley wall adjacent to meander bends. Local slope gradients up to 115% were observed in the headscarps. There are several gullies along the south valley wall within this reach. Analysis of the DoD indicated there were no recent and significant elevation changes at this location, although a higher density of slope gradients greater than 33% were observed.

Tributary Reaches T1 to T4

Land surface changes, geomorphic features, and slope gradients were mapped for the four contributing channels draining the area south of the South Tributary, reaches **T1**, **T2**, **T3**, and **T4**. The results of the digital terrain analyses for these reaches are not discussed at length in this report since they are located outside of the subject lands. However, the historic landslide attributed to the sensitivity of glaciomarine clays within **T4** was mapped to show the location relative to the South Tributary (Brooks, 2019). Observing the spatial distribution of geomorphic features, land surface changes, and slope gradients mapped within reaches **T1** to **T4** compared to those mapped within the South Tributary shows that the geomorphic processes operating in those tributaries are likely to be operating within the South Tributary.

Summary

Analysis of the hillshade model, land surface change raster (i.e., DoD), and slope gradient distribution raster revealed ongoing geomorphic processes within the South Tributary. Slope gradients tend to be greater within gullies, along the face of slump headscarps, and where the outside of meander bends are in contact with the valley slope. Slumps were more concentrated within reaches **R2** and **R3**, while the highest concentration of gullies occurs in reach **R2**. Most of the mapped slumps and gullies formed prior to 2012, and significant surface elevation changes that occurred between 2012 and 2019/2020 were identified and mapped, the most notable being the decrease in elevation along the top of the north valley slope adjacent to **1320 Grand-Chêne Court** and along the south valley slope across from it. Beaver activity was also highlighted by the land surface change analysis, particularly extensive backwatering upstream of dams within reach **R3** both upstream and downstream of the recent slope failure.

2.5.3 Longitudinal Profile Comparison Results

The comparison of longitudinal profiles from 2012 (yellow) and 2019/2020 (blue) in **Figure 1** below reveals several changes in channel bed gradient and profile during the intervening period. The locations of reach breaks, surficial geology, detailed assessment, tributary confluences, historical crossings and beaver dams, and the extent of the recent slope failure are also overlayed on the long profiles. Along the length of the subject lands, the elevation of the South tributary drops approximately 32 m over a distance of approximately 2000 m (average channel gradient 1.6%). The long profile for the South Tributary is punctuated by several prominent slope breaks with localized sub-reach scale channel gradients of up to 4%. The longitudinal profiles are generally consistent between the 2012 and 2019/2020 elevation data, with the exception of the significant (2-3m) elevation increases observed at the location of the beaver dams. Surficial geology along the watercourse is largely dominated by glaciomarine clay, with a short section of limestone bedrock outcropping at the downstream end of Reach R2A near the first historic channel crossing. The long profiles are described below reach by reach.

Reaches R1 and R1A

A peak in elevation visible within reach **R1** near 60 m horizontal distance in the 2012 profile represents a former crossing over the channel between agricultural fields that was no longer present in 2019/2020. A short section of relatively level elevation in both profiles within reach **R1A** between approximately 200 to 300 m horizontal distance precedes the location of a historical beaver dam noted in the Historical Assessment and field observations. Two step-like decreases in bed elevation, where short plateaus in elevation precede a sudden drop, are visible in the 2012 profile just downstream of the historic beaver dam at approximately 320 and 380 m but are not present in the 2019/2020 profile, indicating potential erosion during the intervening period.

Reaches R2 and R2A

Reach-scale channel gradient increases relative to **R1**. Along **R2**, there were no significant changes in the channel profile between 2012 and 2019/2020. This section of the reach has three significant breaks in slope at 450 m, 800 m, and 900 m distance downstream. The reach-scale gradient increases with distance downstream along **R2A**, with the profile punctuated by two spikes in elevation associated with channel crossing embankments. The channel gradient of the section between the two crossings is relatively high at approximately 4%. The 2012 and 2019/2020 profiles show a relatively consistent elevation with the exception of an approximately 100 m long section, between approximately 1180 to 1280 m downstream, which lowered by as much as 50-100 cm between 2012 and 2019/2020. This section was backwatered as recently as 2002, as noted in the Historical Assessment.

Reach R3

Reach-scale gradient lowers relative to the section between the historical crossings in **R2A**. There are significant changes in the channel profile between 2012 and 2019/2020 associated with the location of beaver dams located at approximately 1580 m and 1840 m downstream. The 2019/2020 profile shows the flat backwatered sections upstream of where the beaver dams are located. The recent slope failure in the rear yard of **1320 Grand-Chêne Court**, approximately 1595 to 1645 m downstream, occurs along the right (north) bank of the watercourse immediately downstream of the first beaver dam. At the time of the 2023 field assessments, this area was observed to have been dewatered due to rupturing of the beaver dam.

The 2012 channel bed profile shows a step-like drop at approximately 1590 m, then a similar elevation range and gradient to the sections both upstream and downstream. The 2019/2020 profile shows a step-like decrease at around 1620 m, then greater variations in elevation than the 2012 profile. Note that this variability in slope profile is located in the area of the recent slope failure, suggesting that this channel bed variability is associated with colluvial material from the adjacent slopes eroding into the watercourse.

Downstream of the recent slope failure extent, the 2012 profile continues within a similar elevation range and gradient to the upstream sections of **R3** up to the location of a historic beaver dam around 1760 m horizontal distance, where there is another step-like drop. This area dewatered in the spring of 2023, as confirmed by aerial imagery and field observations, and is covered by deep deposits (> 1 m) of soft silty clay with a relatively low channel gradient.

Reach R4

Reach R4 begins downstream of a beaver dam. There is a slope break around 1900 m, after which the gradient decreases in both the 2012 and 2019/2020 profiles. The 2012 profile shows a backwatered section upstream of the confluence with Cardinal Creek.



Figure 1: Comparison of 2012 and 2019/2020 South Tributary Long Profiles

Summary

Overall, the 2012 and 2019/2020 long profiles were similar, with differences notable in the vicinity of historic beaver dams and watercourse crossings. Sections with relatively lower gradients tended to precede historic beaver dams, likely due to deposition caused by backwatering and slower flows. Sections downstream of beaver dams, specifically within reaches R1A and R3, and the section upstream of the first historic crossing showed differences in the local profile pattern and elevation variance between the 2012 and 2019/2020 profiles. Particularly notable is the extent of recent backwatering due to beaver dams immediately upstream and downstream of the recent slope failure.

3 Field Assessment

3.1 Reach Delineation

Reaches are homogeneous segments of channel used in geomorphological investigations. Reaches are studied semi-independently as each is expected to function in a manner that is at least slightly different from adjoining reaches. This method allows for a meaningful characterization of a watercourse as the aggregate of reaches, or an understanding of a particular reach, for example, as it relates to a proposed activity. Reaches are typically delineated based on changes in the following:

- Channel planform
- Channel gradient
- Physiography
- Land cover (land use or vegetation)
- Flow, due to tributary inputs
- Soil type and surficial geology
- Historical channel modifications

Reach delineation follows a scientifically defensible methodology proposed by Montgomery and Buffington (1997), the Toronto and Region Conservation Authority (2004) and others. Several watercourse reaches were previously delineated by Parish Geomorphic (2013), some of which are used in the present study and some of which were amended. While reach delineation can be completed based on longitudinal profiles, the basic reach classification scheme from previous assessments was adopted in order to maintain consistency with existing reports and studies for the subject property.

A total of six reaches were identified within the subject property: **R1**, **R1A**, **R2**, **R2A**, **R3** and **R4**. Reach Reaches **R3** and **R4** were adopted from Parish Geomorphic (2013) mapping, while reaches **R1**, **R1A**, **R2**, and **R2A** were amended from Parish Geomorphic (2013) mapping. Reach **R1** was divided into **R1** and **R1A**, and the reach break at the downstream end of **R1A** was moved slightly farther downstream to a location where the channel elevation distinctly begins to drop at the beginning of **R2**. Reach **R2** was divided into **R2** and **R2A**, with the reach break at the upstream end of **R2A** placed at a location where the floodplain distinctly increases in width. Reach **C10** from the Geomorphic Solutions (2007) and Parish Geomorphic (2013) mapping was also identified as the reach along the main channel of Cardinal Creek into which the South Tributary discharges. Additionally, four tributaries flowing from the south tablelands into the South Tributary were identified and assessed: **T1**, **T2**, **T3** and **T4**. Reach mapping is provided in **Appendix A** for reference.

3.2 General Reach Observations

GEO Morphix Ltd. completed visits on July 12^{th,} 2023, and November 29th, 2023, to document existing channel conditions. **Appendix E** provides a geo-referenced photographic inventory documenting evidence of dynamic adjustment within the system. Photographs of general site conditions are provided in **Appendix F**, and field observations are included in **Appendix G** for reference.

The site visits included the following activities and reach observations:

- Habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow patterns, geomorphological units (e.g., riffle, run, pool), and riparian vegetation for the extent of each reach assessed
- Descriptions of riparian conditions
- Documentation of culvert crossing conditions
- Estimates of bankfull channel dimensions
- Bed and bank material composition and structure
- Observations of erosion, scour or deposition
- Collection of photographs to document the watercourses, riparian areas and/or valley, surrounding land use, channel disturbances such as crossing structures, and areas of erosion and/or evidence of dynamic adjustments
- Completion of rapid channel assessments following the Rapid Geomorphological Assessment (RGA) (MOE, 2003; VANR, 2007) and Rapid Stream Assessment Technique (RSAT) (Galli, 1996) methodologies

General channel characteristics for all assessed reaches are summarized below in **Table 1**.

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Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Notes
R1	3.25	0.60	Clay/Silt		Grasses, Herbaceous	 No riffle pool formation, all runs Historically straightened agricultural ditch Dense instream vegetation Minor basal scouring; rilling from adjacent fields
R1A	2.50	0.55	Clay/Silt		Grasses, Herbaceous	 Flows through historic beaver meadow Heavily encroached and interstitial flow Poorly defined bankfull; low and flat floodplain
R2	6.66	0.75	Clay/Silt- Boulders	Clay/Silt- Cobble	Trees, Herbaceous	 Develops meandering planform Mass movement, exposed roots, down trees, undercutting observed Channel substrate composed of clay-till, exposed along the bed Valley wall contact observed
R2A	2.50	0.40	Clay/Silt		Herbaceous, Grasses	 Channel flows through historic beaver meadow Multiple flow paths and interstitial flow Channel bed compact clay Flat and low floodplain between valley walls
R3	3.83	0.86	Clay/Silt- Cobble	Clay/Silt	Trees, Herbaceous	 Valley narrows, bank in contact with valley wall along right bank Extreme tree fall throughout Large breached historic beaver dam at the downstream extent
R4	3.00	0.75	Clay/Silt- Boulders	Clay/Silt- Gravel	Trees, Herbaceous	 Beaver dam located upstream and downstream end of reach Backwatering at the downstream section Valley wall contact observed
T1	Poorly defined- though ravine		Clay/Silt	-Boulders	Trees, Herbaceous	 Tributary through ravine High gradient Many forced knickpoint due to debris and roots Scour and exposed roots along both banks

Table 1: General reach observation summary

Reach Name	Avg. Bankfull Width (m)	Avg. Bankfull Depth (m)	Riffle Substrate	Pool Substrate	Dominant Riparian Condition	Notes
T2	1.65	0.54	Clay/Silt-	Boulders	Trees, Herbaceous	 Tributary through ravine High gradient Recent slump observed on slope Many forced knickpoints due to debris and roots Basal scour and exposed roots along both banks observed
тз	Poorly defined- ravine	Poorly defined-through ravine		Clay/Silt	Trees, Herbaceous	 Tributary through ravine Rotational slides and undercutting present Many forced knickpoints due to debris and roots Frequent down trees
Т4	1.50	0.56	Clay/Silt- Boulders	Clay/Silt- Gravel	Trees, Herbaceous	 Tributary through ravine Rotational slide, undercutting observed Many downed trees Channel bed flat compact clay
C10	13.32	0.72	Sand- Boulders	Clay- Cobbles	Trees, Herbaceous	 Bedrock exposed throughout, comprising bed in multiple locations Two bedrock knickpoints Three beaver dams backwatering upstream half of reach

3.2.1 South Tributary Reaches

Reach **R1** begins along Cox County Road, flowing under the road and in a generally westward direction towards Cardinal Creek. The channel flows through an actively cultivated agricultural field and exhibits a straightened planform with a low gradient. The channel had no pool-riffle features, and vegetation encroachment was heavy. The riparian buffer between the active field and the channel was narrow (2-3 m) and was composed of grasses and herbaceous vegetation. At the time of the assessment, emergent and submerged aquatic vegetation and floating algae were present throughout the reach. The channel bed and banks were composed of loose silt, and some large cobbles were observed along the banks. Minor basal scour was observed at few locations and rilling from the adjacent field into the channel margins was observed along the downstream extent.

Reach **R1A** extends from **R1** continuing to travel westward for approximately 130 m. The channel exits the agricultural field and flows within a historic beaver meadow, which was heavily encroached by vegetation and surrounded by a wide and flat floodplain composed of grasses. No riffle-pool features were present. The channel was poorly defined in some locations, and interstitial flows through the beaver meadow substrate were observed at several locations throughout the reach. The channel bed and banks were composed of compact silt with a clay channel substrate. A historic beaver dam outflanked to the right (north) by the existing channel and with undercutting (0.55 m) was observed within the downstream extent of the reach. Evidence of erosion was limited along the reach except near the transition to **R2**, where the channel elevation began to drop and basal scour and bank undercutting was observed.

Reach **R2** extends from **R1A** and enters a confined valley setting where the creek continues flowing westward for approximately 500 m. The channel exhibits a meandering planform along the valley floor which ranged from 10-20 m wide with slopes up to 10 m tall. The riparian zone consisted of trees and herbaceous vegetation. The bed material was composed of clay till, which was exposed along the length of the channel, as well as pebble-sized clay conglomerates, soft silt, and cobble and boulder-sized glacial till. Riffle-pool sequences were common throughout the reach, with substrates composed of clay up to boulders in some riffle locations. Exposed till up to 0.5 m in height, and small-scale mass movement was observed where the channel was in contact with the valley wall. Undercutting up to 0.60 m was observed, and bank angles were between 60° and 90°. Exposed tree roots and leaning trees of all ages and large woody debris in the channel was commonly observed. Approximately 60% to 100% of the reach exhibited signs of erosion.

Reach **R2A** extends from **R2** as the channel enters a lower gradient section with a wider floodplain. A sculpted embankment upstream of the first of two historic channel crossings protrudes from the north valley wall towards the southeast into the South Tributary valley. Land cover on the embankment was comprised of forest and meadow encroaching along the abandoned access road. The valley and watercourse trajectory mirror that of the protruding embankment with a wide southeastward bend. Access roads to the historic crossings travel down the valley slopes and cross over the channel with corrugated steel pipe culverts conducting flow below them. Reach **R2A** continues for approximately 300 m and ends at the second historic crossing located at the downstream extent of the Reach. The culverts at both crossings were in a degraded condition at the time of the assessment and both were perched above the channel (2 to 5 m height) on the downstream side. A large proportion of the flow was conducted interstitially through both crossings as the channel outflanked the culverts on their upstream side. A cascade constructed from placed cobble comprised the watercourse immediately downstream of the first crossing, and there was a scour pool eroding into the clay till downstream of the second crossing.

The land cover within the relatively wide floodplain is comprised of dense grasses and some large woody debris. There are multiple distinct channels through this section of the reach which are heavily encroached by grassy vegetation. Some streamflow is via channels located along the base of the valley walls and interstitially through the meadow. No riffle-pool features were present, and the channel bed was composed of compact clay-till. Undercutting up to 0.15 m was observed along the banks in several locations. The channel banks ranged between 30° to 90°, and bank erosion was observed along 5% to 30% of the reach. The 50 m long section of the reach between the first and second channel crossings has a significantly steeper channel gradient and narrower floodplain relative to the upstream section of the reach with a narrow floodplain.

Reach **R3** begins at the downstream end of the second of the two historic channel crossings, where a relatively large scour pool formed on the downstream side of the culvert. From here the channel continues flowing westward towards the main branch of Cardinal Creek. This reach exhibited similar characteristics to those observed along reach **R2**. The channel regained a meandering planform which was in contact with the bounding valley slopes throughout much of the reach. Riffle-pool features were observed, however, not as frequently as in reach **R2**. Channel banks slopes ranged from 60° to 90° and bank erosion was observed along 60% to 100% of the reach. A tall (3-4 m) breached beaver dam was observed approximately 150 m downstream from the beginning of the reach. Flow passed through the abandoned dam and there was a drop in channel elevation on the downstream side, as the channel upstream of the dam flowed through a thick layer of sediment deposited behind the dam. Downstream of this point the valley becomes increasingly narrow and the channel is in contact with the valley slopes in multiple locations. A recent slope failure was identified along the right bank in this section adjacent to **1320 Grand-Chêne Court**. Another tall (2-3 m) beaver dam that had recently breached was observed at the downstream extent of reach **R3**. The dewatering of the beaver pond was evidenced by

relatively deep (> 1 m) loose silty clay deposits with limited vegetation growth as well as tree trunks within the floodplain were covered with dried clay residue at heights up to 1.5 m. Here an approximately 1.40 wide and 0.08 m deep channel has formed in the newly exposed beaver pond sediments, which were unconsolidated to depths greater than 1 m.

In the vicinity of the recent slope failure, extreme tree fall was noted along both valley slopes and the channel was clogged with debris. The channel bed was composed of exposed clay-till and some gravel. Undercutting up to 0.15 m was observed along the right bank. Slumping was observed along both the left and right valley slopes. The right (north) valley slope had a step-like slope profile where slope breaks separated sections with relatively lower and higher gradients. Leaning trees and exposed roots were observed along the right slope. An intact root wad that originated from the slump along the left (south) valley slope was perched across the channel supported by older woody debris.

R4 begins on the downstream side of the recently dewatered beaver dam and continues to flow westward for approximately 200 m until the confluence with Cardinal Creek. The reach break used for the field assessment was at the confluence between the South Tributary and **T4**, as in Parish (2013), and was moved downstream of this to the location of the beaver dam following the field assessment due to the disparity between characteristics of the recently dewatered area and the rest of **R4**. Downstream of the recently breached beaver dam, the channel regains its meandering planform, with several locations of valley wall contact observed. A second active beaver dam at the confluence with Cardinal Creek was observed, resulting in the stream being backwatered for most of reach R4. Exposed tree roots and leaning trees were observed along the banks and valley slopes. Due to high water levels, neither the bed substrate nor channel bedforms (e.g., riffle-pool features) were observable. The channel bank angles ranged from 60° to 90° and evidence of erosion was observed along 60% to 100% of the reach.

3.2.2 Tributaries to the South Tributary

All four watercourses contributing to the South Tributary are located to the south of the subject watercourse and drain agricultural lands. Tributary **T1** outlets to reach **R2** of the South Tributary and has a relatively straight planform through an agricultural field that transitioned to a high gradient ravine as it entered the forested valley setting along the South Tributary. The channel bed in the ravine was composed of clay to large cobbles and boulders. Fallen trees and exposed tree roots were commonly observed along the ravine slopes, and several forced knickpoints due to debris and roots were noted. Undercuts up to 0.40 m were measured, and valley wall contact and scour were observed along both banks throughout the reach. The riparian zone was composed of trees and herbaceous vegetation. The channel banks were nearly vertical and measured up to 4 m in height with signs of erosion observed along 60%-100% of the reach.

Reach **T2** is located south of the South Tributary and flows in a generally westward direction through an agricultural field, then turns northwest where it enters a forested valley of the South Tributary and flows in a high gradient ravine to outlet into reach **R3** approximately 300 m downstream of the **T1** confluence. The tributary exhibits a wandering planform with no true meanders through the ravine. Like **T1**, many fallen and leaning trees, cutbanks, and undercutting up to 0.90 m were observed. Many forced knickpoints due to debris and roots were noted. A recent slump with characteristic regressive slump blocks was observed along the southwest valley slope, located across from a historic failure resulting in a large accumulation of debris and dense tree fall in the channel (Brooks, 2019). The channel bed was composed of exposed clay tills with locations where large boulders and cobbles were present. The channel bank angles ranged from 60° to 90°, and evidence of erosion was observed along 60% to 100% of the channel.

Reach **T3** is similarly located south of the South Tributary and flows from the southwestern edge of the adjacent field through a ravine to discharge into **R3** approximately 200 meters downstream from **T2**. Similar characteristics to those observed along **T2** were noted, including fallen and leaning trees, cutbanks, and undercutting up to 0.42 m. The channel bed was similarly composed of compact clay-till with some large cobbles and boulders observed. A large knickpoint was observed halfway along the reach. Occurring within the compact clay-till, it was approximately 1 m in height and had a large scour pool on the downstream side. Several other forced knickpoints formed due to channel debris were also observed. Channel bank angles ranged from 30° to 90° and evidence of erosion was observed along 60% to 100% of the reach.

Reach **T4** is also located south of the South Tributary and flows westward from agricultural fields into a forested area, where it transitions into a ravine. The tributary through the ravine generally flows northwestern and discharges into **R4** approximately 170 m downstream of the **T3** confluence. The channel exhibits a wandering planform and high gradient. The riparian zone consisted of trees and herbaceous vegetation and the channel bed was composed of exposed clay-till with cobbles and boulders observed in some locations. Evidence of bed scour, specifically large angular conglomerates displaced from the compact clay-till bed, was observed along most of the reach. Evidence of rotational slumping was observed along with leaning trees, undercutting up to 1.50 m, and cutbanks. Forced knickpoints within the channel and scour along both banks were also observed. The channel bank angles were 60°-90°, and erosion was observed along 60% to 100% of the reach.

3.2.3 Main Channel

Reach **C10** begins where the South Tributary meets the main channel of Cardinal Creek and flows generally north for approximately 475 meters to the Old Montreal Road crossing. The channel exhibits an irregular meandering planform and a moderate gradient. The riparian zone was comprised of forested valley slopes and a narrow floodplain with grassy and herbaceous vegetative cover. The channel bed composition varied throughout the reach, with the downstream extent comprised largely of sand to boulder-sized substrate with areas of exposed bedrock and the upstream extent comprised largely of loose clay and glaciomarine clay till with some cobbles. Banks were comprised of the same variable materials, with some bedrock banks and some alluvial soil banks. Basal scour was observed along both banks throughout the reach, as were multiple bar forms and islands. Undercutting up to approximately 0.61 m was observed, primarily within the downstream half of the reach. Bank angles ranged from 10 to 80 degrees throughout the reach, averaging 45 degrees. Two bedrock steps were observed with shallow pools downstream. Three active beaver dams were observed within the upstream half of the reach, causing backwatering up to and beyond the confluence with the South Tributary.

3.3 Rapid Field Assessments

Channel stability and susceptibility to erosion were objectively assessed through the application of the Ontario Ministry of the Environment (MOE; 2003) Rapid Geomorphic Assessment (RGA) technique. The RGA evaluates degradation, aggradation, widening, and planimetric form adjustment at the reach scale. The RGA technique aims to produce a score, or stability index, which qualitatively evaluates the degree to which a stream has departed from its equilibrium condition. A stream with a score of less than 0.20 is classed as 'in regime', indicating minimal changes to channel form or processes. A score of 0.21 to 0.40 indicates that a stream is 'in transition' with the channel undergoing major changes to process and form. A score of greater than 0.41 indicates that a stream is 'in adjustment', exhibiting a new stream type, or a channel that is in the process of adjusting to a new equilibrium (MOE, 2003; VANR, 2007).

The RGA technique is useful for a qualitative reach-by-reach spatial comparison of relative channel stability. Although RGA scores provided by different practitioners for reach assessments conducted at

different times can be compared, different practitioners may interpret indicators differently, and therefore, any temporal comparison is qualitative and other techniques for assessing channel stability and morphological channels derived from sources such as aerial imagery and quantitative data are best relied upon to assess temporal changes. RGA scores and reach descriptions from previous assessments were considered, and are summarized in the following paragraphs, but were not relied upon to assess whether relative channel stability had increased or decreased over the period between assessments.

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system and to consider the ecological functions of the watercourse (Galli, 1996). Observations were made of channel stability, channel scouring or sediment deposition, instream and riparian habitats, and water quality. The RSAT score ranks the channel as maintaining a poor (<13), fair (13-24), good (25-34), or excellent (35-42) degree of stream health.

Rapid assessments were completed during the site visits on July 12th, 2023, November 30th, 2023 and October 10th, 2024. Photographs of general channel conditions for all reaches are provided in **Appendix F**, and field observations are included in **Appendix G** for reference. **Table 2** below summarizes the results of the rapid field assessments.

Reach **R1** scored 0.143 on the RGA, indicating that the channel is 'in regime'. The dominant systematic adjustment was aggradation and planimetric adjustment due to the few observations of scour, rilling and re-worked bars. This suggests an increase in channel stability and a reduction in active channel widening since the 2013 rapid geomorphic assessment conducted by Parish Geomorphic in 2013. For the current study, the reach received an RSAT score of 24 or Fair due to poor riparian habitat conditions as there was a lack of riparian vegetation diversity.

Reach **R1A** also received an RGA score of 0.143, indicating that the channel is 'in regime'. The dominant systematic adjustment was aggradation due to the observation of siltation and over-bank deposition of sediments. Consistent with **R1**, the updated RGA score suggests increased channel stability and reduced erosion since 2013, when the reach was determined to be 'in adjustment' with evidence of active widening (Parish, 2013). Note that **R1A** is a portion of what was defined as reach R1 in previous studies; therefore, a direct comparison of RGA scores is not possible for this reach. An RSAT score of 27, or Good, was assigned, with the limiting factor being physical instream habitat due to the lack of diverse instream substrate and lack of riffle-pool features.

Reach **R2** scored 0.600 on the RGA, indicating that the channel is 'in adjustment'. The dominant systematic adjustment was aggradation and widening due to observations of point bars, siltation, and overbank deposition as well as leaning trees, large woody debris, and basal scour throughout the reach. This updated RGA score represents a slight increase in comparison with the 2013 score, possibly suggestive of active channel evolution and widening. The reach received an RSAT score of 22 or Fair. The limiting feature was predominantly channel stability due to unstable bends, tree roots, and scour along much of the reach.

Reach **R2A** scored 0.330 in the RGA, indicating that the channel is 'in transition'. Observations of multiple channels, island formation, and cutoff channels indicate that the dominant systematic adjustment is planimetric. This could indicate a slight increase in channel stability since 2013, when **R2** was determined to be 'in adjustment', with active widening. However, **R2A** is a new reach delineated for the current assessment and was formerly encompassed by **R2**, so a direct comparison between assessments is not possible for this reach. The reach received an RSAT score of 28 or Good. The limiting factor was the physical instream habitat due to the absence of riffle-pool features.

Table 2: Reach classification summary

	RG	A (MOE, 2001)	RSAT (Galli, 1996)			
Reach Name	Score	Condition	Dominant Systematic Adjustment	Score	Condition	Limiting Feature(s)	
R1	0.143	In Regime	Evidence of Aggradation & Evidence of Planimetric Adjustment	24	Fair	Riparian Habitat Conditions	
R1A	0.143	In Regime	Evidence of Aggradation	27	Good	Physical Instream Habitat	
R2	0.600	In Adjustment	Evidence of Aggradation & Evidence of Widening	22	Fair	Channel Stability	
R2A	0.330	In Transition	Evidence of Planimetric Adjustment	28	Good	Physical Instream Habitat	
R3	0.630	In Adjustment	Evidence of Aggradation & Evidence of Widening	23	Fair	Channel Stability	
R4	0.613	In Adjustment	Evidence of Widening	26	Good	Channel Stability & Physical Instream Habitat	
T1	0.336	In Transition	Evidence of Widening	22	Fair	Physical Instream Habitat	
Т2	0.575	In Adjustment	Evidence of Degradation	23	Fair	Channel Stability	
тз	0.614	In Adjustment	Evidence of Widening	23	Fair	Physical Instream Habitat	
Τ4	0.557	In Adjustment	Evidence of Widening	25	Good	Physical Instream Habitat	
C10	0.489	In Adjustment	Evidence of Widening	26	Good	Water Quality / Channel Stability	

Reach **R3** received an RGA score of 0.630, indicating that the channel is 'in adjustment'. Evidence of aggradation and channel widening were the dominant systematic adjustments. This was due to observations of bars, siltation, overbank deposition, leaning trees, exposed roots, and basal scour throughout the reach. Similar to **R2**, the RGA score for **R3** has increased since 2013, suggesting

increased channel sensitivity and continued active channel widening. An RSAT score of 23 or Fair was assigned, with the limiting factor being channel stability due to the unstable banks and scour.

Reach **R4** received an RGA score of 0.613, indicating that the channel is 'in adjustment'. The dominant systematic adjustment was widening due to observations of down trees, exposed roots, and basal scour along most of the reach. Although **R4** was adopted from the 2013 assessment, this portion of the subject channel was included within **R3** for the 2013 RGA. An RSAT score of 26 or Good was assigned. The limiting factor was the physical instream habitat due to the lack of riffle-pool features and little variability in substrate sizes.

Reach **T1** received an RGA score of 0.336, indicating that the channel is 'in transition'. Channel widening was defined as the dominant systematic adjustment due to observations of leaning trees, exposed roots, and basal scour. The reach received an RSAT score of 22, or Fair, with physical instream habitat being the limiting factor due to the lack of variability in instream features.

Reach **T2** scored 0.575 on the RGA, indicating that the channel is 'in adjustment'. The dominant systematic adjustment was degradation due to observations of cut faces on bar forms, exposed tile drains, and head cutting due to knickpoint migration. An RSAT score of 23 or Fair was received. The limiting factor was channel stability due to observations of scour and exposed roots.

Reach **T3** received an RGA score of 0.614, indicating that the channel is 'in adjustment'. Due to observations of leaning trees, exposed roots, and basal scour, the dominant systematic adjustment was widening. The reach was assigned an RSAT score of 23 or Fair. The limiting factor was the physical instream habitat due to a lack of variability of channel bed substrate and features.

Reach **T4** scored 0.557 on the RGA, indicating that the channel is 'in adjustment'. The dominant systematic adjustment was identified as widening due to observations of leaning trees, exposed roots, and basal scour throughout the reach. The reach received an RSAT score of 25, or Good, with the limiting factor being physical instream habitat due to the lack of channel bed substrate variability and no diversity in riffle-pool features.

Reach **C10** received an RGA score of 0.489, indicating that the channel is 'in adjustment'. The dominant systematic adjustment was widening due to observations of down trees, exposed roots, the occurrence of large organic debris, and basal scour along most of the reach. The updated RGA score for **C10** from the current assessment is greater than that from the 2013 assessment, indicating potentially increased sensitivity and continued adjustment within the system. An RSAT score of 26 or Good was assigned. The limiting factors were water quality due to the opaque water, likely caused by fine clay particles in suspension, as well as channel stability.

3.4 Detailed Geomorphological Assessment

Detailed geomorphological assessments were completed for reach **R3** along the South Tributary and reach **C10** along Cardinal Creek during site visits on August 7th, 2024 and October 10th, 2024, respectively. This assessment provided bankfull channel characteristics, including cross-sectional geometry and hydraulics, for the purpose of defining the erosion threshold. Reach **R3** was selected based on field observations, as confirmed by both the RGA and RSAT, which showed this reach was the most susceptible to erosion in the potential zone of impact downstream of the proposed SWMP, which will discharge to reach **R2** upstream. The South Tributary discharges to the upstream end of reach **C10** along the main channel of Cardinal Creek. Representative cross sections were surveyed within representative sections of both reaches. Composite sediment samples for bed and bank materials were collected and analyzed at accredited laboratories. Longitudinal surveys of the channel bed were

completed to determine channel slope and planform. Photographs of general channel conditions are provided in **Appendix F**, and a comprehensive summary of the channel measurements is included in **Appendix H** for reference. A tabular summary of channel measurements is also presented in **Table 3**, within **Section 4.1**.

4 Erosion Threshold Assessment

Erosion thresholds are used to determine the magnitude of flow required to potentially entrain and transport bed and/or bank material (Garcia, 2008; Villard and Parish, 2003). As such, they are used to inform erosion mitigation strategies in channels influenced by conceptual flow and stormwater management plans. The erosion threshold is the theoretical point, typically expressed as a critical discharge or shear stress, at which entrainment of sediment would occur based on the morphology of the channel and characteristics of the bed and bank materials. Bed and bank materials typically exhibit distinct composition and structure, and therefore erosion thresholds are determined for both bed and bank materials. The lower of the bed and bank erosion thresholds is adopted, as it provides a more conservative and limiting estimate of erosion potential.

Erosion thresholds are generally determined using a range of methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied. For cohesive materials, a method such as that described by Komar (1987) or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994) could be applied. An erosion threshold, in the form of a critical discharge, is estimated based on the bed and bank material sizes (D_{crit}) and channel geometry in the assessed reach. Theoretically, above this discharge, the flow produces sufficient force to entrain and transport the bed and/or bank sediments.

The approach described above results in the definition of an inherently conservative, or lower-bound, estimate of the erosion threshold for any given stream channel. There are several factors that contribute to the conservative nature of the approach. Firstly, The erosion threshold is defined for what is determined to be, through a detailed geomorphic assessment of the stream channel, the most erosion-sensitive reach within the subject channel. Secondly, for the most erosion-sensitive reach a distinct erosion threshold is defined for both the bed and the bank materials and the lower of the two values is adopted as the erosion threshold. Thirdly, the approach does not account for channel forms and structures that contribute flow resistance (e.g., vegetation, surface roughness, channel bedforms, channel sinuosity) and which dissipate some of the force available for entrainment of the channel sediments.

4.1 **Previous Erosion Threshold Assessments**

Previously completed erosion threshold assessments provide a range of critical discharges and critical shear stresses for both Cardinal Creek and the South Tributary. As requested by the City of Ottawa, the previous erosion thresholds are reviewed and summarized below.

4.1.1 2007 Erosion Threshold Assessment

Geomorphic Solutions conducted Field assessments along the main branch of Cardinal Creek in October and November 2006. Channel and sediment characteristic results observed during these assessments are summarized in **Table 3** below. Erosion thresholds were modelled for reaches **C4** and **C10**. The bankfull geometry results in reach **C4** include an average bankfull width of 7.6 m, an average bankfull depth of 0.65 m, and a bankfull gradient of 0.09%. Sediments observed within this reach included alluvial silts overlaying a clay till substrate. A Manning's n value of 0.033 was applied. A critical velocity

of 0.49 m/s was based on the permissible shear for the compact clay till, which provided a critical discharge of 1.01 m^3 /s.

Observations for reach **C10** include an average bankfull width of 7.47 m, an average bankfull depth of 0.69 m, and a bankfull gradient of 0.27%. Sediment distributions produced from Wolman (1954) pebble counts produced a median grain size (D_{50}) of 3.0 mm and a D_{84} of 70.0 mm. A Manning's n value of 0.035 was applied. A critical velocity of 0.30 m/s was based on the permissible shear for the median grain size, which provided a critical discharge of 0.05 m³/s. There was no access to the South Tributary during this time. The Geomorphic Assessment did not delineate erosion hazards or estimate an erosion threshold for that watercourse.

The methods applied to estimate the critical discharge are those of Chow (1959), Fischenich (2001), and Komar (1987). The equations used to complete calculations were not provided in the Cardinal Creek Geomorphic Assessment report (Geomorphic Solutions, 2007). It is noted that the threshold for reach **C4** was estimated using methods for cohesive clay substrate due to the clay till substrate and the threshold for reach **C10** was estimated using methods for non-cohesive sediments.

4.1.2 January 2013 Erosion Threshold Assessment

Parish conducted Field assessments along the South Tributary of Cardinal Creek in December 2012. (Parish Geomorphic Ltd., January 2013). Erosion thresholds were modelled for reach **R2** using channel and sediment characteristics that are summarized in **Table 3** below. The bankfull geometry observed in **R2** include an average bankfull width of 3.57 m, an average bankfull depth of 0.37 m, and a bankfull gradient of 1%. Sediment distributions produced from Wolman (1954) pebble counts were noted to be bimodal since sediment sizes that were observed included clay as well as pebble to cobble sized materials. The median particle size derived from these distributions was, therefore, theoretical (i.e., it was not observed in the channel), and thus, the results were not used for the erosion threshold assessment. Instead, the clay till substrate observed throughout the watercourse was used to determine the erosion threshold. A Manning's n value of 0.035 was applied in this assessment.

The method applied to estimate the critical discharge is that of Dunn (1959). The equation used to complete the calculations was not provided in the Cardinal Creek Village Erosion Threshold Assessment of South Tributary; the equation below is from the provided source and is assumed to be the method that was applied (Parish Geomorphic Ltd., January 2013). Dunn (1959) and others developed relations through which critical shear stress could be estimated using the proportion of fine sediments. It is mathematically represented as:

 $\tau_c = 0.1 + 0.1179SC + 0.0028SC^2 - 2.34E^{-5}SC^3$

[Eq. 1]

where τ_c is the critical shear stress and SC is the proportion of silt and clay.

The proportion of substrate that was silt-clay-sized within **R2** was estimated at 80%. The critical shear stress resulting from this estimate is 20.3 N/m³. This critical shear stress was then used to calculate the critical discharge, which was estimated to be 0.43 m³/s. The equation used to calculate this value was not provided in the earlier 2013 report (Parish Geomorphic Ltd., January 2013). The later 2013 Erosion Threshold Assessment of Cardinal Creek Main Branch report outlines that the shear stresses estimated using sediment characteristics and methods outlined in Chow (1959) were used as an input in an entrainment equation to calculate the critical shear stress (Fischenich, 2001; Parish Geomorphic Ltd., May 2013). Dunn (1959) also used critical shear stress in the excess shear stress equation to estimate erosion rates, expressed as a critical discharge. The excess shear stress equation is mathematically represented as:

 $\varepsilon T = k_d \ (\tau_b - \tau_c)^m$

where εT is the erosion rate in m³/s, k_d is an erodibility coefficient in m³/Ns, τ_b is hydraulic boundary shear stress, τ_c is critical shear stress, and m is an empirical exponent.

4.1.3 May 2013 Erosion Threshold Assessment

Parish conducted field assessments along the main branch of Cardinal Creek in April 2013. Erosion thresholds were modelled for reach **C11-B**; observed channel and sediment characteristics are summarized in **Table 3** below. The bankfull geometry results for reach **C11-B** include an average bankfull width of 7.20 m, an average bankfull depth of 0.75 m, and a bankfull gradient of 0.36%. Sediment distributions produced from Wolman (1954) pebble counts produced a D₅₀ of 29.5 mm and a D₈₄ of 73 mm. The particle sizes derived from these distributions were not used in the erosion threshold assessment. Instead, the clay till substrate observed throughout the watercourse was used in determining the erosion threshold. A Manning's n value of 0.034 was applied in this assessment.

Two methods were applied to estimate critical discharges, which were then compared to determine the limiting discharge. Based on the clay till substrate that was observed exposed along the bed throughout the reach, both Chow (1959) and Dunn (1959), which account for the cohesive nature of that material, were used to estimate critical shear stresses. For Chow (1959), a shear stress of 15.3 N/m² was estimated based on a voids ratio of 0.4, which was lowered to 12.25 N/m² due to the sinuous channel planform. This value was used as input in an entrainment equation from Fischenich (2001) to derive the critical discharge estimate of 1.5 m³/s. For Dunn (1959), a shear stress of 21.1 N/m² was estimated based on a silt-clay percentage of 85%. This value resulted in a critical discharge estimate of 3.9 m³/s. Comparing these two estimates, the lower estimate of 1.5 m³/s was chosen as the limiting critical discharge.

Channel Parameter	Geomorphi (20	c Solutions 07)	Parish Geomorphic Ltd. (2013)						
	C4	C4 C10		R2					
Bankfull Conditions									
Average bankfull width (m)	7.6	7.47	7.2	3.57					
Average bankfull depth (m)	0.65	0.69	0.75	0.37					
Channel gradient (%)	0.09	0.27	0.36	1					
D ₅₀ (mm)	< 2.0	3	29.5	Not provided					
D ₈₄ (mm)	< 2.0	70	73	Not provided					
Manning's n roughness coefficient	0.033	0.035	0.034	0.035					
Average bankfull discharge (m ³ /s)	4.89	7.3	8.55	2.21					
Average bankfull velocity (m/s)	0.57	1.4	1.33	1.34					
	Channel Bed E	rosion Threshol	d						
Method	Critical velocity for clay till substrate	Critical shear stress for D_{50}	Critical shear stress for clay till substrate (Chow, 1959)	Critical shear stress for clay till substrate (Dunn, 1959)					
Bed material	Alluvial silt, clay till	Clay to cobble	Clay till	Clay till					

Table 3: Comparison of erosion threshold analysis results

Channel Parameter	Geomorphi (20	c Solutions 07)	Parish Geomorphic Ltd. (2013)	
	C4 C10		С11-В	R2
Critical depth (m)	0.4	0.13	0.72	0.17
Critical velocity (m/s)	0.49	0.3	0.8	0.82
Critical shear stress (N/m ²)	4.7	2.19	12.25	20.3
Critical discharge (m ³ /s)	1.01	0.05	1.5	0.43
Critical Pa	rameters Comp	ared to Bankful	l Conditions	
Critical depth as a % of bankfull	61.54	18.84	96.00	45.95
Critical velocity as a % of bankfull	85.96	21.43	60.15	61.19
Critical discharge as a % of bankfull	20.65	0.68	17.54	19.46

4.2 Methodology

Erosion thresholds were modelled from detailed field observations of reach **R3** within the South Tributary. This reach was selected for the assessment, as it was determined to be the most erosionsensitive reach within the potential zone of impact downstream of the proposed SWM outlet. It is understood that the current concept plan proposes to include a SWM Pond, denoted as Pond 2 within the concept plan, along the northern perimeter of the South Tributary valley corridor. The proposed outlet would discharge into the downstream portion of **R2**. Erosion thresholds were also modelled from detailed field observations of reach **C10** within the main channel of Cardinal Creek, which is downstream of the confluence with the South Tributary.

Threshold targets are determined using different methods that are dependent on channel and sediment characteristics. For example, thresholds for non-cohesive sediments are commonly estimated using a shear stress approach, similar to that of Miller et al. (1977), which is based on a modified Shield's curve. A velocity approach could also be applied. For cohesive materials, a method such as that described by Komar (1987) or empirically derived values such as those compiled by Fischenich (2001), Chow (1959) or Julien (1994) could be applied.

An erosion threshold is quantified based on the bed and bank materials and local channel geometry in the form of a critical discharge. Theoretically, above this discharge, entrainment and transport of sediment can occur. To determine this discharge, the velocity, U, or Shear Stress, t is calculated at various depths for a representative cross-section until the average velocity or shear stress slightly exceeds the critical threshold of the bed material. The velocity is determined using Manning's approach, where Manning's n value is visually estimated through a method described by Acrement and Schneider (1989) or calculated using the Limerino (1970) approach. A Manning's n value of 0.05 was used for the assessment. The velocity is mathematically represented as:

$$U = \frac{1}{n} d^{2/3} S^{1/2}$$

where d is the water depth, S is the channel slope, and n is Manning's roughness.

The shear stress is determined using the depth-slope product, which can be applied to the bed of open channels containing fluid undergoing steady flows. The shear stress is mathematically represented as:

 $t = d\rho g S_{bed}$

[Eq. 4]

[Eq. 3]



Where t is shear stress, d is the water depth, ρ is water density, g is the acceleration due to gravity, and S_{bed} is the channel bed slope.

Because only 75% of bed shear stress and velocities apply to channel banks in uniform cross sections (Chow, 1959), the erosion threshold is scaled appropriately for these materials.

4.3 Results

Reach R3

The bed material within reach **R3** was comprised of thick, loose clay that originated as deposits in a backwater area upstream of a beaver dam that has since dewatered. The loose clay comprised the largest proportion of bed sediment and was chosen as the critical parameter with which to model the erosion threshold discharge. A channel gradient of 0.76% derived from the longitudinal profile plotted using the Detailed Assessment data was used to model the erosion threshold. Based on the type of material observed, a critical velocity approach was taken using the criteria of Julien (1994) for the alluvial mud bed material, as this most closely matched the bed sediments observed within the reach. This material is estimated to have a critical velocity of 0.61 m/s, which was used to determine a threshold discharge, the point at which sediment entrainment begins to occur. In this instance, the critical discharge for the bank materials was predicted to be 0.184 m³/s. A Manning's roughness value of 0.040 was adopted for the critical discharge calculations based on the framework described by Acrement and Schneider (1989). The banks within reach **R3** comprised the same thick, loose clay deposits. The same critical velocity approach applied to the bed material was applied to the bank material.

The results of the erosion threshold assessment are provided in **Table 4** below. The final, modelled erosion threshold is the lesser of the bed and bank materials. For reach **R3** the erosion threshold was determined to be 0.184 m³/s for the alluvial mud bed materials. A pre-development drainage area of 211.28 ha, provided by JFSA (2024), was used to calculate the unitary erosion threshold of 0.00087 m³/s/ha.

Reach C10

The bed material within reach **C10** was comprised of a wide range of materials from clay to bouldersized sediments. Sand to boulder-sized sediments overlying the local calciferous bedrock comprised a large proportion of the bed in the downstream half of the reach, which also included areas where exposed calciferous bedrock comprised the channel bed material. The upstream half of the reach included thick loose clay deposits, generally located immediately upstream of the three active beaver dams within that section, as well as areas of exposed glaciomarine clay till and sand to boulder-sized sediments. Sediment samples were taken from the channel bed and banks at one cross-section in the upstream section and one cross-section in the downstream section. Sediment size analysis results are provided in **Appendix H**. The erosion threshold was modelled for the downstream half of the reach, as the upstream half of the reach was considered less erosion sensitive due to the thick alluvial deposits, ongoing beaver activity, and a lower channel gradient of 0.41%.

The coarse sediments comprised the largest proportion of bed sediments within the downstream half of the reach and these materials were chosen as the critical parameter with which to model the erosion threshold discharge for the bed. A channel gradient of 1.01% for the downstream half of the reach was derived from the longitudinal profile plotted using the Detailed Assessment data. Based on the type of material observed, a critical velocity approach was taken using the criteria of Komar (1987) for the D50 of the bed sediments, as determined through Wolman (1954) pebble counts. This material is estimated

to have a critical velocity of 1.14 m/s, which was used to determine a threshold discharge, the point at which sediment entrainment begins to occur. In this instance, the critical discharge for the bed materials was predicted to be 2.664 m³/s. A Manning's roughness value of 0.040 was adopted for the critical discharge calculations based on the framework described by Acrement and Schneider (1989).

The banks within reach **C10** were primarily clayey soils that included coarser materials up to sand and gravel sized sediments. Based on the type of material observed, a critical velocity approach based on the criteria of Julien (1994) was applied to the bank material, which was classified as fine sandy loamy clay, as this most closely matched the soil observed. This material has an estimated range of critical velocities from 0.45-0.91 m/s (Julien, 1994). Based on flow conditions observed during the field assessment, a critical velocity of 0.76 m/s was selected from that range and used to determine a threshold discharge, the point at which sediment entrainment begins to occur. There was no evidence of sediment entrainment or transport during the field assessment, so velocities within the given range that resulted in flows lower than those observed were considered lower than the likely critical threshold. A critical velocity of 0.76 m/s was selected through an iterative process where the velocity input to the model was incrementally increased until the observed flow conditions were exceeded in all cross-sections represented in the model. In this instance, the critical discharge for the bed materials was predicted to be 1.77 m³/s.

The results of the erosion threshold assessment are provided in **Table 4** below. The final, modelled erosion threshold is the lesser of the bed and bank materials. For reach **C10** the erosion threshold was determined to be 1.77 m³/s for the alluvial mud bed materials. A pre-development drainage area of 3,279.64 ha, provided by JFSA (2024), was used to calculate the unitary erosion threshold of 0.00055 m³/s/ha.

An erosion threshold of 0.184 m³/s was determined for reach **R3**. Given the geomorphic characteristics of the site, a conservative approach was adopted for defining the erosion threshold, which is lower than the threshold of 0.43 m³/s previously defined for reach **R2** upstream through the 2013 Parish Geomorphic assessment, but which is more consistent with the previously defined erosion thresholds for reaches with fine-grained cohesive sediments elsewhere in the Cardinal Creek watershed. An erosion threshold of 1.77 m³/s was determined for **C10**. This is greater than both previously defined erosion thresholds along this section of the main channel of Cardinal Creek. The previous erosion threshold of 0.05 m³/s defined for reach C10 through the Geomorphic Solutions (2007) assessment was based on a critical velocity approach for transient fine-grained bed materials. These materials were also observed during the current field assessment but were not considered the dominant bed material nor the most sensitive characteristic in the reach. The coarse materials and exposed bedrock make the channel bed more resistant to erosion than the channel banks through this reach. The active mode of adjustment observed in C10 during the current assessment, as well as the 2007 assessment, was widening, indicating that the channel banks are adjusting. Thus, the soils comprised of fine materials along the banks were considered more sensitive to erosion than the bed. The previous erosion threshold of 1.5 m³/s was defined for reach **C11-B** through the Parish Geomorphic (2013) assessment based on a shear stress approach for the compact sandy-clay bed materials. The active mode of adjustment observed during the 2013 assessment was also widening, indicating that the channel banks in the reaches downstream of Old Montreal Road were likely sensitive to adjustment at that time as well. The continued sensitivity of the channel banks, based on the dominant mode of adjustment identified as widening through all previous and current assessments and an erosion threshold based on channel bank materials, is a conservative approach appropriate for the main channel.
	Results by Reach						
Channel Parameter	R3	C10					
Bankfull Conditions							
Average bankfull width (m)	3.62	13.4					
Average bankfull depth (m)	0.37	0.68					
Channel gradient (%)	0.76	1.01					
D ₅₀ (mm)	<2.0	45					
D ₈₄ (mm)	<2.0	120					
Manning's n roughness coefficient	0.040	0.040					
Modelled bankfull discharge (m ³ /s)	1.75	16.85					
Modelled bankfull velocity (m/s)	0.99	2.00					
Modelled bankfull shear stress (N/m ²)	29.46	69.34					
Pre-development drainage area (ha)	211.28*	3,280					
Channel Bed I	Erosion Threshold						
Bed material	Alluvial mud	D50					
Reference	Julien, 1994	Komar, 1987					
Critical velocity at the bed (m/s)	0.61	1.14					
Critical depth (m)	0.26	0.47					
Apparent shear stress acting on the bed (N/m ²)	11.06	28.29					
Critical discharge (m ³ /s)	0.184	2.66					
Channel Banks Erosion Threshold							
Bank material	Alluvial mud	Alluvial loamy clay					
Reference	Julien, 1994	Julien, 1994					
Critical velocity at the banks (m/s)	0.61	0.76					
Critical depth (m)	0.41	0.39					
Critical shear stress acting on banks (N/m ²)	13.59	17.86					
Critical discharge (m ³ /s)	0.504	1.77					
Final Erosion Threshold							
Limiting critical discharge (m ³ /s)	0.184	1.77					
Unitary erosion threshold* (m ³ /s/ha)	0.00087	0.00055					

Table 4: Detailed assessment and erosion threshold analysis results

* Provided by JFSA (2024)

5 Pre- to Post-Development Erosion Exceedance Analysis

In support of the proposed Stormwater Management (SWM) plan, an erosion exceedance analysis was completed for the receiving watercourse (CVC, 2015; TRCA, 2012). Our understanding is that runoff from the proposed development will be directed to a SWM Pond that will outlet to the downstream portion of **reach R2**, which is located immediately upstream of reach **R3**. As detailed above, reach **R3** was determined to be the most erosion-sensitive reach downstream of the proposed outlet. The South Tributary then discharges to the main channel of Cardinal Creek at the upstream end of reach **C10**.

An erosion exceedance analysis was completed using the threshold determined for reach **R3**, which was identified as the most erosion-sensitive reach within the receiving watercourse to assess potential changes in downstream erosion processes.

To support the definition of erosion control criteria for the proposed outlet, an erosion threshold assessment was completed for reach **R3** along the South Tributary and for reach **C10** along the mainstem of Cardinal Creek.

Using the results of the erosion threshold assessment and hydrological modelling provided by JFSA (2024) for pre- and post-development conditions, analyses of erosion potential within the receiving watercourse was completed with our in-house Erosion Exceedance Model based on four erosion exceedance indices:

- 1) Cumulative time of exceedance
- 2) Number of exceedance events
- 3) Cumulative effective discharge and volume
- 4) Cumulative effective work index (i.e. cumulative effective stream power)

These indices have been applied elsewhere in numerous jurisdictions, such as Conservation Halton and Toronto and Region Conservation Authority and have been widely accepted by Ontario Conservation Authorities. They provide an evaluation of the number, duration, and magnitude of exceedance events. We note that the most relevant indicator is the cumulative effective work index, as this value reflects both the duration and magnitude of erosion exceedance events.

Time of exceedance, number of exceedances, and cumulative effective discharge and volume can be calculated from the discharge record and established critical discharge. The cumulative time of exceedance is simply the summed duration of time where discharge exceeds the established erosion threshold, and the number of exceedances is the count of erosion exceedance events throughout the discharge record. The cumulative effective discharge represents the average magnitude of discharge exceeding the erosion threshold during a given erosion event, whereas the cumulative effective volume represents the total discharge volume that exceeds the erosion threshold throughout the modelled discharge record.

For more relevant indicators, namely the cumulative effective work index, hydraulic information is required. Our model applies the discharge to a characteristic cross-section. Using Manning's approach, the discharge at each time step in the continuous hydrological model is converted into a velocity, depth of flow, shear stress, and/or stream power. These parameters are calculated based on field measurements of slope, cross-section, and channel roughness. This provides analysis that is appropriate to the specific site conditions.

Flow data for nodes within reaches **R3** and **C10** were provided by JFSA (2024) in 10-minute increments for a 36-year period from 1967 to 2003 (excluding 2001). The flow nodes are located at the downstream end of the respective reaches in which they are located. A map showing the flow-node locations is provided in **Appendix I** for reference. The hydrological modelling reflects local rainfall data from that period. The hydrological modelling was analyzed to calculate the aforementioned erosion indices. The pre- and post-development hydrographs, overlain with the respective erosion threshold and bankfull discharge, are provided in **Appendix I** for reference.

The simulation used an erosion threshold value of 0.184 m³/s for reach **R3** and 1.77 m³/s for reach **C10**. These erosion thresholds were determined through the Erosion Threshold Assessment detailed above (**Table 4**).



5.1 Methods

To calculate erosion indices, both velocity and shear stress were calculated at each time step. Through an iterative process, water depth and velocity were calculated for each discharge passing through a representative cross-section. The cross-section is divided into floodplain and bankfull sections. The cross-section is further broken into panels. Velocity, U, is calculated for each panel using Manning's approach. This is a conservative approach as it allows dissipation of flood energy in the floodplain.

The total discharge, Q_{T_i} at each time step is based on the summation of the discharge of all panels, Q_i , such that:

$$Q_{T=\sum Q_i}$$
[Eq. 5]

 Q_i is discharge through a panel (which is set at 10 percent of the cross-section). Q_i is defined as:

$$Q_i = U_i w_i d_i$$

where, w_i and d_i are the width and the depth for each panel. The discharge for each panel was then summed to give a total discharge. This is more accurate than using average cross-sectional dimensions of a simple trapezoidal channel, as the bed is usually irregular, and a panel approach more accurately represents the true cross-sectional area.

For each event, the discharge is converted into a maximum depth and average velocity. The maximum depth is used to calculate the maximum bed shear stress, $\tau_{o_{max}}$ based on:

$$\tau_{o_{\max}} = d_{\max} \rho g S_{\text{bed}}$$
[Eq. 7]

where d_{max} is the maximum water depth, ρ is water density, g is the acceleration due to gravity, and S_{bed} is the channel bed slope.

Cumulative total work, ω_{tot} is defined as:

$$\omega_{\text{tot}} = \sum \tau_{0_{\text{max}}} \cdot U_{\text{avg}} \cdot \Delta t$$
 [Eq. 8]

where, U_{avg} is average velocity (Q_{tot}/A_{tot} , where A_{tot} is wetted area), while cumulative effective work index (ω_{eff}) is defined by:

$$\omega_{\text{eff}} = \sum \tau - \tau_{cr}. U. \Delta t, \omega < 0 = 0$$
[Eq. 9]

where, τ_{cr} is the critical shear stress.

Time of exceedance t_{ex} defined as:

$$t_{\rm ex} = \sum \Delta t \quad \text{for} (Q_T > Q_{\rm threshold})$$
 [Eq. 10]

where, $Q_{\text{threshold}}$ is the discharge at the erosion threshold.

The cumulative effective discharge volume (CEV) is defined as:

$$CEV = \sum Q \text{ (for } Q > Q_{threshold})$$
[Eq. 11]

Similarly, the cumulative effective discharge (CED) is defined as:

$$CED = CEV/t_{ex}$$
 [Eq. 12]

[Eq. 6]



5.2 Results

Modeling results indicate a post-development decrease in erosion potential for the receiving watercourse. Specifically, results show a 4.58% reduction in post-development Cumulative Effective Work Index (α eff; CEWI). CEWI is considered the most relevant index with respect to erosion potential, as it reflects both the magnitude and duration of a given erosion event. The cumulative effective discharge volume (CEV) represents the total volume of flow exceeding the erosion threshold. In this instance, the cumulative pre-development CEV for **R3** decreases by 8.20% from 568,078 m³ to 521,517 m³. The duration and number of exceedances are expected to increase by 4.65% and 5.49%, respectively. **Table 5** summarizes the results for the key erosion exceedance metrics from the modeling conducted using the hydrological simulation data provided by JFSA (2024).

Simulation		CEV (m ³)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
Cumulative (1967-2003)	(PRE)	568,078	5,349	624	237
	(POST)	521,517	5,104	653	250
	Change	-8.20%	-4.58%	4.65%	5.49%

Table 5: Reach R3 erosion exceedance assessment results

Hydrograph analysis indicates that under post-development conditions, peak flows are reduced, and recession curves are extended for several days following peak flows. Overall, modeling results showed a 5.8% increase in cumulative discharge for the receiving watercourse, with most of the modelled increase in streamflow occurring at discharges below the erosion threshold. These results indicate that the proposed stormwater management plan for the site effectively mitigates any increases in downstream erosion potential for the South Tributary.

For reference, a year-by-year breakdown of pre- to post-development changes in erosion indices from 1967-2003 is provided in **Appendix H**, and pre- and post-development hydrographs are provided in **Appendix I**.

For the mainstem of Cardinal Creek (**Reach C10**), modeling results indicate an insignificant increase in post-development erosion potential. Specifically, results show a 0.4% increase in post-development CEV and a 1.2% increase in CEWI. Similarly, both the duration and the number of exceedances were not significantly different between pre- and post-development conditions with increases of 2.2% and 0.9%, respectively. **Table 6** summarizes the results for the key erosion exceedance metrics for the subject reach.

Simulatio	n	CEV (m ³)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
Cumulative (1967-2003)	(PRE)	9,596,301	88,298	1,474	216
	(POST)	9,636,289	89,397	1,506	218
	Change	0.42%	1.24%	2.16%	0.93%

Table 6: Reach C10 erosion exceedance assessment results

Analysis of the pre-to post-development hydrographs for **Reach C10** demonstrates near identical plots for both existing and proposed conditions. These results indicate that the proposed development will not have a detectable impact on erosion rates with the mainstem of Cardinal Creek.

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6 Erosion hazard assessment and recommendations

Numerous slumps and gully features were mapped through both field assessment and desktop terrain analysis of the South Tributary, as described in the sections above. The results of the terrain analysis showed that with few exceptions slumps and gully features along the receiving watercourse are relatively stable. For example, along Reach R2 which borders the subject lands 9 of 11 mapped gully features showed no significant elevation changes which would indicate a recent widening, deepening, or an upslope progression of the gully. The remaining 2 of 11 gullies showed localized elevation decreases consistent with erosion and gully expansion. While further gully expansion into the tableland may occur under existing conditions, under proposed conditions surface runoff from most of the contributing areas to existing gullies will be redirected to the main channel via the stormwater management pond. This will result in significantly oversized gully features relative to their post-development contributing areas. Gully growth predominantly depends on the size of the contributing area conveying runoff to the feature (Burkard and Kostachuk, 1997; Morgan 2005). Furthermore, under existing conditions, the mapped gullies along the South Tributary, particularly those along the north valley wall, are well-vegetated, indicating a degree of relatively long-term stability. Therefore, any potential risk of future gully expansion onto the subject lands is considered negligible and effectively managed by the proposed stormwater management plan.

From a geomorphic perspective, gullies along the South Tributary were observed to contribute some sediments to the channel. Therefore, infilling or flow alterations to the gullies adjacent to the subject site could reduce sediment loading to the channel. However, results from field and desktop assessments indicate that the gullies adjacent to the subject site are unlikely to contribute a significant volume of sediment to the channel. Rather, assessment results indicate that the most significant sediment contributions are from upstream channel banks, valley wall slopes, and from tributaries draining lands to the south. Therefore, any reductions in long-term sediment contributions to the South Tributary due to the development of the subject lands is not anticipated to pose any measurable or significant impact on sediment supply to the South Tributary.

Valley-wall slope failures due to slumping have also been identified as a potential erosion hazard risk along the South Tributary. Numerous slumps were mapped along the receiving water course, upstream and downstream of the proposed SWM Pond outlet location. However, with the exception of the slope failure at **1320 Grand-Chêne Court**, none of the slumps appear to have occurred since 2012. The cause of the aforementioned slope failure was attributed to a combination of top of slope fill placement and ongoing erosion at the toe of the valley slope at this location (Paterson 2023). To address slope stability issues along the receiving watercourse, the Paterson Group conducted a slope stability assessment to determine a geotechnical hazard setback along the north bank of the subject tributary. The assessment included a two-dimensional slope stability analysis of 23 slope cross-sections and was undertaken in accordance with the City of Ottawa's standard guidelines for slope stability assessments. A limit of hazard lands and setbacks were defined for the South Tributary and included both a 6 m erosion access allowance, a stable slope allowance (where required), and a 5 m toe erosion allowance. The toe erosion allowance of 5 m was determined in consultation between the Paterson Group and GEO Morphix and was based on an evaluation of the composition and configuration of the valley wall slopes along the subject watercourse.

Specifically, to address the erosion hazard at **1320 Grand-Chêne Court,** the primary recommended design element is a robust yet fish-friendly erosion protection measure along the slope toe. A bioengineered feature such as a vegetated rock revetment would provide the necessary mass (assuming stones are appropriately sized) and "hardness" for toe stability and improve near-bank cover with woody vegetation. Root wads and other similar structures installed at the embankment toe would also offer similar benefits. Such features should be installed along the full length of slope toe whether or not it is

currently in contact with flows. Moreover, the existing channel and flow alignments should be maintained to limit the area of disturbance. Extensive toe protection would address risks to the embankment due to future channel adjustments and changing contact points along the embankment toe.

Aggressive livestaking is proposed along the bank treatments to augment the long-term stability of the banks and to reduce erosion potential, as vegetation establishes. Livestaking will enhance near-bank aquatic habitat by providing shade, thereby helping to regulate water temperature. through shading. This shaded area will also provide refuge for fish. As a result of the design, flow velocity will be reduced during higher flows, and therefore, they can also provide refuge for fish during storms. Furthermore, the shrubs are a source of small organic debris and terrestrial insects and, therefore, provide foraging opportunities to fish and serve as an important food source for many aquatic organisms.

Additional design elements are recommended to address the erosion hazard along the valley slope above the vegetated rock revetment and below the slip. The remediation design would mitigate erosion potential along the slope by capturing and directing runoff to a stable outlet downslope while improving slope stability by incorporating bioengineering and a high density of woody plantings. The design would seek to limit any disturbance to the existing slope and avoid impacts to nearby trees to the maximum extent possible. Machinery access would be limited to the top of the slope, and some manual labor would be required along the lower portion of the slope.

Considering these constraints, installing a series of siltsocks (Filtrexx® SiltsocksTM, or equivalent) along the portion of the slope below the failure location is recommended. The slope below the failure location would be regraded by removal of the previously dumped fill originating from excavations during the development of the properties along Grand-Chêne Court, where feasible, back to original condition to create a level slope which ties into the existing adjacent valley walls. The silt socks will be sized to a specific diameter and staked in place with shade-tolerant live woody plantings, which will be spaced apart at a specified distance along each silt sock. The siltsocks will be filled with Growing MediaTM, or equivalent, to promote vegetation establishment. The siltsocks are to be embedded beneath the surface of the topsoil to help capture and distribute subsurface flow/runoff. Finally, the slope will be topped by a layer of compost spray with a specified thickness with MicroBlend® (or equivalent) and a woodland seed mix.

The proposed restoration activities will help alleviate pressure along the valley wall, control erosion along the slope face, and lower siltation levels in the watercourse through increased stabilization. The combination of slope and bank treatments will also benefit local fish communities.

7 Pre-Development Baseline Monitoring

Erosion monitoring is being undertaken to characterize existing conditions within the South Tributary to establish a baseline for comparison to post-development conditions. Changes in channel geometry captured by seasonally surveying monumented cross-sections are being used to determine the natural variability of geomorphic adjustments within a system. This approach will also document any existing erosion concerns and inform potential stabilization and restoration activities.

Monumented channel cross-sections have be installed and are being monitored annually during both fall and spring (following freshet conditions). Cross-section installations and re-surveying nclude the following tasks:

• Establish and survey monumented cross-sections to assess changes in channel and bankfull geometry over time

- Install and measure erosion pins at each cross-section (one in each bank) to assess erosion/deposition rates over time
- Characterize bank materials and stability at each cross-section
- Complete grain size analysis using the modified Wolman (1954) pebble count or a bed material sample at each monumented cross-section to assess changes in substrate composition over time
- Collect monumented photographs at each cross-section location

It is recommended that erosion monitoring activities be conducted for two years prior to initiation of development within the subject lands. Monitoring is schedule to occur twice a year, once during the spring and once during the fall during each monitoring season. Monitoring sites are dispersed within the reaches of the South Tributary, both upstream and downstream of the proposed development, to capture the variability of existing conditions and geomorphic adjustments within the system to be used as a reference for future monitoring efforts.

8 Summary and Conclusions

GEO Morphix Ltd. was retained by Tamarack Developments to complete a fluvial geomorphic and erosion threshold assessment in support of the proposed development at Cardinal Creek South Village, Ontario. This report summarizes the existing geomorphic conditions of the receiving system and provides recommendations to address the recent slope failure at **1320 Grand-Chêne Court**, an erosion threshold for the most erosion-sensitive channel reach, and recommendations for pre-development baseline monitoring.

The geomorphology of the South Tributary and the recent slope failure were assessed using a combination of desktop and field assessments. Previous studies on the South Tributary were reviewed to provide context for the current assessment. A desktop assessment, which included the analysis of two sets of high-resolution bare-earth digital elevation models, revealed the location of valley wall slumps and valley wall gullies within the study area. With the exception of the slope failure at **1320 Grand-Chene Court**, our assessment indicates that most of these features have developed at a time scale greater than that evaluated here through terrain analysis (i.e., approximately 10 years). The frequency of valley wall contacts with evidence of erosion and lateral migration was found to be higher in reach **R2** and **R3**, relative to **R2A**, which had a wider and more continuous floodplain along the valley. The density of valley wall slumps was also greater in reach **R2** and **R3**, indicating the potential link between channel and valley processes in valley wall slumps. Beaver activity within the South Tributary has historically impacted the geomorphology of the system and continues to impact contemporary geomorphology as well. The field assessment identified and confirmed features such as abandoned beaver dams, degraded watercourse crossings, and slumping along the valley slopes.

Both desktop and field assessments identified and confirmed evidence of a recent slope failure adjacent to **1320 Grand-Chêne Court** and documented channel and slope geomorphology at that location. Ongoing valley slope toe erosion throughout the South Tributary and at the location of the recent slope failure, in particular, was noted. Recommendations were provided to mitigate the impact that toe erosion may have on slope processes adjacent to the subject property.

The results of the detailed geomorphological assessment provided information relevant to the erosion threshold analysis. An erosion threshold, expressed as a critical discharge was determined for both the bed and bank materials within reach **R3** along the South Tributary and reach **C10** along the main channel of Cardinal Creek. Reach **R3** was selected based on field observations indicating the reach was the most susceptible to erosion along the receiving watercourse downstream of the proposed SWM outlet; an erosion threshold of 0.184 m³/s was determined for this reach. An erosion threshold was determined



for both the bank and bed materials within reach **C10**, and the lesser of the two values was chosen as the limiting discharge (i.e., $1.77 \text{ m}^3/\text{s}$). This reach was assessed as it is the first reach on the main channel downstream of the confluence with the South Tributary.

Analysis of the pre-to post-development hydrographs for reach **R3** demonstrate decreases in all erosion indicators, suggesting a reduction of erosion potential within the South Tributary under post-development conditions. Analysis of the pre- and post-development hydrographs for reach **C10** demonstrate negligible changes in all erosion indicators, suggesting limited changes in erosion potential within the main channel under post-development conditions. The stormwater management plan is thus not expected to exacerbate erosion within the South Tributary or the main channel of Cardinal Creek.

This assessment was developed and undertaken to provide guidance in the development of an appropriate SWM and erosion mitigation strategy for the proposed development located on the tableland to the north of the South Tributary and adjacent to reaches **R1**, **R1A**, and **R2**. Pre-development monitoring within the South Tributary was also initiated. Future reports will further summarize the results of ongoing baseline monitoring being conducted along the South Tributary.

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

Respectfully submitted,

Paul Villard, Ph.D., P.Geo., CAN-CISEC Jan Franssen, Ph.D Director, Principal Geomorphologist Senior Watershed Scientist

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Appendix A: Reach Delineation



M O R P H I X™

Tributary to Cardinal Creek





Appendix B: Historical Aerial Photographs













Location: Cardinal Creek South Tributary Year: 2011 Source: GEO Ottawa



Location: Cardinal Creek South Tributary Year: 2014 Source: GEO Ottawa



Location: Cardinal Creek South Tributary Year: 2021 Source: GEO Ottawa

Appendix C: Surficial Geology



Appendix D: Digital Terrain Analysis







Reach Break and ID Approximate Boundary of 1320 Grand-Chene Court

Appendix E: Georeferenced Photographic Inventory





Photo Locations

Tributary to Cardinal Creek

City of Ottawa

Legend



183

Ø

Corr Country Rd

Reach Break and ID



Watercourse

Approximate Boundary of 1320 Grand-Chene Court

Approximate Development Area





Imagery: City of Ottawa, 2021. Watercouse: OHN, 2021/GEO Morphix Ltd., 2023.Reach Break and ID: Parish, 2013/ GEO Morphix Ltd., 2024. Approximate Development Area: DSEL, 2022. Print Date: January 2024. PN23076. Drawn By: J.F., K.M., M.O., K.S.

Appendix F: Photographic Record














































Appendix G: Field Observations

ate:	2	023-11-2	8	Field Sta	ff:	KS KM			Watersh	ed/Subwat	ershed:	CAR	DINI	AL CRI	FEK_
ime:	*****	764		Stream:		CARDINA	LCRE	FKTRIB	UTM (Up	stream):			4		
/eather:	SI	UNACLOUD	-200	Reach:		RI			UTM (Do	wnstream)	:		andras and a strange	: }	
and Use 3	Valle (Tabl	le 2)	Channel (Table 3)	Туре	сі (т	hannel Zone Table 4)	FI (T	ow Type able 5)		Evidence of G	roundwa	ter Locat	ion:	<u> </u>	hoto:
iparian Veget	ation					Aquatic & I	nstream	Vegetatio	n		Wat	er Qual	ity		
ominant Type (Table 6) Encroachment	3/4	overage Channe None 1 Fragmented 4 Continuous 2	el Widths 4 10 > 10	Age (yrs) AImmature (Established □ Mature (>3	<5) (5-30) 0)	Type (Table 8) Reach	12 " 0 x	ody Debris In Cutbank In Channel Not Present	WD Density	WDJ/50m:		Odour (Table 16) 	Tu (Ta	rbidity able 17)
hannel Chara	teristics	1						•							
inuosity Type (Table 9)	1	Sinuosity Degree (Table 1	ee	Bank Ar □ 0 - 30	gle	Bank Erosion □ < 5%		Table 19) Bank	Clay/Silt	Sand Gi	ravel Co	obble E	Boulder	Parent	
Gradient (Table 11)	1	# of Channe (Table 1	2)	□ 30 - 6 □ 60 - 9	0 0	□ 5 - 30% □ 30 - 60%		Riffle Pool							
Entrenchment (Table 13)	1	Bank Failu (Table 1	re 4) 5	Under	cut	□ 60 - 100%	(i	Bed no riffle-pool morphology)	A			□ 			
(Table 15)	E	Bankfull Indicator (Table 18	rs 3) 1,5			Bankfull Width (m)	2.5	4,0		Wetted	Width (n) .(<		3.10	
Sed Sorting (Table 20)	WS	Sediment Transpo Observed	rt 🗆 Yes	No □ Not	Visible	Bankfull Depth (m)	0.40	0,80		Wetted	Depth (n	0.11		0.14	
ode (Table 21)		% of Bed Activ	ve 6			Undercuts (m)	/	10-1 (mil	Velo	city (m/s	5) 0.17.		D.144	
Geomorphic nits (Table 22)	10	Mass Moveme (Table 2	3) N/A			(m)	RUNS	EVNS	RVN	Meender	Metho	d shu		BALL TO.	STOL.
Spacing (m):	N/A	% Riffle	s: N/A	% Pools:	AIN	Riffle Length (m)	EVAS	EVIS	RIN	S	Amphtut (n		2	"MGAT	MA GH
tes:	. 000		<u> </u>	2									<u>, 1</u> 4		
CTRAIGHT	1 POOL AG. D	+EHIVKE	3												
SOFT SI	LTY D	ED EG (She MI	FRAFN	THEN	<i>E</i> 100	ENT DEN	(F						· · · · · · · · · · · · · · · · · · ·		
- KILLS F	RASP	FC SCOUR O	BSER JT AG	VED A FIEL	TT	HE DIS F	YTE	NT G OB	SERV	ED TH	POU	3HOU	the Charles		
THIN YE	6 81	FPER BET	WEER	V 146 1	ELEL	D + WHIE	1200	JRSE	6 12 -						
								- H							

Last edited: 04/04/2023

Gr

General Site Characteristics Project Number: 23076

Date:		202	3-11-28		Stream:				CHEDINAL PREFE TEIR
Time:		-			Reach:				R1
Weat	ner:	SUN 1	16- QUOLD	DC	Location:				DOLEHANS
Field	Staff:	KS	KW	- 2	Watershed	/Subwa	atershed	:	CARDINIAL CREE
Featu	res	Monitorin	0	Site	Sketch			State Lawrence State	
	Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree Woody debris Beaver dam Vegetated island	Monitorin Lor ↓ Mon ↓ Mon	g ng-profile numented XS numented photo ection diment sampling ision pins bur chains I Symbols	MEI 1 V 012Sr 0FSI	SUVMP SUVMP K Hation	× × × × × × × × ×	00000000000000000000000000000000000000	V V V V V V V V V V V V V V V V V V V	REACH BREAK-Compass RIA T BASAL SCOUR DENSE INSTREAM VEG T PILL
Flow T H1	ype Standing water H14	Back wat	er				8 8		SLUMP
H2 H3 H4 H5	Scarcely perceptible f Smooth surface flow Upwelling Rippled	low				W	B G	1	
H7 H8 H9 Substr	Broken standing wave Chute Free fall H9A ate	e Dissipate	s below free fall	ncil	NE	W	& & & &	₩~~	ACTIVE
S1 S2 S3 S4 S5 Other BM	Silt Sand Gravel Small cobble Large cobble	56 S S7 L S8 E S9 E	Small boulder Large boulder Bimodal Bedrock/till	KIPI	APIHN	N N	8	TX Y	K- MEHS 2
BS DS WDJ VWC	Backsight Downstream Woody debris jam Valley wall contact	RB R US U TR T FC F	Rebar Jpstream Ferrace	Gr htl	2BACEOUS		W N	Ŵ	NTHIN USM)
805	Bottom of slope	FP F	lood plain	Photo	S:	_			
TOS	Top of slope	KP K	Inick point	Notes					

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: ____ Completed by: _____

Page _____ of _____



Rapid Geomorphic Assessment

Project Number: 230740

Date:	28	-11-23	Stream:		3	OUTH TR	IB CAR	DINAL	CREEK
Time:	11:	15 AM	Reach:		R	ļ	-		
Weather:	OVE	ERCAST -7'C	Location:		C	ARDINAL	CREE	K VILL	AGE
Field Staff:	KS	KM	Watershed/Subwa	ate	rshed: Cf	TRDINAL	CRE	EK	
		Ge	eomorphological Indicator	•			Pres	ent?	Factor
Process	No.	Description					Yes	No	Value
	1	Lobate bar						1	
	2	Coarse materials in riffle	es embedded					1	
Evidence of	3	Siltation in pools					1		194
Aggradation	4	Medial bars						1	2/-
(AI)	5	Accretion on point bars			and the second			1	1 4
	6	Poor longitudinal sorting	of bed materials					1	
	7	Deposition in the overba	ank zone		· · · · · · · · · · · · · · · · · · ·		1		1
					Sum	of indices =	2	Б	0.286
	1	Exposed bridge footing(s)					NIA	
	2	Exposed sanitary / storr	m sewer / pipeline / etc.		a tana ang kanalan na sang kanalan sa			1	
	3	Elevated storm sewer of	utfall(s)						-
	4	Undermined gabion bas	kets / concrete aprons / e	etc.			and a second		
Evidence of	5	Scour pools downstream	n of culverts / storm sewe	er o	utlets			V	
Degradation	6	Cut face on bar forms						and the second s	0/6
	7	Head cutting due to knie	ckpoint migration		-			and the second s	
	8	Terrace cut through old	er bar material					and a second	
	9	Suspended armour laye	r visible in bank					and the second s	1
	10	Channel worn into undis	sturbed overburden / bed	roc	k			1	
	- L				Sum	of indices =	0	6	6
	1	Fallen / leaning trees /	fence posts / etc.					N.	
	2	Occurrence of large org	anic debris			0		and a set]
	3	Exposed tree roots						1]
	4	Basal scour on inside m	eander bends					and the second second	
Evidence of	5	Basal scour on both side	es of channel through riffl	le			×		
(WI)	6	Outflanked gabion bask	ets / concrete walls / etc.					NIA	
()	7	Length of basal scour >	50% through subject read	ch		_	_	1	0/0
	8	Exposed length of previ	ously buried pipe / cable ,	/ et	c.			1	6,
	9	Fracture lines along top	of bank					1	
	10	Exposed building foundation	ation					NIA	
					Sum	of indices =	0	8	0
	1	Formation of chute(s)							
	2	Single thread channel to	o multiple channel		<u> </u>]
Planimetric	3	Evolution of pool-riffle f	orm to low bed relief form	n					2,
Form	4	Cut-off channel(s)							-17
Adjustment	5	Formation of island(s)] .
(P1)	6	Thalweg alignment out	of phase with meander fo	orm	-				
	7	Bar forms poorly forme	d / reworked / removed				\backslash		
					Sum	of indices =	2	5	0,286
Notes:				St	ability Index	(SI) = (AI	+DI+WI	+PI)/4 =	0,143
					In Regime	In Transi	tion/Str	ess In A	djustment
				M	0.00 - 0.20	0.2	21 - 0.40		0.41

Rapid Stream Assessment Technique Project Number: 23076

Date:	28-11-23	Stream:		SOUTH TRIB	CARDINAL CREEK	
Time:	11:15 AM	Reach:		RI	al-an haddel	
Weather:	OVERCAST -7'C	Location:		CARDINAL C	REEK VILLAGE	
Field Staff:	KS KM	Watershed/Subwate	rshed:	CARDINAL	CREEK	
Category	Poor	Fair		Good	Excellent	
olon a foran yo ni fora (1997) Garafi m	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughin failure 	of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 	
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer bi m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) rerhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 	
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predom large, si scarce 2-3 rece per stree 	l tree roots inantly old and maller young roots ent large tree falls am mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 	
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	Bottom generall plant/sc	1/3 of bank is y highly resistant il matrix or material	Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material	
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	• Channe general	Lcross-section is y V- or U-shaped	 Channel cross-section is generally V- or U-shaped 	
Point range		030405		07 0 8	0 9 0 10 0 11	
	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% embedded (35- 59% embedded for large mainstem areas)		 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 	NI,
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	Moderat pools Pool sub 30-59%	te number of deep ostrate composition o sand-silt	 High number of deep pools 61 cm deep) 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 	
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Streaml and/or ` sedimer uncomn 	oed streak marks 'banana"-shaped nt deposits non	Streambed streak marks and/or "banana"-shaped sediment deposits absent	
	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, la uncomm Small lo fresh sa top of lo 	arge sand deposits non in channel ocalized areas of ind deposits along ow banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 	
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	Point ba well-veg armoure fresh sa	ars small and stable, getated and/or ed with little or no nd	• Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand	
Point range				5 04 6	0708	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: ______ KS____

GEO MORPHIX*

Date: 29	-11-23	PN: 23076	Location: 5	OUTH TRIB CARDINAL]
Category	Poor	Fair	Good	Excellent]
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffle and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 s Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 	NIA
Habitat	Riffle depth < 10 cm for large mainstem areas	 Riffle depth 10-15 cm for large mainstem areas 	• Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas 	NIA
nton se 1. Maria - Maria Maria Maria - Maria - Maria	Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	 Large pools generally 30 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structur 	 Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure 	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	
	 Extensive channel alteration and/or point bar formation/enlargement 	 Moderate amount of channel alteration and/o moderate increase in point bar formation/enlargement 	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	 No channel alteration or significant point bar formation/enlargement 	
	 Riffle/Pool ratio 0.49:1 ; ≥1.51:1 	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1	
	 Summer afternoon water temperature > 27°C 	 Summer afternoon wate temperature 24-27°C 	 Summer afternoon water temperature 20-24°C 	 Summer afternoon water temperature < 20°C 	NIA
Point range		034	0506	0708	
	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Ouality	 Brown colour TDS: > 150 mg/L 	Grey colour TDS: 101-150 mg/L	Slightly grey colour TDS: 50-100 mg/L	Clear flowTDS: < 50 mg/L	
	 Objects visible to depth < 0.15m below surface 	Objects visible to depth 0.15-0.5m below surface	Objects visible to depth 0.5-1.0m below surface	 Objects visible to depth > 1.0m below surface 	
	Moderate to strong organic odour	 Slight to moderate organic odour 	• Slight organic odour	• No odour	
Point range		0304	₫4506	0708	
Riparian Habitat	Narrow riparian area of mostly non-woody vegetation	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	Canopy coverage: <50% shading (30% for large mainstem areas)	Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	 Canopy coverage: >80% shading (> 60% for large mainstem areas) 	
Point range	0 0 1	₫ 2 🗆 3	0405	0607	
Total overall	score (0-42) = ZA	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS____

	L CREEK	CARDINA	ed/Subwatershed:	Watersh		KS KM	Field Staff:		28-11-23		Date:
		N /	stream):	KUTM (Up:	RDINAL CREE	SOUTH TRIB OF	Stream:				Time:
			wnstream):	UTM (Do		RIA	Reach:	-2.0	SUN-CLOUD		Neather:
/	/ Photo:	er Location:	vidence of Groundwate		Flow Type (Table 5)	able 4)	Туре) 12 (т	Channel (Table 3)	alley Type 3	,3 Vi	Table 1)
		r Quality	Wate	on	am Vegetatio	Aquatic & Instr				etation	liparian Vege
>	Turbidity (Table 17)	Odour Table 16)	WDJ/50m: (1	WD Density	Woody Debris	Type (Table 8) Reach	Age (yrs) □ Immature (<5) ℡ Established (5-30) □ Mature (>30)	nel Widths 1 - 4 [4 - 10] > 10 [Coverage Channe □ None □ 1 □ Fragmented 5 4 S(Continuous □ >	4	Dominant Type (Table 6) Encroachment (Table 7)
					Li Not Fresent	Coverage %			tics	acterist	Channel Char
otlets	Parent Roo	ble Boulde	Sand Gravel Cob	Clay/Silt	(Table 19) Bank	Bank Erosion	Bank Angle	ree	Sinuosity Degre (Table 10	2	Sinuosity Type (Table 9)
					Riffle Pool	□ 5 - 30% □ 30 - 60%	□ 30 - 60 □ 60 - 90	els 12)	# of Channel (Table 12	1.	Gradient (Table 11)
				×	Bed (if no riffle-pool morphology)	□ 60 - 100%	□ Undercut	1re (4) 2,5	Bank Failur (Table 14	1	Entrenchment (Table 13)
٢	0.80 1.80	1.4	Wetted Width (m)	2.5	0.02	Bankfull Width (m)		8)	Bankfull Indicators (Table 18	u	Down's Model (Table 15)
3	0.35 0.13	0.27	Wetted Depth (m)	0,55	1.0	Bankfull Depth (m)	No Not Visible	d? Ves	Sediment Transpor Observed	WS	Sed Sorting (Table 20)
2	2,65 0.98	3.82	(0.30) Velocity (m/s)	/	0 /	Undercuts (m)	ENCROUCH	ve ()	% of Bed Activ	\geq	Transport ode (Table 21)
			Velocity Estimate Method	/	· _	Pool Depth (m)	RUNS 100%	nt (3)	Mass Movemen (Table 23	4	Geomorphic nits (Table 22)
- 80 - 14 - 14	/ /	/	Meander Amplitude (m)			Riffle Length (m)	% Pools:	es:	% Riffles	1	Riffle-Pool Spacing (m):
OUR	IDERS. BAN END OF DED AND E WATERCI	R MEAN IN WS IN ERO TIL TH	ME IRREGULA CHANNEL WII T HAS BEE ICE DIS UN	ER. 30 DE OF A THA DISTAN INS.	VEG COV ETHER SI ER DAM ASES W .Z BEG	D HERBACEOUS ND LOW ON I ISTORIC BEAN DEMENT INCRE WHERE F	I MEADOW TO IS FLAT AN GINS AT H AND CONFIN ST VALLEY	H OPEN >PLAIN CH BEG DKOPS FORES	LOWS THROUGH NED, FLOOD D OF REAC CLEVATION D CONFEROUS	EL FI DEFI S EN T. E A C	tes: CHANN OT WELL- ZEACH, W UNDERCUS ENTERS
<u>, e</u>											otos:

Version #4 Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS___

General Site Characteristics

Project Number: 23076

Date:		2023-11-28		Stream:	CHEDINAL CREEKTER
Time:		-		Reach:	KIA
Weath	ier:	SUN+CLOUD -20	x?	Location:	ORLEANS
Field S	Staff:	KS KM	~	Watershed/Subwatershed:	CAPDINAL COFFE
Partic			C :+		
reatur	Reach break		SIC	e sketch / PEACH	Compass
一 只	Station location	Monumented XS		E BREAK	
<u>х</u> х	Cross-section	O Monumented photo			
>	Flow direction	Monumented photo	XA	LLEY BEG.	W V-
\sim	Riffle				
\bigcirc	Pool	Sediment sampling		V. X-	X-meAS3
CITED .	Sediment bar	Erosion pins			
+++++++++++++++++++++++++++++++++++++++	Eroded bank/slope	Scour chains		NV NV I	
	Undercut bank	Additional Symbols		* 30*	
XXXXXX	Bank stabilization		H	ISTORIC -> REPART	
	Leaning tree		B	EAVER DAM	
XX	Fence		VN	DEPCUTTHPU	
	Culvert/outfall		RI	MOM OISSIN	N N
	Swamp/wetland			101	Partial insters-
WWW	Grasses		No.		titial flow
Eur I	Tree		- <u>1</u>		
	Instream log/tree				JK W
***	woody debris				Nr m
A A	Vegetated island				K CATURATED
Flow T			n.	NY V NY	10
H1	Standing water H1A	Back water			MEAC2
H2	Scarcely perceptible f	low	1		
НЗ	Smooth surface flow				
H4	Upwelling		8		
H5	Rippled		NI		
H6	Unbroken standing w	ave		PECTHONOR	
H7	Broken standing wave	e		CHREEFEC	
H8	Chute			NI MANNET	MEADOW
H9	Free fall H9A	Dissipates below free fall	<u> </u>	NY Y' W	Ar
Substr	rate	aa a <u><u><u><u></u></u></u></u>			
51	Slit	50 Smail Doulder	Mar	NEG THENT.	
52	Sana	SP Bimodal		ELICKONCOME LAN	W MENS
33	Small cobbio	SO Bedrock/till		W W .	
54		SS Beurock/un		X/	TAL
Other	Large cobble				1 Al Al
BM	Benchmark	EP Erosion pin		, 1/	
BS	Backsight	RB Rebar		NIZ IM T A	
DS	Downstream	US Upstream		Vr r Al	V
WDJ	Woody debris jam	TR Terrace			
vwc	Valley wall contact	FC Flood chute		RIV	AG DEATN
BOS	Bottom of slope	FP Flood plain	Pho	tos:	
TOS	Top of slope	KP Knick point	Note	es:	

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: VS___ Completed by: KM____

Page _____ of _____

Rapid Geomorphic Assessment Project Number: 23076 Date: 28-11-23 Stream: SOUTH TRIB CARDINAL CREEK Time: 11:30 AM Reach: RIA Weather: OVERCAST - 5 °C Location: CARDINAL CREEK VILLAGE **Field Staff:** KS KM Watershed/Subwatershed: CARDINAL CREEK Geomorphological Indicator Present? Factor Process Value No. Description Yes No 1 Lobate bar 2 Coarse materials in riffles embedded 3 Siltation in pools 2/7 Evidence of Agaradation 4 Medial bars (AI)5 Accretion on point bars 6 Poor longitudinal sorting of bed materials 7 Deposition in the overbank zone 2 5 Sum of indices = 0.286 1 Exposed bridge footing(s) N/A 2 Exposed sanitary / storm sewer / pipeline / etc. 3 Elevated storm sewer outfall(s) 4 Undermined gabion baskets / concrete aprons / etc. Evidence of 5 Scour pools downstream of culverts / storm sewer outlets Degradation °15 6 Cut face on bar forms (DI) 7 Head cutting due to knickpoint migration 8 Terrace cut through older bar material 9 Suspended armour layer visible in bank 10 Channel worn into undisturbed overburden / bedrock 6 C Sum of indices = 5 1 Fallen / leaning trees / fence posts / etc. 2 Occurrence of large organic debris 3 Exposed tree roots Basal scour on inside meander bends 4 Evidence of 5 Basal scour on both sides of channel through riffle Widening 6 Outflanked gabion baskets / concrete walls / etc. (WI)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 NIA Sum of indices = 1 0.143 1 Formation of chute(s) 2 Single thread channel to multiple channel Evidence of Evolution of pool-riffle form to low bed relief form 3 Planimetric Form Cut-off channel(s) 4 Adjustment 5 Formation of island(s) (PI) 6 Thalweg alignment out of phase with meander form Bar forms poorly formed / reworked / removed 7 Sum of indices = (0) 0.143 Notes: Stability Index (SI) = (AI+DI+WI+PI)/4 = 0,143 **In Regime** In Transition/Stress In Adjustment 0.00 - 0.20 0.41 0.21 - 0.40

Senior staff sign-off (if required): ______ Checked by: _K___ Completed by: _K___



Rapid Stream Assessment Technique Project Number: 2307-10

Date	19-11-72	Stream	SOUTH TOIR CARDINAL COFFE					
Time	11:20 11	Beach		DUVIN TRIB	UNKDINAL CKEEK			
Mosthow	ULODANI E'C	Leastien.		RIA				
Field Staff	VERUASI -D	Watershed (Subwate	rehodi	CARDINAL CA	REEK VILLAGE			
Field Staff.	no nm	watersned/Subwate	rsneu:	CARDINAL	REEK			
Category	Poor	Fair		Good	Excellent			
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infrequence sloughin failure 	of bank network ent signs of bank g, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 						
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predomi large, sr scarce 2-3 rece per streat 	tree roots nantly old and naller young roots ant large tree falls am mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 			
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	• Bottom generall plant/so	1/3 of bank is y highly resistant il matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 			
	 Channel cross-section is generally trapezoidally- shaped 	Channel-cross-section is generally trapezoidally- shaped	 Channel generall 	cross-section is y V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range	00102	030405		ğı 7 🗆 8	0 9 0 10 0 11			
04-19-19 04-19-19 09-09	 > 75% embedded (> 85% embedded for large mainstem areas) 	dded (> led for large eas) + 50-75% embedded (60- 85% embedded for large mainstem areas) + 25-49% embedded (35- 59% embedded for large mainstem areas) + Riffle embeddedness 59% embedded for large mainstem areas) + Riffle embeddedness 25% sand-silt (< 35% embedded for large mainstem areas) + Riffle embeddedness 25% sand-silt (< 35%						
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	 Moderat pools Pool sub 30-59% 	e number of deep strate composition sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streamb and/or " sedimen uncomm 	oed streak marks banana"-shaped it deposits non	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	N		
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, la uncomm Small lo fresh sa top of lo 	arge sand deposits ion in channel calized areas of nd deposits along w banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 			
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	Imon, arge and high sh sand• Point bars small and stable, well-vegetated and/or armoured with little or no fresh sand• Point bars few, small a stable, well-vegetated and/or armoured with or no fresh sand					
Point range								

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: ______

Version #2 Last edited: 10/02/2023

Date: 28	-11-23	PN: 23076	Location: පි	OUTH TRIB CARDINAL
Category	Poor	Fair	Good	Excellent
	Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)	Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	 Dominated by one habitat, type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffle and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble
Habitat	• Riffle depth < 10 cm for large mainstem areas	 Riffle depth 10-15 cm for large mainstem areas 	• Riffle depth 15-20 cm for large mainstem areas	Riffle depth > 20 cm for large mainstem areas
	Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	Large pools generally 30 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	 Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure 	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	 Extensive channel alteration and/or point bar formation/enlargement 	 Moderate amount of channel alteration and/o moderate increase in point bar formation/enlargement 	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	 No channel alteration or significant point bar formation/enlargement
	 Riffle/Pool ratio 0.49:1 ; ≥1.51:1 	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1
	 Summer afternoon water temperature > 27°C 	 Summer afternoon wate temperature 24-27°C 	• Summer afternoon water temperature 20-24°C	 Summer afternoon water temperature < 20°C
Point range	0 0 1 0 2	₫ 3 □ 4	0506	0708
	 Substrate fouling level: High (> 50%) 	Substrate fouling level: Moderate (21-50%)	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)
Watar Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	Stightly grey colour TDS: 50-100 mg/L	Clear flow TDS: < 50 mg/L
water Quality	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surfaction 	Objects visible to depth 0.5-1.0m below surface	Objects visible to depth > 1.0m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	• No odour
Point range	0 0 1 0 2	□ 3 □ 4	□ 5 □ 6	547 🗆 8
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	 Wide (> 60 m) mature forested buffer along both banks
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	Canopy coverage: 50- 60% shading (30-44%) for large mainstem areas)	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	 Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	001	2 3	⊠ 4 □ 5	0607
Total overall s	core (0-42) = 2 7	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)

Senior staff sign-off (if required): _____ Checked by: KS

ate:		2023-11-28	r 9	Field Sta	ff:	KS + KA	٨			Wat	ershe	d/Subwa	tershed	: (A	RDIN	JAL C	PEE
me:				Stream:		Cardina	l Cre	eK	Tub	UTM	l (Ups	tream):			B. 95.		
eather:		SUNTCLOVE) - 30	Reach:		R2				UTM	I (Dow	nstream	ı):				
and Use 1)	З <mark>Va</mark> (Ta	ible 2)	t hannel Table 3)	Туре	3 Cha	ble 4)	Z (1	l ow ' Table	Type 5)	۱	E E	vidence of	Groundwa	ater Loc	ation: <u>1</u> 4	Roughking	Photo:
parian Vegeta	ation					Aquatic & I	nstream	n Ve	getatio	on			Wa	ter Qua	ality		
minant Type (Table 6)		Coverage Channel V	Widths 4	Age (yrs) ∃ Immature (<	<5)	Type (Table 8)	JIA W	oody In Cu	Debris utbank		ensity W	WDJ/50m:		Odou (Table :	16)		Turbidity (Table 17)
(Table 7)	2	□ Fragmented	10 t 0 t	Established (Mature (>30	(5-30)))	Reach Coverage %		In Cl Not I	hannel Present	□ Mo	d h	1-2		1			2
annel Charac	teristi	CS															
nuosity Type (Table 9)	2,3	Sinuosity Degree (Table 10)	Э	Bank Ang □ 0 - 30	gle	Bank Erosion □ < 5%		(Tabl	e 19) Bank	Clay	/Silt	Sand (Gravel C	obble	Boulde	r Paren	t Roo
Gradient (Table 11)	2	# of Channels (Table 12)	1	30 - 60)	□ 5 - 30%		F	Riffle	X		A	X	X	A	X	1
trenchment (Table 13)	1-2	Bank Failure (Table 14)	1,2	Underci	ut	0×60 - 100%	х (if no rifi morp	Bed fle-pool holoay)	-9							
(Table 15)	Μ	Bankfull Indicators (Table 18)	1,3			Bankfull Width (m)	5,00		10.0) <i>></i>	5,00	Wetted	l Width (n	n) 1,2	S	1,15	2,10
Sed Sorting (Table 20)	PS	Sediment Transport Observed?	□ Yes		Visible	Bankfull Depth (m)	0.77		0170		0.75	Wetted	Depth (r	n) (),()	B	6,08	0.11
Transport de (Table 21)	\searrow	% of Bed Active	/	-		Undercuts (m)	0.30	X	0.60		0.26	Vel	ocity (m/	s) 4,41	(1)	1.55(17	10.39(
Geomorphic its (Table 22)	5,6	Mass Movement (Table 23)	4	olo RANS	30	Pool Depth (m)	0.19		0.21		6,23	Veloc	ity Estima Metho	od WB		WB	NB
Riffle-Pool Spacing (m):	15.0	% Riffles:	30	% Pools:	30	Riffle Length (m)	1510		6.00		10.0	Meande	r Amplitue (r	de n) 819	3	8.7	
es:	9 A.			1		Ę.						100	WAVE	ENG	14: 8:00	200 . 15.	Owa
- MOVED	VIS.	PRACH BREAK D	MMIST	EAM		-MANY BO	NDE	es/	COBB	LES	IN S	TREAM	1 12 50	y 2 2	See Sin p		
- SILIN	MINN	IN POOLS - (L	17 751	LT + PEBS	10 70	-VWC FRE	GUER	11		- EX	POSE	DTRE	E Ros	51% (ALL +	iges)	FREQU
- CIA	Y COI	NGLOMERATES	1000	FCIAN	GLAC	LES TILL (CORRI	ES.	- BAL	IL DE	ERCI	+ CDA	APACT	CIA		1 000	NPRICE
- SMP	ILL S	SCALE MASS A	AOVEN	IENT (P	NOTATION	AL SLIDE) OE	SV IN	Je	SOME	LOC	ATTIC	ins u	THERE	CH4	INNE	LIS	N
CON	TACT	- W VALLEY	WAL					(d			21. 191	17	n de la compañía de la	<u></u>			
× SI		7-07-77 5	100	Alexand	Env	O PONIOS	ATA	4				- OFA	<u>ail 1.</u>	De .	ACCE	FOFD	CAL
os: THA	TD	ATE. OBSER	ATTO	NS ON	THIS	SHEET P	ERTA	IN	TO	US	HAI	F FR	LOM V	RIA	TO	71 00	NFUE
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CREEK

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General Site Characteristics

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Project Number: 2307(0

Date: 3023-11-28 CARDINALCREEKTRIB Stream: Time: R2 **Reach:** -200 SUN + CLOUD Weather: Location: ORLEANS KS KM Field Staff: CARDINAL Watershed/Subwatershed: Features Monitoring Site Sketch Reach break -o-o-o- Long-profile 只 Station location Monumented XS Cross-section Monumented photo 0 Flow direction Monumented photo ~~ Riffle direction 10W F Pool Sediment sampling CONTRO Sediment bar Erosion pins PANINE ####### Eroded bank/slope 8 Scour chains ----Undercut bank **Additional Symbols** VEG BARS **XXXXXX** Bank stabilization ->>>> Leaning tree x----x Fence MEAS3 Culvert/outfall 1 \bigcirc Swamp/wetland VVV Grasses 3 Tree Instream log/tree * * * Woody debris *XXXXX Beaver dam MEAS 2 VU VV Vegetated island **Flow Type** RIFFLE - POOL SEQUENCES H1 Standing water H1A Back water H2 Scarcely perceptible flow НЗ Smooth surface flow Upwelling H4 H5 Rippled H6 Unbroken standing wave H7 Broken standing wave H8 Chute MEAS H9A Dissipates below free fall Free fall H9 Substrate Silt Small boulder **S1 S6 S7 S2** Sand Large boulder **S**3 Gravel **S**8 Bimodal 0 UPILEY MAL **S4** Small cobble **S9** Bedrock/till BOULDERS **S**5 Large cobble N CHANNES Other 0 BM Benchmark EP Erosion pin a BS Backsight RB Rebar DS Downstream US Upstream WDJ Woody debris jam Terrace TR VWC Flood chute Valley wall contact FC BOS Bottom of slope FP Flood plain Photos: TOS Top of slope KP Knick point Notes:

Version #4 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: _____ Completed by: <u>XM</u>

Page _____ of _____

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Decels Charge	atorio		oioct Nu	mbor	2307	(0												MORPHIX
Ceach Charac		2023-	07-12	iniber.	Field Sta	ff:	KMIKS				Wate	ershed	l/Subw	atershe	ed: Ca	rdin	al cr	rek
Fime:		10:15 AN	1	8	Stream:		Cardin	011	ree	K-tik	UTM	(Upst	ream):		45	. 497	946,-	75. 45320
Neather:		Sunna	, 270	°C	Reach:		R2				UTM	(Dow	nstrear	n):				
Land Use		alley Type	2 (1	hannel able 3)	Туре	, Ch (Ta	annel Zone	3	Flow (Table	Type 5)	1] 🗆 Ev	idence of	Ground	water Loc	ation:	[Photo:
	tation						Aquatic &	Instre	am Ve	getatio	on			W	/ater Qu	ality		
Dominant Type (Table 6)	114	Coverage	Channel W	Vidths A 4 C 10 B	Age (yrs) I Immature (• I Established	<5) (5-30)	Type (Table 8) Reach	1	Woody In C In C	Debris utbank hannel		nsity	VDJ/50m 2-3		Odou (Table	IF 16)	דו (ד 	able 17)
(Table 7)	10	Continuou	s 🖾 > 10	0]	Mature (>30	"	Coverage %	~~		Present						and the second		
Channel Chara	cteris	tics							/= 1	- 10)	Chara (C:14	Cand	Currunal	Cabble	Pouldor	Daront	Pootlete
Sinuosity Type	512	Sinuosi	(Table 10)	2	Bank An	gle	Bank Erosion □ < 5%		(Tab	Bank		Silt		Gravei				
(Table 9) Gradient (Table 11)	2	_ # of	(Table 10) f Channels (Table 12)		□ 30 - 6))	□ 5 - 30% □ 30 - 60%			Riffle Pool	M M				A D			
Entrenchment (Table 13)	- transfer	Ba	nk Failure (Table 14)	6/2	Under	ut	¥ 60 - 100%	XSI	(if no ri mor	Bed ffle-pool phology) X	52	x 53		Ņ	Ø Ks		XS2	x53
Down's Model (Table 15)	du	Bankfull I	Indicators (Table 18)	1/5/7			Bankfull Widt (m	h 14.5	57	5		3	Wette	d Width	(m) 2,1	7	1.25	0,75
Sed Sorting (Table 20)	·M	Sediment	Transport Observed?	🗆 Yes	No 🗆 Not	Visible	Bankfull Dept (m	h) 0,5	.6	6,75		0.69	Wette	d Depth	(m) එර)36	0,183	0.12
Transport Mode (Table 21)	3	% of I	Bed Active	NIA			Undercuts (m	0.4	3	0.13		NA	Ve	elocity (r	m/s) ().	9	0.29	0.07
Geomorphic Units (Table 22)	5/6/8	Mass	Movement (Table 23)	a contraction of the second se			Pool Dept (m	n) 0,1<	b xsi	0183		NA	Velo	ocity Esti Me	mate Wi ethod Bp			
Riffle-Pool Spacing (m):	3-10		% Riffles:	30	% Pools:	60	Riffle Length (m) 5		ŅĄ		2	Meand	er Ampli	(m) 7	8	NA	~10
Notes: V: D=1M	~~ ´	ALON	G BED	THRO	ughove,	FINEL	Y LAMINATE	DCL	91 E.	XPOSE	ED P	<u>r si</u>	OPE T	OE. N	IULTIPL	E SEC	TIONS (N BOULDEP
V: D2-IM	2	Va Pa:	=IM															
$T_2 = 3.6$	555	T3	=13.54s									ġ						
Photos:				******				v							1. georg			
/ersion #4	*****						Se	enior st	aff sigr	n-off (if	requir	ed):		Checke	ed by:	(Completed	by:

Version #4 Last edited: 04/04/2023

There bure many

Rapid Stream Assessment Technique Project Number: 230710

Date:	12023-07-12	Stream:		Condina	Creek Trib	
Time:		Reach:		R2		
Weather:	Eunny 78°C	Location:		Arleans		
Field Staff:	KMIKS	Watershed/Subwate	rshed:	Cardina	1 monto	
Category	Poor	Fair		Good	Excellent	
no de Eliterio Antonio de Carlos Storio Res	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughin failure 	of bank network ent signs of bank g, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 	
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer ba m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) erhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 	
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	 Exposed predomi large, sr scarce 2-3 rece per streat 	tree roots nantly old and naller young roots ant large tree falls am mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 	
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	ottom 1/3 of bank is enerally highly erodible naterial lant/soil matrix pmpromised			
7-1	 Channel cross-section is generally trapezoidally- shaped 	Channel cross-section is generally trapezoidally- shaped	 Channel generall 	cross-section is y V- or U-shaped	 Channel cross-section is generally V- or U-shaped 	
Point range	00112	030405	06	0708	□ 9 □ 10 □ 11	
	 > 75% embedded (> 85% embedded for large mainstem areas) 	50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% em mainstei	embedded (35- bedded for large n areas)	 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 	
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	 Moderation pools Pool sub 30-59% 	e number of deep strate composition sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 	
Channel Scouring/ Sediment Deposition	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streamb and/or " sedimen uncomm 	ed streak marks banana"-shaped t deposits on	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	
	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, la uncomm Small loo fresh san top of loo 	rge sand deposits on in channel calized areas of nd deposits along w banks	 Fresh, large sand deposits rare or absent from channe No evidence of fresh sediment deposition on overbank 	
6) 7 22 10 10 10 10 10 10	• Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point bar well-veg armoure fresh sar 	rs small and stable, etated and/or d with little or no nd	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by:

РНІХ"

Date: 20	23-07-12	PN: 23070	Location: (neans		
Category	Poor	Fair	Good	Excellent		
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	 Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 		
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 		
Habitat	• Riffle depth < 10 cm for large mainstem areas	 Riffle depth 10-15 cm for large mainstem areas 	 Riffle depth 15-20 cm for large mainstem areas 	 Riffle depth > 20 cm for large mainstem areas 		
	Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	• Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure		
	Extensive channel alteration and/or point bar formation/enlargement	Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	No channel alteration or significant point bar formation/enlargement		
	 Riffle/Pool ratio 0.49:1 ; ≥1.51:1 	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1		
NIA	NIA • Summer afternoon water temperature > 27°C • Summ		Summer afternoon water temperature 20-24°C	 Summer afternoon water temperature < 20°C 		
Point range	000102	3 0 4	0506	0708		
	Substrate fouling level: High (> 50%)	 Substrate fouling level: Moderate (21-50%) 	 Substrate fouling level: Very light (11-20%) 	• Substrate fouling level: Rock underside (0-10%)		
Water Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	 Slightly grey colour TDS: 50-100 mg/L 	Clear flow TDS: < 50 mg/L		
Water Quality	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surface 	• Objects visible to depth 0.5-1.0m below surface	Objects visible to depth > 1.0m below surface		
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	 Slight organic odour 	• No odour		
Point range	0 0 1 0 2	0304	0506	0708		
Riparian Habitat Conditions	 Narrow riparian area of mostly non-woody vegetation Riparian area predominantly woode but with major localit gaps 		 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks		
	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)		
Point range	001		0405			
Total overall s	score (0-42) = 3,2	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)		

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KM/KS

Rapid Geom	orph	ic Assessment	Project Numb	er: 230	710			мокрніх"	
Date:	2	123-17-12	Stream:		Cardena	al mo	ok -	trih	
Time:		<u> </u>	Reach:		R2	<u> </u>	L. C.	1110	
Weather:	C.	MM11 2800	Location:		Arleav	77			
Field Staff	01	IN VE	Watershed (Cubu	unterrals of t	Contralin	1.5	Pro er	. 6	
rielu Stall;	K	MIN	watersneu/Subw	/atersneo:	Caran	na	UNU		
Process		Geomorphological Indicator						Factor	
	No.	Description					No	Value	
	1	Lobate bar	X						
	2	Coarse materials in riffles		X					
Evidence of	3	Siltation in pools		X		n 857			
Aggradation	4	Medial bars	X.		0.02.				
(AI)	5	Accretion on point bars	X.						
	6	Poor longitudinal sorting	of bed materials			\square		_	
	7	Deposition in the overbar	ik zone	www.configuration.com		X			
				Su	m of indices =	6		<u> </u>	
	1	Exposed bridge footing(s)	NA						
	2	Exposed sanitary / storm	sewer / pipeline / etc.		NIA				
	3	Elevated storm sewer out	NIA			_			
	4	Undermined gabion bask	NIA						
Degradation	5	Scour pools downstream	d'		0.400				
(DI)	6	Cut face on bar forms		X					
	7	Head cutting due to knick			<u>X</u>				
	8	Terrace cut through older	·		Δ				
	9	Suspended armour layer		<u> </u>					
	10	Channel worn into undist	urbed overburden / bec	Irock		X.	0		
L		-		Su	m of indices =	a,	3		
	1	Fallen / leaning trees / fe	Χ,	-	0.857				
	2	Occurrence of large organ	X						
	3	Exposed tree roots	X						
Evidence of	4	Basal scour on inside mea	X						
Widening	5	Basal scour on both sides	X						
(WI)	6	Outflanked gabion basket							
	7	Length of basal scour >5	X		,				
	8	Exposed length of previou							
	9	Fracture lines along top o		<u> </u>					
-	10	Exposed building foundat	1 -	1					
[1	1		Su	n of indices =	0		<u> </u>	
	1	Formation of chute(s)		<u> </u>	0.280				
Evidence of	2	Single thread channel to		<u> </u>					
Planimetric	3	Evolution of pool-riffle for		Δ					
Form	4	Cut-off channel(s)		<u> </u>					
(PI)	5	Formation of island(s)		<u> </u>					
	6	Thalweg alignment out of	\triangle	9 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1					
	7	Bar forms poorly formed	LĂ -	-					
				Su	n of indices =	'd	2	<u> </u>	
Notes: See q.	enerc	al reach charact	enstics	Stability Inde	x (SI) = (AI	+DI+WI+	PI)/4 =	0.60	
				In Regime	In Transi	tion/Stres	ss In A	djustment	
				0.00 - 0.2	0 🗆 0.2	21 - 0.40	T	1 0.41	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

.

Gen	eral Site Cha	racte	ristics	Proj	ect Number: 2307/6		MORPHIX"	
Date:		2023-07-12			Stream:	CONDINAL CHOOK		
Time:		10:15 AM			Reach:	R2		
Weather:		G	Same Pole		Location	NZ NILBOUR		
Field Sheff		V	SVIM CON			O n (a)	1)	
				Watershed/Subwatershed:	Cara	na creek		
Featu	res	Monito	ring	Site	Sketch		Compass	
	Reach break	-0-0-0-	Long-profile		X XS	2	\bigcap	
×	Station location		Monumented XS	······	T, is		()	
	Cross-section	Q	Monumented photo		/) ·/			
\sim	Riffle		direction		flor			
\bigcirc	Pool		Sediment sampling		(6)	>DK0	P? 0.35M	
CITED .	Sediment bar		Erosion pins					
+++++++++++++++++++++++++++++++++++++++	Eroded bank/slope	8	Scour chains		(@/			
	Undercut bank	Additio	nal Symbols		15		en e	
XXXXXX	Bank stabilization				12			
	Leaning tree				1(38)			
XX	Fence							
	Culvert/outfall							
\bigcirc	Swamp/wetland							
VVV	Grasses).)			
	Tree							
	Instream log/tree				5	R		
A A X	Boavor dam				<pre></pre>		n in the second second second second	
WW	Vegetated island				1/10/1			
Flow T	vegetated isiand	Anterior de						
H1	Standing water H1	A Back w	vater		1 100/			
H2	Scarcely perceptible	flow						
НЗ	Smooth surface flow	•				292		
H4	Upwelling		. n.			Non Alexandre		
H5	Rippled				\$ 8 ² 7	10gg	•	
H6	Unbroken standing v	vave			eality	21		
H7	Broken standing way	/e			1			
H8	Chute							
Substr	Free fall H9	A Dissip	ates below free fall					
S1	Silt	56	Small boulder		()		XSI	
S2	Sand	S7	Large boulder		il il The		110:214M	
S 3	Gravel	S8	Bimodal		1 7105	CLAY	ND. SIGCM	
S 4	Small cobble	S 9	Bedrock/till			KILL	REW: 14.57M	
S 5	Large cobble				×	1 and 1	CIVILIE	
Other					153	OW HY		
BM	Benchmark	EP	Erosion pin		105	53	START POINT	
BS	Backsight	RB	Rebar		-	Auc		
DS	Downstream	US	Upstream			/		
WDJ	Woody debris jam	TR	Terrace	U.	5	YXSI		
VWC	valley wall contact	FC	Flood chute		/ _/			
BOS	Bottom of slope	FP	Flood plain	Photo	S:	e - mai de como		
TOS	Top of slope	KP	Knick point	Notes	:			

1



General Site Characteristics

Project Number: 23076

Date:		2023-11-30			Stream: CARDINAL CREEK		
Time:		~			Reach:		kaa
Weather:		Cin	104 -20C		Location:		ORIEDNIC, DN
Field Staff:		KE YM			Watershed/S	ubwatershed:	CARDINALCREEK
			Sit	e Sketch		Compass	
	Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree	Monitor	ring Long-profile Monumented XS Monumented photo Monumented photo direction Sediment sampling Erosion pins Secour chains mal Symbols	Sit	r Sketch T2 1 col 1 col 1 col 1 col	PRIES WIT PRIES WIT CROSSING PRIES	$ \begin{array}{c} $
***	Woody debris	ni stronovalor ovelje je			1 999	(FM	MULTIPLE
*****	Beaver dam			1	9		Frowphins
	Vegetated island				3 1	7 MERS	ADJACENT TO Z
Flow Type			untor .		ã (C/	1/17	LARGE CE IS
H1 H1	Standing water HI	A Back V	vater		EL DA	X S	REND <
H2	Scarcely perceptible	now		!		SV	POOL B
на	Unwelling				E KPHV	X Jr.	E E
H5	Rinnled			1	EV G	IN FERG	POOLING
Нб	Unbroken standing v	ave	a		2 V 12		91 11 1
HZ	Broken standing way	ve			WV.		10:00 -
H8	Chute	-				T AA	\$7 KK
H9	Free fall H9	A Dissip	ates below free fall		2/ 1/	WER WG	" V X MEAS
Substr	rate	•			3	BUL	
S1	Silt	S6	Small boulder		The second		
S2	Sand	S7	Large boulder	SATU	TIEPE 31	NK.	
S 3	Gravel	S 8	Bimodal		4 D	1	
S4	Small cobble	S9	Bedrock/till			1	A R
S 5	Large cobble			SE(ONDARY	1	The strong
Other				FLOV	upath -		y a g
BM	Benchmark	EP	Erosion pin	HIGH	HER THEN	COBBLES ON	7 8763
BS	Backsight	RB	Rebar	LAR	SIEY INTER-	CLAY BED D/	SOF
DS	Downstream	US	Upstream	STIT	11/12	TI CONFLUE	INCE ()
WDJ	Woody debris jam	TR	Terrace				
vwc	Valley wall contact	FC	Flood chute				//
BOS	Bottom of slope	FP	Flood plain	Pho	tos:		
TOS	Top of slope	КР	Knick point	Note	es:		, , , , , , , , , , , , , , , , , , ,

Senior staff sign-off (if required): _____ Checked by: \underline{VS} Completed by: \underline{VM}

Page _____ of _____
ate:		2023-11-30	· · ·	Field Staff:	KS KM			Waters	hed/Subwatershe	d: C.M.Q.I	DIAINE	NOBEY
me:	A. S.			Stream:	SOUTH C	MP2 D	INHE TRIP	UTM (Upstream):		. Saran	⁹ 4-6 20 20 21 55 494 - 3	V PO PO
eather:		CLOVDY -20C		Reach:	1220	<u>- 8 1</u>		UTM (E	ownstream):			
and Use	V a (T	alley Type 2 C	hannel Table 3)	Type	ble 4)	2	Flow Type (Table 5)	1 0	Evidence of Groundw	ater Location	ı:	Photo:
parian Vege	tation				Aquatic & I	instrea	am Vegetati	on	Wa	ater Quality		
ominant Type (Table 6) incroachment (Table 7)	3/4 B	Coverage Channel V In None In 1 - In Fragmented In 4 - In Continuous In 2 ->	Vidths A 4 □ 10 5 0 7	Age (yrs) 1 Immature (<5) (Established (5-30) (Mature (>30)	Type (Table 8) Reach Coverage %	12	Woody Debris A In Cutbank A In Channel Not Present	WD Densi Low Mod High	WDJ/50m:	Odour (Table 16)	ד ר)	urbidity Table 17)
annel Chara	cterist	ics							J <u>L</u>			
inuosity Type (Table 9)	2/5	Sinuosity Degree (Table 10)	2	Bank Angle □ 0 - 30	Bank Erosion □ < 5%		(Table 19) Bank	Clay/Silt	Sand Gravel	Cobble Bou	Ider Parent	Rootlet
Gradient (Table 11)		# of Channels (Table 12)	2	1 30 - 60 1 60 - 90	∑ 5 - 30% □ 30 - 60%		Riffle Pool					
trenchment (Table 13)	١	Bank Failure (Table 14)	2	Undercut	□ 60 - 100%		Bed (if no riffle-pool morphology)	X			ם נ	
own's Model (Table 15)	C	Bankfull Indicators (Table 18)	1/3/5		Bankfull Width (m)	20	3.0	/	Wetted Width (m) 0,78	1.30	1
Sed Sorting (Table 20)	ws	Sediment Transport Observed?	□ Yes	No 🗆 Not Visible	Bankfull Depth (m)	0.75	0.45		Wetted Depth (m) D.08	0.08	/
Transport de (Table 21)	/	% of Bed Active			Undercuts (m)	0.15	š. /	_	Velocity (m	(s) 0.34	0.23	/
Geomorphic its (Table 22)	8	Mass Movement (Table 23)	/	RUNS 100	Pool Depth (m)	1	1	/	Velocity Estim Meth	ate W B	WB	/
Riffle-Pool Spacing (m):	/	% Riffles:	/	% Pools:	Riffle Length (m)	and the second		-	Meander Amplitu (de m)	/	- aller
es:						1 (1997) 1 (1997) 1 (1997) 1 (1997)			and the second se			
CHANNEL	FLO	WS UNDER CRI	DISING	IND OLD B	EAVER ME	hpoi	N					
FININ MA	rthe	AT THE OF	TERST	TIAC FLOW 1	HEOGHOUT	NIN	EMCIT	dillan 1	1 AMINNIK			
CHANNE	N C L B	HANNEL NOT	CLA	MON MON		2 IDt	2 HVV	<u> </u>	I I I I I I I I I I I I I I I I I I I			
CAROF	SEC	IN OBSERVE	-D MILAFA	HED SOU II	N SPOTS/	olp .	FION PA	tht.			<u></u>	
tos:						62 						7

Version #4 Last edited: 04/04/2023 1. 18 1

Senior staff sign-off (if required): _____ Checked by: K Completed by: KM

Panid Geomorphic Assessment

Project Number: 23070

Dato:	200	12-11-20	Stream:		CAPPINA	1 CR	FFK +	RIR
	000	0-11 00	Reach		1220	and the states	<u></u>	n 12 45 f
	010	inter alla			PLU BOLFOR	10	8	
Weather:	CLD	UDY -20	Location:		OKLEHT	<u>13,01</u>	1	er.
Field Staff:	KS	KW	Watershed/Subv	watershed:	CAPDIN	AL (CREEK	di anti anti anti anti anti anti anti ant
Dracacc			Geomorphological Indicat	or		Pre	sent?	Factor
Process	No.	Description				Yes	No	Value
2	1	Lobate bar			5		X	And an and a gradient
	2	Coarse materials in ri	ffles embedded			1 3 4	X	
Evidence of	3	Siltation in pools				X		
Aggradation	4 Medial bars						X	_
(AI)	5	Accretion on point ba	rs				X	-
	6	Poor longitudinal sort	ing of bed materials			5.	X	
	7	Deposition in the over	rbank zone				X	
				S	um of indices =	ł	le	0.143
	1	Exposed bridge footin	ıg(s)		NA		100	
	2	Exposed sanitary / st	orm sewer / pipeline / etc.		NIA			
	3	Elevated storm sewer	outfall(s)		NIA		l ke	
	4	Undermined gabion b	askets / concrete aprons /	etc.	NA			
Evidence of	5	Scour pools downstre	am of culverts / storm sev	ver outlets		X		
(DI)	6	Cut face on bar forms	3			1.1.4	X	
	7	Head cutting due to k	nickpoint migration				X	1 Shares
	8	Terrace cut through c	lder bar material		1	<u> </u>	X	-
	9	Suspended armour la	yer visible in bank				X	
10 Channel worn into undisturbed overburden / bedrock							1.8	
		-		S	um of indices =	3	4	0.833
	1	Fallen / leaning trees			X			
	2	Occurrence of large of	X					
	3	Exposed tree roots	X					
	4	Basal scour on inside		X				
Evidence of Widening	5	Basal scour on both s		X				
(WI)	6	Outflanked gabion ba	skets / concrete walls / et	с.	NIR		-	- 1 N
	7	Length of basal scour	>50% through subject re	ach			X	
	8	Exposed length of pre	eviously buried pipe / cable	e / etc.	NIA	<u> </u>		
	9	Fracture lines along t	× 6 8 8/3.	10	K			
	10	Exposed building four						
			9 ²⁷ 5	S	um of indices =	2	S	0.280
	1	Formation of chute(s)*				K	
Evidence of	2	Single thread channe	l to multiple channel			X	S. 1.	
Planimetric	3	Evolution of pool-riffl	s. Marine de la construcción de la con	1.1	X			
Form	4	Cut-off channel(s)	X					
Adjustment	5	Formation of island(s		X				
(P1)	6	Thalweg alignment o		X	4			
	7	Bar forms poorly form		X				
				S	um of indices =	4	3	0,591
Notes:				Stability Inc	dex (SI) = (AI	+DI+W	[+PI)/4	= 0.33
		1.4		In Regime	e In Transi	tion/Str	ess In	Adjustmen
				0.00 - 0.	20 0.2	21 - 0.40		0.41

MORPHI

Rapid Stream Assessment Technique Project Number: 23076

Date:	2023-11-30	Stream:		CARNINA	MEEK TOIN			
Time:		Reach:		220	VEER IEB			
Weather:	CLOUDY -20C	Location:		(picanic	Anl			
Field Staff:	KS KM	Watershed/Subwate	rshed:	CARDINAL CREEK				
Category	Poor	Fair	- 2 - 1 - 53	Good	Fycellent			
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infrequencies sloughir failure 	o of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream bend areas Stream bend areas stable Outer bank height 0.9- 1.2 m above stream 1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 					
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predomi large, si scarce 2-3 rece per stree 	Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile				
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	 Bottom generall plant/so 	1/3 of bank is y highly resistant il matrix or material	• Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material			
1310 - Marine	Channel cross-section is generally trapezoidally- shaped	Channel cross-section is generally trapezoidally-shaped	 Channel generall 	cross-section is y V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range	00102	030405	06	078	□ 9 □ 10 □ 11			
NO	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	 25-49% 59% em mainster 	embedded (35- ibedded for large m areas)	 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 			
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 b Low to moderate number of deep pools % sand- Pool substrate composition 60-80% sand-silt Moderate pools Pool substrate 30-59% sa 		e number of deep strate composition sand-silt	 High number of deep pools 61 cm deep) 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment Deposition	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streamb and/or " sedimen uncomm 	ed streak marks banana"-shaped t deposits ion	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 			
	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 		 Fresh, la uncomm Small loo fresh sar top of loo 	rige sand deposits ion in channel calized areas of nd deposits along w banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 			
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	Point bars common, moderate to large and unstable with high amount of fresh sand	 Point bar well-veg armoure fresh sar 	rs small and stable, etated and/or d with little or no nd	Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand			
Point range	00102			5 🗆 6	7 0 8			

Senior staff sign-off (if required): _____ Checked by: ___K__ Completed by: ___KM___

MORPHIX

Date: 202	3-11-30	PN: 23076	Location: ()	FIERNSON		
Category	Poor	Fair	Good	Excellent		
Cuttyory	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	 Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas) 	• Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)		
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
NO VIFFIES Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 		
Habitat	 Riffle depth < 10 cm for large mainstem areas 	 Riffle depth 10-15 cm for large mainstem areas 	 Riffle depth 15-20 cm for large mainstem areas 	 Riffle depth > 20 cm for large mainstem areas 		
RIFFED (Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	 Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure 		
	• Extensive channel alteration and/or point bar formation/enlargement	Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	 No channel alteration or significant point bar formation/enlargement 		
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	 Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1 	Riffle/Pool ratio 0.9-1.1:1		
NIA	 Summer afternoon water temperature > 27°C 	 Summer afternoon water temperature 24-27°C 	 Summer afternoon water temperature 20-24°C 	Summer afternoon water temperature < 20°C		
Point range	00102	3 0 4	□ 5 □ 6	□ 7 □ 8		
	 Substrate fouling level: High (≥ 50%) 	 Substrate fouling level: Moderate (21-50%) 	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock-underside (0-10%)		
	 Brown colour TDS: > 150 mg/L 	Grey colour TDS: 101-150 mg/L	Slightly grey colour TDS: 50-100 mg/L	 Clear flow TDS: < 50 mg/L 		
Water Quality	• Objects visible to depth < 0.15m below surface	 Objects visible to depth 0.15-0.5m below surface 	• Objects visible to depth 0.5-1.0m below surface	Objects visible to depth > 1.0m below surface		
aces data N	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	• No odour		
Point range	0 0 1 0 2	□ 3 □ 4	056	0708		
Riparian Habitat Conditions	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks		
	Canopy coverage: <50% shading (30% for large mainstem areas)	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	Canopy coverage: >80% shading (> 60% for large mainstem areas)		
Point range	□ 0 □ 1	□ 2 □ 3	4 0 5	□ 6 □ 7		
Total overall	score (0–42) =	Poor (<13) F	air (13-24) Good (25-	34) Excellent (>35)		

Senior staff sign-off (if required): _____ Checked by: <u>V</u> Completed by:

KM

GFC

General Site Characteristics Project Number: 23076 Date: 2023.07-12 Stream: OUNNO NOO 11:15 Time: R2A Reach: 2800 Weather: Location: 0 (teans UNNI **Field Staff:** A/ Watershed/Subwatershed: NNA CNQ0. Features Monitoring DS Site Sketch Compass Reach break -o-o-o- Long-profile REACH BREAK 只 Station location Monumented XS SCOUR POOL Cross-section 0 Monumented photo 2-5M TRIP Flow direction Monumented photo PERCHED CUL RT (WET) Riffle direction PATH XING Pool H Sediment sampling CITED . Sediment bar Erosion pins ######## 8 Eroded bank/slope Scour chains ----Undercut bank **Additional Symbols** XXXXXX Bank stabilization WK-> X53 130 SUMAC Leaning tree x----x Fence Culvert/outfall 1 5-10 M PERCHED CULVERT (DRY) Swamp/wetland \bigcirc VVV Grasses G Tree Instream log/tree MBANKMENT *** Woody debris SIDE OF XING *** Beaver dam STREAM FLOWS INTO VV Vegetated island XS7 GROUND ON US **Flow Type** H1 Standing water H1A Back water H2 Scarcely perceptible flow H3 Smooth surface flow H4 Upwelling H5 Rippled H6 Unbroken standing wave H7 Broken standing wave **H8** Chute Free fall H9 H9A Dissipates below free fall Substrate **S1** Silt Small boulder **S6 S2** Sand **S7** Large boulder **S**3 Gravel **S8** Bimodal **S4** Small cobble **S9** Bedrock/till **S**5 Large cobble Other WOOD X51 BM Benchmark NETTLE EP Erosion pin BS Backsight RB Rebar DS Downstream US Upstream TRIB WDJ TR Terrace Woody debris jam VWC Valley wall contact FC Flood chute BOS Bottom of slope FP Flood plain Photos: TOS Top of slope KP Knick point Notes: ELEVATION PTA WL 63 M

Version #4 Last edited: 21/02/2023 Senior staff sign-off (if required):

Checked by:

Completed by: KMKS Page

of

Reach Characteristics Object Number: Object Number: Object Number: Object Number: Outpet Stream: Outpet Stream: <t< th=""><th>RPH1X"</th></t<>	RPH1X"
Date: Quite: Stream: Cuilding Creating UTM (Upstream): Weather: SUNN 128°C Reach: R2A UTM (Downstream): Land Use 1 Valley Type Channel Type Channel Zone Table 4) UTM (Downstream): Riparian Vegetation Meater Grade 1) Aquatic & Instream Vegetation Water Quality Dominant Type 1 Ys/4 Coverage Channel Xides Age (yrs) Turble 6) Turble 6) Turble 6) Turble 6) Promonent (Table 5) 1 Coverage Channel Widts Age (yrs) Mood Deris WD Density Odour Turble 6) Turble 6) Turble 6) Turble 6) Turble 6) Turble 6) Coverage 4 Cove	K
Innet Innet Innet R2A UTM (Downstream): Land Use I Valley Type Channel Type Channel Zone Flow Type Evidence of Groundwater Location: Phot Riparian Vegetation Masses Aquatic & Instream Vegetation Water Quality Dominant Type I 3/4 Coverage Channel Type Aquatic & Instream Vegetation Water Quality Dominant Type I 3/4 Coverage Channel Type Masses Aquatic & Instream Vegetation Water Quality Dominant Type I 3/4 Coverage Channel Type Moode Debris Woody Debris Wo Density Masses Channel Characteristics Sinuosity Degree G Channels Device Bank Angle Bank Erosion Its bes Masses Sinuosity Degree Age - 60 De -30% Riffle Sand Gravel Cobble Boulder Parent Its bes Grable 10 Z Bank Angle Sand Erosion Its bes Sand Gravel Cobble Boulder Parent Its bes Grable 11 Z # of Channels Masses Mass Bank Erosion Its bes Mass	
Wretter: Othannel Type Channel	
(Table 1) (Table 2) (Table 3)	Annual (1997)
Riparian Vegetation Productive degree Channel Withts Age (yrs) Type Woody Degree Wo Density Odour Turbic (Table 7) 3 % Continuous \$\$\frac{1}{2} < 0\$ \$\$\frac{1}{2}\$\$ \$\$\$\frac{1}{2}\$\$ \$\$\$\$\$ \$	
Dominant Type (Table 6)(Table 6)(Table 7)Coverage (Table 6)Channel WidthsAge (VfS)Type (Table 5)(Table 7)(Table 7)(Table 6)(Table 7)(Table 7)(Tab	t v
Encroachment (Table 7) If regeneted If 4 = 10 If results (3 = 30) Reach I is substrated (3 = 30) Channel Characteristics Coverage % I is substrated (3 = 30) Reach I is substrated (3 = 30) Reach I is substrated (3 = 30) Sinuosity Type (Table 19) I coverage % I is substrated (3 = 30) Reach I is substrated (3 = 30) Reach I is substrated (3 = 30) Gradient (Table 11) I coverage % I is substrated (3 = 30) Gradient (Table 11) I coverage % I is substrated (3 = 30) Gradient (Table 13) I coverage % I is substrated (3 = 30) I is substrated (3 = 30) <thi (3="30)</th" is="" substrated=""> <thi is="" sub<="" th=""><th>7)]</th></thi></thi>	7)]
Channel Characteristics Sinuosity Type (Table 9) 7 Sinuosity Degree (Table 10) Z Bank Angle 0 - 30 Bank Frosion 0 < 5%	
Sinuosity Type (Table 9) 7 Sinuosity Degree (Table 10) 2 Bank Angle (Table 10) Bank Angle (1 able 10) Bank Angle (- 30) Bank Angle (- 5%) Bank Mill Bank Sand Gravel Cobile Soluter Particity Gradient (Table 11) 2 # of Channels (Table 12) 1 \$2,00-60 5 - 30% Riffle 3 1 1 1 \$2,00-60 5 - 30% Riffle 3 1 1 1 1 \$2,00-60 5 - 30% Riffle 3 1 </th <td>otlete</td>	otlete
Gradient (Table 11) 2 # of Channels (Table 12) 1 \$20 - 60 \$\$60 - 90 \$5 - 30% Riffle \$90 90	
Entrenchment (Table 13) 2 Bank Failure (Table 14) QUndercut Q 60 - 100% Bed (fin or fifte-pool morphology) x52 XS3 XS1 XS2 XS2 XS2 XS1 XS2 XS2 XS2 XS1 XS2 XS2 XS2 XS1 XS2 XS2 XS2 XS3 XS1 XS2 XS2 XS2 XS2 XS1 XS2 XS2 XS1 XS2	
Down's Model (Table 15) IIV Bankfull Indicators (Table 18) IIV Bankfull Indicators (Table 18) IIV Bankfull Width (m) 2 3 2.5 Wetted Width (m) I.12 0.645 0 Sed Sorting (Table 20) M Sediment Transport Observed? Pes INo Not Visible Bankfull Depth (m) 0.50 0.666 0.46 Wetted Depth (m) 0.04 0.072 0 Transport (Table 21) 3 % of Bed Active NH Undercuts (m) NA NA Velocity (m/s) 0.32 0.100 0 Geomorphic Units (Table 22) SI/68 Mass Movement (Table 23) 1 Pool Depth (m) 0.185 0.095 0.29 PS Velocity Estimate Method Wiffill M Riffle-Pool Spacing (m): 3 % of Riffles: 25 % Pools: 50 Riffle Length (m) 10 NA 3 Meander Amplitude (m) NA 2 1 Notes: TwoHISTORIC PATH XINGS W/IN R2A wouttFLANKED / UNDERMINED VULCE THR OUGHOUT APPROX 10-11 INTERSETITALY IN XING EMBANIKMENT SUBGTRATE (NO POOLING US), VALLEY BOTIDAL IS APPROX 10-11 <td>3</td>	3
Sed Sorting (Table 20) Yes No Not Visible Bankfull Depth (m) 0.50 0.666 0.4% Wetted Depth (m) 0.04 0.072 0 Transport Mode (Table 21) 3 % of Bed Active Nin Undercuts (m) NA NA NA Velocity (m/s) 0.32 0.10 0 Geomorphic Units (Table 22) SI68 Mass Movement (Table 23) 1 Pool Depth (m) 0.185 0.095 0.29 SS Velocity Estimate KS3 Velocity Estimate Neffle N// N/// N// N/// N/// N///	44
Transport Mode (Table 21) 3 % of Bed Active Mith Undercuts (m) NA NA NA Velocity (m/s) 0.32 0.10 0.10 Geomorphic Units (Table 22) 516/8 Mass Movement (Table 23) 1 Pool Depth (m) 0.185 0.095 0.29 PS XS3 velocity (m/s) 0.32 0.10 0 Riffle-Pool Spacing (m): 3-10 % Riffles: 25 % Pools: 50 Riffle Length (m) 0 NA 3 Meander Amplitude (m) NA 2 0 Notes: Two HISTORIC PATH XINGS W/IN R2A W OUTFLANKED/UNDERMINED CULVERTS, FLOW SEEMS TO TRE INTERSTITALLY N XINGS EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS APPROX 10-1	328
Geomorphic Units (Table 22) Slop Mass Movement (Table 23) I Pool Depth (m) 0.185 0.095 G.29 So Velocity Estimate Method Math dial Method Riffle-Pool Spacing (m): 3-10 % Riffles: 25 % Pools: SD Riffle Length (m) IO NA 3 Meander Amplitude (m) NA 2 I Notes: Two HISTORIC PATH XINGS W/IN R2 W OUTFLANKED / UNDERMINED CULVERTS, FLOW SEEMS TO TRA- INTERSTITATION N XING EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS APPROX IO-1	05
Riffle-Pool Spacing (m): 3-10 % Riffles: 25 % Pools: 50 Riffle Length (m) 10 NA 3 Meander Amplitude (m) NA 2 Notes: Two HISTORIC PATH XINGS W/IN R2A, WOUTFLANKED/UNDERMINED CULVERTS, FLOW SEEMS TO TRA INTERSTITALLY IN XING EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS APPROX 10-1 INTERSTITALLY IN XING EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS APPROX 10-1	4
Notes: TWO HISTORIC PATH XINGS WILN R2A, WOUTFLANKED/UNDERMINED CULVERTS, FLOW SEEMS TO TRE INTERSTITATION XING EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS APPROX 10-1	
INTERSTITALLY IN XING EMBANKMENT SUBSTRATE (NO POOLING US), VALLEY BOTTOM IS AFFROX TO-I	VEL
ELECTION OF A CONCENTRATION OF AND A CONCENTRATION OF A CONCENTRATICA	2
WIDE, FLAT W MEANDERING CHANNEL GRADDI VEG MITHONDER MOUTHER VIVE	
FAILURE I (US) LOCATED WIN THE REACT.	
$T_{-} 19,285$ $T_{2} = 6,655$ $T_{1} = 5,055$	
	n an
Photos:	

Version #4 Last edited: 04/04/2023

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GEO

Rapid Stream Assessment Technique Project Number: 23070

Date:	2023-07-12	Stream:		Cavalinal creek-Thb				
Time:	VIVED V/ LV	Reach:		R2A				
Weather	CUMMAN 280C	Location:	officer in	orleans	s molijuli m			
Field Staff:	SUVIVIA, COU	Watershed/Subwaters	shed:	carainal	creek			
	KVI KJ	Fair	0.0 10 10 10	Good	Excellent			
Category	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infrequestion sloughi failure 	6 of bank network nent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer I m abov 1.5 m for larg Bank o 	h bend areas stable bank height 0.6-0.9 ve stream bank (1.2- above stream bank ge mainstem areas) overhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 			
Channel Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Expose predor large, scarce 2-3 re per str 	ed tree roots ninantly old and smaller young roots cent large tree falls ream mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 			
hite schier, n Mit sca Hiterraatska	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	Botton genera plant/s	n 1/3 of bank is ally highly resistant soil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 			
Bharlin Killin, China an China Bhuchin Bhring	 Channel cross-section is generally trapezoidally- shaped 	Channel cross-section is generally trapezoidally-shaped	Chann gener	el cross-section is ally V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range		030405		6 0 7 0 8				
	 > 75% embedded (> 85% embedded for large mainstem areas) 	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49 59% (mains	% embedded (35- embedded for large stem areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)			
	Few, if any, deep pools Pool substrate composition >81% sand- silt	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	• Moder pools • Pool s 30-59	rate number of deep substrate composition 9% sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Strea and/c sedim uncor 	mbed streak marks or "banana"-shaped nent deposits mmon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 			
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	Fresh uncor Smal fresh top o	n, large sand deposits mmon in channel I localized areas of sand deposits along f low banks	 Fresh, large sand deposits rare or absent from channe No evidence of fresh sediment deposition on overbank 			
Point bars present at Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand		Point bars common, moderate to large and unstable with high amount of fresh sand	 Point well- armo fresh 	bars small and stable vegetated and/or pured with little or no sand	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 			
Point range								

Date:	023-07-12	PN: 23070	Location:	orleans.		
Category	Poor	Fair	Good	Excellent		
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 		
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
Physical Instream Habitat	Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble	Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 		
	large mainstem areas	Riffle depth 10-15 cm for large mainstem areas	Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas 		
	30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	 Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure 		
(Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 	 Slight amount of channel alteration and/or slight increase in point bar formation/enlargement 	 No channel alteration or significant point bar formation/enlargement 		
. 112	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1		
NIH	 Summer afternoon water temperature > 27°C 	 Summer afternoon water temperature 24-27°C 	 Summer afternoon water temperature 20-24°C 	 Summer afternoon water temperature < 20°C 		
Point range		3 0 4	0506	0708		
	• Substrate fouling level: High (> 50%)	 Substrate fouling level: Moderate (21-50%) 	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)		
Water Quality	Brown colour TDS: > 150 mg/L	 Grey colour TDS: 101-150 mg/L 	 Slightly grey colour TDS: 50-100 mg/L 	Clear flow TDS: < 50 mg/L		
	 Objects visible to depth < 0.15m below surface 	Objects visible to depth 0.15-0.5m below surface	 Objects visible to depth 0.5-1.0m below surface 	 Objects visible to depth > 1.0m below surface 		
	Moderate to strong organic odour	 Slight to moderate organic odour 	Slight organic odour	No odour		
Point range	00102	0304		7 0 8		
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks		
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	Canopy coverage: >80% shading (> 60% for large mainstem areas)		
Point range			0405	607		
'otal overall so	ore (0-42) = 23	Poor (<13) Fa	ir (13-24) Good (25-34	4) Excellent (>35)		

Version #2 Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: ____ Completed by: _____

Rapid Geom	orphic	Assessment	Project Number:	23076	2			MORPHIX			
Date:	202	13-07-12	Stream:	C	avden	al ci	reek-	1110			
Lime:	<u>nv</u> u		Reach:	R2	2A						
Weather:	Cu	MMU 289C	Location:	-0	rlean	S					
	<u> </u>	AIVC	Watershed/Subwate	rshed: (erv d L	MAL	cree	K			
Field Staff:	<u>V</u>	MIF)				Pres	ent?	Factor			
Process	T	(Geomorphological Indicator	and the second		Yes	No	Value			
	NO.	Description				X					
	1	Lobate bar	d land				X				
х. 	2	Coarse materials in rif	ries embedded			X	1	N 857			
Evidence of	3	Siltation in pools				X		0.0-1			
Aggradation (AI)	4	Medial bars	~			X	and a second	-			
(/1)	5	Accretion on point bar	s of had materials			X		-			
	6	Poor longituainal sorti	hank zono			X		1			
	/	Deposition in the over		Sum of	indices =	6	1				
	1				AIA						
	1	Exposed bridge footing	g(s)		NIA						
	2	Exposed sanitary / sto	orm sewer / pipeline / etc.		NIN			-			
	3	Elevated storm sewer	outfall(s)		NIA	- Sec.		-			
E denne of	4	Undermined gabion ba	NIÚ	X		200					
Degradation (DI)	5	Scour pools downstrea	am of culverts / storm sewer of	outiets		\mathbf{X}		- 01500			
	6	Cut face on bar forms	· · · · · · · · · · · · · · · · · · ·			13	X				
	7	Head cutting due to k	nickpoint migration				X	-			
	8	Terrace cut through o	Ider bar material				X	-			
	9	Suspended armour la	yer visible in balk	-k		X		-			
	10	Channel worn into un	disturbed overburden / bedroc	Sum o	f indices =	3	3				
[1	Fallen / leaning trees	/ fence posts / etc.		-	X					
	2	Occurrence of large o	X								
	3	Exposed tree roots	X								
	4	Basal scour on inside	X								
Evidence of	5	Basal scour on both s	X		0.85T						
Widening	6	Outflanked gabion ba	skets / concrete walls / etc.	_	NA			_			
(001)	7	Length of basal scour	>50% through subject reach		1.08	X					
	8	Exposed length of pre	eviously buried pipe / cable / e	etc.	NIA						
	9	Fracture lines along t	op of bank				~				
	10	Exposed building four	ndation		NA						
				Sum	of indices =	- 0					
	1	Formation of chute(s)		2		X				
	2	Single thread channe	el to multiple channel			—	X				
Evidence of	3	Evolution of pool-riff	e form to low bed relief form				X.	- n 786			
Planimetric	4	Cut-off channel(s)			X	0.000					
Adjustment	5	Formation of island(s	5)				X				
(PI)	6	Thalweg alignment o	ut of phase with meander form	n		X					
	7	Bar forms poorly for		X		A . A					
	<u> </u>	/		Sum	of indices :	= 2	5	0.63			
Alabara Cala	194	and a south	change Levicture	Stability Index	(SI) = (A	I+DI+W	I+PI)/4	- =			
Notes: St	Ger	rever heren	UNITAL TUNDING	In Regime	In Trans	sition/St	ress Ir	Adjustmen			
				0.00 - 0.20		.21 - 0.4	0	0.41			

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KMKS

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	- 72

each Charac	terist	ics Pr	oject N	lumber:	2307	6	11.20											MORPHIX
ate:		2023-	07-1	12	Field Sta	ff:	KMIKS		1.0		Watershed/Subwatershed: Valauncu Creek				Yer			
me:		12:00			Stream:		Carcunc	u cr	ee k	-Trib	UTM (Upstream):							
eather:		SUNNY	1, 28	SOC	Reach:		R3				UTM (Downstream			m):				
able 1)	Va (Ta	able 2)	Channel Type Channel Zone Flow Type (Table 3) (Table 4) (Table 5)				/idence o	of Ground	lwater Lo	cation:	P	hoto:						
parian Veget	ation						Aquatic &	Instrea	am Ve	getatio	on			V	Vater Qu	ality		
ominant Type (Table 6)	1/4	Coverage	Channel	- 4 □	ige (yrs) Immature (•	<5)	Type (Table 8)	- Harrison	Woody	Debris Sutbank	WD Der	nsity	WDJ/50n	n:]	Odo (Table	ur 16)	Tu (Ta	rbidity ble 17)
ncroachment (Table 7)	2		a 94 s 14>	10 ¥	Mature (>30))	Reach Coverage %	15		Present	🗆 High						L	
annel Chara	cterist	ics					1											
i nuosity Type (Table 9)	5/2	Sinuosi	ty Degre (Table 10	e d	Bank An □ 0 - 30	gle	Bank Erosion □ < 5%		(Tab	le 19) Bank	Clay/S	Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Gradient (Table 11)	2	# of	Channel (Table 12		□ 30 - 6 \ 60 - 9	0	□ 5 - 30% □ 30 - 60%			Riffle Pool	8							
ntrenchment (Table 13)	1	Bai	n k Failur (Table 14	e 1) 6/2	Under	cut	4 60 - 100%	XSI	(if no r mor	Bed iffie-pool phology)xs		¥53				,,	XS2	X53
own's Model (Table 15)	dlu	Bankfull I	ndicator (Table 18	s) 1/5/7			Bankfull Wid (n	th n) 3		5		3.5	Wett	ed Widtl	n (m) (),	80	0.87	1
Sed Sorting (Table 20)	4	Sediment 1 O	Franspor bserved	rt □ Yes	$No \square Not$	Visible	Bankfull Dep (n	th n) 0.50	3	1.3		0,75	Wett	ed Deptl	n (m) 🕠	24	0.175	0.07
Transport ode (Table 21)	3	% of B	ed Activ	e NIA			Undercuts (n	n) NA		0.15		0.06	V	elocity (m/s) 0.	465	0.237	0.27
Geomorphic hits (Table 22)	5/6/8	Mass N	lovemen (Table 23	it]			Pool Dep (n	th n) 0,42	2 us Xsi	0.175		0.26	рs Ve Xs3	locity Est M	imate Wi ethod Bi	ALL	21	11
Riffle-Pool Spacing (m):	3-10m		% Riffles	: 25	% Pools:	50	Riffle Length (n	n) 3,5	5 151	NA		2	Mean	der Ampl	(m)			7
tes:					RECENT	U DR	AINED BEA	VER	PONE	TAC	DSE	XTE	NTO	F REA	CH WH	CATIN	R3	MRETS
VI D,=IM	V2 D2	= IM	V3 D3=	IM	· 14	· VAL	LEY BOTTOM	NDE	PINIC	2 PAT	74 72	IRCA	1 Cott	RECE	NTLY	EXPOS	ED SU	IBSTRATI
T.=2.153	1 12	= AILLS	13=	31+5 A	LITEEL	B3	ARMUNIC	SLAPS	E EA	HURE	2	VAL	LEV	IS NA	RRAIL	+ BAI	VK 1	3 IN
SLUPE F	+11LUP	VIN/ ONI	RIGE	HT SIDE	EXTR	EME	TOFF FAL	LACE	ROSS	CHA	NNEI	LU	5 +	DS A	ROUND	SF2	VALLE	EY BOTTON
EXTREN	AELY	DIFFICI	ALT T	O TRAN	ERSE .	BED	, IS MAJO	RITY	CLA	y w	SOL	LE (BRAVI	EL (80/20	3)		
LANGE	t New York	8111100		1.1.4.1.3		and the second state of the												
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otos:																		

Version #4 Last edited: 04/04/2023

Photos:

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Senior staff sign-off (if required): _____ Checked by: _____ Completed by: \underline{KMKS}

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Rapid Stream Assessment Technique Project Number: 2307(0

Date:	2023-07-12	Stream:		Cardinal Creek TID				
Time:		Reach:		R3				
Weather:	SUMM. 28°C	Location:	initiad in.	Orleans	10 (1-434 SP116)			
Field Staff:	KMIKS	Watershed/Subwater	rshed:	Cardinal Creek				
Category	Poor	Fair	- 99 2(C+2)	Good	Excellent			
calego, y	 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infrequestion sloughing failure 	6 of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer b m abov 1.5 m a for larg Bank o 	bend areas stable bank height 0.6-0.9 re stream bank (1.2- above stream bank re mainstem areas) verhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 			
Channel Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	• Young exposed tree roots common • 4-5 recent large tree falls per stream mile	 Expose predom large, s scarce 2-3 rec per stree 	d tree roots ninantly old and smaller young roots cent large tree falls eam mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 			
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil/matrix compromised 	• Bottom genera plant/s	1/3 of bank is lly highly resistant oil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or materia 			
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	 Channe genera 	el cross-section is Ily V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range	000102	030405		6 0 7 0 8	□ 9 □ 10 □ 11			
	 > 75% embedded (> 85% embedded for large mainstem areas) 	• 50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% ei mainst	% embedded (35- mbedded for large em areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)			
-33	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	Modera pools Pool su 30-599	ate number of deep Ibstrate composition % sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment	Streambed streak marks and/or "banana"-shaped sediment deposits common	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Stream and/or sedime uncom 	nbed streak marks "banana"-shaped ent deposits mon	 Streambed streak marks and/or."banana"-shaped sediment deposits absent 			
	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, uncom Small I fresh s top of 	large sand deposits mon in channel localized areas of and deposits along low banks	Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank			
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point b well-ve armou fresh s 	ears small and stable, egetated and/or red with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 			
Point range		3 0 4		0506	0708			

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Date: 20	123-	PN: 23070	Location:	ardinal creek		
Category	Poor	Fair	Good	Excellent		
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas)	 Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 		
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 		
Habitat	Riffle depth < 10 cm for large mainstem areas	• Riffle depth 10-15 cm for large mainstem areas	 Riffle depth 15-20 cm for large mainstem areas 	 Riffle depth > 20 cm for large mainstem areas 		
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure		
(• Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 	 Slight amount of channel alteration and/or slight increase in point bar formation/enlargement 	 No channel alteration or significant point bar formation/enlargement 		
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	Riffle/Pool ratio 0.7-0.89:1 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1		
NA	 Summer afternoon water temperature > 27°C 	 Summer afternoon water temperature 24-27°C 	 Summer afternoon water temperature 20-24°C 	 Summer afternoon water temperature < 20°C 		
Point range	00102		0506	0708		
	 Substrate fouling level: High (> 50%) 	 Substrate fouling level: Moderate (21-50%) 	 Substrate fouling level: Very light (11-20%) 	Substrate fouling level: Rock underside (0-10%)		
Water Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	 Slightly grey colour TDS: 50-100 mg/L 	• Clear flow • TDS: < 50 mg/L		
and a country	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surface 	• Objects visible to depth 0.5-1.0m below surface	 Objects visible to depth > 1.0m below surface 		
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	• No odour		
Point range	0 0 1 0 2	□ 3 □ 4	0506	2708		
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	Wide (> 60 m) mature forested buffer along both banks		
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	• Canopy coverage: >80% shading (> 60% for large mainstem areas)		
Point range	001	0203	0405	067		
Total overall s	core (0-42) = 23	Poor (<13) Fa	air (13-24) Good (25-3	84) Excellent (>35)		

Version #2 Last edited: 10/02/2023 Senior staff sign-off (if required): ______ Checked by: _____ Completed by: KMKS

Date: 30.0.3-0-12 Stream: Concurrent of learns Time: Reach: R3 Weather: KM/Y28°C Location: OT Learns Field Staff: CM/Y28°C Location: OT Learns Process Geomorphological Indicator Present? Present? Process Geomorphological Indicator Present? Present? Evidence of Agrination paols X Agrination X Agrination Agrination Sittation in paols X Agrination X Agrination (A) Accretion on point bars X Agrination X Agrination 6 Poor longitudinal sorting of bed materials X Agrination A 7 Deposition in the overbank zone Sum of indices = (g I I Exposed senitary / storm sewer outetais N/A 2 Exposed senitary / storm sewer outetas N/A I Idea on bar / storms	Rapid Geom	orphi	ic Assessment	Project Numb	er: 23D	76			MORPHIX
Time: Reach: R3 Weather: QUMU 28°C Location: 0140005 Field Staff: XM / KS Watershed/Subwatershed: Carcural Creets Process Geomorphological Indicator Present? Present? No. Description Yes No 1 Lobate bar X X 2 Cearse materials in rifles embedded X X Exidence of Aggradation 4 Medial bars X X 5 Accretion on point bars X X X 7 Deposition in the overbank zone Sum of indices = C I Evidence of Degradation 6 Evosed bridge footing(s) N/A I I 2 Exposed bridge footing(s) N/A I I I Evosed bridge footing(s) N/A I I 5 Scour pools downstream of culverts / storm sever outlets N/A I I I I Evosed bridge footing(s) N/A I I I I I I I I I I I I<	Date:	20	23-07-12	Stream:		Conoun	alc	NOO.K.	-trib
Weather: SUMM 28°C Location: Differing Field Staff: KM / KS Watershed/subwatershed: CM M M C Ye Ye Process No. Description Present? Present? Present? Evidence of Aggradation 1 Lobate bar X X X Evidence of Aggradation 4 Medial bars X X X 5 Accretion on point bars X X X X 6 Poor longitudinal sorting of bed materials X X X X 7 Deposition in the overbank zone X	Time:		an die en in deel deel deel deel deel deel deel dee	Reach:		R3	<u> </u>	4. 54.7 8	3 8 3 65r
Field Staff: CM FS Watershed/Subwatershed: Cm Cm </th <th>Weather:</th> <th>Cul</th> <th>NNU 28°C</th> <th>Location:</th> <th></th> <th>OILPAN</th> <th>10</th> <th></th> <th></th>	Weather:	Cul	NNU 28°C	Location:		OILPAN	10		
Process Geomorphological Indicator Present? Present? <thpresent?< th=""> Present? Present</thpresent?<>	Field Staff:	K	M/KS	Watershed/Subw	vatershed:	Caxa	inal	CVP	PY
Process No. Description Yes No. Evidence of Aggradation (AI) 1 Lobate bar X X 5 Accretion on point bars X X X 6 Poor longitudinal sorting of bed materials X X X 7 Deposition in the overbank zone X X X X 8 Evidence of Degradation (D) 1 Exposed bridge footing(s) N/A X	-		Geo	omorphological Indicato	r		Pre	sent?	Eactor
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Bill of the second second of the second s		2	Exposed sanitary / storm	sewer / nineline / etc	eres produced and produced	NIA	+	+	-
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3 Exposed tree roots X		2	Occurrence of large orgar	nic debris			X	1	
4 Basal scour on inside meander bends X		3	Exposed tree roots				X		
Evidence of Widening (WI) 5 Basal scour on both sides of channel through riffle 0 6 Outflanked gabion baskets / concrete walls / etc. NA 0 7 Length of basal scour >50% through subject reach X 0 8 Exposed length of previously buried pipe / cable / etc. NA X 9 Fracture lines along top of bank X X 10 Exposed building foundation NA X 10 Exposed building foundation NA X 2 Single thread channel to multiple channel X X 3 Evolution of pool-riffle form to low bed relief form X X 4 Cut-off channel(s) X X X 5 Formation of island(s) X X X 6 Thalweg alignment out of phase with meander form X X X 7 Bar forms poorly formed / reworked / removed X X X X		4	Basal scour on inside mea	ander bends			X		
(WI) 6 Outflanked gabion baskets / concrete walls / etc. NA 0 7 Length of basal scour >50% through subject reach X 0 8 Exposed length of previously buried pipe / cable / etc. NA 0 9 Fracture lines along top of bank X 0 10 Exposed building foundation NA X 10 Exposed building foundation NA X 11 Formation of chute(s) X X 2 Single thread channel to multiple channel X 3 Evolution of pool-riffle form to low bed relief form X 4 Cut-off channel(s) X X 5 Formation of island(s) X X 6 Thalweg alignment out of phase with meander form X X 7 Bar forms poorly formed / reworked / removed X X Sum of indices = S Notes: Set Set Met Met Chang (FmtMill) Stability Index (SI) = (AI+DI+WI+PI)/4 = 0	Evidence of Widening	5	Basal scour on both sides	of channel through riff	le		X		x 857
7 Length of basal scour >50% through subject reach X 8 Exposed length of previously buried pipe / cable / etc. N/A 9 Fracture lines along top of bank X 10 Exposed building foundation X Sum of indices = 0 1 Formation of chute(s) X 2 Single thread channel to multiple channel X 3 Evolution of pool-riffle form to low bed relief form X 4 Cut-off channel(s) X 0 5 Formation of island(s) X 0 6 Thalweg alignment out of phase with meander form X 0 7 Bar forms poorly formed / reworked / removed X 5 Sum of indices = 3 5	(WI)	6	Outflanked gabion basket	s / concrete walls / etc.		NA			0.0
8 Exposed length of previously buried pipe / cable / etc. NA 9 Fracture lines along top of bank X 10 Exposed building foundation NA Sum of indices = 0 Sum of indices = 0 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 with meander form 7 Bar forms poorly formed / reworked / removed Sum of indices = 3 Sum of indices = 3		7	Length of basal scour >50	0% through subject rea	ch		X		
9 Fracture lines along top of bank X 10 Exposed building foundation NA Sum of indices = 0 1 Formation of chute(s) X X 2 Single thread channel to multiple channel X 3 Evolution of pool-riffle form to low bed relief form X 4 Cut-off channel(s) X 5 Formation of island(s) X 6 Thalweg alignment out of phase with meander form X 7 Bar forms poorly formed / reworked / removed S Sum of indices = Sum of indices = S		8	Exposed length of previou	usly buried pipe / cable	/ etc.	NIA			
10 Exposed building foundation N/H Image: Sum of indices = 10 Sum of indices = 10 1 Formation of chute(s) X 2 Single thread channel to multiple channel X 3 Evolution of pool-riffle form to low bed relief form X 4 Cut-off channel(s) X 5 Formation of island(s) X 6 Thalweg alignment out of phase with meander form X 7 Bar forms poorly formed / reworked / removed S		9	Fracture lines along top o	fbank		- tha		X	
Evidence of Planimetric Form 1 Formation of chute(s) X 4 Cut-off channel(s) X 5 Formation of island(s) X 6 Thalweg alignment out of phase with meander form X 7 Bar forms poorly formed / reworked / removed Sum of indices = X		10	Exposed building foundati	ion		NIH			
Evidence of Planimetric Form 1 Formation of chute(s) X 4 Evolution of pool-riffle form to low bed relief form X 4 Cut-off channel(s) X 5 Formation of island(s) X 6 Thalweg alignment out of phase with meander form X 7 Bar forms poorly formed / reworked / removed Sum of indices = Sum of indices = S					Su	m of indices =	0		
Evidence of Planimetric Form 2 Single thread channel to multiple channel X 4 Evolution of pool-riffle form to low bed relief form X X 4 Cut-off channel(s) X X 5 Formation of island(s) X X 6 Thalweg alignment out of phase with meander form X X 7 Bar forms poorly formed / reworked / removed X X Sum of indices = S		1	Formation of chute(s)					X	
Planimetric Form 3 Evolution of pool-riffle form to low bed relief form X Adjustment (PI) 4 Cut-off channel(s) X V 5 Formation of island(s) X V V 6 Thalweg alignment out of phase with meander form X V V 7 Bar forms poorly formed / reworked / removed Sum of indices = S Notes: Set Wered reach charg Charge Charg	Evidence of	2	Single thread channel to r	multiple channel				X]
Form 4 Cut-off channel(s) X 0 Adjustment 5 Formation of island(s) X 0 6 Thalweg alignment out of phase with meander form X 0 7 Bar forms poorly formed / reworked / removed X 0 Sum of indices = 2 5 Notes: Set Crewed reach charg Clenchic Stability Index (SI) = (AI+DI+WI+PI)/4 = 0	Planimetric	3	Evolution of pool-riffle for	m to low bed relief forn	n			X	
Adjustment (PI) 5 Formation of island(s) X 6 Thalweg alignment out of phase with meander form X X 7 Bar forms poorly formed / reworked / removed X X Sum of indices = X Sum of indices = X Sum of indices = X Stability Index (SI) = (AI+DI+WI+PI)/4 = 0	Form	4	Cut-off channel(s)			X	0,280		
6 Thalweg alignment out of phase with meander form 7 Bar forms poorly formed / reworked / removed Sum of indices = 3 Sum of indices = 3 Notes: Set Crewer of meach charge (Hensthick) Stability Index (SI) = (AI+DI+WI+PI)/4 = 0	(PI)	5	Formation of island(s)					X	
7 Bar forms poorly formed / reworked / removed X Image: Sum of indices = 2 S Sum of indices = 2 S Notes: Set General neach chang (fensili() Stability Index (SI) = (AI+DI+WI+PI)/4 = 0		6	Thalweg alignment out of	phase with meander fo	rm		X		
Sum of indices = 2 5 Notes: See Cremeral reach charg (fensill(). Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.		7	Bar forms poorly formed	/ reworked / removed			X		
Notes: See General reach charg (tenstics. Stability Index (SI) = (AI+DI+WI+PI)/4 = 0.		ry a tanka analasia			Su	m of indices =	2	S	
	Notes: Sel (here	ral reach chan	a crenchice	Stability Inde	ex (SI) = (AI	+DI+WI	+PI)/4 =	0.60
In Regime In Transition/Stress In Adjus				and the second	In Regime	In Transi	tion/Stre	ess In A	djustment
□ 0.00 - 0.20 □ 0.21 - 0.40 V型 0.				μ	0.00 - 0.2	0 🗆 0.2	1 - 0.40	V	0.41

Version #3 Last edited: 10/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KM/KS

General Sit	te Charac	teristics	Pro	iect Number:	120910		MORPHIX
Date:		2023-07-12		Stream:	23010	mident	
Time:	1	2:00		Peach		wana	creek
Weather:	C	10011 000	C		F	3	
Field Staff:	0	VMIRS	L .	Location:	(211Pans	
Features	Mon	<u>Kenter</u>		watershed/Subw	atershed:	Cardun	al creek
Features Reach bread Station location Cross-section Flow direct Riffle Pool Sediment b Eroded ban Undercut bac Eroded ban Undercut bac Exxxxx Bank stabili Mark stabili Eroded ban Undercut bac Exxxxx Bank stabili Mark stabili Mark stabili Sediment b Eroded ban Undercut bac Exxxxx Bank stabili Mark stabili Mark stabili Sediment b Swamp/wet VV Grasses Tree Instream log X * X Woody debri Beaver dam Vegetated is Flow Type H1 Standing wa H2 Scarcely per <th>Mon ak ation on ion ar k/slope ank zation e fall land g/tree is is land ter H1A Back ceptible flow ace flow anding wave ling wave H9A Dissi</th> <th>itoring Long-profile Monumented XS Monumented photo Monumented photo direction Sediment sampling Scour chains Scour chains Scour chains itional Symbols water water pates below free fall Small boulder Large boulder Bimodal Bedrock/till</th> <th>IM D GRAP CLAY</th> <th>e Sketch</th> <th>X XS3 X X HISTORIO DEGRIS + 30 BLOCKING FLOW COM XS1</th> <th>DS SLOPE FAILU TALL DS BEAVER I THUES BEN THUES BEN</th> <th>Compass Compass Compass ARE 2 SIDE DAM ? ALL US SIDE VEATH</th>	Mon ak ation on ion ar k/slope ank zation e fall land g/tree is is land ter H1A Back ceptible flow ace flow anding wave ling wave H9A Dissi	itoring Long-profile Monumented XS Monumented photo Monumented photo direction Sediment sampling Scour chains Scour chains Scour chains itional Symbols water water pates below free fall Small boulder Large boulder Bimodal Bedrock/till	IM D GRAP CLAY	e Sketch	X XS3 X X HISTORIO DEGRIS + 30 BLOCKING FLOW COM XS1	DS SLOPE FAILU TALL DS BEAVER I THUES BEN THUES BEN	Compass Compass Compass ARE 2 SIDE DAM ? ALL US SIDE VEATH
S Downstream VDJ Woody debris WC Valley wall cor	RB US jam TR ntact FC	Rebar Upstream Terrace Flood chute	110	TRIB			
OS Bottom of slop	e FP	Flood plain	Photo-		(
S Top of slope	KP	Knick point	Motors				
· ·			notes:	s.			

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Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

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Nate:	12-07-25	2		Field Staff	KG KN	Λ	Bend ID:		
Time	120123	»M		Stream:	TRIBH	APDINAL AREEK	Subwaterst	ed.	CARDINAL ORGEN
Weather:	SUNNY	HUND 2	2.5.C	Reach:	B3	B3 Watershed: 07			OTTAINA RIVER
	1 000101011								
RB or LB? Outside bank)	<u>Bankfull</u> Width (m)	<u>Bankfull</u> Height (m)	<u>Bank</u> Height (m)	Root Depth (m)	Root Density (%)	Surface Protection (%)	Bank Angle (°)		Bank Material (Table 19)
RB	6	1.3	1,3	0.25	30	20	(SEE SKETCH) 35-90	Ģa Till ⊠ Clay ⊠ Silt	□ Sand □ Large Cobble y □ Gravel □ Small Boulder □ Small Cobble □ Large Boulder □ Bedrock
Sketch (View ocation, bed & bar	ved Downstrea nk materials, approx.	m) Include: meas water level, eviden	surements, bank slope ce of erosion, stratifica	, evidence of geomo ition in bank sedime	rphic processes/adjust nts, soil horizons, ban	ments, geomorphic/bed kfull indicators, woody d	form units, vegetat ebris, roots, etc.	ion type 8	& Geomorphic Unit (Table 22)
E E	9 Left	Bank	90% SHF	DED		Right Bank			🗆 Riffle 🗆 Run 🖄 Pool 🗆 None
	T A				4 1		I		Type of Bank Failure (Table 14)
	The	PE W	RCHED ROOT AD POSSIBLY	E	TAN	J &	2		 □ Fall/slough □ Undercutting □ Parallel slide □ Slab failure □ Motation slip and slump
	the li	NN FF	ROMRB?	Sh2	VINS	90°			Adjacent Infrastructure
		Y. J. C		42	1/1/F	-947 0.		•	Utilities Parking lot
		AN C	392		SAL	Phillip			Building Dathway
		8/02	11213		ART	•			
		PNY /1	gen Be	Popl	45	a di sa			Distance from TOB (m):
			Web IK	61	T			Antoninana ang kari ng Panja an Apa da at a M	Notes: HOUSE ON TABLE
		ONA 1	HARDE		1.3M				LAND ADJACENT TO RB
		Ø/A	W.C.	15°	1				VALLEY WALL
		dir	10-						NO ALLUVIAL STRATA OF
			CI CI	AYTILL	l				BED CLAY TILL
			•		SLUMF				BANK BASE CLAY TILL
		EVTRE	ANE WO	100:01	F				MANY EXPOSED ROOTS,
		EALLE	I TOFES	WD: 01	JEM				TALLEN + LEANING TREE
	and the second second second second	THUCE	VINCO	1.06 011	10171	a han se mana fa a san an hanna an fa an an an de san an an an de san an an de san an an de san an an de san a	interested in the low restored	And the second s	Photos: WINN SLUARY

Version #4 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: ____ Completed by: _____

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					A2. 61							GEO
Reach Chara	cteris	tics P	roject	Number	230710			T				MORPHIX*
Date:		2133-1	1-38		Field Staff:	KS KW		Waters	hed/Subwatersh	ed: CAFDII	NAL CR	EFK
Time:	e.				Stream:	CAPDINA	r creektrib	UTM (U	pstream):			
Weather:		SUN & C	LOVP	-2%	Reach:	129		UTM (D	ownstream):			
(Table 1)	V а (т	alley Type able 2)	2	Channel (Table 3)	Туре	Channel Zone (Table 4)	Flow Type(Table 5)		Evidence of Groun	dwater Location:	P	hoto:
Riparian Vege	ation					Aquatic & I	nstream Vegetatio	on	1	Nater Quality		
Dominant Type (Table 6)	1/2	Coverage	Channe	- 4 [- 10	Age (yrs) ∃ Immature (<5) ▲Established (5-30)	(Table 8)	Woody Debris	WD Densit	WDJ/50m:	Odour (Table 16)	ти (Та	ble 17)
Encroachment (Table 7)		t Continuou	s 🏹>	10	Mature (>30)	Reach Coverage %	2.5 □ Not Present	🗆 High			L	<u></u>
Channel Characteristics												
Sinuosity Type (Table 9)	2	Sinuosi	ty Degre (Table 10	e) 3	Bank Angle □ 0 - 30	Bank Erosion □ < 5%	(Table 19) Bank	Clay/Silt	Sand Gravel	Cobble Bouide	er Parent	Rootlets
Gradient (Table 11)	3	# of	Channe (Table 12	is 2)	10 - 60 10 - 90	□ 5 - 30% □ 30 - 60%	Riffle Pool	R				
Entrenchment (Table 13)	1	Ba	nk Failur (Table 14	e +) 1/2	Undercut	X 60 - 100%	Bed (if no riffle-pool morphology)					
Down's Model (Table 15)	ŧ	Bankfull I	ndicator (Table 18	s 13/5		Bankfull Width (m)	1.70 3,00		Wetted Widt	n (m) 1,40	1.75	/
Sed Sorting (Table 20)	PS	Sediment 1 0	Franspor bserved	t □ Yes	KNO 🗆 Not Visible	Bankfull Depth (m)	0.50 0.75		Wetted Dept	n (m) 0,08	0.10	
Transport Mode (Table 21)	3	% of B	ed Activ	e ()		Undercuts (m)	0.10 0.24		Velocity (m/s) 0,29	0.78	
Geomorphic Units (Table 22)	5/6/8	Mass N	lovemen (Table 23	13	RUNS% 30	Pool Depth (m)	0.24 FROZEN	FROZE	Velocity Est	imate WIFFル ethod 略所しし	wiftle BALL	1
Riffle-Pool Spacing (m):	10		% Riffles	3 0	% Pools: 30	Riffle Length (m)	3 /		Meander Ampl	itude (m) 7	5	10
Notes:			0.4					0-11 Ame	howard and a set on a de			
-2nd HALF -LARGE	10 (Um	tall)	el br	AT T	teked due He cente	10 BEAVER	VEACH CAU	SING	H LAARGE (CH FROZEN)	0006	
- EVIDENCE	DE POOL	DEWA	TERIN	16 FI	ROM EXT	OSED/SILT nume not F	Y BAPE BF rozen) D/S	NKS F	ht u/s ext beaver d	ENT AM.		
- EVIDENCE DE RECENT BEAVER ACTION OBSERVED												
Photos: DEW	UN TE	KING.	TRE	ETKI	NUKS NAT	VIS EXIEN	11 2000221	JEVIM	FINIS WERE	- INN DEG	er beto	<u>F</u> F
Version #4						Sen	ior staff sign-off (if i	required):	Checke	ed by: KS	Completed b	y: <u>KM</u>

Version #4 Last edited: 04/04/2023

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General Site Characteristics

Project Numbers (1209)

MORPHIX"

Date:		21	28-11-28		Stream:	CARDINALCREEKTRIR
Time	1	Nameda 76-0	<u> </u>		Reach:	RU
Weat	her:	02	N + CIDUD -	200	Location:	ADISBAIC
Field	Staff:	Vs	+ VAL	UN V	Watershed /Subwatershedu	CALETINI CRETEK
		100			Water shed/ Subwater shed.	CHEDINGL CEEEE
Featu	res	Monito	oring	Sit	e Sketch	Compass
	Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree Woody debris	Additic	Long-profile Monumented XS Monumented photo Monumented photo direction Sediment sampling Erosion pins Scour chains Sonal Symbols		BEAVER DAM (2m) O CONFIVENCE WITH CARDINAL CREEF. CREEF. CREEF. CREEF.	STOUR. STOUR. Tree ROOTS BACKWATEPED BACKWATEPED MEAS2
	Beaver dam				S BEAUER	Sm tall
$\overline{\mathbb{V}}$	Vegetated island				> DAIN - CHARMA	
Flow 1	уре				J.O.	
H1	Standing water H1.	A Back v	water		3 W	CUTUMNNEL
HZ	Scarcely perceptible	flow		3	1 11	000
H3	Smooth surface flow			-	TO FROZEN	3
H5	Dippled				PO PO	5 10
H6	Unbroken standing w	121/2				D'O
HZ	Broken standing way	ave				101-2
ня	Chute			/	V	1 15
H9	Free fall	Diccin	ates below free fall		$\gamma / / / / / / / / / / / / / / / / / / /$	ž.
Substr	ate	<u>- 21331</u>		1	J/A/Ar A	AIE
S1	Silt	S6	Small boulder		11/11/2	Jos and Stand
S2	Sand	50	Large boulder	F		
S 3	Gravel	58	Bimodal	- W		ENDACED
S4	Small cobble	S9	Bedrock/till	1		OHOL CIT
S 5	Large cobble		,			BURCHIN
Other					1/11: >>	FROM WITERING
BM	Benchmark	EP	Erosion pin		111110	DEWHIEF
BS	Backsight	RB	Rebar	1	11.1114	
DS	Downstream	US	Upstream		TAN LAND	ACT
WDJ	Woody debris iam	TR	Terrace	j ž	T-MC	(BB-m) B
VWC	Valley wall contact	FC	Flood chute		(OFBOIL ONED	V DZJ
BOS	Bottom of slope	FP	Flood plain	Dhat	FEMUH BREN	- FOV
TOS	Top of slope	KD	Knick point	-100	-	
		111	Knick point	Note	5:	

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Rapid Geomorphic Assessment

Project Number: 23076

28-11-23 Stream: SOUTH TRIB CARDINAL C							
M	Reach:	R4	04,5	s (165-1-190	2		
-2'C	Location:	CARDINIAL	reet	VILL	AC 8		
364/ 9. · ·	Watershed/Subwatershed:	CARDINIA	COF	N VILL	AGL		
	Geomorphological Indicator	UNADINA	D	EK	T		
ption		national and states of the	Voc	No	Factor		
har		2011 V 634 01	Tes	NO	Value		
materials in rif	les embedded	and the second second		+ ;	17 I SER 31		
n in pools	ics embedded	<u>요. 산업대한 실망</u> 가 안전 전		+	۸.		
bars	2647-4547-4659-278 2869-2874-2874-2874-2874-2874-2874-2874-2874	l patrici			4/_		
ion on point bar	and the second shares as the share	we test epotenti			1 1		
ngitudinal sorti	on of bed materials			-	712-5387-52		
ition in the over							
		Sum of indices =	Δ	2	052		
d bridge footing							
d sanitany / cto	rm cowor / nincline / ste	Provident Aller		NIA			
d storm source		NIA					
ninod gabion ba		NIA	-				
nineu gabiori ba	skets / concrete aprons / etc.	<u>a an saide</u>	1.000	NIA	3,		
e on har forms	in or curverts / storm sewer outlets	and the second second		NIA	15		
utting due to kn	ickpoint migration	<u> </u>			1 23		
e cut through old	der har material	55 (A. 1975) 14					
ded armour lav	er visible in bank						
el worn into und	isturbed overburden / bedrock						
a states a		ium of indices =	2	7	0.10		
/ leaning trees /	fence posts / etc				Unde		
ence of large or	anic debris				e i des		
d tree roots							
cour on inside n	neander bends		1	n or bru			
cour on both sid			51				
ked gabion bas		ALLA	17				
of basal scour >	>50% through subject reach		~	NIA			
d length of prev	iously buried pipe / cable / etc.		NIA	2			
e lines along top	o of bank		and an an an array	10111	동생, 김 씨가		
d building found	ation			NIA	na Literatura		
	S	um of indices =	5	2	0.71		
ion of chute(s)							
thread channel t	o multiple channel		~		i Martina		
on of pool-riffle	form to low bed relief form			-			
channel(s)			~		4,		
ion of island(s)		1	1/1				
g alignment out			- 104 C				
ms poorly forme	d / reworked / removed						
	S same and same s	um of indices =	A	2	0.53		
	Stability Ta	AT (ST) - (AT			0110		
	Th Desime		ion /Chur	TF1)/4 =	0.013		
			IUII/ Stre	:55 IN AC	ajustment		
		Stability Inc In Regime 0.00 - 0.	Sum of indices = Stability Index (SI) = (AI-I) In Regime In Transit 0.00 - 0.20 0.2	Sum of indices = 4 Stability Index (SI) = (AI+DI+WI- In Regime In Transition/Stree 0.00 - 0.20 0.21 - 0.40	Sum of indices A C Stability Index (SI) = (AI+DI+WI+PI)/4 = In Regime In Transition/Stress In Ac 0.00 - 0.20 0.21 - 0.40 X		

Senior staff sign-off (if required): ______ Checked by: _____ Completed by: _____KS___

Rapid Stream Assessment Technique Project Number: 23076

Date:	28-11-23	Stream:		SOUTH TRIB	CARDINAL CREEK			
lime:		Reach:		R4				
Weather:	OVERCAST -2°C	Location:		CARDINAL CI	REEK VILLAGE			
ield Staff:	KS KM	Watershed/Subwater	rshed:	CARDINAL	CREEK			
Category	Poor	Fair		Good	Excellent			
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughin failure 	of bank network ent signs of bank g, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 			
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer based on above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) erhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 			
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	 Exposed predom large, si scarce 2-3 rece per stre 	l tree roots inantly old and maller young roots ent large tree falls am mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 			
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottem 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	• Bottom general plant/sc	1/3 of bank is y highly resistant il matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 			
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	• Channe general	cross-section is ly V- or U-shaped	Channel cross-section is generally V- or U-shaped			
Point range	0 0 1 0 2	03405		0708	□ 9 □ 10 □ 11			
3	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% 59% en mainste	embedded (35- nbedded for large m areas)	 Riffle embeddedness 25% sand-silt (< 35% embedded for large mainstem areas) 			
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	, deep pools ate n >81% sand Low to moderate number of deep pools. Moderate number of deep pools• Pool substrate composition 60-80% sand-silt• Moderate number of deep pools• Pool substrate composition 30-59% sand-silt		te number of deep ostrate composition o sand-silt	 High number of deep pools 61 cm deep) 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 			
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Stream and/or sedimen uncomr 	bed streak marks `banana"-shaped nt deposits non	Streambed streak marks and/or "banana"-shaped sediment deposits absent			
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, I uncomr Small Ic fresh sa top of Ic 	arge sand deposits non in channel ocalized areas of and deposits along ow banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 			
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	Point bars common, moderate to large and unstable with high amount of fresh sand COBBLE	Point ba well-ve armour fresh sa	ars small and stable, getated and/or ed with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 			
Point range			j	5 0 6	5 7 0 8			

Senior staff sign-off (if required): _____ Checked by: KS____

Date: 28	-11-23	PN: 23070	Location:	SOUTH TRIB CARDINAL
Category	Poor	Fair	Good	Excellent
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channe width (45-65% for larg mainstem areas) 	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)
	Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low)	 Few pools present, riff and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	es • Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water)
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and san 5-24% cobble 	Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble	 Riffle-substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble
Habitat	 Riffle depth < 10 cm for large mainstem areas 	Riffle depth 10-15 cm large mainstem areas	for Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas
	Large pools generally < 30 cm deep (< 61 cm for (large mainstem areas) and devoid of overhead cover/structure	Large pools generally 3 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structe	80- • Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure
	 Extensive channel alteration and/or point bar formation/enlargement 	Moderate amount of channel alteration and, moderate increase in point bar formation/enlargement	• Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	No channel alteration or significant point bar formation/enlargement
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1
	 Summer afternoon water temperature > 27°C 	 Summer afternoon was temperature 24-27°C 	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C
Point range	00102	□ 3 5⁄4	0506	0708
	 Substrate fouling level: High (> 50%) 	 Substrate fouling level Moderate (21-50%) 	• Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)
Water Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	Slightly grey colourTDS: 50-100 mg/L	Clear flow TDS: < 50 mg/L
could quality	 Objects visible to depth < 0.15m below surface 	 Objects visible to depth 0.15-0.5m below surfa 	• Objects visible to depth ce 0.5-1.0m below surface	Objects visible to depth > 1.0m below surface
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour
Point range	00102	0304	05 🕅 6	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localize gaps 	Forested buffer generally > 31 m wide along major portion of both banks	• Wide (> 60 m) mature forested buffer along both banks
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59%) for large mainstem areas)	 Canopy coverage: >80% shading (> 60% for large mainstem areas)
Point range	001	□ 2 □ 3	0405	∮ 6 □ 7
Total overall s	core (0-42) = Z(o	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)

5

Senior staff sign-off (if required): _____ Checked by: <u>\CM</u> Completed by: <u>KS</u>

Date:	2	023-1	1-28		Field St	aff:	KS + KA	1		Wate	rshed	/Subw	atershe	d: CA	ROIN	AL. CE	LEEK
'ime:	-				Stream	1	CARDIN	ni cr	EEKTRIR	UTM	(Upsti	eam):		10.00			<u>UUR</u>
Veather:	SV	N+ (I	QUO	-200	Reach:		TI		1976	UTM	(Down	nstrear	n):				
and Use 3/	Valle (Tabl	ey Type e 2)	2	Channe (Table 3)	Туре	7 C	hannel Zone Fable 4)	2 (low Type Fable 5)	1	🗆 Evi	dence o	f Groundw	vater Loc	ation:	F	Photo:
liparian Veget	ation						Aquatic &	Instream	n Vegetati	on			Wa	ater Qua	ality		
Cominant Type (Table 6) Encroachment	1/2	overage None Fragmen Continuo	Chann ted tes	el Widths 1 - 4 4 - 10 > 10	Age (yrs) □ Immature ■ Established ■ Mature (>3	(<5) (5-30)	Type (Table 8) Reach	5	oody Debris In Cutbank In Channel	WD Der	nsity W	/DJ/50m	:	Odou (Table :	16)	Tu (Ta	able 17)
hannel Chara	cteristics		<u> </u>		<u>^</u>	-,	Coverage %	-0 -		<u> </u>						-	
inuosity Type (Table 9)	9	Sinuo	sity Degr (Table 1	ee 0) 2	Bank A □ 0 - 30	ngle)	Bank Erosion □ < 5%		(Table 19) Bank	Clay/S	ilt s	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Gradient (Table 11)	3	# C	of Channe (Table 1	2)	□ 30 - 6 ¥ 60 - 9	50 90	□ 5 - 30% □ 30 - 60%		Riffle Pool차/	AA			Ā	X	× □		
ntrenchment (Table 13)	3 7	В	ank Failu (Table 1	re 1121 4) 5,10	Under	cut	A 60 - 100%	Designed	Bed if no riffle-pool morphology)								
own's Model (Table 15)	eic .	Bankfull	Indicato (Table 1	rs 8) 13/6			Bankfull Widt (m	h pooked	VORLY	P0 01	oply	Wette	d Width (m) 1.5		1.75	
(Table 20)	MS	ediment	t Transpo Observed	I? □ Yes	No 🗆 Not	Visible	Bankfull Dept (m	h ** //	1 7			Wette	d Depth (m) (),()	<u>4</u>	0.06	
de (Table 21)	3	% of	Bed Acti				Undercuts (m	0.40	0.23	0	.32	Ve	locity (m	/s)		/	
its (Table 22)	8	Piciss	(Table 2	3) 4			(m					Moonda	Meti	hod		/	
Spacing (m):			% Riffle	s:	% Pools:	/	Riffle Length (m) /		-		ricanue	(m)			and and a second se
es: RAVINE	FLOWFI	DFR	on f	IG FIE	LD HIG	HG	PADIENT					14					
DEBRIS IN MANY (N CHY	INNE S +	EL (O	MMON	- HIGH	GHOI	ENTRATION	JDE	BRIS B	EFO	RE	CON	FILE	NCE	WITH	MAIN	ITRIC
SIOUR C	N B	OFH	BAI	JKS DOTS/1	EANIN CAN	210	DRIEK-NE	D TH	N KONPHO	- 10	FUKC	EDC	THNO	<u>-3 IN</u>	FIOM	NIKE	CTION
VI- HL	19 C	VOLDO	EN K	uu ist i	EIIIAUA	S	INCO UN	milait	11	ø	RI	Enc =EA	HW	HS F	PFK	NINE	
tos:				1.11				5 3						-pe			

Last edited: 04/04/2023

General Site Characteristics

Project Number: 2309(a

Date:		2023-	-11-28		Stream:		(ARDINAL CREEK TRIB
Time:		- setting			Reach:			and the second s
Weath	ier:	SUN +	CIANO -20	C	Location:		1	DELEANC
Field S	Staff:	KSK	M	~	Watershed/S	ubwatershed	s (CHEDINAL CREEK
Featur	es	Monitoring		Site	Sketch		Call Street of Call	Compass
	Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank	Co-o-o- Long Monu Monu Monu Monu direct Sedir Erosi Scou Additional S	-profile umented XS umented photo umented photo tion ment sampling on pins r chains Symbols		CA DEBRIS HCC. AT DIS EXTEN	PDINAL T	CREE	EXPOSED ROOTS
	Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree Woody debris Beaver dam Vegetated island			RI Mi	FTLE IIKE ENTURE	* X	A A A A	POWNY LEANING
Flow T	Standing water H1	Back water	<u>,</u>	t	la une .	51	1r	
H2 H3 H4 H5 H6 H7	Scarcely perceptible Smooth surface flow Upwelling Rippled Unbroken standing way Chute	flow ave e		ME	S A	X		THU VEPICAL BANKS
H9	Free fall H9	Dissipates	below free fall		\bigcirc	- MAC	A-u	APGE DOWN TREE +
Substr	ate				S	1354		root ball
S1 S2 S3 S4 S5	Silt Sand Gravel Small cobble Large cobble	S6 Sr S7 La S8 Bii S9 Be	nall boulder Irge boulder modal edrock/till	G	E	Here &) TE	O S
Other						-1 15	digno a	SLOPE
BM BS DS WDJ VWC BOS	Benchmark Backsight Downstream Woody debris jam Valley wall contact Bottom of slope	EP Er RB Re US Up TR Te FC Flo FP Flo	osion pin ebar ostream errace ood chute ood plain	INSTRE VEG		KK K	+ (}	5 passes
TOS	Top of slope	KP Kr	nick point	Notes				

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: K

Page _____ of _____

Rapid Geomorphic Assessment

Project Number: 23076

Date:	28.	-11-23	SOUTH TR	IB CAL	RDINAL	CREEK					
Time:	12	:55 PM	Reach:		TRIBI		Co ligne				
Weather:	OVI	ERCAST -2'C	Location:		CARDINAL	CREE	K VIII	ACE			
Field Staff:	KS	KM	Watershed/Sub	watershed:	CARDINIAL	COCE	N VILL	noc			
		6	eomorphological Indicat	tor	CINDINIL	Dreet	Scont?	Τ			
Process	No.	Description				Voc	No	Factor			
	1	Lobate bar		24(7)()(2)()(2)()(2)()(2)()(2)()(2)()(2)		165		- Value			
	2	Coarse materials in riffle	es embedded				+	1.125.25			
Evidence of	3	Siltation in pools		16.	안녕한 이 같은 것이 같았다.	1	+				
Aggradation	4	Medial bars		19	Desence	201	1	2/-			
(AI)	5	Accretion on point bars	Constant and a constant	the state of the state	1	Du parte	+				
	6	Poor longitudinal sorting	of bed materials				1	88, 1918, 86			
	7	Deposition in the overba			-						
	1853		antha agus a	Su	m of indices =	2	5	0.786			
	1	Exposed bridge footing(c)					10,200			
	2	Exposed sanitary (storr	n cowor / ningling / ata	r DOBJE Niel narodzielski use	1 S		NA	-			
	3	Elevated storm sewer or	utfall(c)	•			NIA				
1	4	Undermined gabion bad	kots (concrete aprene	(ata	9 St	-	NA				
Evidence of	5	Scour pools downstream	of culverts / storm se	elc.	den and the second s		NIA	2			
Degradation	6	Cut face on bar forms	Tor curverts / storm set	m sewer outlets N/A							
	7	Head cutting due to knic	knoint migration		<u> </u>			1 '5			
	8	Terrace cut through olde	er har material					-			
	9	Suspended armour lave	r visible in bank								
	10	Channel worn into undis	turbed overburden / be	drock		\ \					
	- I			Sur	n of indices =	2	2	6 AG			
	1	Fallen / leaning trees / f	anco posta / ota		in or indices	-		010			
	2	Occurrence of Jarge orga	anic dobric					State 11			
	3	Exposed tree roots									
	4	Basal scour on inside me	ander bends		Alter Bener Dans						
Evidence of	5	Basal scour on hoth side	s of channel through rif	fla	a ana ing ang ang	100 Basel					
Widening	6	Outflanked gabion baske	ts / concrete walls / et					Δ.			
(***)	7	length of basal scour	50% through subject ro	ach			NIA	17			
	8	Exposed length of previo	usly buried nine / cable								
	9	Fracture lines along top	of bank	.,			NIA				
	10	Exposed building foundation	tion		· · · · · · · · · · · · · · · · · · ·		AILA				
	See. 4			Sur	n of indices =	Δ	NIA 2	1.67			
	1	Formation of chute(s)		541		1		10124			
	2	Single thread channel to	multiple chapped								
Evidence of	3	Evolution of pool-riffle fo	rm to low bod relief for	~							
Form	4	Cut-off channel(c)	The control of the relief for	111				21			
Adjustment	5	Formation of island(c)	S. I. J. Pres	11167-6		17					
(PI)	6	Thalweg alignment out of	f phase with meandor f	orm				1. (J.C. 176)			
	7	Bar forms poorly formed	/ reworked / removed	onn							
and the second second	· · · · ·	poorly formed	, icworked / ieinoved	C	of indiana			6 l			
Notes	24	······	<u> na sta na statistika a da ana stati</u>	Sun		hann	5	0,286			
			1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 - 1 -	Stability Index	x (SI) = (AI+	DI+WI	+PI)/4 =	0,386			
7 - 2				In Regime	In Transit	ion/Stre	ess In Ad	djustment			
				0.00 - 0.20	0.2	1 - 0.40		0.41			

Senior staff sign-off (if required): _____ Checked by: _KM_ Completed by: _KS_

Rapid Stream Assessment Technique Project Number: 23076

				1	10. ma					
Date:	28-11-23	Stream:		SOUTH TRIB	CARDINAL CREEK					
Time:	12:55 PM	Reach:		TRIB 1						
Weather:	OVERCAST - 5 'C	Location:		CARDINAL (REEK VILLAGE					
Field Staff:	KS KM	Watershed/Subwater	shed:	CARDINAL	CREEK					
Category	Poor	Fair		Good	Excellent					
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughin failure 	o of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 					
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer bar m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) /erhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 					
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predom large, s scarce 2-3 reco per stree 	d tree roots inantly old and maller young roots ent large tree falls eam mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 					
	Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	 Bottom general plant/sc 	1/3 of bank is lly highly resistant oil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or materia 					
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	• Channe general	l cross-section is Ily V- or U-shaped	 Channel cross-section is generally V- or U-shaped 					
Point range		3 0 4 0 5		5 0 7 0 8	09010011					
	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% 59% er mainste	6 embedded (35- mbedded for large em areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)					
	Few, if any, deep pools Pool substrate composition >81% sand- silt	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	 Modera pools Pool su 30-59% 	ite number of deep bstrate composition 6 sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 					
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Stream and/or sedime uncom 	bed streak marks "banana"-shaped ent deposits mon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 					
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, uncomi Small lo fresh sa top of l 	large sand deposits mon in channel ocalized areas of and deposits along low banks	 Fresh, large sand deposits rare or absent from channe No evidence of fresh sediment deposition on overbank 					
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	Point-bars common, moderate to large and unstable with high amount of fresh sand	 Point b well-ve armour fresh sa 	ars small and stable, getated and/or red with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 					
Point range		03 📫 4		□ 5 □ 6						

Senior staff sign-off (if required): _____ Checked by: K

Date: 28-	-11-23	PN:	23076		,	Location: St	WATH TRIE	CARDINAL	Twiston married
Category	Poor		Fair		G	bod	E	cellent]
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wette 60% width main	ed perimeter 40- of bottom chann (45-65% for lar stem areas)	el rge	 Wetted perir of bottom ch (66-90% for mainstem ar 	neter 61-85% hannel width Flarge reas)	 Wetted pe bottom ch 90% for la areas) 	rimeter > 85% of annel width (> rge mainstem	
	 Dominated by one habitat a type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pand r Velocingeneirs shallormain: and pr velocingeneirs velocingeneirs diveneirs 	pools present, rif uns dominant. ity and depth rally slow and ow (for large stem areas, runs pools dominant, ity and depth sity intermediate	fles	 Good mix be runs and poor Relatively di and depth of 	etween riffles, ols verse velocity f flow	 Riffles, rur habitat pre Diverse ve of flow pre fast, shallo water) 	s and pool sent locity and depth sent (i.e., slow, w and deep	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle comp predo cobbl 5-249 	substrate osition: ominantly small e, gravel and sa % cobble	nd	 Riffle substration composition gravel, cobb material 25-49% cob 	ate : good mix of le, and rubble ble	 Riffle subs composition gravel, rub with little s > 50% col 	trate n: cobble, ble, boulder mix and bble	
Habitat	• Riffle depth < 10 cm for large mainstem areas	 Riffle large 	depth 10-15 cm mainstem areas	for	 Riffle depth large mainst 	15-20 cm for em areas	 Riffle dept large main 	n > 20 cm for stem areas	
	Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	 Large 46 cr for la areas overh 	e pools generally n deep (61-91 cr rge mainstem) with little or no nead cover/struct	30- n b ture	 Large pools cm deep (91 large mainst some overhe cover/struct 	generally 46-61 -122 cm for em areas) with ead ure	Large pool cm deep (large main good over cover/strue	s generally > 61 > 122 cm for stem areas) with head cture	
	• Extensive channel alteration and/or point bar formation/enlargement	 Mode chann mode point formate 	rate amount of nel alteration and rate increase in bar ation/enlargemen	d/or nt	 Slight amound alteration and increase in p formation/er 	nt of channel d/or slight point bar nlargement	 No channe significant formation/ 	l alteration or point bar enlargement	
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle, 0.69:	/Pool ratio 0.5- 1 ; 1.31-1.5:1		• Riffle/Pool ra ; 1.11-1.3:1	ntio 0.7-0.89:1	Riffle/Pool	ratio 0.9-1.1:1	
	 Summer afternoon water temperature > 27°C 	 Sumr temp 	ner afternoon wa erature 24-27°C	ater	 Summer after temperature 	ernoon water 20-24°C	 Summer a temperatu 	fternoon water re < 20°C	NIA
Point range	001022		0304		05	□ 6		7 🗆 8	
	Substrate fouling level: High (> 50%)	 Subst Mode 	rate fouling leve rate (21-50%)	el:	• Substrate for Very light (1	uling level: 1-20%)	 Substrate Rock unde 	fouling level: rside (0-10%)	
Water Quality	Brown colour TDS: > 150 mg/L	• Grey • TDS:	colour 101-150 mg/L		Slightly grey TDS: 50-100	colour) mg/L	 Clear flow TDS: < 50 	mg/L	
	 Objects visible to depth < 0.15m below surface 	• Objec 0.15-	ts visible to dep 0.5m below surf	th ace	 Objects visib 0.5-1.0m be 	le to depth low surface	 Objects vis > 1.0m be 	ible to depth low surface	N/A
	Moderate to strong organic odour	 Slight organ 	to moderate ic odour		 Slight organi 	c odour	• No odour	\sim	
Point range	0 0 1 0 2		0304		05	SØ 6		7 🗆 8	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Ripar predo but w gaps 	an area minantly woodea ith major localiza	d ed	 Forested buf > 31 m wide portion of bo 	fer generally along major th banks	• Wide (> 60 forested bu banks	0 m) mature iffer along both	
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canop 60% for lan areas 	by coverage: 50- shading (30-44% rge mainstem)	6	 Canopy cove 60-79% shad for large mai 	rage: ding (45-59% nstem areas)	 Canopy comover >80% shat large main 	verage: ding (> 60% for stem areas)	
Point range	001		0203		04	05		5 🖏 7	
Total overall s	score (0-42) = 22	Pa	or (<13)	Fa	air (13-24)	Good (25-3	34) Ex	cellent (>35)	

Senior staff sign-off (if required): _____ Checked by: K

ate:	0	2023-1	1-28	1	Field	Staff:		KS KI	M		<	Wate	shed,	/Subw	atershe	d: CY	RDIN	JHL C	REEK
me:	-				Strea	m:		CALDI	NML (REE	KTPE	UTM (Upstr	eam):			<u></u>	<u> </u>	- Contact
eather:	Ş	UN T (101	D-2°C	Reach	:	-	Ta				UTM (Down	stream	n):		the second second		
able 1)	Valle (Tab	ey Type le 2)	2	Channel (Table 3)	Туре	13	Chan (Table	nel Zone e 4)	2	Flow (Table	Type = 5)	1	🗆 Evic	dence o	f Ground	water Lo	cation:		_ Photo:
parian Vegeta	ation							Aquatic	& Instr	eam Ve	egetatio	on			W	ater Qu	ality		
minant Type (Table 6)	1/2 0	overage None	Channe 1	- 4	Age (yrs) I Immatu	e (<5)		Type (Table 8)	5	Woody	Debris Cutbank	WD Den	sity W	DJ/50m	:	Odo (Table	ur 16)		Turbidity (Table 17)
(Table 7)	7	Fragmente		- 10)	Establish Mature (ed (5-30 >30))	Reac Coverage %	\$\$	In C	hannel Present	□ Mod	l	1		1			2
annel Charac	teristics	5																	
(Table 9)	2	Sinuosit	y Degre Table 1	e 3	Bank □ 0 -	Angle 30	B	ank Erosio] < 5%	ı	(Tab	le 19) Bank	Clay/Si	lt S	and	Gravel	Cobble	Boulde	r Paren	it Root
Gradient (Table 11)	3	# of ANINE	Channe (Table 1	Is 2)	□ 30 □ 60	- 60 - 90] 5 – 30%] 30 – 60%			Riffle Pool	X			XX		X D		
(Table 13)	3	a Ban	k Failu Table 1	re 2 4) 2	🗆 Und	lercut		1 60 - 100%		(if no ri mor	Bed ffle-pool phology)								C
(Table 15)	fe	Bankfull Ir (dicator Table 18	s 13k			I	Bankfull Wi	dth (m)	\$8	1.63	PO	deiy Fined	Wette	d Width	(m) 🖏	48	0,93	1,20
Sed Sorting (Table 20)	NP 5	Sediment T Ol	ranspo oserved	rt □ Yes		Not Visible	. 1	Bankfull De	pth (m) ליל	3	0.55	96 100	decy Fines	Wette	d Depth	(m) ().(135	0.0%	0.90
Transport de (Table 21)	3	% of Be	ed Activ	e ()				Undercuts	(m) Dr (10	0.85	Ô	,15	Ve	locity (m	n/s)	/	/	<u> </u>
Geomorphic its (Table 22)	5/6	Mass M (ovemer Table 23	^t 1/4		/	- 51	Pool De	m)	S	0,90			Velo	city Estin Met	nate thod	(Ľ
Riffle-Pool pacing (m):		9	% Riffle:	s: 100	% Pool	s: /	Rif	fle Length ((m)					Meand	er Amplit	ude (m)	00	1	particular and a second
es:		- A 1-0 W			6 - A	4 1/4 5	N 4								<u>) 6 8</u>		19		
ANDE INC	20M	AL TIL	-CP	DOWN	1 10	MH	NT	-RIBUTI	HAY -	he me	el lev	MACE	37 10	INAT	C/IIAN	NEV	run	N 10. 1	ABAAAL
ORSERVEN	1 MINIAL	VIUN	01	NERKI		unn	NNL	r, tran	1140	IK TC.	of CA	POSE	UF	-001	strik	IN CR	-011	NGC	Dum Bli
CHANNEL	BED	COMP	OSEI	70 C	CLAU	SUBP	AVE	MENT	F COB	BLES	+ RC	JULD	EPS						and the second
MANY FO	PRED	KNICH	: poi	NIS FR	OM	14001	SY P	FBRIS						ŝ				2 .42	
BSERVER	REC	ENTR	EGRE	SIDN M	C SCA	ND A	<u>elec</u>	NS 4- 80	M M	TOPI	C SUV	mp	-7 E	VIDE	NCF	OF	MIN	or on	ies hsv
ILLS FROM	A FIE	ID EN	IEKIN	3781 01	能站有	INIT	NRP	TEVEP	1.						5				

Version #4 Last edited: 04/04/2023

Senior staff sign-off (if required): _____ Checked by: KS___ Completed by: KM____

General Site Characteristics

Project Number: 33076

Date:		20	23-11-28		Stream:		CARDINK	L CREP	K TRIR
Time:					Reach:		12	- opero C	1- 11-14
Weath	er:	CII	N + PININ -	206	Location:	<u></u>	Anitha	10	
Field S	Staff:	KS	+ KM	W V	Watershed/Sul	bwatershed:	CARDINIA	n port	sk_
Featur	96	Monito	ring	Cit	Skotekan	*	MEPINI		
	Reach break	L	_ong-profile	SIL	HANGE W. MI		ATIN THIB		
' 只 '	Station location	II P	Monumented XS	TRAN	Rillon Ch	1 10.	~	(2)
××	Cross-section		Monumented photo	-0.51	VILLA & MI	112 1	55		1
>	Flow direction	I	Monumented photo	-0.86	lant of	F F +	0 9	>	\bigcirc
\sim	Riffle	♥ c	direction	1988	With D'L	7-2			
\bigcirc	Pool		Sediment sampling	He.	www.	1 all	racrade]	
	Sediment bar		Erosion pins		WEUS A	5 000 /	Autoriu .		
+++++++++++++++++++++++++++++++++++++++	Eroded bank/slope	ŏ s	Scour chains		3 >	1 200	5		
	Undercut bank	Additio	nal Symbols	-	0540	2 DAA	- Iss		
KXXXXX	Bank stabilization				DEER aDm)	Jook (SIDNE		
1	Leaning tree			C	3 VICUT	1992	GAVANTE	25	
XX	Fence				<i>Q</i> '	N/K	Calpran,	128	
	Culvert/outfall				V	())友		1 St	15
	Swamp/wetland			SLU	MP II	N Xo	++ to 65.	200	1 LU
	Grasses				(1)	1 Still	CUTFACE	Pa a	12
	Instream log/tree				V. VIC	1 Ann	Im Starco		155
***	Woody debris			1	y U	KKA .	(2001		122
-XXXXXXXXX	Beaver dam				kin 7	1812		- A	20
(V)	Vegetated island				1	AU 7	EXTRE	ME	18.2
Flow T	ype			1	AFRS 7	I F	DEP	CHAN	ng a
H1	Standing water H1/	Back v	vater	1	MIL I	12.	Q.		SI
H2	Scarcely perceptible	low			X	Tex	V		18-
НЗ	Smooth surface flow			15	2	XIK		C	12 N
Н4	Upwelling			1	TYDASED	27	C C)	195
H5	Rippled				21000	4 4			13.8
H6	Unbroken standing w	ave		(No man /	DI		1	20
H7	Broken standing wav	e		j	-	NA T		Sr.	1 A
H8	Chute	. and a		10	4	2) VYP	FROM		
H9	Free fall H94	Dissip	ates below free fall	10		9)1	1001	m	
Substr	ate	~ ~ ~	Concell has the		-C) (1		C	
51	SIIT	50	Small boulder		C (25	n		
52	Gravel	5/	Bimodal	to and the second se	· · · · · · · · · · · · · · · · · · ·	ANTERO	é h		
SA	Small cohble	50	Bedrock/till	59	X.X	X ON	IZM V		
55	Large cobble	00		IV	X.	VAD BAKL) ** * *		
Other				1	(7				
BM	Benchmark	EP	Erosion pin			X.	- MEAS	1	
BS	Backsight	RB	Rebar		X	7	- 8-0000 83		048552644
DS	Downstream	US	Upstream		.0/		evidenting offer Virenee	-	
WDJ	Woody debris jam	TR	Terrace	5). In do.	P TONOF	HUEY SLOPE		
VWC	Valley wall contact	FC	Flood chute	U	JAW /	6 W 3			
BOS	Bottom of slope	FP	Flood plain	Phot	:0S:				
TOS	Top of slope	КР	Knick point	Note	es:				
L	·						je.		2

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: K

Page _____ of _____

Rapid Geomorphic Assessment

Project Number: 73076

Date:	28	0-11-23	Stream:		SOUTH TO	IB C	ARNINIA	I PREFL
Time:	11	20 PM	Reach:		TRIB 2		11 VINA	E CALE -
Weather:	CLO	UDY WITH SUN -2.0	Location:		CARNINIAL	APE	CK JI	I AC.E
Field Staff:	K	S KM	Watershed/Subwat	ershed:	CAPHINAL	- UNE	EN VIL	LAGE
		Geomo	orphological Indicator		CHADINA	Dr		
Process	No.	Description	or photogical indicator	800 01 04 001 11 681 9466	like Listen strand	Voc	No	Factor Value
	1	Lobate bar		<u>Sanata mendera</u>	6. 1918, 199 of	165	NO	
	2	Coarse materials in riffles en	mbedded	<u>ta Sangingan ang San</u>				2.21. J. 19 19 19
Evidence of	3	Siltation in pools				~		
Aggradation	4	Medial bars	ant geboerts	Providence (Providence)		0.501		3
(AI)	5	Accretion on point bars	Regimentation of the second	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	and the second second	1	+ `	1/2
	6	Poor longitudinal sorting of h	ped materials	<u>, 1997 - 1997 - 1997</u> 1997 -	t to Carl I a the second	~		
	7	Deposition in the overbank z	one				-	-
	2152		Delcion	Sur	n of indices =	3		A79
	1	Exposed bridge footing(s)	An anna an anna an an an an an an an an a					101761
	2	Exposed sanitary / storm cou	wor / ningling / ata T	I C DIGALAN			NIA	-
	3	Elevated starm cover outfall	wei / pipeinie / etc. 1	LEDRAIN				-
	1	Undermined appier backets	(5)	and the second secon			NIA	4
Evidence of	5	Scour pools downstroom of c	/ concrete aprons / etc			52.3	NIA	5,
Degradation	6	Cut face on bar forms	Luiverts / storm sewer (Dutiets			NIA	-11
(DI)	7	Head cutting due to knickpoi	int migration			-		L W
	8	Terrace cut through older ba	un matarial					4
	9	Suspended armour laver visi				-		
	10	Channel worn into undisturbe	ed overburden / bodroc	le.				-
	1.10	Chamler worth into undisturbe	ed overburden / bedroc	K Sun	n of indices =	E		0.833
	1	Fallen / leaning trees / fonco	posts / ota				<u> </u>	010-0
	2	Occurrence of Jarge organic	dobrio				4	
	3	Exposed tree roots					-	
	4	Basal scour on inside meand	er bende			-		
Evidence of	5	Basal scour on both sides of	channel through riffle					1
Widening	6	Outflanked gabion baskets /		<u>4.4.0 (4.4.1)</u>	. Bernubur	1, 21, 81, 7		
(001)	7	l ength of basal scour > 50%	through subject reach				NIA	612
	8	Exposed length of previously	buried pipe (cable (of		10 1 1 1	-	+	18
	9	Eracture lines along top of ba	burieu pipe / cable / el	C. TILE C	SKAIP		+	
	10	Exposed building foundation		TH COUNT			NIA	-
	10			Curr	ofinding	1	NIA	
	1	Formation of shuts (a)		Suil		ما		0.75
		Circle thread line is		All is pilled of				
Evidence of	2	Single thread channel to mult	tiple channel					
Planimetric		Evolution of pool-riffle form to	o low bed relief form			1 6.15 		0
Adjustment	4 F	Cut-off channel(s)			0.8 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 - 5 -	<u>. 60 ()</u>		4
(PI)	 	The lust of Island(s)				1		+
A SALE	7	Inalweg alignment out of pha	ase with meander form					
	/	Bar forms poorly formed / rev	worked / removed			1		
		1.7	<u>tana tan</u>	Sum	of indices =	2	5	0.286
NOTES:		1.22	St	ability Index	(SI) = (AI+	DI+WI	+PI)/4 =	0.575
				In Regime	In Transiti	on/Str	ass In A	djustment
				0.00 - 0.20	0.21	- 0.40	Z	0.41

Senior staff sign-off (if required): _____ Checked by: ____CM_ Completed by: ____KS___

GE

Rapid Stream Assessment Technique Project Number: 23076

	CONTRACTOR OF A CONTRACTOR OF			A	
Date:	28-11-23	Stream:		SOUTH TRIB	CARDINAL CREEK
Time:	1:20 PM	Reach:		TRIB 2	
Weather:	CLOUDY W SUN	Location:		CARDINAL C	REEK VILLAGE
Field Staff:	KS KM	Watershed/Subwater	rshed:	CARDINAL C	REEK
Category	Poor	Fair		Good	Excellent
۲۰ - ۲۰ ۲۰ - ۲۰ (۲۰ ۲۰ - ۲۰ (۲۰ ۲۰ ۲۰ ۲۰ - ۲۰ (۲۰ ۲۰	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughir failure 	of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer bar m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) verhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	 Exposed predom large, s scarce 2-3 rece per stree 	d tree roots inantly old and maller young roots ent large tree falls eam mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	Bottom general plant/sc	1/3 of bank is ly highly resistant oil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	 Channe general 	l cross-section is ly V- or U-shaped	Channel cross-section is generally V- or U-shaped
Point range	0 0 1 0 2	3 0 4 0 5		5 0 7 0 8	□ 9 □ 10 □ 11
	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% 59% er mainste	embedded (35- nbedded for large em areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	 Modera pools Pool su 30-59% 	te number of deep bstrate composition 6 sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Stream and/or sedime uncomr 	bed streak marks "banana"-shaped nt deposits non	 Streambed streak marks and/or "banana"-shaped sediment deposits absent
veposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Freshuncom Small lo fresh sa top of l 	large sand deposits mon in channel ocalized areas of and deposits along ow banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	Point bars common, moderate to large and unstable with high amount of fresh sand	 Point ba well-ve armour fresh sa 	ars small and stable, getated and/or ed with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand
Point range		3 3 4	[5 0 6	0708

Senior staff sign-off (if required): _____ Checked by: KS_____

MO

Date: 28-	11-23	PN: 23076	Location: S	OUTH TRIB CARDINAL	Sector Management
Category	Poor	Fair	Good	Excellent	Ī
	• Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	• Wetted perimeter 40 60% of bottom channel width (45-65% for large mainstem areas)	• Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas)	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 	
Tabitat	Riffle depth < 10 cm for large mainstem areas	Riffle depth 10-15 cm for large mainstem areas	 Riffle depth 15-20 cm for large mainstem areas 	 Riffle depth > 20 cm for large mainstem areas]
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	-
	Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 	 Slight amount of channel alteration and/or slight increase in point bar formation/enlargement 	 No channel alteration or significant point bar formation/enlargement 	
	 Riffle/Pool ratio 0.49:1 ; ≥1.51:1 	 Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1 	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1	
	 Summer afternoon water temperature > 27°C 	 Summer afternoon water temperature 24-27°C 	 Summer afternoon water temperature 20-24°C 	 Summer afternoon water temperature < 20°C 	N
Point range	0 0 1 0 2	□ 3 🛱 4	0506	0708	
	 Substrate fouling level: High (> 50%) 	 Substrate fouling level: Moderate (21-50%) 	Substrate fouling level: Very light (11-20%)	 Substrate fouling level: Rock underside (0-10%) 	
Water Ouality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	Slightly grey colour TDS: 50-100 mg/L	Clear flow TDS: < 50 mg/L	
Ç,	Objects visible to depth < 0.15m below surface	Objects visible to depth 0.15-0.5m below surface	 Objects visible to depth 0.5-1.0m below surface 	 Objects visible to depth > 1.0m below surface 	
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	 Slight organic odour 	• No odour	
Point range	00102	0304	□ 5 \[0 6	0708	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks	
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	 Canopy coverage: >80% shading (> 60% for large mainstem areas) 	
Point range	001	2 2 3	0405	□ 6 ♀ 7	
otal overall so	ore (0-42) = 72	Poor (<13)	air (13-24) Good (25-2		

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS

Date:		2023-1	+28		Field S	taff:	KS KI	M		Waters	hed/Subv	vatershe	d: Ch	PRIM	al Crar	risk
'ime:		galitagene			Stream	1:	CARDINI	ALCR	FEKTRIR	UTM (U	Instream)	*	u. (191	FUIN	TL LEE	the free
Veather:		SUN + CL	000 -	-200	Reach:		T3	no cr	act they		ownstrea					
and Use	,3 (alley Type Table 2)	2	Channel (Table 3)	Туре	-7 C	hannel Zone	1	Flow Type (Table 5)] Evidence d	of Groundw	vater Loc	ation:	/	Photo:
iparian Vege	etation			1		•	Aquatic 8	Instre	am Vegetati	on		Wa	ater Ou	ality		
ominant Type (Table 6)		Coverage	Channel	Widths 4	Age (yrs)	(<5)	Type (Table 8)	$\overline{\ }$	Woody Debris	WD Densit	WDJ/50n	n:	Odou (Table	ir 16)	ו ד ד)	urbidity Table 17)
incroachment (Table 7)	3	☐ Fragmente	d 🛛 4 -	10 10	□ Establishe □ Mature (>	d (5-30) 30)	Reach Coverage %		☑ In Channel □ Not Present	□ Mod Ɓ High	1-2					2
nannel Char	acteris	tics					,									
i nuosity Type (Table 9)	2	Sinuosit	y Degree (Table 10)	2	Bank A □ 0 - 3	ngle 0	Bank Erosion □ < 5%		(Table 19) Bank	Clay/Silt	Sand	Gravel (Cobble	Boulder	Parent	Rootlet
Gradient (Table 11)	3	# of	Channels	1	₫ 30 -	60	□ 5 - 30%		Riffle							
ntrenchment	0	Bar	k Failure	1.2	□ 60 –	90 rcut	⊠ 30 - 60% ⊠ 60 - 100%		Pool	Z					Z	
(Table 13)	2]	(Table 14)	5,6					(if no riffle-pool morphology)	Z					R	
own's Model (Table 15)	e,c	Bankfull Ir	ndicators Table 18)	\sim			Bankfull Wid (r	th Poor Defin	ny podruh Vedine	р 06410 0641	Wette	ed Width (m) 015	5	0150	0.102
Sed Sorting (Table 20)	Ps	Sediment T	ransport oserved?	Yes	No 🗆 No	t Visible	Bankfull Dep (n	th 🕅 n)	30 3A 8A	R	Wette	ed Depth (m) (),()	S	0.15	0.04
Transport de (Table 21)	$\overline{\ }$	% of B	ed Active	G			Undercuts (n	n) (),3	0 0,42	0,15	\$ ve	elocity (m/	's) /		1	1
Geomorphic its (Table 22)	4,5	Mass M (ovement Table 23)	4			Pool Dep (n	th n) 0.12	0.25	0.2	Velo	ocity Estima Meth	ate /		1	1
Riffle-Pool Spacing (m):	1	9/	6 Riffles:		% Pools:	$\overline{\}$	Riffle Length (n	n) 🖊			Meand	er Amplitu (I	de /		/	1
es: +hGH	GRAD	IENT TR	BUT	ARY T	LOWIN	5 THR	ROUGH RA	VINE	UNDER	CUTTIN	G RODO	TIONAL	SUE		5050	EALT
ALONG E	BANK	S. FALLE	IN TR	RES	ACROS	S CHA	NNEL FRE	OUE	NT MARI	NG TF	AVEL	ALON	3 WA	FERCE	JURSE	DIFFICI
SECOND I	APG	IN COMPA	ACT CL	A9 11	LL >1	MTA	LL W SCON	LRI	2001 ON	DIS	SIDE +	HALFWA	YAL	ONG	REACH	1
TO GULI	YTOR	IGINATIA	IG FRI	MA A	G FIFI	DTO	THE EA	Com.	NO.SOM	TAU	AT W	SEX	TENT	OF	REACH	r, ADJAC
							A S. Mine Mine B	91						1		
							<u></u>									
tos:																

General Site Characteristics Project Number: 23070

Date:		808	3-11-28		Stream:		CARDINAC	CREEK TRIB
Time:					Reach:		T3	
Weath	er:	SUN	105- QUAID+	C	Location:		ORLEANS	
Field S	itaff:	KS	KW		Watershed/Subw	atershed:	CARDINAL	CREEK
Featur	AS	Monitori	ng	Site	Sketch		and the second	Compass
	es Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall Swamp/wetland Grasses Tree Instream log/tree Woody debris	Monitori → → → Lo M M M M M di M Sa Sa Addition	ng ong-profile onumented XS onumented photo onumented photo rection ediment sampling rosion pins cour chains al Symbols	M	Sketch EAS 3 V((0.30) S(0.04) S(0.04)	S S S S S S S S S S S S S S S S S S S	A A A A A A A A A A A A A A A A A A A A	Compass 71 (0.15) E
*	Beaver dam			ME	N - X	X2		
Flow T	vegetated Island			1	A	10 - 11	Om P	SCOUR
H1	Standing water H1	Back w	ater			A.		MONG
H2	Scarcely perceptible	flow				3	ENDASED	BOTH
H3	Smooth surface flow				A .	1stime	E 200tr	BANKS
H4	Upwelling				A R	\$T_		
H5	Rippled	-			U X	2/44		
H6	Unbroken standing w	ave		19	A V	É.	.0	
H/	Chute	e			× F	- [xp		
	Eroo fall	Discin	ates below free fall		ほうし	Ede	age No.	
Subet	rate	- Dissipe			3 WY	TT	(2)	
Substi	Silt	56	Small boulder	1		Vice	V.*	
S2	Sand	57	Large boulder	10	E DX1	1/1		
53	Gravel	58	Bimodal		51 0	1		
S4	Small cobble	59	Bedrock/till		12 2	£		
S 5	Large cobble				T			
Other	-			L	- /	1		
BM	Benchmark	EP	Erosion pin					-1-1-4
BS	Backsight	RB	Rebar	TOF	OF		00	120
DS	Downstream	US	Upstream	MAT	EVISIOPE -	1/~	J.S.	
WDJ	Woody debris jam	TR	Terrace	Acres	16.00	m)/	V.P.	
vwc	Valley wall contact	FC	Flood chute		KNICKY	POINT		
BOS	Bottom of slope	FP	Flood plain	Pho	tos:			
TOS	Top of slope	KP	Knick point	Not	es:	5.	200 - 100 -	
			P					

Version #4 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

1.0

Rapid Geomorphic Assessment

Project Number: 73070

Date:	28	-11-23	Stream:		SOUTH TR	BCA	RDINAL	CREEK
Time:	2	15 PM	Reach:	a and a straight	TRIB 3		O INCOMENTS	Safe Stadion Print &
Weather:	OV	ERCAST - 2'C	Location:		CARDINA	ODEE	KIMI	ACE
Field Staff:	K	3 KM	Watershed/Sub	watershed:	CARDINAL	COF	FK	rige .
	- 1. 5. (A A	6	eomorphological Indicat	or		Dre	cont?	
Process	No.	Description	comorphological indical	.01		Voc	No	Factor Value
	1	Lobate bar		Sum 10 10		103	NO	
	2	Coarse materials in riffl	es embedded	<u>, i di sana ka</u>				4. 00052
Evidence of	3	Siltation in pools			C	1		-
Aggradation	4	Medial bars	satulary, granadyr	26 110000 38	Solatos	1 Adda	1616 0850	51
(AI)	5	Accretion on point bars	and the second second	30200-2000	$= (a_{i_k}, a_{i_j}) \in (a_{i_j}, a_{i_j})$			1 7
	6	Poor longitudinal sorting	g of bed materials		en and 1996, and 1997 and 1997. No. – Antonio Parla Constanti		1	
	7	Deposition in the overba	ank zone			100	1	1
	- si		e da de place	Su	m of indices =	2	5	0,714
	1	Exposed bridge footing(s)	A Stimb			ALA	
	2	Exposed sanitary / store	m sewer / pipeline / etc.	Close and a	CORE GERM		NUA	tente en en
	3	Elevated storm sewer o	utfall(s)	1	and the second second second			
	4	Undermined gabion bas	kets / concrete aprons /	etc.		Sector.	NIA	1.10
Evidence of	5	Scour pools downstream	n of culverts / storm sev	ver outlets			MIA	2
(DI)	6	Cut face on bar forms						5/5
	7	Head cutting due to knie	ckpoint migration			~		
	8	Terrace cut through old	er bar material		na ja nyastaasi	~		ગુજરાષ્ટ્ર છે. ગુ
	9	Suspended armour laye	r visible in bank	C.C. S. S. GUN				8 i.S. 1.
	10	Channel worn into undis	sturbed overburden / be	drock		~		
	1.942	Registrational Providencial III - B		Su	m of indices =	3	2	Oilo
	1	Fallen / leaning trees / f	fence posts / etc.	an is air ad	a, , cee cloup i	~		
	2	Occurrence of large orga	anic debris			~		
	3	Exposed tree roots			all parts for	1	[1
Enderson of	4	Basal scour on inside m	eander bends			1	Nejs Con pj	1971 1
Widence of	5	Basal scour on both side	es of channel through rif	fle		1		61
(WI)	6	Outflanked gabion bask	ets / concrete walls / etc	a ng minakang ang a	- 19 - 1 M	in sin i	NIA	14
	7	Length of basal scour >	50% through subject re	ach				
	8	Exposed length of previo	ously buried pipe / cable	e / etc.			NIA	
	9	Fracture lines along top	of bank	<u>, 13,512, 13, 1,615</u>	diter and dates		-	
	10	Exposed building founda	ition		0.01.01.01.4-944	1.00	NIA	
				Sur	m of indices =	le	1	0.857
	1	Formation of chute(s)			28 12 0 79-10 S	2 ¹ 1		
Evidence of	2	Single thread channel to	multiple channel				1	998 - <u>1</u>
Planimetric	3	Evolution of pool-riffle fo	orm to low bed relief for	m			1	1000
Form	4	Cut-off channel(s)					1	21
(PI)	5	Formation of island(s)		1		5 M M	-	7
	6	Thalweg alignment out o	of phase with meander f	orm		1		
	7	Bar forms poorly formed	I / reworked / removed				1.0.00	
<u></u>			and the set of the set of the	Sur	n of indices =	2	5	0,286
Notes:				Stability Inde	x (SI) = (AI+	DI+WI	+PI)/4 =	0.614
Normal Constraints of the second sector of the second sector of the			a the second	In Regime	In Transiti	ion/Stre	ess In A	djustment
				0.00 - 0.20	0 0.21	L - 0.40	¥	0.41

Senior staff sign-off (if required): _____ Checked by: ____ Completed by: ____

KS

Rapid Stream Assessment Technique Project Number: 23076

Date:	28-11-23	Stream:		SOUTH TRIE	, CARDINAL CREEK	
Time:	2:15 PM	Reach:		TRIB 3		
Weather:	OVERCAST-2'C	Location:	an a	CARDINAL CI	REEK VILLAGE	
Field Staff:	KS KM	Watershed/Subwater	shed:	CARDINAL	PREK	1
Category	Poor	Fair		Good	Excellent	
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughir failure 	of bank network ent signs of bank ig, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 	
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer bar m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) rerhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 	
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predom large, s scarce 2-3 rece per stree 	d tree roots inantly old and maller young roots ent large tree falls am mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 	
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	 Bottom general plant/sc 	1/3 of bank is ly highly resistant bil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 	
	 Channel cross-section is generally trapezoidally- shaped 	Channel cross-section is generally trapezoidally- shaped	 Channe general 	l cross-section is ly V- or U-shaped	Channel cross-section is generally V- or U-shaped	
Point range		3 0 4 0 5		0708	0 9 0 10 0 11	
	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	• 25-49% 59% er mainste	embedded (35- nbedded for large em areas)	 Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas) 	
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	 Modera pools Pool su 30-59% 	te number of deep bstrate composition 6 sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 	
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Stream and/or sedime uncomr 	bed streak marks "banana"-shaped nt deposits non	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	N
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, luncomi Small lo fresh sa top of l 	arge sand deposits non in channel ocalized areas of and deposits along ow banks	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 	
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point be well-ve armour fresh sa 	ars small and stable, getated and/or ed with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 	
Point range		□ 3 10 4		3506		

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Date: 28	-11-23	PN: 23070	Location: 5	OUTH TRIB CARDINAL	P. D. Viljeren mart
Category	Poor	Fair	Good	Excellent	
	Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas)	Wetted perimeter 40 60% of bottom chann width (45-65% for lat mainstem areas)	Wetted perimeter 61-85% of bottom channel width ge (66-90% for large mainstem areas)	Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas)	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, rift and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate 	fles • Good mix between riffles, runs and pools • Relatively diverse velocity and depth of flow	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 	
Physical Instream	Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble	 Riffle substrate composition: predominantly small cobble, gravel and sa 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 	
Habitat	• Riffle depth < 10 cm for large mainstem areas	 Riffle depth 10-15 cm large mainstem areas 	for • Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas 	
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 46 cm deep (61-91 cr for large mainstem areas) with little or no overhead cover/struct 	30- • Large pools generally 46-61 nn cm deep (91-122 cm for large mainstem areas) with some overhead cure cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure	
	 Extensive channel alteration and/or point bar formation/enlargement 	Moderate amount of channel alteration and moderate increase in point bar formation/enlargement	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	 No channel alteration or significant point bar formation/enlargement 	
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	• Riffle/Pool ratio 0.9-1.1:1	
	Summer afternoon water temperature > 27°C	 Summer afternoon wa temperature 24-27°C 	• Summer afternoon water temperature 20-24°C	• Summer afternoon water temperature < 20°C	NI
Point range				0708	
	 Substrate fouling level: High (> 50%) 	 Substrate fouling leve Moderate (21-50%) 	I: • Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)	
Water Quality	 Brown colour TDS: > 150 mg/L 	Grey colourTDS: 101-150 mg/L	 Slightly grey colour TDS: 50-100 mg/L 	Clear flow TDS: < 50 mg/L	
Tracer Quality	Objects visible to depth < 0.15m below surface	 Objects visible to dep 0.15-0.5m below surf 	the Objects visible to depthe o.5-1.0m below surface	Objects visible to depth > 1.0m below surface	NI
	Moderate to strong organic odour	 Slight to moderate organic odour 	Slight organic odour	• No odour	
Point range	00102	0304		7 0 8	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly woode but with major localiz gaps 	• Forested buffer generally > 31 m wide along major portion of both banks	 Wide (> 60 m) mature forested buffer along both banks 	
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	 Canopy coverage: 60-79% shading (45-59% for large mainstem areas) 	 Canopy coverage: >80% shading (> 60% for large mainstem areas) 	
Point range	001	□ 2 □ 3	0405	□ 6 顷 7	l
Total overall s	core (0-42) = 23	Poor (<13)	Fair (13-24) Good (25-	34) Excellent (>35)	

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: ______

Time: - Stream: CHPDINAL CREETIN UTM (Upstream): UTM (Upstream): Weather: SUN + CLOUD - 2°C Reach: T UTM (Downstream): UTM (Downstream): Land Use (Table 2) A Channel Type (Table 3) Channel Zone (Table 4) Flow Type (Table 5) I Evidence of Groundwater Location: Riparian Vegetation Aquatic & Instream Vegetation Water Quality Odour (Table 6) I I Evidence of Groundwater Location: I Dominant Type (Table 7) None I - 4 Immature (<5) Immature (<5) In Cutbank Low WDI/50m: Immature (<5) Encroachment (Table 7) Fragmented (4 - 10) Established (5-30) Ant Channel Mod Immature (<5) Immature (<50) <	Photo: Turbidity (Table 17)
Weather: SUN + CLOUD - Arc Reach: T.Y UTM (Downstream): Land Use (Table 1) Valley Type (Table 2) Channel Type (Table 3) Channel Zone (Table 3) Flow Type (Table 4) I Evidence of Groundwater Location: Riparian Vegetation Aquatic & Instream Vegetation Water Quality Dominant Type (Table 6) I Coverage Channel Widths Age (yrs) Model (Table 8) Woody Debris WD Density Odour Encroachment (Table 7) Fragmented (Table 10) I + 4 Immature (<5)	Photo: Turbidity (Table 17)
Land Use (Table 1) Valley Type (Table 2) Channel Type (Table 3) Channel Zone (Table 3) Flow Type (Table 4) I Evidence of Groundwater Location: Riparian Vegetation Aquatic & Instream Vegetation Aquatic & Instream Vegetation Water Quality Dominant Type (Table 6) N3 Channel Widths Age (yrs) Mode Immature (<5) Encroachment (Table 7) Pragmented A + 10 Established (5-30) Mature (>30) In Cutbank Low WDJ/50m: Channel Characteristics Continuous > 10 Mature (>30) Mature (>30) Not Present High Immature (<5) Sinuosity Type (Table 10) Sinuosity Degree (Table 10) Bank Angle (Table 10) Bank Angle (Table 11) Bank Angle (Table 12) Bank Failure (Table 14) Bank Failure (Table 15) Clay/Silt Sand Gravel Cobble Boulder Pare (Table 10) Down's Model (Table 11) Clay Bank Failure (Table 12) Immature (<5) Immature (<5) Bankfull Width (Table 12) Immature (<5) Ed (f' no riffe-pool (morphology) Immature (<5) Immature (<5) Immatur	Photo: Turbidity (Table 17)
Aquatic & Instream Vegetation Mater Quality Dominant Type (Table 6) Aquatic & Instream Vegetation Type (Table 6) Woody Debris WD Density (Table 8) Water Quality Encroachment (Table 7) Fragmented (Continuous) 4 - 10 Established (5-30) Mature (>30) Not Present Mod Q Channel Characteristics Sinuosity Degree (Table 9) Sinuosity Degree (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Erosion (Table 10) (Table 19) Clay/Silt (Table 19) Sand (Cay/Silt) Gradel (Table 10) Mature (>30)	Turbidity (Table 17)
Dominant Type (Table 6) Coverage (Table 6) Coverage (Table 7) Woody Debris (Table 8) WD Density (Table 8) Odour (Table 8) Encroachment (Table 7) Fragmented (Table 7) 1 - 4 (Table 7) Immature (<5) (Continuous (Continuous (Continuous (Table 10) Age (yrs) (Table 30) Immature (<5) (Table 10) Mature (>30) No Present (Table 9) Mod (Table 10) Immature (>5) (Table 10) Sinuosity Type (Table 9) Sinuosity Degree (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Erosion (Table 10) (Table 19) Clay/Silt (Table 19) Sand (Cay/Silt (Table 19) Gravel (Table 19) Cobble (Cay/Silt (Table 10) Bank Angle (Table 12) Bank Angle (Table 12) Bank Angle (Table 12) Bank Angle (Table 14) Bank Angle (Table 14) Bank Failure (Table 13) Cobble (If no riffle pool (Table 14) Bank Failure (Table 18) Cobble (If no riffle pool (Table 18) Bankfull Width (m) Bankfull Width (Cay) Cobble (If no riffle pool (If no riffle pool (If no riffle pool (If no riffle pool) Dovel Dovel Dovel Dovel Dovel Dovel Dovet Dovel Dovel	Turbidity (Table 17)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	
Channel Characteristics Sinuosity Type (Table 9) Sinuosity Degree (Table 10) Bank Angle (Table 10) Bank Angle 0 - 30 Bank Erosion 0 < 5%	
Sinuosity Type (Table 9) A Sinuosity Degree (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Angle (Table 10) Bank Erosion (Table 19) (Table 19) Clay/Silt Sand Gravel Cobble Boulder Part Part (Table 11) Gradient (Table 11) 3 # of Channels (Table 12) 1 30 - 60 5 - 30% Riffle 1	
Gradient (Table 11) 3 # of Channels (Table 12) 30 - 60 5 - 30% Riffle A A A Entrenchment (Table 13) 3 A Bank Failure (Table 14) 1.2, 510 30 - 60% Pool Bed (If no riffle-pool morphology) A A A C Down's Model (Table 15) C,C Bankfull Indicators (Table 18) A A Bankfull Width (m) 2.03 Pool 0.50 Wetted Width (m) 1.42 1.05	ent Rootlei
Entrenchment (Table 13) Image: Constraint of the state s	
Down's Model (Table 15) C Bankfull Indicators (Table 18) Bankfull Width (m) Disco Wetted Width (m) I/42]
	0.85
Sed Sorting (Table 20) PS Sediment Transport Observed? Yes No Not Visible Bankfull Depth (m) Diss Poper 012	0.07
Transport lode (Table 21) % of Bed Active O Undercuts (m) 0,50 1,50 0,15 Velocity (m/s) 0,06 0,10	0.15
Geomorphic Inits (Table 22) YIS Mass Movement (Table 23) YIS Mass Movement (Table 23) YIS Velocity Estimate Method WIFTLE BHL	wiftle Bhec
Riffle-Pool Spacing (m): % Riffles: 9 D % Pools: 1 D Riffle Length (m) / Meander Amplitude (m) 3.00 3.50	5,00
-KAVINE FLOW TROM AG FIELD - HIGH GRADIENT	
- FALLEN TREES AMEDIC PHANNER FOR AND	
- FORCED KNICK WOLNIS COMMON, SEVERAL CHICANE FRATURES @ DIS EXTENT	
- EXPOSED KOOTS/ LEANING TREES COMMON	KEW0.
SCOVE ON SUTH DHIVES	

Version #4 Last edited: 04/04/2023
General Site Characteristics

Project Number: 2307(0

Date:		202	12-11-28		Stream:		CHEDINAL (DEEK TI	218
Time					Reach:		-U	1.
Weath	lor	() n	WAY FOR	200	Location		ANIKANIC	
Field		Ve	VN TSVN G	A V	Watershed (Subwate	rched	CHURCHING CUER	-K
Field a		142	Em	(water sheu/ Subwate)
Featur	es	Monitor	ring	Site	e Sketch	1	TRASITIONCOMPA	ass
	Reach break	-0-0-0- [ong-profile	M	AINTRIB	en l'	YOUNDERE	
×			Monumented XS			0	TREES 7	
	Cross-section		Monumented photo		<u>C</u>	V	K C	
\sim	Riffle	↓ r	direction		O a	e al	NF D	
\bigcirc	Pool		Sediment sampling		V		A T	
CITE C	Sediment bar		Erosion pins			AL A		
+++++++++++	Eroded bank/slope	8 9	Scour chains		A.	E		
	Undercut bank	Additio	nal Symbols			KA A	MANY	
XXXXXX	Bank stabilization				A v	t.	DOWN KR	LES.
	Leaning tree				FOC VX	X	EXIDOCED Y	1001
xx	Fence			NI	tris -	K	4	
	Culvert/outfall				3 3	9	X	
	Swamp/wetland					-	32 .0	
VVV	Grasses				(3	11P	
\Box	Tree					X		
	Instream log/tree	e Na seren			0	-	EV D	
***	Woody debris					N)	1	
*	Beaver dam				9	ATT. ()+ poor (011+)	
	Vegetated island				V V		2	
Flow T	уре				$\sum_{i=1}^{n}$	1 AV		
H1	Standing water H1	A Back v	vater	82	X	1 c	CALLY AN RATH	
H2	Scarcely perceptible	flow		district of	Nit	X _ 2	RANS	
НЗ	Smooth surface flow			engen Angen	50		8,0° ° ° ° ° °	
H4	Upweiling			and the second	al hi.	- EXPO	SEP ROOT	
Нб	Rippieu Unbroken standing v	121/0		en e	the stand	meas	2.	
HZ	Broken standing way			House House	VARY/	-VEN CI	MONFD OF CLAT	
HS	Chute	C		- Second	LEP	PALLON	et el av	
H9	Free fall H9	A Dissip	ates below free fall	Caledon -	JE a	NO WOR BI	No No 18 a	
Substr	ate			Maran	THE W	e	Alleran	
S1	Silt	S6	Small boulder	Program a Magar	tak	0/601 1na		
S2	Sand	S7	Large boulder	Baya20	×07-4	UUN *-		
S 3	Gravel	S 8	Bimodal	C	NH @ G	0	0 0	
S4	Small cobble	S 9	Bedrock/till	V	VI2E	Wa and	V	
S 5	Large cobble				0 88	- crosso	ON C	
Other					~ ~ ~	ROTH	BHAKS V	
BM	Benchmark	EP	Erosion pin		<u>nt</u>	183 8 6 9 8		
BS	Backsight	RB	Rebar	PO	1 Je 10		a e-lle.	
DS	Downstream	US	Upstream	10.	21m] (m)	5-4-1		
WDJ	Woody debris jam	TR	Terrace		XT	1	1	
VWC	Valley wall contact	FC	Flood chute					
BOS	Bottom of slope	FP	Flood plain	Phot	os:	7		
TOS	Top of slope	KP	Knick point	Note	s:			

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _KM___

Rapid Geomorphic Assessment

Project Number: 23076

Date:	29	5-11-23	Stream:		SOUTHTR	IB CA	RDINAL	CREEK
Time:	2:	45 PM	Reach:		TRIB 4 (FARTH	EST DIS	51
Weather:	OV	ERCAST2"C	Location:		CADDINIAL	CDE	EF VII	LACE
Field Staff:	K	KM	Watershed/Su	bwatershed:	CARDINAL	A DE	ENVIL	LAGE
[1 -60	G	amorphological India	ator	CIRVINA	- UKE	EN	T
Process	No	Description			S. M. C.	Pro	esent?	Factor
	1	Lobate bar	N N N N N N N N N N N N N N N N N N N	Strait (of a		res	INO	value
	2	Coarse materials in riffle	embedded	Child Children and				- Marcaelli (B
Evidence of	3	Siltation in pools	.s cinbedded	a terretaria de la composición de la co	2320, 9606, 82	-	-	
Aggradation	4	Medial bars	ia iono o 13 i 26 Mai Elektro 21 Mai	Deers of the set of th	alike nare			12,
(AI)	5	Accretion on point bars	addine "Space and " share.	a i dhearacha prìte	ante presentation	~		-17
	6	Poor longitudinal sorting	of bed materials	<u></u>	<u> </u>			-
	7	Deposition in the overba	nk zone					-
	2346		editionen mu	SI	im of indices =	2	E	6286
	1	Exposed bridge footing(-)				3	10:200
×	2	Exposed sanitary / storn	o cowor (pipolino (ot				NIA	-
	3	Elevated storm sewer of	t sewer / pipeline / et			14.1	NIA	
	4	Undermined gabion bask	rets / concrete apropo	· / otc			NIA	-
Evidence of	5	Scour pools downstream	of culverts / storm s	ower outlets			NIA	- 4,
Degradation	6	Cut face on bar forms	of curverts / storm s	ewer outlets			NIA	11/6
(01)	7	Head cutting due to knic	kpoint migration				The state of the	
	8	Terrace cut through olde	r bar material	in the second				
	9	Suspended armour layer	visible in bank					
	10	Channel worn into undist		-				
	ASSA	en l'area vereneral. L'are	- Hereiten (hereiten son son son son son son son son son so	Sı	Im of indices =	Δ	1	0.00
	1	Fallen / leaning trees / fe	ence posts / etc.			1		
	2	Occurrence of large orga		<u> </u>	6,			
	3	Exposed tree roots						
	4	Basal scour on inside me						
Evidence of Widening	5	Basal scour on both sides	1	1010				
(WI)	6	Outflanked gabion baske	an a	NIA	1 7			
. F * - 1	7	Length of basal scour >5	1					
	8	Exposed length of previo	usly buried pipe / cab	le / etc.			NIA	1
	9	Fracture lines along top of	of bank	2011 - 10 July -	1			1 6 6
	10	Exposed building foundat	ion				NIA	
			, 14. an each a tha thair said	Su	m of indices =	6		0.857
	1 1 - 1	Formation of chute(s)	la ast		resting a second			
Evidence of	2	Single thread channel to	multiple channel		1996 C. 2000	1.200	~	5. 25 F
Planimetric	3	Evolution of pool-riffle for	rm to low bed relief fo	orm			1	
Form	4	Cut-off channel(s)		and the second			1	21_
(PI)	5	Formation of island(s)	<1	1	17			
	6	Thalweg alignment out of	phase with meander	form	1	-		사실 가입다.
	7	Bar forms poorly formed	/ reworked / removed	1	1. 1. S	1		105
3 11 11 11 11			A MARINE DE LA MARINE	Su	m of indices =	2	5	0.286
Notes:				Stability Inde	ex (SI) = (AI+	DI+WI	+PI)/4 =	0.557
	-		and and an and a second	In Regime	In Transiti	on/Stre	ess In A	djustment
			1 ×.	0 00 - 0 2	0 0 0 0 0 0	0.40		

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____KS___

GEO

Rapid Stream Assessment Technique Project Number: 23076

Date: 28-11-23 Stream: SOUTH TRIB CARDINAL CRE						
Time:	7:45	Reach:		TA (FARTHE	ST DIS TRIB)	
Weather:	OVERCAST = 2°C	Location:		CARDINAL CA	EEK VILLAGE	
Field Staff:	KS KM	Watershed/Subwater	rshed:	CARDINAL CRI	EEK	
Category	Poor	Fair		Good	Excellent	
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughir failure 	o of bank network ent signs of bank ng, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 	
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Bank overhang > 0.8-1.0 m 	 Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas) Bank overhang 0.8-0.9m 	 Stream Outer b m above 1.5 m a for large Bank ov 	bend areas stable ank height 0.6-0.9 e stream bank (1.2- bove stream bank e mainstem areas) verhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 	
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	Young exposed tree roots common 4-5 recent large tree falls per stream mile	 s • Exposed tree roots predominantly old and s large, smaller young roots scarce • 2-3 recent large tree falls per stream mile • Exposed large and central large and tree falls 		 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 	
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised	 Bottom general plant/se 	1/3 of bank is Ily highly resistant oil matrix or material	 Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material 	
	Channel cross-section is generally trapezoidally- shaped	 Channel cross-section is generally trapezoidally- shaped 	Channel cross-section is generally V- or U-shaped		Channel cross-section is generally V- or U-shaped	
Point range		039405		5 0 7 0 8	<u> </u>	
00000000000000000000000000000000000000	 > 75% embedded (> 85% embedded for large mainstem areas) 	50-75% embedded (60- 85% embedded for large mainstem areas)	• 25-49% 59% er mainste	% embedded (35- mbedded for large em areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem areas)	
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt	 Modera pools Pool su 30-59% 	ate number of deep Ibstrate composition % sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 	
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	Streambed streak marks and/or "banana"-shaped sediment deposits common	 Stream and/or sedime uncom 	nbed streak marks "banana"-shaped ent deposits mon	 Streambed streak marks and/or "banana"-shaped sediment deposits absent 	
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, uncom Small I fresh s top of 	large sand deposits mon in channel localized areas of and deposits along low banks	 Fresh, large sand deposits rare or absent from channe No evidence of fresh sediment deposition on overbank 	
usense se sta les register Se sui	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	Point bars common, moderate to large and unstable with high amount of fresh sand	Point b well-ve armoun fresh s	ars small and stable, egetated and/or red with little or no and	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 	
Point range				5 0 6		

Senior staff sign-off (if required): _____ Checked by: _KS___

NIA

Date: 28	-11-23	PN: 23076	-		Location:	SOUTH TRIB	CARDINAL	and the second
Category	Poor	Fair		G	ood	Exc	ellent	า
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 4 60% of bottom cha width (45-65% for mainstem areas) 	0- nnel large	 Wetted peri of bottom c (66-90% fo mainstem a 	meter 61-85% hannel width r large reas)	Wetted peri bottom char 90% for larg areas)	meter > 85% of nnel width (> ge mainstem	
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	and runs dominant. • Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate)		 Good mix be runs and po Relatively di and depth o 	etween riffles, ols verse velocity f flow	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble		 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 		 Riffle substruction composition gravel, rubb with little sa > 50% cobb 	ate : cobble, le, boulder mix nd le	
nabitat	Riffle depth < 10 cm for large mainstem areas	Riffle depth 10-15 c large mainstem area	m for as	 Riffle depth large mainst 	15-20 cm for em areas	Riffle depth large mainst	> 20 cm for em areas	
	Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 		Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure		 Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead 		
1	• Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 		 Slight amound alteration and increase in p formation/er 	nt of channel d/or slight oint bar llargement	No channel a significant po formation/er	alteration or Dint bar Dargement	
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	ool ratio 0.49:1 ; • Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1			tio 0.7-0.89:1	Riffle/Pool ra	tio 0.9-1.1:1	
	 Summer afternoon water temperature > 27°C 	 Summer afternoon v temperature 24-27% 	vater C	 Summer after temperature 	ernoon water 20-24°C	 Summer afternoon water temperature < 20°C 		N
Point range		□ 3 □ 4		05	□ 6	07	□ 8	
	 Substrate fouling level: High (> 50%) 	 Substrate fouling lev Moderate (21-50%) 	el:	Substrate for Very light (1)	uling level: 1-20%)	 Substrate for Rock undersi 	Jling level: de (0-10%)	
later Quality	Brown colour TDS: > 150 mg/L	Grey colourTDS: 101-150 mg/L		Slightly greyTDS: 50-100	colour mg/L	• Clear flow • TDS: < 50 m	g/L	
	 Objects visible to depth < 0.15m below surface 	Objects visible to deployed on the objects visible to deployed on the objects visible to deployed on the objects visible of the obje	pth face	 Objects visib 0.5-1.0m bel 	le to depth ow surface	 Objects visib > 1.0m below 	e to depth v surface	N
	organic odour	 Slight to moderate organic odour 		 Slight organi 	c odour	No odour	>	
oint range	00102	□ 3 □ 4		0 5	□ 6	1 7	08	
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly woode but with major locali; gaps 	ed zed	 Forested buff > 31 m wide portion of bot 	er generally along major h banks	• Wide (> 60 n forested buffe banks	n) mature er along both	
Conditions• Canopy coverage: <50% shading (30% for large mainstem areas)• Canopy coverage: 50- 60% shading (30-44% for large mainstem areas)• Canopy coverage: 60% shading (30-44% for large mainstem areas)		age: ing (45-59% istem areas)	Canopy cover >80% shadin large mainste	age: g (> 60% for m areas)				
Point range		□ 2 □ 3		□ 4	□ 5	□ 6	Ègo 7	
otal overall so	core (0-42) = 25	Poor (<13)	Fa	ir (13-24)	Good (25-3	4) Excel	lent (>35)	

Senior staff sign-off (if required): _____ Checked by: KM_ Completed by: KS_

Date:		10-10-	21		Eist	1 CL											
Time:		10:20	64		Field	1 Staff:		KS CN	1 MK	4	Wa	iters	hed/Subwate	arshody	07-1-0		MORP
Veather:		10:00 e	1111/		Stre	am:		CARDIN	IAL	CREEK	UTI	M (L	Jpstream):	.i sneu.	OTTAWA	RIVER	2
and Use		alley Type		LOUD	Read	:h:		010		1	UTI	M (D	ownstream):				
Table 1)	1 0	Table 2)	2	(Table	el Type 3)	9	Char (Tabl	nel Zone	2/3	Flow Type			Fvidence of Gr	oundurat			
iparian Vege	etation							A guadia 0		(Table 5)				oundwater	Location:		_Photo:
ominant Type	1/4	Coverage	Chan	nel Widths	Age (yrs)	_	Aquatic &	Instre	eam Vegetat	ion			Water	Quality		
(Table 6)	14	□ None		1 - 4	🗆 Immatu	re (<5)		(Table 8)	1,2,	Woody Debris	WDD	ensit	Y	(Odour		
ncroachment	10	Fragmente	ed 🗆	4 - 10	🖄 Establis	hed (5-30				In Cutbank		w	WDJ/50m:	(Ta	able 16)	(Table 17)
(Table 7)	12	Continuou	s 🖄	> 10	🕅 Mature	(>30)		Reach	10		M Mo	d	DAMS		2		
annel Chara	acteris	tics						coverage %	10	I NOT Present		h					0
nuosity Type	2	Sinuosit	ty Dear	ee 🗌	Bank	Angle		male Provide							and and and and		
(Table 9)	6.		(Table 1	0) 3	00-	30		< 5%		(Table 19)	Clay/	Silt	Sand Grav	vel Cobb	le Boulder	Parent	
Gradient	3	# of	Channe	Is 2	∞ 30	- 60		5 - 30%		Dank							Rootlets
(rable II)			(Table 1	2)	60	- 90	Ø	30 - 60%		RITTIE					5		
(Table 13)		Ban	k Failu	e 21c	🖓 Unc	lercut		60 - 100%		Red							
Wo'c Medel		-	(Table 1	4)						(if no riffle-pool morphology)							
(Table 15)	m	Bankfuli In	idicator	s 1,3,			B	ankfull Widt	h		Г		7	F -			
Sed Sorting		Sodiment T]			(m) DE	E DETAIL	ED A.	SSE	S, Wetted Wid	lth (m)	SEE DET	ALLEDA	
(Table 20)	MS	Ob	ranspor oserved	Yes	No 🗆 N	lot Visible	В	ankfull Depti	h				1	Ļ			55655,
Transport			_		1			(m)				Wetted Dep	th (m)			
le (Table 21)	N/A	% of Be	d Activ	eO			U	ndercuts (m)	0.61	0.21	0	66	Volesite				
Geomorphic	Δι	Mass Mo	ovemen	t			7	Deal Dool	0.01	0.01	2	19 -	velocity	(m/s)			
	Tilala	()	Table 23) N/A				(m)	0.33	0.32	0	92	Velocity Es	timate			
Riffle-Pool pacing (m):	10-20	%	Riffles	25	% Poole	7.	1				1	112		1ethod			
					70 P0015:	+5	Riffle	e Length (m)	10-30				Meander Amp	litude -	+ 10	0	
S: DETAIL	ED A	SSESSME	ENT C	OMPLE	ED CON	CURR	ENT	WWR	ADID	Acosso				(m)		1.8	9,5
SING ANI	1LOG	METHOD	5			I.			ALL	- ASSESSMIR	NT-		NO BE OR V	VW ME	ASUREM	INTS T	AKENI
			and the second second														LINGIN
									·····								
······································																	
· · ·				1						******		-					
S:										****							
	and the second								-		-				2.		
n #4	2022							Coni-	n ob-ff						1		
Jucu. 04/04/	2023							Seriic	starr :	sign-off (if rea	uired):		Chacka	d bu			- AL



Rapid Geomorphic Assessment

Project Number: 230710

Date:	10	10-24	Stream:	290 10	CARDINAL	COF	FV				
Time:	10-	10-27	Beach:		CANDINA	- CAL					
Weather	10	. 50	Keach.		CIO						
weather:	10	SUN/CLOUD	Location:		ORLEAN	5					
Field Staff:	KS	5 CM MK	Watershed/Subw	atershed:	OTTAWA	RIVE	ER				
Process		Geom	orphological Indicato	r		Pre	sent?	Factor			
1100033	No.	Description .				Yes	No	Value			
	1	Lobate bar				X					
	2	Coarse materials in riffles e	mbedded				X				
Evidence of	3	Siltation in pools				X		3/2			
Aggradation	4	Medial bars				X		·T			
	5	Accretion on point bars					X				
	6	Poor longitudinal sorting of	bed materials				X				
	7	Deposition in the overbank	zone			-	X	a had			
				Su	m of indices =	3	4.	0.428			
	1	Exposed bridge footing(s)					NIA				
	2	Exposed sanitary / storm se	ewer / pipeline / etc.				NIA				
	3	Elevated storm sewer outfa	ll(s)				NIA				
Evidence of	4	Undermined gabion baskets	/ concrete aprons /	etc.			×	-			
Degradation	5	Scour pools downstream of	Scour pools downstream of culverts / storm sewer outlets								
(DI)	6	Cut face on bar forms				X		6			
	7	Head cutting due to knickpo	bint migration				X				
	8	Terrace cut through older be	ar material				X				
	9	Suspended armour layer vis	sible in bank				X				
	10	Channel worn into undisturt	bed overburden / bed	FOCK	an of indiana	X	Δ	2.020			
		1		50	m of indices =	5	1	0.320			
	1	Fallen / leaning trees / fence	e posts / etc.			X					
	2	Occurrence of large organic	×								
	3	Exposed tree roots	X								
Evidence of	4	Basal scour on inside means		X	-						
Widening	5	Basal scour on both sides of		X		5/					
(IW)	6	Outflanked gabion baskets /	concrete walls / etc.				×	. %			
	/	Length of basal scour >50%	s through subject rea	cn		X					
	8	Exposed length of previously	y buried pipe / cable	/ etc.			N/A				
	9	Fracture lines along top of D	апк				X				
	10	Exposed building foundation		C	m of indicas -	e	N/A				
				30	in or indices =	2	3	0.625			
	1	Formation of chute(s)					×				
Evidence of	2	Single thread channel to mu	Iltiple channel			X					
Planimetric	3	Evolution of pool-riffle form	to low bed relief form	n			X	A,			
Form	4	Cut-off channel(s)				X		17			
(PI)	5	Formation of island(s)				X					
	6	Thalweg alignment out of pr	hase with meander fo	orm		X					
	7	Bar forms poorly formed / re	eworked / removed	-	an affin di	4	X				
				Su	m of indices =	4	3	0.57			
Notes:				Stability Ind	ex (SI) = (AI+	DI+WI	+PI)/4 =	0.49			
				In Regime	In Transit	ion/Stre	ess In A	djustment			
				0.00 - 0.2	20 0.2	1 - 0.40	Į į	0.41			

Date:	10-10-24	Stream:		CARDINAL	IRECK		
Time:	10:50	Reach:		CIO			
Weather:	10° SUNICIOUD	Location:		CRLEANS			
Field Staff:	KS CM MK	Watershed/Subwate	rshed:	OTTAVIA RIVER			
Category	Poor	Fair		Good	Excellent		
	 < 50% of bank network stable Recent bank sloughing, slumping or failure frequently observed 	 50-70% of bank network stable Recent signs of bank sloughing, slumping or failure fairly common 	 71-80% stable Infreque sloughin failure 	of bank network int signs of bank g, slumping or	 > 80% of bank network stable No evidence of bank sloughing, slumping or failure 		
Channel	 Stream bend areas highly unstable Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas) Stream bend areas unstable Stream bend areas unstable Stream bend areas unstable Outer bank height 0.9- 1.2 m above stream bank (1.5-2.1 m above stream areas) Stream bend areas unstable Stream bend areas Stream			bend areas stable ink height 0.6-0.9 stream bank (1.2- bove stream bank mainstem areas) erhang 0.6-0.8 m	 Stream bend areas very stable Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas) Bank overhang < 0.6 m 		
Stability	 Young exposed tree roots abundant > 6 recent large tree falls per stream mile 	 Young exposed tree roots common 4-5 recent large tree falls per stream mile 	 Exposed predomin large, sm scarce 2-3 recent per stread 	tree roots hantly old and haller young roots ht large tree falls im mile	 Exposed tree roots old, large and woody Generally 0-1 recent large tree falls per stream mile 		
	 Bottom 1/3 of bank is highly erodible material Plant/soil matrix severely compromised 	 Bottom 1/3 of bank is generally highly erodible material Plant/soil matrix compromised 	Bottom 1 generally plant/soi	/3 of bank is highly resistant I matrix or material	Bottom 1/3 of bank is generally highly resistant plant/soil matrix or material		
	 Channel cross-section is generally trapezoidally- shaped 	 Channel cross-section is generally trapezoidally- shaped 	 Channel generally 	cross-section is V- or U-shaped	Channel cross-section is generally V- or U-shaped		
Point range	0 0 1 0 2	□ 3 □ 4 章 5	6	0708	□ 9 □ 10 □ 11		
	 > 75% embedded (> 85% embedded for large mainstem areas) 	 50-75% embedded (60- 85% embedded for large mainstem areas) 	 25-49% 59% emb mainsten 	embedded (35- bedded for large n areas)	Riffle embeddedness < 25% sand-silt (< 35% embedded for large mainstem_areas)		
	 Few, if any, deep pools Pool substrate composition >81% sand- silt 	 Low to moderate number of deep pools Pool substrate composition 60-80% sand-silt 	 Moderate pools Pool subs 30-59% 	e number of deep strate composition sand-silt	 High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas) Pool substrate composition <30% sand-silt 		
Channel Scouring/ Sediment	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambed streak marks and/or "banana"-shaped sediment deposits common 	 Streambe and/or "t sediment uncommon 	ed streak marks panana"-shaped deposits on	Streambed streak marks and/or "banana"-shaped sediment deposits absent		
Deposition	 Fresh, large sand deposits very common in channel Moderate to heavy sand deposition along major portion of overbank area 	 Fresh, large sand deposits common in channel Small localized areas of fresh sand deposits along top of low banks 	 Fresh, lan uncommo Small loc fresh san top of low 	 Fresh, large sand deposits rare or absent from channel No evidence of fresh sediment deposition on overbank 			
	 Point bars present at most stream bends, moderate to large and unstable with high amount of fresh sand 	 Point bars common, moderate to large and unstable with high amount of fresh sand 	 Point bar well-vege armoured fresh san 	s small and stable, etated and/or d with little or no d	 Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand 		
Point range				5 🗆 6			

Senior staff sign-off (if required): _____ Checked by: ____ Completed by: ____ S

Date: 10-10-24		PN: 23070	Location:	CIO CARDINAL CREEK		
Category	Poor	Fair	Good	Excellent		
	 Wetted perimeter < 40% of bottom channel width (< 45% for large mainstem areas) 	 Wetted perimeter 40- 60% of bottom channel width (45-65% for large mainstem areas) 	 Wetted perimeter 61-85% of bottom channel width (66-90% for large mainstem areas) 	 Wetted perimeter > 85% of bottom channel width (> 90% for large mainstem areas) 		
	 Dominated by one habitat type (usually runs) and by one velocity and depth condition (slow and shallow) (for large mainstem areas, few riffles present, runs and pools dominant, velocity and depth diversity low) 	 Few pools present, riffles and runs dominant. Velocity and depth generally slow and shallow (for large mainstem areas, runs and pools dominant, velocity and depth diversity intermediate) 	 Good mix between riffles, runs and pools Relatively diverse velocity and depth of flow 	 Riffles, runs and pool habitat present Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) 		
Physical Instream	 Riffle substrate composition: predominantly gravel with high amount of sand < 5% cobble 	 Riffle substrate composition: predominantly small cobble, gravel and sand 5-24% cobble 	 Riffle substrate composition: good mix of gravel, cobble, and rubble material 25-49% cobble 	 Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand > 50% cobble 		
- Hubitat	 Riffle depth < 10 cm for large mainstem areas 	 Riffle depth 10-15 cm for large mainstem areas 	• Riffle depth 15-20 cm for large mainstem areas	 Riffle depth > 20 cm for large mainstem areas 		
	 Large pools generally < 30 cm deep (< 61 cm for large mainstem areas) and devoid of overhead cover/structure 	 Large pools generally 30- 46 cm deep (61-91 cm for large mainstem areas) with little or no overhead cover/structure 	Large pools generally 46-61 cm deep (91-122 cm for large mainstem areas) with some overhead cover/structure	Large pools generally > 61 cm deep (> 122 cm for large mainstem areas) with good overhead cover/structure		
	Extensive channel alteration and/or point bar formation/enlargement	 Moderate amount of channel alteration and/or moderate increase in point bar formation/enlargement 	Slight amount of channel alteration and/or slight increase in point bar formation/enlargement	No channel alteration or significant point bar formation/enlargement		
	• Riffle/Pool ratio 0.49:1 ; ≥1.51:1	• Riffle/Pool ratio 0.5- 0.69:1 ; 1.31-1.5:1	• Riffle/Pool ratio 0.7-0.89:1 ; 1.11-1.3:1	Riffle/Pool ratio 0.9-1.1:1		
	 Summer afternoon water temperature > 27°C 	Summer afternoon water temperature 24-27°C	 Summer afternoon water temperature 20-24°C 	• Summer afternoon water temperature < 20°C N/A		
Point range		□ 3 □ 4	□5 ¢6	0708		
	Substrate fouling level: High (> 50%)	Substrate fouling level: Moderate (21-50%)	Substrate fouling level: Very light (11-20%)	Substrate fouling level: Rock underside (0-10%)		
Water Ouality	Brown colour TDS: > 150 mg/L	• Grey colour • TDS: 101-150 mg/L	 Slightly grey colour TDS: 50-100 mg/L 	Clear flow TDS: < 50 mg/L		
	Objects visible to depth < 0.15m below surface	Objects visible to depth 0.15-0.5m below surface	 Objects visible to depth 0.5-1.0m below surface 	 Objects visible to depth > 1.0m below surface 		
	 Moderate to strong organic odour 	 Slight to moderate organic odour 	Slight organic odour	No odour		
Point range	0 0 1 0 2	ଷ 3 🗆 4	0506	0708		
Riparian Habitat	 Narrow riparian area of mostly non-woody vegetation 	 Riparian area predominantly wooded but with major localized gaps 	 Forested buffer generally > 31 m wide along major portion of both banks 	• Wide (> 60 m) mature forested buffer along both banks		
Conditions	 Canopy coverage: <50% shading (30% for large mainstem areas) 	 Canopy coverage: 50- 60% shading (30-44% for large mainstem areas) 	Canopy coverage: 60-79% shading (45-59% for large mainstem areas)	 Canopy coverage: >80% shading (> 60% for large mainstem areas) 		
Point range	001	□ 2 □ 3	0405	036 🗆 7		
Total overall se	core (0-42) = 2.6	Poor (<13) F	air (13-24) Good (25-3	4) Excellent (>35)		

Date:	2024-08-00	Reach:	K3.				
Time:	ID:24am	Location:	ORIFANS				
Weather:	SUN ASOC	Watershed/Subwatershed:	CARDINAL ORFER				
Field Staff:	KM HM	Rain in last 24 hours:	🗆 None 🗆 Yes: Amount mm				
Point No.	Code	Notes	Survey Direction				
1			Upstream to Downstream				
			Downstream to Upstream				
			Cross-sections				
	TOTAL STATION		No. of Cross-sections Surveyed: K				
	1.1110 3 111 1014		Monitoring Cross-sections: No XYes				
			XS ID: 5 / /				
			Erosion Pin Installed: No XYes				
			xs id: 5 / /				
			Velocity & Sediment Transport				
			Velocity 0.40 m/s Method:				
	······		Dischargem ³ /s WIFFLEBMU				
	- <u>e</u>		Sed. Transport (Table 21): Suspended				
			□ Saltation □ Sliding □ Rolling				
			Percentage of Bed Active:%				
			Valley Type				
			Confined Partially Unconfined				
			Channel Zone				
			Headwater Transfer Deposition				
			Land Use				
			FOREST/FLOODPLAIN (MAPSH)				
			Vegetation				
			Aquatic Vegetation: ALGHE				
			Coverage of Reach:%				
			🛛 🕅 In Stream 🗆 Margins 🗆 On Bank				
			Riparian Vegetation: 🗆 No 🛱 Yes				
			Extent of Riparian Cover:				
			□ Fragment □ None 🛱 Continuous				
			Riparian Cover (channel widths):				
			Age Class of Riparian Vegetation:				
			Immature Established Mature				
			(<5 yrs) □ (5-30 yrs) □ (>30 yrs)				
		-	Extent of Encroachment:				
			None Minimal D Moderate				
			☐ Heavy				
			Density of Woody Debris:				
			Low 🗆 Moderate 🗆 High				
1			Blockage(s) in Channel:				
			□ Infrastructure □ Dam □ LWD				

Version #3 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by:

Page

KN

of 17



MORPHIX

General Site Characteristics

Project Number: 23076

Date:		2020	1-08-06		Stream:			CHRDINI	AL CREE	K S. TRIB
Time:		10:34	am		Reach:			R3		
Weath	ner:	CUN	2500		Location:			ORIFANS		
Field :	Staff:	KM 1	+M		Watershed	/Subwaters	hed:	CARDINA	CRES	F
Featur	'es	Monitoring		Site	Sketch		1		Cor	npass
	Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Bank stabilization Leaning tree Fence Culvert/outfall	-o-o-o- Long Moni Moni direc Sedi Eros Scou Additional	I-profile umented XS umented photo umented photo tion ment sampling ion pins ur chains Symbols		BARS.	X	2 4	VALLE WALLE WALLE CON	inct f	2
	Swamp/wetland Grasses Tree Instream log/tree Woody debris Beaver dam Vegetated island			07-08	K K K K	INS31	A A A	- pown Tipe		φ 1
Flow 1	ype	 De als suchs 		1×	A H		X KI	(0.15m) =		~
H1 H2 H3 H4 H5 H6 H7 H8	Scarcely perceptible Smooth surface flow Upwelling Rippled Unbroken standing way Chute	A Back wate flow vave re	r	VALLEN WALL	M W SAPPTOX S	- The me	nppel	5-M 5-M	A A	
H9	Free fall H9	A Dissipates	below free fall		<u> </u>	KIN	TAL	010		
Substr S1 S2 S3 S4 S5 Other BM BS DS WDJ VWC	ate Silt Sand Gravel Small cobble Large cobble Benchmark Backsight Downstream Woody debris jam	S6 S1 S7 La S8 Bi S9 Bi S9 Bi S9 Bi US U TR Ta EC Fi	mall boulder arge boulder imodal edrock/till rosion pin ebar pstream errace	A 1	VV sivmps VV VV VV VV	X	X XSL X XSL X STN DE TID E POOL	BEAVER DAM 2 J NOING AD POWOOD TRIB		
BOS	Bottom of slope	FP FI	ood plain	Photo	DS:					
TOS	Top of slope	KP K	nick point	Notes	5:		****			

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____

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Project Number:	130	10
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MORPHIX

Date:	2024-08-06	Cross-section:	XSI
Time:	11:13 gm	Reach:	K3
Weather:	SUN YEAC	Location:	OPTEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CHRDINHL CREEK

					Notes	Cross-sectional Morphology (Table 22)
						🗆 Riffle 🗖 Pool 🗆 Run 🗆 Other
	1		149.24.9			Substrate Sample:
						🛛 Bed 🔀 Bank 🗆 Subpavement 🗆 Water 🗆 None
	TS	PN231	76-25	1		Pebble Count Measurements A/B/C Axes (cm):
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						FINES [1 121 131
					1	12 12 22 32
					+	18 23 33
						4 4 4 14 14 14 24 24 24 34 34
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					<u> </u>	
				<u> </u>	+	
					<u> </u>]	
					<u> </u>]	
					+	
						Particle Shape: D Platy D Very Angular
-			-			
						Li Sub-Rounded Li Well Rounded
÷	•••• ¹⁰ ••••••••					Embededness:%
						Subpavement: [Pebble ABC axis gu
	10.55430.4 -	11163-33			- 57 3	Sorting (Table 20): Well Moderate Poor Very p
	i i	saya D	ta na shudi t		nolisoci nu	Sediment Transport
	8.258 J				es asian.	🗆 Obsv 🕱 Not Obsv 🗆 Not Visible - Reason:
			X (2) (3) (4)	0	N Q 9 9	If Observed (Table 21):
		A.C.				□ Suspended □ Sliding □ Rolling □ Saltation
						Percentage of Bed Active:%
			Same S. Course		1	Velocity
- - (3)			diase asis			D Measuredm/s Method: WB
dł			wfier s0 roi	A L		Estimated 0.13 m/s XS ID: VSI
(1)			Underect			Distance 0,5 m Time 4,75 s V D.10 m
<u></u>		an a	nie noisco i		0.000200.00	Distance 0,5 m Time 2.85 s V Q.17 m
131	1		Sus en T		damag neer	Distance 0.5 m Time 4.06 s V 0.12 m
lan i			ade(nor.)et	59 I	· aiq-nit	Discharge
	211 1 2		-4980 100°F:		0.6457.055330	Estimated m ³ /s Method
		and a second				Denth m Width m Vco m
					+	Depth m Width Web m
						Depth m Width Mrss m,

Page <u>3</u> of 17



Last edited: 21/02/2023

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Project Number	r: 220710
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Date:	2024-08-010	Cross-section:	XSR
Time:	11:35 am	Reach:	R3
Weather:	SUN 25°C	Location:	OPLEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CARDINAL CREEK

				Notes	Cross-sectional Morphology (Table 22)
v					🖾 Riffle 🗆 Pool 🗆 Run 🗆 Other
					Substrate Sample:
					🔁 Bed 🛕 Bank 🗆 Subpavement 🗆 Water 🗆 None
					Pebble Count Measurements A/B/C Axes (cm):
ts	> PN 230	176 - XS'	1		A B C A B C A B C A B C
					FINES 1 11 P1 131
					2 12 12 32
					3 1.3 2.3 3.3
					4 4 4 14 14 14 24 24 24 34 34 34 3
				÷	5 15 25 35
					6 16 36 36
					2 17 17 37
					8 8 8 18 18 18 28 28 28 38 38 3
			1		9 19 29 39
					20 30 40
			1		Particle Shape: Platy Very Angular
					□ Sub-angular □ Angular □ Rounded
					Sub-Rounded Well Rounded
					Embededness: %
					Subpavement:
	78 8 June 3 18	1.73		680.0	
	in a second s	and the second of the second s		activation of	Sediment Transport
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	A State of the second			RR) 083030 0	If Observed (Table 21):
					Percentage of Bed Active: 04
			1	and Printers	Velocity
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		10.981, 900-1		hip the bearing	
					Li Estimatedm ³ /s Method:
					Death manual Ministry XS ID:
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		e barret de la legerad			Depenm wiathm V ₆₀ m/s
			-	1	Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

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MOF

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Bank Charac	teristics		Proje	ect Number: 230	070			MORP	ніз
Date:	2024-08-1	00	C	ross-section:		XSa			
Time:	11:35am		R	each:		123			104
Weather:	SUN 2501		L	ocation:		OPLEAN	NS		
Field Staff:	KM HM		N	latershed/Subwater	shed:	CARDI	NALC	REEK	
Sketch (Viewed location, bed & bank	Downstream) Include materials, approx, water I	e: measurements, b evel, evidence of en	ank slope, osion, strati	evidence of geomorphic proce fication in bank sediments, so	esses/adjus il horizons,	tments, geomor bankfull indicato	phic/bedform un ors, woody debris	its, vegetation ty s, roots, etc.	pe 8
	Left Bank					Right	Bank		
HPPIOX Z HAI HEI YEI O J J HEI O J HEI O J HEI O J HEI O J HEI O J HEI O J HEI O J HEI O J HEI O J HEI O J HEI HEI HEI HEI HEI HEI HEI HEI	EUMANU ALEMINANU PONCEOUS GOVERFINE SEDIMENIS U SEDIMENIS U FINESI H PEBBI	MBEDDED WODDY DEBP		V Carriero Car	ELINY CUMMC	Sm HEP VEG FINH SS UNUU SS UNUU SS UNUU PEVBLE S UNGUDMEN	to VIHILEY BRIED OF SYEP SEDIME SEDIME	NALL NIS	
			VU	KRD					-
	t Bank Materials			Features Station location		Righ	t Bank Mat	erials	
		1994 a 1994		Monumented XS		I Bearock		obble	
Clay	Large Cobble		[0]	Monumented photo	X	Clav	□ Large C	obble	
Silt	Small Boulder			Undercut bank		Silt	□ Small B	oulder	
□ Sand	Large Boulder		++++++	Eroded bank/slope		Sand	🗆 Large B	oulder	
Bank Height:	0170	m	DEXXXXX	Bank stabilization	Ba	ank Height:	0.45	m	
Bank Angle:	4S	o	*-*-×	Fence	E	Bank Angle:	25	o	
Root Depth:	0.1	m	VVV	Grasses	F	loot Depth:	0,0	m	
Root Density:	35	%		Leaning tree	Ro	ot Density:	17	%	
Undercut:	20.0	m	G	Tree		Undercut:	ND	m	
Erosion Pin:	6.CD	m	* * *	Woody Debris	E	Frosion Pin:	NIA	m	
Torvane:	K.CD	kg/cm ²		Sediment sample		Torvane:	- iñ	kg/	cm
Penetrometer:	0150	kg/cm ²	0	Erosion pin	Per	etrometer:	-1.0-	kg/	cm
Foot Used:	Yes No		0	Scour/bed chain		Foot Used:		J NO	
Additional Not	tes						1		
ni Angelani A		4.0. 40							
	n an search the state of the point and states and					ada a se a		an a	
Photos:									
/ersion #4		Senior staff	sian-off (if required):	Checke	d by:	Comple	ted by: KM	

Last edited: 21/02/2023

Page <u>6</u> of <u>1</u>

MORPHIX*

Detailed Cross-Section Characteristics

Project Number:

Date:	2024-08-06	Cross-section:	XS3
Time:	11:46 am	Reach:	P-3
Weather:	SUN 250	Location:	OPLEANS
Field Staff:	ILM HM	Watershed/Subwatershed:	CARDINIAL CREEK

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	ļ							R	iffle		Pool		Ru	n		ner		
						Subs	trate	e Sa	mple	:								
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						Pebb	le C	ount	: Mea	sur	eme	nts A	// B	/C /	Axes ((cm)	:	
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	ts-	S DN'	130710.	-X53		FIN	ES			11				<u>þ1</u>		1	31	
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		1		1														

Project Number: 23070 **Bank Characteristics** Date: Cross-section: -010 XS -0 Time: yleam **Reach:** 27 Weather: 50 Location: NRI E NI **Field Staff:** Watershed/Subwatershed: FER N 12 AR N Sketch (Viewed Downstream) Include: measurements, bank slope, evidence of geomorphic processes/adjustments, geomorphic/bedform units, vegetation type & location, bed & bank materials, approx. water level, evidence of erosion, stratification in bank sediments, soil horizons, bankfull indicators, woody debris, roots, etc. Left Bank **Right Bank** 10m to thele BERD KUNPOL FINES EMBBEDED WOODY DE BRIS FINES ODO 11 UNW peposn FINEST PEBBLES/CLAM **Left Bank Materials** Features **Right Bank Materials** □ Bedrock □ Gravel 只 Station location □ Bedrock □ Gravel □ Small Cobble Monumented XS □ Small Cobble Clay □ Large Cobble 0 Monumented photo □ Clav □ Large Cobble Silt □ Small Boulder -----Undercut bank □ Small Boulder □ Silt Large Boulder □ Sand □ Large Boulder +++++++ Eroded bank/slope □ Sand 0.85 XXXXX Bank Height: Bank stabilization Bank Height: m m 0 30 0 Bank Angle: Fence x - - x - - x Bank Angle: 1.1 6.07 Root Depth: VVV Grasses Root Depth: m m Root Density: % Leaning tree Root Density: % NG 6.28 Undercut: m 3 Tree Undercut: m NIA Erosion Pin: *** Woody Debris m Erosion Pin: m 2,50 Torvane: kg/cm² Sediment sample Torvane: kg/cm² 10 Penetrometer: kg/cm² шш Erosion pin Penetrometer: kg/cm² 8 🗆 Yes 🖾 No Foot Used: Scour/bed chain Foot Used: □ Yes □ No **Additional Notes Photos:** Version #4 Senior staff sign-off (if required): _____ Checked by: _ _ Completed by: Last edited: 21/02/2023 Page 8 of 17

Project Number: 73070

Date:	2034-08-06	Cross-section:	
Time:	12:01pm	Reach: R-3	
Weather:	SUN' 250C	Location: ORLEANS	1.
Field Staff:	KM HM	Watershed/Subwatershed: CARDINAL CREEK	•

			µr Riffle ⊔ Pool ⊔ Run ⊔ Other
			Substrate Sample:
			🛛 🕅 Bed 🛱 Bank 🗆 Subpavement 🗆 Water 🗆 None
			Pebble Count Measurements A/B/C Axes (cm):
			A B C A B C A B C A B
			FINES 111 21 131
	TS-S PN23	076- XSV	2 12 22 32
			3 13 28 33
			4 4 4 14 14 14 24 24 24 34 34 3
			5 5. 25 35
			6 16 26 36
			7 7 27 87
			8 8 8 18 18 18 28 24 28 38 88 1
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			Embededness:%
			Subpavement: [Pebble ABC axis gui
3148 P 3	a - e Press 40 MP	195	Sorting (Table 20): 🗆 Well 🗆 Moderate 🗆 Poor 🗆 Very pa
	- 1 - 5 1의 - 이미 - 20 31일원 	a la possació d	Sediment Transport
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			If Observed (Table 21):
	and a state of the		□ Suspended □ Sliding □ Rolling □ Saltation
			Percentage of Bed Active:%
			Velocity
			D Measured m/s Method: WIFFLE BAL
2010 - 100 -	<u>1996</u>		Fistimated 0.31 m/s XS ID: XSU
3			Distance m Time 2.89 c V D.2U m
			Distance 1 m Time 3.31 c V 0.219 m
			Distance m Time 3.03 e V 0.23 m
		16-00 - 00 - 00 - 00 - 00 - 00 - 00 - 00	
			Measuredm³/s XS ID:
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	and the second		
			Depthm Widthm V ₆₀ m/

MORPHIX



Senior staff sign-off (if required): _____

Checked by: _____ Completed by: _____

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Project Number: 23076

Date:	2024-08-06	Cross-section:	XSS-M
Time:	12:09 pm	Reach:	P3
Weather:	SUN 2500	Location:	OPLEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CARDINAL CREEK

Notes	Cross-sectional Morphology (Table 22)
	🗆 Riffle 🗆 Pool 💆 Run 🗆 Other
	Substrate Sample:
	Bed 🕅 Bank 🗆 Subpavement 🗆 Water 🗆 None
	Pebble Count Measurements A/B/C Axes (cm):
	ABCABCABCABCABC
	EINTEC II 21 41
TE & DN 225710 VEE-M	
15- PH 430 10 - KSS 1.	
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	Particle Shape: Platy Very Angular
	Sub-angular 🗆 Angular 🗆 Rounded
States and second se	Sub-Rounded 🗆 Well Rounded
	Embededness: %
	Subpavement: [Pebble ABC axis guid
Elandor, elandor de 18	Sorting (Table 20): Well Moderate Poor Very poor
sense i	Sediment Transport
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	If Observed (Table 21):
	Suspended Sliding Rolling Saltation
	Percentage of Bed Active: 75 %
	Velocity
	□ Measured m/s Method: WIFFIE BALL
mai 1 2 1 Dath 1	Estimated 0.23 m/s XS ID: XSS-M
	Distance m Time 4,31 s V D.23 m/s
2 (2011) S (Distance I m Time 4.20 s V D.23 m/s
neige	Distance m Time 4.03 s V 0.24 m/s
nuo un sterito le subrito de subrit	Discharge
20 41810 PAGE 936 (2.2.2 a) 200	Estimated m ³ /s Method:
	Denth m Width m Vcc m/c
	Depth m Width m Vcc m/s
	Depth m Width m Veo m/s
	Use v_{60} if Depth < 0.75 m and v_{20} / v_{80} if Depth > 0.75 m



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Project Number: 23070

Date:	2024-08-06	Cross-section:	XSQ
Time:	12:25pm	Reach:	P3
Weather:	SUN 2500	Location:	ORLEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CARDINAL OFFER

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						Su	ıbst	rate S	ample	9:		<u> </u>					
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Senior staff sign-off (if required): ____

__ Checked by: __

Page <u>13</u> of <u>17</u> '

GEO





Detailed	Cross-Section	Characteristics
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Project Number: 23076

Date:	2024-08-06	Cross-section:	XSZ
Time:	12.41pm	Reach:	K3
Weather:	SUN 250C	Location:	ORLEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CHRDINAL CREEK

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Page 1 of 13

Detailed Cross-Section Characteristics Project Number: 33070

Date:	2024-08-06	Cross-section:	XS8
Time:	12:49	Reach:	R3
Weather:	SVN 25C	Location:	OPLEANS
Field Staff:	KM HM	Watershed/Subwatershed:	CARDINAL CREEK

						□ Riffle VI Pool □ Run □ Other
						Substrate Sample
						Bethle Court Mongurements A / P / C Aves (cm):
						Pebble Count Measurements A/B/C Axes (CIII):
					ļ	A B C A B C A B C A B C
		-	~			FINES 11 11 p
_	ts-3	PN 2307	6 -> X58			P 12 12 (32
						3 3 33
						4 4 4 14 4 14 24 14 24 34 34 34 34
						5 15 35
						6 6 6 36
						7 7 7 37
			1			8 8 8 18 18 18 28 28 28 38 38 38
l.		1				9 19 29 39
						V10 V0 V40
						Particle Shape: Platy Very Angular
						□ Sub-angular □ Angular □ Rounded
				<u> </u>		□ Sub-Rounded □ Well Rounded
-						Embododnosti P/
						Subnavement:
						Subpavement: [Pebble ABC axis guide]
			1625 2625			Subpavement:
					5.55% 5.55%	Subpavement: % Subpavement: [Pebble ABC axis guide] Sorting (Table 20): Well Moderate Poor Very poo Sediment Transport
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					eres eres eres eres eres eres eres eres	Embeddedness: % Subpavement: [Pebble ABC axis guide] Sorting (Table 20): Well Moderate Poor Very pool Sediment Transport Obsv Not Obsv Not Obsv Not Visible - Reason: If Observed (Table 21): Suspended Sliding Rolling Saltation Percentage of Bed Active: % Velocity
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					6 11 1000000000000000000000000000000000	Embeddedness:
						Embeddedness:
						Embeddedness:

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GEO





Project Code: 23076

etalleu A	1996991101		Reach:	LACOMIAL CREEK
Date:	10	-10-24	Location:	CARDINAL CREEK
Time:	10	0:30	Watershed/Subwatershed:	OTTAWA RIVER mm
Weather:	1	O'C SUN/CLOUD	Rain in last 24 hours:	None Ves: Amount
Field Staf	ff:	KS CM MIR	Notes	Survey Direction
Point	t No.	Code	Notes	Upstream to Downstream
	9000	BSSTN-1		Downstream to Upstream
	9001	WL, BED, DAM	WATER LEVEL,	Cross-sections
	1 J		CHANNEL BED,	No. of Cross-sections Surveyed: 10
	9433		BEAVER DAM	Monitoring Cross-sections: 🗆 No 🗹 Yes
1				XS ID://
	10000	ISLAND-WL	WATER LEVEL,	Frosion Pin Installed: No 🛱 Yes
	10000	ISLAND-BED	CHANNEL BED ALON	
	10057		SIDE CHANNEL	Velocity & Sediment Transport
	TOOT			welocity & Sculletter Method:
L	PTVA	> 73076-101024	*	- Welocity m3/s WB
	TUNT	1 60010		Discharge // J
				Sed. Transport (Table 21). Suspenses
			100 T	Percentage of Bed Active: 78
				Valley Type
10				🖾 Confined 🗆 Partially 🗆 Unconfined
				Channel Zone
				□ Headwater 🕅 Transfer 🖾 Deposition
		3		Land Use
				FOREST
				Vegetation
				Aquatic Vegetation: SUB/EMERGEN
				Coverage of Reach: 10_%
				→ In Stream Margins □ On Bank
				Binerier Vogetation: No M Yes
		0	5 5 S	
		1		Fragment I None Excontinues
				Riparian cover (chainer widths).
			2 2 7 4 9 4 9	
				Age Class of Riparian Vegetation:
				Immature Established Mature
ļ				□ (<5 yrs) Ø (5-30 yrs) Ø (>30 yr
				Extent of Encroachment:
				🗆 None 🕅 Minimal 🗆 Moderat
				Heavy Extreme
			<u><u></u></u>	Density of Woody Debris:
				Low 🕅 Moderate 🗆 High
				Blockage(s) in Channel:
2				□ Infrastructure ⊠ Dam □ LW

Senior staff sign-off (if required): _

Checked by:

.

Project Number: 23076

Date:	10-10-24	Stream:	CARDINAL DICE
lime:	10:30	Reach:	010
Neethory	ID'S SUNICIOUD	Location:	ORLEANS
	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER
		Site Sketch	Compass
Features Reach break Station location Cross-section Flow direction Riffle Pool Sediment bar Eroded bank/slope Undercut bank Swamp/wetland VV Grasses Tree Instream log/tree X Woody debris Beaver dam Vegetated island Flow Type H1	Monitoring →→→→ Long-profile → Monumented XS Monumented photo Monumented photo direction Sediment sampling Erosion pins Scour chains Additional Symbols Additional Symbols ↓ HERBACEOUS VEG ↓ HERBACEOUS VEG ↓ HERBACEOUS VEG ↓ HERBACEOUS VEG ↓ GRASSY ISLAND ↓ JOINTED BEDROCK A BEAVER DOWNED TREES	Site Sketch CAS -CULVERT ON MONTREAL $CASS - CULVERT$ ON MONTREAL $CASS - CULVERT$ CH 05510 510 510 54 4 AT CH 05510 510 510 54 4 AT CH 051 4 510 510 54 4 AT BO AV $CASS - COLVERT V 510 - CULVERT ON ONE SION STOP STO$	Compass VW VW P TOE A-IOM SCOUR RB O.GI M UC RB B-IOM SCOUR LB O.ZI M UC LB O.ZI M UC LB O.53 M POOL C-20M SCOUR LB O.55M UC LB D-0.18,025 UC RB E-0.38M POOL F-0.32M POOL F-0.32M POOL KP-0.30M TALLUS O.FOM TALLUS O.FOM TALLUS O.FOM TALLOS G-0.13 M UC LB H- GEAVER DAM O.ZI M UC 3 I = 0.93,0.85 POOL J - BEAVER DAM O.46M POOL
 H2 Scarcely perceptil H3 Smooth surface fl H4 Upwelling H5 Rippled H6 Unbroken standing H7 Broken standing H8 Chute H9 Free fall 	ole flow ow g wave wave H9A Dissipates below free fall	SMALL EP V V V BEAVER AXSA V V V ON SIDE CHANNEL P V V V CHANNEL P V V V V V V V CHANNEL P V V V CHANNEL P V V V V V V V CHANNEL P V V V V V V V V V V V V V V CHANNEL P V	- BEAVER N 20M SCOULD DOWINED I.OM POOL TREES L = 0,35M UC M- 0,42 M POOL N - BEAVER DAM AVER I.05,1.20 PCO WINED EES T DEP. UP TO 0.39M DEPTH R
SubstrateS1SiltS2SandS3GravelS4Small cobbleS5Large cobbleOtherBMBMBenchmarkBSBacksightDSDownstreamWDJWoody debris ial	S6 Small boulder S7 Large boulder S8 Bimodal S9 Bedrock/till S10 CLAY TILL EP Erosion pin RB Rebar US Upstream m TR	SIO SW WD, BEAVER DOWNED TREES VISSI 2 X52 EXP SOIL, V XXX NX51 DEBRISAT VW TOE IN CHANNEL E3, V	South TRIB
vwc Valley wall conta BOS Bottom of slope TOS Top of slope	ct FC Flood chute FP Flood plain KP Knick point	Photos: Notes: ISLANDS TO TREES GHOUT REACH, 3 BEAVER	IN 2 LOCATIONS, ISLAND DAMS ACROSS MAIN

Version #4 Last edited: 21/02/2023

Senior staff sign-off (if required): _

Page ____ of ____

GEO

ORPHIX

GEO MORPHIX*

Detailed Cross-Section Characteristics

Project Number: 23076

Date: 10-10-24		Cross-section:	X51
Time:	12:00	Reach:	010
Weather:	10'SUN/CLOUD	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

				Notes	Cross-sectional Morphology (Table 22)
RTKA-> 23	0710 - 10	1024			🖾 Riffle 🗆 Pool 🗆 Run 🗆 Other
PTID -> 100					Substrate Sample:
PT CODE	XSI				🗆 Bed 🗀 Bank 🗆 Subpavement 🗆 Water 🔯 None
	XSIBE				Pebble Count Measurements A/B/C Axes (cm):
	XSIW				A B C A B C A B C A B C
	XSIP	- CENT	TER BAR		8.Z 1016 8.3 9.5
	XSIP	Ē	11		H 3.3 FO 10
	LVW	- UB	VWC		4,9 165 27 30,5
					11 9 48 17 110 03 17 114 05 85 58 56
					3.8 7.5 123 11
					4 13.9 19.6 HI.5
	1				5.6 10 8.8 9.2
• 5 [°] &					72 45 39 24 12 05 13 19 85 7 54 3
					413 18 12 7/9
in a state of the					ma ma 7 B
					Particle Shape: 🕅 Platy 🛛 Very Angular
					🖄 Sub-angular 🖾 Angular 🗆 Rounded
					Sub-Rounded □ Well Rounded
· Ann New much of the					Embededness: 10 %
					Subpavement:CLAY TILL [Pebble ABC axis guide]
21.135.24	M HOLE IN	2.8		1.00	Sorting (Table 20): 🗆 Well 🔯 Moderate 🗆 Poor 🗆 Very poor
	CV610.1.1	AU 030 540		neorgal na	Sediment Transport
		1636			🗆 Obsv 🖾 Not Obsv 🗆 Not Visible - Reason:
		1.00		and contractors	If Observed (Table 21):
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6	-	stosAsha	E		Velocity
		duel'i too		282	Measuredm/s Method:R
and the second s		V. Censity	5 A	ig bee	Estimatedm/s XS ID:
		- mebrili			Distance m Times Vs m/s
		44, 101, 201		y Debas	Distance <u>1</u> m Time <u>1.12</u> s V <u>0.89</u> m/s
- market		onsvilo _{se}		Names the	Distancem Time 1.00 s V0.94_m/s
		N. SIL I'D'	N Standard	nig pia	Discharge
		0.500 000		Line and Lin	Estimatedm ³ /s Method:
					☐ Measuredm³/s XS ID:
					Depthm Widthm V ₆₀ m/s
			· · · · · · · · · · · · · · · · · · ·		Depthm Widthm V ₆₀ m/s
					Depthm Widthm V ₆₀ m/s
					Use V ₆₀ if Depth < 0.75 m and V ₂₀ / V ₈₀ if Depth > 0.75 m
Language	I				

Version #3 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: ____ Completed by: __KS

GEO



Page 2 of 20



Project Number: 23076

Date:	10-10-24	Cross-section:	XS2
Time:	12:45	Reach:	CIO
Weather:	10°C SUN/CLOUD	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

				Notes	Cross-section	nal Morphology	(Table 22)	
RTK 4 -> 2	80710-11	01024			🗆 R	iffle Pool		ther
PTID >> ZI	00		* .		Substrate Sa	imple:		
PT CODE ->	XS2				Bed D	Bank 🗆 Subpa	vement 🗆 Water	r 🗆 None
	XS2 BF				Pebble Coun	t Measurement	s A/B/C Axes	(cm):
	XS2 WE				ABC	ABC	ABC	ABC
					FINES	11	21	31
					1	12	22	32
						13	2.3	33 -
					4 4 4	14 14 14	24 24 24	34 34 34
					5	15	25	35
					a	16	26	36
					7	17	27	37
					8 8 8	18 18 18	28 28 28	38 38 38
					9	19	29	39
					18	20	30	40
					Particle Sha	pe: 🗆 Platy	Very Ang	ular
					Sub-angula	ar 🗆 Angular	Rounded	1/8/11
					Sub-Round	led D Well Rour	nded /	
					Embededness	5: %		S.
	+				Subpavement	t:	[Pet	ble ABC axis guide
212113	e Trans In	01.1		1993	Sorting (Tabl	le 20): 🗆 Well 🗆	Moderate 🗆 Po	or 🗆 Very poo
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	STATES AND ADDRESS			CA DOUBLEST			the second s	
1000		. 312.5 .			D Obsv 🕅 No	t Obsv 🗆 Not Vi	sible - Reason:_	10. s.
				and anshore	If Observed	ot Obsv 🗆 Not Vi (Table 21):	sible - Reason:_	41.52 C
					Obsv 🎾 No If Observed Suspended	ot Obsv 🗆 Not Vi (Table 21): d 🗆 Sliding 🗖	sible - Reason:_ Rolling 🗆 Salt	ation
					Obsv A No If Observed Suspended Percentage o	ot Obsv 🗆 Not Vi (Table 21): d 🔲 Sliding 🗆 f Bed Active:	sible - Reason:_ Rolling □ Salt	ation%
		in in in in in in in in in in in in in i			Obsv A No If Observed Suspended Percentage o Velocity	ot Obsv 🗆 Not Vi (Table 21): d 🗆 Sliding 🗆 f Bed Active:	sible - Reason:_ Rolling 🗆 Salt	ation %
		Class Autoritation Characteritation Characteritation			Obsv A No If Observed Suspended Percentage o Velocity Measured	ot Obsv Not Vi (Table 21): d Sliding f Bed Active:	sible - Reason:_ Rolling	ation %
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		e Barton Anton Suck Hetabo ent Deptin of Density	5	richtend pits o distriction alsolutions ess richtend richtend richtend richtend	Obsv A No If Observed Suspended Percentage o Velocity Measured Estimated Distance	t Obsv 🗆 Not Vi (Table 21): d 🗆 Sliding 🗆 f Bed Active: m/s M m/s N	sible - Reason:_ Rolling	ation %
		endos entre entre entre Heraho entre Applic of Density Undensity	5	61967666 545 619677777777777777777777777777777777777	Obsv A No If Observed Suspended Percentage of Velocity Neasured Estimated Distance	ot Obsv 🗆 Not Vi (Table 21): d 🗆 Sliding 🗆 f Bed Active: m/s M m/s M m/s M mTime m Time	sible - Reason:_ Rolling	ration % m/s m/s
		ente activitation activitation lande Anglo act Deptin of Density Undercus rosion Pin		incritication production establistication of establistication of registering registering for the observation for the sample	Obsv A No If Observed Suspended Percentage o Velocity Measured Distance Distance Distance	ot Obsv 🗆 Not Vi (Table 21): d 🗆 Sliding 🗆 f Bed Active: m/s M m/s M m/s M m Time m Time m Time	sible - Reason:_ Rolling	ation % m/s m/s m/s
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Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____



GEO





Project Number:

Date:	10-10-24	Cross-section:	X53
Time:	13115	Reach:	CIO
Weather:	10° SUN/CLOUD	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

KTK A → 2 \$076-101024 □ Riffle S[Pool □ Run □ Other PT 000E → x53 □ Substrate Sample: X538F □ A is C A				N	lotes	Cross-sectional Morphology (Table 22)
PT D D PT CODE y S3 Partice Cont A: B: C A: B: C Partice Statistics Statistics Statistics Partice Statistics Statistics	RTKA->	3076-	101024			🗆 Riffle 🛛 Pool 🗆 Run 🗆 Other
PT CODE √S3 PT CODE √S3 SSBF Pebble Count Measurements A/B/C Axes (cm): A:B:C	PTIDS	300				Substrate Sample:
Pebble Count Measurements A/B/C Axes (cm): XSSPF A B C A	PT CODE.	-> VC2				🗆 Bed 🗆 Bank 🗆 Subpavement 🗆 Water 🖾 None
X33 X333 X33 X33	11 100-100	VSBI	3F			Pebble Count Measurements A/B/C Axes (cm):
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3.4 0.2 15 1.6 9.4 6.35 10.94.139 1.51.75.164 6.81.452.9 9.2 0.2 7 5.9 13 0.2 5.9 5.12 143 0.2 14 132 5.9 13 0.2 14 12.5 15 143 0.2 14 12.5 15 143 0.2 14 12.5 15 143 0.2 14 12.5 15 143 0.2 14 12.5 14 15 0.2 14 12.5 15 15 0.2 14 12.5 15 15 0.2 14 12.5 15 16 17.4 0.2 7.5 15 17.4 0.2 7.5 15 16 16 15 16.0 16.0 16.0 17.4 0.2 7.5 15 16 17.4 0.2 7.5 15 16 17.4 <						15.4 11.4 10 19.8
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5:2 0:2 7 5:9 13 0.2 5:9 3:5 13 0.2 5:9 3:5 13 0.2 5:9 3:5 13 0.2 5:9 3:5 13 0.2 5:9 5:5 13 0.2 7:8 5:9 13 0.2 7:8 5:9 14 12:3 17:4 0:2 7:8 17:4 0:2 7:8 1:3 9 20 20 20 20 12:8 20 20 17:4 0:2 7:8 1:3 20 20 20 20 20 12:8 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20						9.4 6 3.5 10 9.4 39 11.5 7.3 64 6.8 4.5 2.9
13 0.2 5.9 9.5 13 0.2 5.9 9.5 13 0.2 2.0 2.3 14 12.8 13 0.2 1.3 15 0.2 7.5 1.4 12.8 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 17.4 0.2 7.5 1.3 16 504-angular Well Rounded Well Rounded 17.4 0.2 7.5 1.3 17.5 5050-angular Mell Rounded Well Rounded 17.5 5050-angular 1.4 12.8 17.5 5050-angular 1.5 1.5						5.2 0.2 7 5.9
13 0.2 20 2.5 145 0.2 14.5 5.4 12.8 17.4 0.2 14 12.8 13 17.4 0.2 14 12.9 14 17.4 0.2 14 12.9 14 17.4 0.2 14 12.9 14 17.4 0.2 1.3 14 12.9 17.4 0.2 1.3 14 12.9 17.4 0.2 1.3 14 15 17.4 0.2 1.4 12.9 14 17.4 0.2 1.4 12.9 14 17.4 0.2 1.4 12.9 14 17.4 0.2 1.4 12.9 14 17.5 1.5 1.6 1.5 1.6 14 17.5 1.6 1.6 1.6 1.6 1.6 1.6 17.5 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6						13 0.2 8.9 3.5
Image: Second state of the second s						18 0.2 20 2.8
Image: Sector of the sector						16 14,5 4,8 19,5 14 3,8 89 7.5 3,9 6 5 4
Image:						18 0.2 14 12.9
Particle Shape: MPlaty Very Angular Sub-angular Mangular Rounded Subpayment: CLAY TILL Pebble ABC axis guide] Sorting (Table 20): Sorting (Table 20): Well Moderate Obsy MNO bosv Not Visible - Reason: If Observed (Table 21): Suspended Suspended Silding Rounded Massured Measured m/s Method: Massured Suspended Suspended Silding Suspended Silding Suspended Silding Measured m/s Method: Massured Suspended Suspended Silding Suspended Silding Suspended Silding Sus						17:4 0:2 7:8 1:3
Image: Sub-angular Image: Sub-angular Rounded Image: Sub-Angular I						Particle Shape: APlaty DVery Angular
Image: Solution of the second seco						🖾 Sub-angular 🖄 Angular 🗆 Rounded
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Subpavement: CLAY TILL [Pebble ABC axis guide] Sorting (Table 20): Well Moderate Poor Very poor Sediment Transport Obsv Mot Obsv Not Visible - Reason: If Observed (Table 21): Suspended Sliding Rolling Saltation Percentage of Bed Active: % Measured m/s Method: % Velocity Measured 5 Substance 0.5 m Time 1.29 Substance 0.5 m Time 1.40 Substance m3/s Method: 1.01 1.01 Substance 1.05 m Time 1.40 1.01 Weissing 1.01 1.01 1.01 1.01 Substance 0.5 m Time 1.40 1.01						Embededness: <u>36</u> %
Sorting (Table 20): Well \$\overline\$ Moderate \not Poor \Very poor Sediment Transport Sediment Transport Obsv \$\overline\$ Not Visible - Reason: In Obsv \$\overline\$ Not Visible - Reason: Image: Sediment Transport Support Sediment Transport Image: Sediment Transport Support S						Subpavement: <u>CLAT TILL</u> [Pebble ABC axis guide
Sediment Transport Sediment Transport Sediment Transport Solution Solution Supported (Table 21): Supported (Table 20): <td>1917 - 192</td> <td>16 a ANEE 10</td> <td>36 M</td> <td></td> <td>2.521</td> <td>Sorting (Table 20): Well Moderate Poor Very poor</td>	1917 - 192	16 a ANEE 10	36 M		2.521	Sorting (Table 20): Well Moderate Poor Very poor
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Image: Second state in the second s			tri sogii sitas		idesibiliste	Percentage of Bed Active:%
Image: Solution of the second state of the second stat	p		alana dust			Velocity
Image: Second state sta			42050 2005		85	□ Measuredm/s Method:B
Image: Second state in the second s			officers O apr	51	ng tree	Estimated <u>6.06</u> m/s XS ID: <u>3</u>
			Sector State			Distance <u>0,</u> ら m Time <u>11, 89</u> s V <u>0,04</u> m/s
			Encerion Prin		e andara y	Distance 0.5 m Time \$,20 s V 0.00 m/s
Discharge	0101.g.s		eneviol		0.062.309	Distance <u>0.5</u> m Time <u>7.40</u> s V <u>0.07</u> m/s
Image: Second state sta			1910/16/304		nin u	Discharge
Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system Image: Solution of the second system<			0970-1004		1800.020	Estimatedm ³ /s Method:
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						Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: KS

GEO

MORPHIX"

GEO



Page 6 of 20

Project Number: 23076

Date:	10-10-29	Cross-section:	XS4						
Time:	13:45	Reach:	CIO						
Weather:	10' SUN/CLOUD	Location:	CARDINAL CREEK						
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER						

					Notes	Cro	ISS-SE	ectio	nal M	orpho	ology	(Ta	ble	22)			
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Version #3 Last edited: 21/02/2023 Senior staff sign-off (if required): _____ Checked by: _____ Completed by: \underline{KS}

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MORPHIX"


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GEO

Detailed Cross-Section Characteristics

Project Number:

Date:	10-10-24	Cross-section:	XS5
Time:	14:15	Reach:	010
Weather:	10' CLOUDY	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

			Notes	Cros	s-sectio	onal Morph	ology	(Table	22)		
RTKA-> 2307	6-10102A				I I	Riffle 🛱 I	Pool	🗆 Run		her	
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Senior staff sign-off (if required): _____ Checked by: _____ Completed by: _____KS____

GEO



GEO MORPHIX"

Detailed Cross-Section Characteristics

Project Number: 23076

Date:	10-10-24	Cross-section:	XS6				
Time:	14:45	Reach:	C10				
Weather:	10°C CLOUD	Location:	CARDINAL CREEK				
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER				

				Notes	Cro	ss-se	ectior	nal M	orpholog	y (Tal	ple 2	2)			
RTK4-> 230	70-1010	24					R	iffle	Pool		un		ther		
PT 10 -> 6000)				Sub	strat	te Sa	mple	;						
PT CODE ->	VSIO						ed 🗆	Bank	C 🗆 Subpa	vemer	nt 🗆	Wate	r 🖾	None	1
	XSGW	n 8-			Pet	ble (Count	t Mea	suremen	ts A/I	B/C	Axes	(cm) :	
	VSID B	jetts Smit			A	В	С	Α	BC	A	B	C	A	B	C
	100					5		BI	EDROCK	BE	DRO	CK	BE	DRO	cK
						6			12		22			32	
						4.2)		13	1	23			33	
	-				85	714	12.3	5	31 118	24	24	24	34	34	34
						5	1		15		25			35	
						10			16		26			36	
						17			17		27			37	
					3	2.6	0.8	18	18 18	28	28	28	38	38	38
						6	1		19	1	29			39	
						294	9		20		30			40)
				-	Pai	rticle	Sha	pe: 🗹	Platy	E	Ver	y Ang	gular	/	~
						Sub-a	ingula	ar 🕱	Angular	Ľ	Rou	unded			///
						Sub-R	Round	led 🗆	Well Rou	inded		/		X	//
					Em	bedeo	dness	;; (0 %			6	A	Ŋ.	
				_	Sul	pave	ement	t:	BEDRO	CK		– [Pel	bble A	BC axi	s quide]
	a 1 202 3 10			10.01	Sor	tina	(Tabl	e 20);	: 🗆 Well 🕻	Mode	erate		oor 🗆] Ver	y pool
		N. COUVE		0.10636038	Se	dime	nt Tr	ansp	ort		it and				
		111		CX 19941 3 11		They		t Obs	v 🗆 Not V	/isible	- Rea	son:			del 1.
		10-01		and south	Tf	Ohse	rved	(Tabl	e 21):	910400) 6g1	61 10			and the
						Suspe	endec		Slidina 🗆] Rollir	ng D] Salt	tatior	n	
		the second se		<u>, oùddrodd</u>		rconta		f Bed	Active:		3 O (2)			%	
		Strengt C. C. C.	9	o digentic hereis	Ve	locity	M N	Dea							
	_					Meac	, ured		m/s	Metho	1: \	WB	• • •	1000	
	and a sum and	ant of the				Fetim	ated	0.5		XS ID	. ((0	:V	diana	11101
		V3 8 20 1 1 1	025			stance		1.0	m Tim	3,4	11	s V	0	.29	m/s
(T) and a second second		20213202		in the second second		stance		1.0	Time	3.	76	• V	0	7 10	m/s
x		114 00150*		dractice a sub-		stance	e	1.0	m Time	7.	31	_5 V	0	.42	
	and the second second	201121 1968(a) -11 - 1		Programme 1 Theory		scance	e					_3 V			
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						Meas	ured		m³/s	XS II	יג 	N			m/c
					De	epth _		m	width _		<u>_</u> n	I V60			
			-	And a second sec	De	epth_		m	Width_		n	V60)		
					De	epth_			width _		m	V 60)		
						Use	V60 if	Depth	n < 0.75 m	and V ₂₀	0 / V80	if Dep	pth >	0.75	m

Version #3 Last edited: 21/02/2023

Senior staff sign-off (if required): _____ Checked by: _____ Completed by: ____KS

GEO

Bank Characteristics

Project Number: 23076



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GEO MORPHIX*

(= 11, 00)

Detailed Cross-Section Characteristics

Project Number: 23076

	10-10 24	Cross-section:	XST
Date:	10-10-21	Reach:	CIO
Time:	10.5 0/0/101	Location:	CARDINAL CREEK
Weather:	10 - 010009	Watershed/Subwatershed:	OTTAWA RIVER
Field Staff:	KS CM MA	Watersheer, sesterat	VIIIIVA I INTE

	Notes	Cross-sectional Morphology (reason						
		🗆 Riffle 🕅 Pool 🕅 Run 🗆 Other						
KINT COUTO IOIGON		Substrate Sample:						
PTID - YOU		🗆 Bed 🔲 Bank 🗆 Subpavement 🗆 Water 🖾 None						
YI CODE TAT		Pebble Count Measurements A/B/C Axes (cm):						
NS+WC		A B C A B C A B C A B C						
XST Dr		315 7 BEDROCK BEDROCK						
		EA 473 22 12						
		3.8 10,4 21 33						
		17 25 36 15 1A A12 24 24 24 34 34 34						
		46.56.50 15 25 35						
		11 12.2 26 86						
		8 6 1 37						
		9,4 TH 201 - 20 - 20 - 20 - 20 - 20 - 20 - 20						
		19 13 718 444 39 213 20 21 20 00 00						
		9 2.2						
		2.2 39						
		Particle Shape: 🕅 Platy 🗌 Very Angular						
		🗆 Sub-angular 🖾 Angular 🗆 Rounded						
		□ Sub-Rounded □ Well Rounded						
		Embededness:%						
		Subpavement: <u>BEDROCK</u> [Pebble ABC axis guide						
	1	Sorting (Table 20): Well Moderate Poor Very poor						
	noncour i	Sediment Transport						
	CA DOUTON	Reason:						
	the second second							
	1 in and the							
	and stored							
and the second s	index lides	Percentage of Bed Active: 78						
Bank Angle		Velocity						
Roat Shoth	2	Measuredm/s Method:						
R lot Denteroy	gg ti ge	SAEstimated 0,20 m/s XS ID: +						
Madama Angela		Distance m Times Vm/s						
	Debris	Distance m Times Vs /m/						
		Distance 1 m Time 4,83 s V 0,21 m/						
	nu,	Discharge						
	THEOD DEA	Estimated m ³ /s Method:						
		- Macaurad m ³ /c XS ID:						
		Death m Width m Veo m/						
		Depthm Widthm v ₆₀ m						
		Use V ₆₀ if Depth < 0.75 m and V ₂₀ / V ₈₀ if Depth > 0.75 m						

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GEO MORPHIX"

Detailed Cross-Section Characteristics

Project Number: 23076

Date:	10-10-24	Cross-section:	X58				
Time:	15:30	Reach:	C10				
Weathor	In'S CIOLED (SULN	Location:	CARDINAL CREEK				
Field Stoff	KE CM LOX	Watershed/Subwatershed:	OTTAWA RIVER				

					Notes	Cross-sectional Morphology (Table 22)	
OTKA	2207	ADDIDICOL				🕅 Riffle 🗆 Pool 🗆 Run 🗆 Other	
PT IN	2201	<u>-101024</u>				Substrate Sample:	
DT MAR	- Yeo	1				🗆 Bed 🛛 Bank 🗆 Subpavement 🗆 Water 🕅 None	
	- 101	D				Pebble Count Measurements A/B/C Axes (cm):	
						ABCABCABCAB	
						10 10:4 5 3.8	
						374 678 125 674	
						14.5 5.8 4.8 11.5	
						18 13 99 28 21 4 6 4 12 4 341	
						12.5 3.7 673 10.4	
						9.8 12 124 10.1	
						8 10 6 7.8	
						15 12:4 3 15 12 3.5 6.3 3.5 2.8 2 1.8 1	
						915 10.5 595 9	
						76 76 3 13	
						Particle Shape: A Platy Dery Angular	
1						🖄 Sub-angular 🖾 Angular 🗆 Rounded	
					□ Sub-Rounded □ Well Rounded		
				Embededness: 5 %		Embededness: 5 %	
· · · · · · · · · · · · · · · · · · ·				Subpavement: BEDROCK	Subpavement: BEDROCK [Pebble ABC axis qu		
					10 10 10 10 10 10 10 10 10 10 10 10 10 1	Sorting (Table 20): Well Moderate Poor Very p	
	022.12.22.22		10010-00-0		0.1002100	Sediment Transport	
			- (11) -		CA ISBURG	Dobry M Not Obry D Not Visible - Reason:	
		112 1 Sand	V1810 1	1 - 1	Abg Married	Tf Observed (Table 21):	
	Capitan C				n <u>alessed aver</u> t	Suspended Sliding Rolling Saltation	
	abioo8	part P	East2		phylady	Bernertage of Pod Active:	
10			distant de a		nitesilidate	Velocity	
			JanA Shee			Managurad m/s Method: WB	
- 61			10050 1005		25	The Hundrad on 2 Ab m/c VS ID: 3 LEFT CHANN	
			chens0 ic.	9	19 (ree	Destimated 0.575 m/s x5 10 0 = 0 1 0 14100	
101			umeball			L Distancem limes v	
60 L			nig noiseac		V Detern	Ubistance m limes V	
VELOCI	TY X	5 8 RIG	HT CHAN	INEL	ent sampr	Distancem IImes v1	
uto//fos	D(M)	T(S)	VCMIS	> AVG	V (MIS)	Discharge	
RI	1	2.43	0.41	013	39	Estimatedm ³ /s Method:	
- t	1	2.70	0.37			☐ Measuredm ³ /s XS ID:	
						Depthm Widthm V ₆₀ n	
	1					Depthm Widthm V ₆₀ n	
						Depthm Widthm V ₆₀ r	
						Use V_{60} if Depth < 0.75 m and V_{20} / V_{80} if Depth > 0.75 m	

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Detailed Cross-Section Characteristics

Project Number: 23076

Date:	10-10-24	Cross-section:	X59-M
Time:	15:45	Reach:	010
Weather:	10° CLOUD	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

					Notes	Cro	055-56	ectio	nal M	lorph	olog	y (Tab	ole 22)				
RTKA-	-72307	6-10102	4					₿ R	iffle		Pool		un 🗆	Othe	er		
PTID	> 900					Su	bstra	te Sa	mple	3:							
PTCO	DE->	X59		1			ЪB	ed 🕅	Ban	k 🗆 S	Subpa	vemer	nt 🗆 Wa	ater [] No	ne	
	atta atta and	X59WL				Pe	bble (Coun	t Mea	asure	emen	ts A/I	B/C Ax	es (c	:m):		
		XSARF			2.	A	В	С	Α	B	С	A	ВС		4	B	C
							7.6		Ч	11	5.6	6	2.76	1.	8	31	
							278			12\	4,4	ź	275	2	1.2	32	
							134		3.1	13	1		171		2	,9	
						244	1.8	112	7.4	A 4	0.4	P.4	0.8 0.	4 3	16 2	18	126
							3.1		2.	615			3:4		3	1.0	
							2.4		2:	z 16			.26			1.8	
							2.9		1.1	17			174		2	2,4	r
						28	184	0,4	126	1.84	010	184	171 0	46	14 3	2.6	3,6
					1000		191		0.	8 19		[1.4		1	An	2
1							0,4	1	G,	8 20			309		0	1,4	
						Pa	rticle	Sha	pe: 🛛	Plat	y		Very A	ngula	ar	/	2
						囟	Sub-a	ngula	ır Ø	Ang	ular	C	Round	led	6	/	1
							Sub-R	lound	ed 🛛] Wel	l Rou	nded		1.	X	\checkmark	
						Em	nbedeo	dness	:		%			K	5	9	
						Su	bpave	ment	:					Pebble	ABC	axis	guide]
	0.1.3 4 81.00	M 2004 72			1993	So	rting	(Tabl	e 20)	: 🗆 V	Vell 🕅	Mode	erate 🗆	Poor		'ery	poor
			10000000		110400510	Se	dime	nt Tr	ansp	ort							
- Ale	- aldalae				1000 (PRO 1997)		Obsv	MNO	t Obs	v 🗆 I	Not V	sible -	Reaso	า:		. 11	
1.75		1				If	Obse	rved	(Tab	le 21):						
	antione.						Suspe	ended		Slidin	ig 🗆	Rollin	g □S	altati	on		
			and a solution		and the light of	Pe	rcenta	ige of	Bed	Activ	e:	an ann an ann			0	%	
-		-				Ve	locity	1									
			rigans		20		Measu	ured		r	n/s N	lethod	WB)		60 :	122.0
			volana Cito	Я	esol pr	N	Estim	ated	0.8	9	m/s)	S ID:	9		: 510		
1. 1.7			Under e. it			Dis	stance	e		m	Time	1.19	S	V	0.8	4	m/s
		and a second sec	ALL ROLLONG		ends0 y	Di	stance	9	1	_m	Time	1.13	<u>3</u> s	v_(3.80	8	m/s
		and the second second	366/101		ald west the	Di	stance	2	Ì	m	Time	1.00	<u>9</u> 5	V	9,0	4	_m/s
			0.00000	12.1	()24-D	Di	schai	ge									
	1,2-8 1, 1-8		1.345 2012 Y		100002-0292		Estim	ated		n	n³/s M	lethod	100000 ANA			C 7	
							Meas	ured			m ³ /s	XS ID):	624	oW. h	più.	dirit is
		+			+	De	epth		n	Wid	itth		_m V	60			m/s
						De	epth		n	n Wid	ith		m \	60			m/s
						De	epth		n	n Wio	ith		m	60			m/s
							Use	V60 if	Depth	1 < 0.	75 m a	nd V ₂₀	/ V80 if [Depth	> 0	75 n	n
		1	1	1	- Piece			nule	1632	100119	c					1	

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Detailed Cross-Section Characteristics

Project Number:

Date	10-10-24	Cross-section:	X510
Time:	14:15	Reach:	C10
Weather:	10°C SUNICLOUD	Location:	CARDINAL CREEK
Field Staff:	KS CM MK	Watershed/Subwatershed:	OTTAWA RIVER

	Notes	
RTKA-> 23076-101024		
PT10-> 1000		Substrate Sample:
PT RODE -> X510		□ Bed □ Bank □ Subpavement □ Water ¥ None
		Pebble Count Measurements A/B/C Axes (cm):
		A B C A B C A B C A B C
		16.8 6.0 10.4 0.2
		876 A.A 1012 P2
		6 118 4.8 3
		148:10:8: 6:0 3:4 2:6 0:2 11.4 6:8 5.2 34 34 3
		95.10 IIA 8.1
		9 18 598 86
		A 4.8 1.8 7
		12 100 00 78 14 69 40 38 120 38 18 3
		69 1861 09 450 FT 196 WE 170 191 19
		8.) Zil 8.4
		SiA Din 275
		Sub-angular C Angular
		Sub-Rounded 🗆 Well Rounded
		Embededness: <u>50</u> %
		Subpavement: <u>CLAY TILL</u> [Pebble ABC axis guid
8.2 PERC - NULLER - N		Sorting (Table 20): Well 🖓 Moderate Poor Very po
	10062050	Sediment Transport
	$\frac{1}{C_{c}} \frac{1}{C_{c}} \frac{1}$	🗆 Obsy 🕅 Not Obsy 🗆 Not Visible - Reason:
		If Observed (Table 21):
netsiu i cassi i uita-	- iosen a	□ Suspended □ Sliding □ Rolling □ Saltation
Sadd	a miziscisti fi	Percentage of Bed Active: %
Jank Heidha	100650/0572	
-ank Angie		E Managerrad m/s Method: W/B
Root Depth Algert	25	Masured Mis Method
R of Details vitabella for	9341 BI	Nestimated 0.01 miles XS 10:
un la national		Distance m Times vm/
408-05 PRA	Debris	Distancem Times Vm
0 0/	BRIME AB	Distancem Times V58 _m,
10-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-0-	i più	Discharge
	1021-2 0-90	Estimatedm ³ /s Method:
		☐ Measuredm ³ /s XS ID:
		Depthm Widthm V ₆₀ m,
		Depthm Widthm V ₆₀ m,
		Depth m Width m V60m
		$1 \text{ Line } V_{\text{m}} \text{ if } \text{ Depth} \neq 0.75 \text{ m}$ and $V_{\text{m}} / V_{\text{m}} \text{ if } \text{ Depth} > 0.75 \text{ m}$
		1 USE V60 IT DEDUT < 0.75 IT and V207 V80 IT DEDUT > 0.75 IT



Appendix H: Detailed Assessment Summary



Detailed Geomorphological Assessment Summary Reach R3

Project Number:	PN23076	Date:	2024-08-07
Client:	Tamarack Developments	Length Surveyed (m):	88.5
Location:	Cardinal Creek South Tributary	# of Cross-Sections:	8

Reach Characteristics			
Drainage Area:	1.9 km ²	Dominant Riparian Vegetation Type:	Herbaceous, Grasses
Geology/Soils:	Ottawa Valley Clay Plains	Extent of Riparian Cover:	Continuous
Surrounding Land Use:	Forested valley	Width of Riparian Cover:	>10 channel widths
Valley Type:	Confined	Age Class of Riparian Vegetation:	Immature to Established
Dominant Instream Vegetation Type	: Algae	Extent of Encroachment into Channel:	Moderate
Portion of Reach with Vegetation:	5%	Density of Woody Debris:	Moderate

Hydrology				
Estimated Discharge (m ³ /s):	0.03	Estimated Bankfull Discharge (m ³ /s):	1.27	*
Modelled 2-year Discharge (m ³ /s):		Estimated Bankfull Velocity (m/s):	0.95	*
Modelled 2-year Velocity (m/s):		* Bankfull parameters affected by beaver dam activity		

Profile Characteristics		Planform Characteristics		
Bankfull Gradient (%):	0.41	Sinuosity:	1.33	
Channel Bed Gradient (%):	0.76	Meander Belt Width (m):	25.8	*
Riffle Gradient (%):	4.61	Radius of Curvature (m):	15	
Riffle Length (m):	4.29	Meander Amplitude (m):	10	
Riffle-Pool Spacing (m):	0.00	Meander Wavelength (m):	15	
		*Parish Geomorphic Ltd 2013		

Longitudinal Profile



Bank Characteristi	Jank Characteristics								
	Minimum	Maximum	Average		Minimum	Maximum	Average		
Bank Height (m):	0.45	0.85	0.61	Penetrometer Value (kg/cm3):	0	1.5	0.7		
Bank Angle (deg):	15	90	39	Bank Material (range):	Clay/si	It to pebble size	ed clay		
Root Depth (m):	0.05	0.16	0.11			conglomerates			
Root Density (%):	5	30	18						
Bank Undercut (m):	0.00	0.29	0.07						

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	2.10	4.71	3.62
Average Bankfull Depth (m):	0.16	0.46	0.37
Bankfull Width/Depth (m/m):	7	13	10
Wetted Width (m):	0.92	1.87	1.31
Average Water Depth (m):	0.02	0.14	0.05
Wetted Width/Depth (m/m):	14	75	33
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.04	0.19	0.11
Manning's <i>n</i> :		0.040	



Photograph at cross section 1 (looking downstream)

Representative Cross-Section #1





Channel Thresholds						
Flow Competency (m/s):		Tractive Force at Bankfull (N/m ²):	15.05			
for D ₅₀ :	0.27	Tractive Force at 2-year flow (N/m ²):	N/A			
for D ₈₄ :	0.27	Critical Shear Stress (D ₅₀) (N/m ²):	1.46			
Unit Stream Power at Bankfull (W/m ²):	14					

General Field Observations

Channel Description

Reach **R3** was characterized by a sinuous channel set within a confined, wooded valley. The valley floor was previously inundated due to beaver activity and had since drained to reveal accumulated fine sediment deposits (e.g. clay to sand sized particles). Short grasses and herbaceous vegetation are populating the deposits, forming a beaver meadow. At the time of inspection, a channel was forming within the meadow and actively reworking the deposits of fine sediments. The channel bed morphology consisted of alternating riffle-pool sequences comprised primarily of fine sediments. A small proportion of the channel sediments were gravel sized and were generally limited to riffle features. The channel banks were vegetated but were relatively soft in composition and thus sensitive to erosion (e.g. slumping). The channel exhibited evidence of systematic aggradation and widening. For example, channel banks were generally unstable and in-channel bars/fine sediment deposits were common.







Detailed Geomorphological Assessment Summary

Reach C10

Project Number:	PN23076	Date:	10-10-24
Client:	Tamarack Developments	Length Surveyed (m):	459.0
Location:	Cardinal Creek	# of Cross-Sections:	10

Reach Characteristics			
Drainage Area:	3280 ha	Dominant Riparian Vegetation Type:	Forest
Geology/Soils: G	ilaciomarine clay till; bedrock	Extent of Riparian Cover:	Continuous
Surrounding Land Use:	Forest, Residential	Width of Riparian Cover:	4 to 10 Channel Widths
Valley Type:	Confined	Age Class of Riparian Vegetation:	Established and Mature
Dominant Instream Vegetation	Type: Attached algae	Extent of Encroachment into Channel:	Minimal
Portion of Reach with Vegetation	n: 10%	Density of Woody Debris:	Moderate
_			

Hydrology			
Estimated Discharge (m ³ /s):	0.50	Estimated Bankfull Discharge (m ³ /s):	16.85
		Estimated Bankfull Velocity (m/s):	2.00

Profile Characteristics		Planform Characteristics	
Bankfull Gradient (%):	0.85	Sinuosity:	1.49
Channel Bed Gradient (%):	0.81	Meander Belt Width (m):	Confined system, N/A
Riffle Gradient (%):	1.75	Radius of Curvature (m):	15.0
Riffle Length (m):	0.74	Meander Amplitude (m):	20.0
Riffle-Pool Spacing (m):	0.55	Meander Wavelength (m):	32.0

Longitudinal Profile



Bank Characteristics

	Minimum	Maximum	Average		Minimum	Maximum	Average
Bank Height (m):	0.40	10.00	1.65	Penetrometer Value (kg/cm3):	0.25	3.00	1.00
Bank Angle (deg):	10	85	45	Bank Material (range):	Bedrock,	clay, silt, grave	el, cobble
Root Depth (m):	0.10	1.57	0.46				
Root Density (%):	5	25	14				
Bank Undercut (m):	0.00	0.42	0.06				

Cross-Sectional Characteristics

	Minimum	Maximum	Average
Bankfull Width (m):	8.90	23.21	13.32
Average Bankfull Depth (m):	0.50	1.05	0.72
Bankfull Width/Depth (m/m):	11	41	20
Wetted Width (m):	4.12	17.93	9.01
Average Water Depth (m):	0.09	0.54	0.28
Wetted Width/Depth (m/m):	19	81	39
Entrenchment Ratio (m/m):	>2.2 (Slight/Low Entrenchment)		
Maximum Water Depth (m):	0.21	1.00	0.51
Manning's <i>n</i> :	0.040		







Substrate Characteristics

Particle Size (mm)	
D ₁₀ :	2.0
D ₅₀ :	45.0
D ₈₄ :	120.0

Subpavement: Particle Shape: Embeddedness (%): Particle Range (riffle): Particle Range (pool): Bedrock, clay till Platy, sub-angular, sub-rounded 5 to 50 Sand to boulder Clay to cobble

Cumulative Particle Size Distribution



	Tractive Force at Bankfull (N/m ²):	59.72
1.14		
1.79	Critical Shear Stress (D ₅₀) (N/m ²):	32.78
126		
	1.14 1.79 126	Tractive Force at Bankfull (N/m²): 1.14 1.79 Critical Shear Stress (D ₅₀) (N/m²): 126

General Field Observations

Channel Description

The subject reach was characterized by a meandering channel set within a confined wooded valley. Dominant riparian vegetation consisted of trees and grasses, which provided limited cover over the channel. Channel bed morphology was characterized by alternating riffle-pool sequences. The channel exhibited evidence of systematic widening. For example, leaning trees, accumulation of organic debris in the channel and basal scour throughout the reach was observed. Additionally, evidence of planimetric adjustment was noted due to multiple channels, the formation of two islands, and cutoff channels were noted. The channel also displayed multiple indicators associated with "good" channel health. For example, the channel was characterized by a variable bed morphology with diverse flow conditions and habitat refuge potential. Notably, extensive beaver activity was observed, including the establishment of three beaver dams towards the upstream extent of the assessed reach, resulting in the formation of several cutoff channels and scour pools. The channel flowed over bedrock along the center of the reach while exposed till, gravel and cobbles were noted along the up and downstream extents. Valley wall contact was observed at two locations, and large armour stones and geotextile were in place for protection.



Cross Section 8 - Facing Downstream

Appendix I: Hydrographs



MORPHIX



Approximate Boundary of 1320 Grand-Chene












































































Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
1967	(PRE)	12,945	145	24	8
	(POST)	11,781	138	24	8
	Change	-8.99%	-5.29%	1.39%	0.00%
1968	(PRE)	11,968	136	23	9
	(POST)	11,108	131	24	10
	Change	-7.19%	-3.56%	2.92%	11.11%
	(PRE)	6,258	60	7	4
1969	(POST)	5,927	57	7	3
	Change	-5.29%	-5.15%	-4.76%	-25.00%
	(PRE)	11,451	112	14	7
1970	(POST)	11,213	111	14	7
	Change	-2.08%	-0.32%	4.94%	0.00%
	(PRE)	6,538	70	11	5
1971	(POST)	5,780	65	11	5
	Change	-11.59%	-7.83%	0.00%	0.00%
	(PRE)	52,781	468	41	12
1972	(POST)	49,639	450	43	13
	Change	-5.95%	-3.76%	5.28%	8.33%
1973	(PRE)	19,824	198	25	10
	(POST)	18,406	188	26	10
	Change	-7.15%	-4.80%	1.32%	0.00%
1974	(PRE)	1,644	17	3	1
	(POST)	1,458	16	2	1
	Change	-11.32%	-9.84%	-6.67%	0.00%
	(PRE)	12,405	128	18	7
1975	(POST)	11,186	118	17	7
	Change	-9.83%	-7.99%	-3.74%	0.00%
	(PRE)	2,142	36	9	3
1976	(POST)	1,854	33	9	5
	Change	-13.43%	-6.89%	-1.79%	66.67%
	(PRE)	6,392	63	8	5
1977	(POST)	5,792	59	8	5
	Change	-9.39%	-6.32%	2.13%	0.00%
	(PRE)	6,097	58	6	4
1978	(POST)	5,699	56	7	4
	Change	-6.54%	-2.55%	10.53%	0.00%
	(PRE)	42,835	387	36	10
1979	(POST)	39,014	362	37	10
	Change	-8.92%	-6.44%	3.23%	0.00%
1981	(PRE)	90,500	690	45	12

Table H.1: Annual breakdown of erosion exceedance assessment for R3.

Simulation		CEV (m³/s)	ര _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
	(POST)	83,672	687	57	14
	Change	-7.54%	-0.39%	26.47%	16.67%
1982	(PRE)	4,622	54	10	4
	(POST)	4,096	50	9	4
	Change	-11.37%	-7.71%	-1.75%	0.00%
	(PRE)	8,805	95	15	5
1983	(POST)	7,818	88	15	5
	Change	-11.21%	-6.76%	2.30%	0.00%
	(PRE)	7,496	85	14	8
1984	(POST)	6,814	81	15	8
	Change	-9.10%	-5.00%	2.35%	0.00%
	(PRE)	2,785	34	6	6
1985	(POST)	2,545	31	6	6
	Change	-8.60%	-7.26%	-5.26%	0.00%
	(PRE)	48,678	440	42	14
1986	(POST)	44,194	413	44	16
	Change	-9.21%	-6.28%	4.35%	14.29%
	(PRE)	18,010	179	23	9
1987	(POST)	16,386	168	23	9
	Change	-9.02%	-6.32%	0.74%	0.00%
1988	(PRE)	19,501	168	13	5
	(POST)	17,513	153	13	5
	Change	-10.20%	-8.75%	-2.56%	0.00%
1989	(PRE)	3,598	52	12	6
	(POST)	3,157	48	12	6
	Change	-12.24%	-6.94%	-1.39%	0.00%
	(PRE)	18,196	191	28	11
1990	(POST)	16,236	175	27	10
	Change	-10.77%	-8.33%	-3.03%	-9.09%
	(PRE)	5,115	63	12	6
1991	(POST)	4,429	58	12	6
	Change	-13.41%	-9.02%	-2.74%	0.00%
	(PRE)	22,763	195	15	4
1992	(POST)	21,863	192	17	5
	Change	-3.95%	-1.25%	11.24%	25.00%
	(PRE)	1	0	0	1
1993	(POST)	16	1	1	1
	Change	2067.95%	227.40%	200.00%	0.00%
	(PRE)	9,408	112	20	11
1994	(POST)	8,757	110	22	11
	Change	-6.92%	-1.71%	6.61%	0.00%
1995	(PRE)	28,116	223	11	1

Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
	(POST)	26,418	219	14	2
	Change	-6.04%	-1.81%	30.30%	100.00%
	(PRE)	3,758	47	9	4
1996	(POST)	3,262	44	10	4
	Change	-13.19%	-6.90%	1.79%	0.00%
	(PRE)	0	0	0	0
1997	(POST)	15	1	1	1
	Change	N/A	N/A	N/A	N/A
	(PRE)	1,516	24	6	5
1998	(POST)	1,418	23	6	5
	Change	-6.49%	-3.01%	0.00%	0.00%
	(PRE)	10,274	118	20	7
1999	(POST)	8,862	107	20	9
	Change	-13.74%	-8.97%	-0.83%	28.57%
	(PRE)	10,438	112	17	7
2000	(POST)	9,305	104	17	8
	Change	-10.85%	-7.25%	0.00%	14.29%
2002	(PRE)	40,681	343	36	10
	(POST)	38,106	341	41	9
	Change	-6.33%	-0.64%	14.49%	-10.00%
	(PRE)	14,779	171	30	9
2003	(POST)	12,780	156	30	10
	Change	-13.53%	-8.53%	0.00%	11.11%

Table H.2: Annual breakdown of erosion exceedance assessment for C10.

Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
1967	(PRE)	203,225	2,371	48	7
	(POST)	203,821	2,417	49	8
	Change	0.29%	1.95%	3.14%	14.29%
	(PRE)	242,214	2,595	49	6
1968	(POST)	242,769	2,621	50	6
	Change	0.23%	1.03%	1.71%	0.00%
	(PRE)	154,337	1,282	18	3
1969	(POST)	155,155	1,292	18	3
	Change	0.53%	0.72%	0.92%	0.00%
	(PRE)	297,915	2,415	34	5
1970	(POST)	300,174	2,455	35	5
	Change	0.76%	1.66%	2.96%	0.00%
1971	(PRE)	135,453	1,463	28	6
	(POST)	135,373	1,472	28	6
	Change	-0.06%	0.64%	1.20%	0.00%

Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
1972	(PRE)	842,902	7,279	112	11
	(POST)	849,589	7,366	114	12
	Change	0.79%	1.20%	1.64%	9.09%
	(PRE)	401,077	3,594	57	8
1973	(POST)	403,033	3,638	58	8
	Change	0.49%	1.22%	2.05%	0.00%
	(PRE)	47,959	401	6	1
1974	(POST)	47,945	411	6	1
	Change	-0.03%	2.33%	5.88%	0.00%
	(PRE)	298,134	2,622	41	7
1975	(POST)	298,558	2,663	42	7
	Change	0.14%	1.56%	3.27%	0.00%
	(PRE)	14,791	495	15	3
1976	(POST)	14,566	503	15	3
	Change	-1.52%	1.67%	2.25%	0.00%
	(PRE)	151,246	1,667	32	7
1977	(POST)	151,748	1,689	33	7
	Change	0.33%	1.32%	2.06%	0.00%
	(PRE)	139,062	1,281	22	7
1978	(POST)	139,625	1,298	22	7
	Change	0.41%	1.34%	2.33%	0.00%
1979	(PRE)	711,457	6,237	96	10
	(POST)	714,009	6,317	99	10
	Change	0.36%	1.30%	2.43%	0.00%
	(PRE)	1,488,881	9,983	118	10
1981	(POST)	1,496,436	10,054	120	10
	Change	0.51%	0.71%	1.84%	0.00%
	(PRE)	81,917	926	18	4
1982	(POST)	81,756	940	18	4
	Change	-0.20%	1.45%	2.80%	0.00%
	(PRE)	108,441	1,249	25	3
1983	(POST)	108,624	1,265	25	3
	Change	0.17%	1.23%	2.04%	0.00%
	(PRE)	88,231	1,177	26	6
1984	(POST)	88,329	1,202	26	6
	Change	0.11%	2.07%	3.27%	0.00%
	(PRE)	62,390	749	15	6
1985	(POST)	62,133	757	16	6
	Change	-0.41%	1.06%	2.20%	0.00%
	(PRE)	714,283	6,439	103	12
1986	(POST)	716,402	6,513	105	12
	Change	0.30%	1.14%	2.10%	0.00%

Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
	(PRE)	284,474	2,976	55	7
1987	(POST)	285,780	3,022	56	7
	Change	0.46%	1.52%	2.44%	0.00%
	(PRE)	353,897	2,838	39	5
1988	(POST)	354,782	2,868	40	5
	Change	0.25%	1.06%	2.13%	0.00%
	(PRE)	83,055	1,082	24	6
1989	(POST)	82,904	1,105	24	6
	Change	-0.18%	2.13%	3.55%	0.00%
	(PRE)	287,109	3,112	59	7
1990	(POST)	287,829	3,154	60	7
	Change	0.25%	1.35%	2.28%	0.00%
	(PRE)	65,587	1,309	34	5
1991	(POST)	65,758	1,324	35	5
	Change	0.26%	1.16%	1.46%	0.00%
	(PRE)	430,641	3,434	48	6
1992	(POST)	434,300	3,491	50	6
	Change	0.85%	1.67%	2.76%	0.00%
	(PRE)	0	0	0	0
1993	(POST)	0	0	0	0
	Change	N/A	N/A	N/A	N/A
1994	(PRE)	208,435	2,537	52	11
	(POST)	209,398	2,608	54	11
	Change	0.46%	2.81%	4.50%	0.00%
1995	(PRE)	478,847	3,212	33	1
	(POST)	481,704	3,236	33	1
	Change	0.60%	0.75%	1.01%	0.00%
	(PRE)	65,024	797	16	4
1996	(POST)	64,687	795	16	4
	Change	-0.52%	-0.21%	0.00%	0.00%
	(PRE)	1,773	66	2	1
1997	(POST)	1,769	66	2	1
	Change	-0.23%	-0.10%	0.00%	0.00%
	(PRE)	26,011	526	14	5
1998	(POST)	25,823	534	14	5
	Change	-0.72%	1.61%	2.41%	0.00%
	(PRE)	102,465	1,643	40	8
1999	(POST)	101,675	1,658	40	8
	Change	-0.77%	0.92%	1.69%	0.00%
	(PRE)	139,039	1,648	34	6
2000	(POST)	139,403	1,659	34	6
	Change	0.26%	0.71%	0.99%	0.00%

Simulation		CEV (m³/s)	ω _{eff} (N/m²)	t _{ex} (hrs)	# Of Exceedances
2002	(PRE)	681,511	5,731	90	9
	(POST)	686,527	5,815	92	9
	Change	0.74%	1.46%	2.04%	0.00%
2003	(PRE)	174,647	2,345	51	6
	(POST)	174,545	2,374	52	6
	Change	-0.06%	1.21%	1.95%	0.00%