Findlay Creek
Conceptual Channel Design

4795 Bank Street Subdivision
Ottawa, Ontario

Prepared for:
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Submitted:
July 24, 2026

GEO Morphix Project No. 26028

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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 Caivan Communities to undertake a fluvial geomorphological assessment of Findlay Creek and to develop a conceptual natural channel design to support the 4795 Bank Street subdivision development in the Community of Leitrim, Ontario. The study area, bound by Shuttleworth Drive to the north, Blais Road to the south, and Bank Street to the west, herein referred to as the 'subject lands', is situated within the City of Ottawa boundary. A portion of Findlay Creek flows through the subject lands in an east-to-southeast direction through the proposed subdivision development. A map of the subject lands is provided in **Appendix A**, for reference.

As part of the development, a portion of Findlay Creek, starting east of Bank Street, will be realigned within an enhanced corridor providing an opportunity to replace the historic municipal drain with a naturalized feature that improves channel form and function. A conceptual channel and corridor design has been prepared to support the proposed development. The following activities were completed to inform the natural channel design:

- Completion of a background review, including all available materials related to the development lands, including historical aerial photographs, topography, physiography and geology maps of the study area, as well as the Environmental Management Plan for the Urban Expansion Land Areas 9a and 9b, Ottawa, Ontario (Golder et al., 2016)
- Completion of field reconnaissance, including a rapid geomorphic assessment (RGA) to evaluate channel stability, a modified version of the Brierley and Fryirs (2005) River Styles Framework to describe channel forms and processes and to assess channel response and potential future behaviour, the Downs (1995) model of channel evolution to evaluate the magnitude and potential for channel instability, and the rapid stream assessment technique (RSAT) to evaluate existing instream and riparian 'health' conditions
- Completion of a scoped, detailed geomorphic assessment to inform the watercourse design, including cross-section measurements, detailed instream measurements, bankfull channel geometry, riparian conditions, bank material, bank height/angle, and bank root density
- Completion of hydraulic channel sizing and meander belt width calculations using modelled flows provided by JFSA to ensure the erosion hazard is adequately addressed in the overall corridor design
- Recommendation and details for a natural channel design, including planform, cross-sections, and necessary bioengineering details, as well as design implementation, including construction timing, and best management practices

We provide this technical report which summarizes the findings of the geomorphological assessment activities with supporting mapping. The accompanying design figures in **Appendix B** provide additional details and a visual representation of the proposed realignment works and should be reviewed in conjunction with this technical design brief.

2 Background Review

2.1 Physiography and Geology

Channel morphodynamics are largely governed by the flow regime and the availability and type of sediments (i.e., surficial geology) within the stream corridor. These factors are explored because they not only offer insight into existing conditions but also into potential future changes related to a proposed activity. Understanding local surficial geology is important for determining an appropriate erosion hazard limit, as the stability of the channel banks and valley slopes depends, at least in part, on the composition of soils and underlying parent materials (MNR, 2002).

The subject lands are located within the Ottawa physiographic region, characterized predominantly by Russel and Prescott Sand Plains (Chapman and Putnam, 1984). Published mapping provided by the OGS (MRD128) indicates that the local surficial geology along the Findlay Creek watercourse and surrounding lands within the study area largely consists of stone-poor, sandy silt to silty sand-textured till. The study area also contains an isolated corner of coarse-textured glaciomarine deposits within the upstream extent of the reach, consisting of a mix of sand, gravel, with minor silt and clay deposits. Published mapping is consistent with field observations documented in **Section 3.3** below.

2.2 Site History

A series of historical aerial photographs and LiDAR was reviewed to determine changes to the channel and surrounding land use, land cover and topography. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics and potentially how past changes may affect channel planform in the future. Aerial imagery from 1976, 1991, 2002, 2005, 2008, 2011, 2015, and 2022 was reviewed from geoOttawa to understand site history and a hillshade model was interpolated from publicly available LiDAR data (MNR, 2020) to understand the topography and channel setting. Copies of this imagery and hillshade mapping are provided in **Appendix C** and **Appendix D** for reference.

The review of historical aerial imagery for Findlay Creek (1976–2019) shows a clear shift from mostly agricultural land to more residential development. It also reveals the encroachment and narrowing of the channel corridor due to development activities. In 1976, the surrounding lands were predominantly characterized by cultivated agricultural fields. The upstream portion of Findlay Creek flows eastward from a wetland area through a dense forest before passing beneath Bank Street and traversing the southwestern corner of the study area's farmlands. The channel then proceeds southward before turning east along Blais Road. No significant modifications to the channel are evident during this period. Between 1976 and 1991, minimal changes were observed, aside from the expansion of what appears to be industrial land use south of the study area and the addition of a building upstream of the study area, immediately west of Bank Street. From 1991 to 2002, the landscape remained relatively stable, with only minor additions. No significant changes in channel alignment or morphology were observed during this period. Vegetation cover within the forested area and wetland increased, and additional riparian vegetation within the study area also expanded. Industrial use south of the study area extended along Blais Road, as well as at the structure adjacent to the forest and west of Bank Street. By 2011, significant land use changes had occurred. A large area north of the creek, between the wetland corridor and Bank Street, was developed for residential purposes. During this period, the upstream section of the channel was straightened and realigned around the wetland. While the historic alignment within the wetland remains, a berm and control structure now separate the creek from the wetland. Additionally, the forested area between Bank Street and the wetland has decreased in the southern and western parts. The channel corridor in this section is also beginning to be encroached upon by land clearing and infrastructure starting at the western extent. From 2015 to 2019, the residential development at the upstream extent continued to expand, effectively surrounding and narrowing the corridor between the wetland and Bank Street. Additionally, due to the expansion of the residential development, the forested area was completely removed, and the riparian cover was also significantly reduced in this upstream section. The watercourse remains disconnected from the wetland outside of the control structure. North of the study area, development and land clearing have also occurred, and farming appears to be limited to the field northeast of the channel due to fill remaining on-site in the southwestern field. By 2019, development from the wetland to Bank Street was largely complete, with further residential expansion beginning north of the subject lands.

For the subject lands, aerial imagery from 1976 demonstrate that the land was predominantly characterized by cultivated agricultural fields, with limited development. Findlay Creek within the study area possesses some established riparian cover; however, its extent is influenced by active agricultural practices. Between 1976 and 2002, minimal changes were observed within the study area, aside from the riparian vegetation further establishing itself along the banks of the creek. No significant changes in channel alignment or morphology were observed during this period. By 2005, while channel morphology remained the same, fill piles and infilling started to develop within the south-west lands of Findlay Creek. By 2008, a new agricultural building was established within that area. During that year, the development of the Findlay Creek Stormwater Pond was completed just east of the downstream extent of the subject lands. The original channel alignment remains unchanged; however, a stormwater management pond has been constructed adjacent to the creek, narrowing the downstream corridor, and fill piles near the channel corridor further reduce its width. As the municipal works west of Bank Street began, the stormwater pond within the subject lands was developed for sewer servicing. During this time, the culvert separating the upstream and downstream extent of Findlay Creek within the subject lands was also extended. The upstream and downstream addition of rip rap bank armouring at the extents of the culverts can be observed. Since 2008, the original channel and surrounding riparian vegetation have remained relatively unchanged. The land use within the study area remains primarily agricultural.

The review of the 2020 hillshade model aligns with the historical aerial assessment and shows evidence of corridor modifications in both the upstream and downstream direction of the study area. The upstream corridor west of Bank Street indicates a narrowed channel corridor (approximately 33-38 m) to accommodate development on both the north and south banks. The downstream section of the corridor has also been narrowed (approximately 30 m) and realigned along Blais Road to accommodate the SWM pond berm and access road. While the corridor within the study area has remained relatively unchanged, there appears to be evidence of historical municipal drain maintenance in the form of fill piles directly adjacent to the upstream section watercourse and fill / berm grading to support the creation of the SWM facility to the east of the downstream section of watercourse.

Based on review of the geomorphological study completed by Parish Aquatic Services as part of the Environmental Management Plan Report (Golder et al., 2016) we understand that Findlay Creek was officially named a Municipal Drain in 1914. In 1917 additional work was carried out on the Drain and in 1941 maintenance was also carried out on the Drain. Due to the information available in the final drain report reviewed by Parish Aquatic Services, it is unknown if maintenance was implemented after 1941. In 2004, the portion of the Findlay Creek Municipal Drain which commenced west of Albion Road until it reached Rideau Road was abandoned due to land development and is now classified as a natural watercourse. The watercourse on the subject lands is part of Findlay Creek which was abandoned as a Municipal Drain.

3 Watercourse Characteristics

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

This follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004). Reaches are first delineated as a desktop exercise using available data and information such as aerial photography, topographic maps, geology information and physiography maps. The results are then verified in the field.

Based on desktop analysis and field verification, two sub-reaches were identified on the subject lands, **Reach FC-1a** and **FC-1b**. After review of the channel survey completed by Stantec in April 2026, it was observed that there was a change in channel gradient between the upstream and downstream sections of channels around the existing culvert within the subject site. Based on this change in channel gradient we have labelled our mapping with sub-reaches to distinguish the change in gradient. **Reach FC-1a** is upstream of the existing culvert and has an overall gradient of 0.12% and **Reach FC-1b** is downstream of the existing culvert and has an overall gradient of 0.67%. As all other factors in reach delineation were consistent throughout the subject site, for the purpose of discussions related to field observations and geomorphological assessments we will discuss the section of Findlay Creek within the subject site as one reach. This approach is generally consistent with the previous geomorphological study completed by Parish Aquatic Services as part of the Environmental Management Plan Report (Golder et al., 2016), as they had labelled the entire section of Findlay Creek west of Bank Street, within the subject site, and until the watercourse stops running parallel to Blais Rd. as Reach FC-1. We have included additional sub-reaches based on land use and corridor changes west of Bank Street, and due to further detailed assessment of the watercourse on the subject lands, which is of a more in-depth scope than what was originally required for the previous geomorphological study.

3.2 Reach Observations

Field investigations were completed on April 22nd, 2026, and included the following observations:

- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of bed and bank material composition and structure
- Confirmation of valley form (i.e., unconfined, partially confined, confined)
- Observations of erosion, scour, or deposition
- Collection of photographs to document the watercourse, riparian areas, adjacent land use, and channel disturbances such as crossing structures

These observations and measurements are summarized below. Field descriptions are supplemented and supported with representative photographs included in **Appendix E**. Field sheets, including those completed for reach characterization and rapid assessments, are provided in **Appendix F**.

Within the subject site, Findlay Creek was characterized by a relatively straight watercourse that was partially confined due to the presence of modified berms adjacent to the watercourse, stemming from historical municipal drain activities and the creation of the Findlay Creek SWM Facility and associated grading. The watercourse was predominantly surrounded by agricultural land use or previous agricultural lands that are now classified as cultural meadow. The riparian border was moderate in width (between 1 and 10 channel widths) and was mostly composed of established trees and shrubs providing moderate cover to the watercourse. Erosion was present along approximately 60% of the channel banks, with bank angles ranging between 30 and 90 degrees. The channel was moderately entrenched with a low to moderate gradient. Riffle-pool sequences were observed throughout the channel but were not predominant, making up approximately 30% of the reach overall. Riffle substrate was generally coarse, ranging from sand to cobbles, and had instances of moderate levels of embeddedness. Observed pools mostly contained finer materials composed of clay, silt, sand and organics. The remainder of the channel bed substrates ranged from clay and silt to boulders. Channel bank substrate ranged from clay and silt to cobbles, with many observed instances of boulders within the banks as well. Bankfull widths measured during the preliminary field assessment ranged from 3.92 to 5.05 m, and bankfull depths ranged from 0.45 to 0.82 m.

3.3 Reconnaissance-Level Geomorphological Assessment

Reconnaissance-level assessments were carried out on the subject reaches to identify dominant geomorphic processes and channel forms, document stream health, and identify any areas of concern related to channel erosion or channel instability. The assessment method combines several complementary geomorphic assessment techniques, which are described below.

The assessments applied a modified version of the Brierley and Fryirs (2005) River Styles Framework, a set of procedures used to describe channel forms and processes and to assess channel response and potential future behaviour. These procedures are integrated into our geomorphic field assessment protocol. The Framework draws on established geomorphic models, such as Thorne (1999), Schumm (1985), and Downs (1995), to identify active fluvial processes, relative stability, dominant sediment transport mechanisms, and the energy in a system to do geomorphic work (e.g., mobilize sediment, erode bed/banks, reshape the channel). It also indicates the type and degree of sinuosity, system gradient, confinement, and the number of channels present in equilibrium conditions. Collectively, this information provides insight into the geomorphic structure, function, systematic adjustments, and the evolutionary trajectory of a river system, which, in turn, is used to inform river management applications (Brierley and Fryirs, 2005).

Our geomorphic field assessment protocol also incorporates the Downs (1995) model of channel evolution, a method used to evaluate the magnitude and potential for channel instability. This model uses physical indicators of systematic adjustment including channel, bank and bar morphology and stability to classify the type of channel evolution. By classifying channels using this model, the nature of fluvial and hillslope processes that are working to change the system can be inferred. Channels are classified as varying degrees of stable, depositional, migrating laterally, enlarging, and experiencing various types of erosion (Downs, 1995; Simon and Downs, 1995).

Information gathered as part of the River Styles Framework and the Downs model of channel evolution is reviewed in tandem with rapid geomorphic assessment techniques to fully characterize a given fluvial system. Applied techniques include the Rapid Geomorphic Assessment (RGA) and Rapid Stream Assessment Tool (RSAT), which are described below.

The Rapid Geomorphic Assessment (RGA) technique evaluates systematic adjustments characterized as degradation, aggradation, widening, and planimetric form adjustment at the reach scale (MOE, 2003; VANR, 2007). The RGA method relies on the absence or presence of these indicators to evaluate the systematic adjustments in the reach associated with natural causes or human activities. Systematic adjustments typically result in changes to the floodplain, channel or valley characteristics. The end result of the RGA is to produce a score, or stability index, which evaluates the degree to which a reach has departed from the equilibrium condition. A reach with a score of less than 0.20 is classified as 'in regime', indicating minimal changes to its shape or processes over time. A score of 0.21 to 0.40 indicates that the reach is 'in transition' or 'stress' and is experiencing a change to process and form outside the natural range of geomorphic variability. A score of greater than 0.41 indicates that the reach is in adjustment, likely exhibiting continued adjustment to the point of either returning to equilibrium or moving toward a new equilibrium (MOE, 2003; VANR, 2007).

In addition, the Rapid Stream Assessment Tool (RSAT) was applied, which evaluates stream health, based on an inclusion of biological indicators (Galli, 1996). This technique relies on a scale ranging from 'poor' to 'excellent' for observations concerning channel stability, channel scouring/sediment deposition, physical instream habitat, water quality, and riparian habitat conditions, to provide a qualitative assessment of stream health. The evaluation produces values that indicate whether the channel is in poor (score <13), fair (score 13-24), good (score 25-34), or excellent (score >34) condition (Galli, 1996).

Reconnaissance-level geomorphological assessment results are summarized in **Table 1.** Detailed Reach information is included in **Section 3.4** and **Appendix F**.

Table 1: Reconnaissance-level geomorphological assessment results

RGA (MOE, 2003)			RSAT (Galli, 1996)			Downs (1995)	Channel Classification†
Score	Condition	Dominant Systematic Adjustment*	Score	Condition	Limiting Features	Channel Evolution	
0.30	In transition	• Widening • Aggradation	24.5	Fair-Good	Channel stability	• Enlarging "E"	Class: Alluvial Load type: Mixed Planform: Straight Relative stability: Moderate-High

* RGA adjustment processes shown in order of prominence (i.e., high to low scores)
† Established applying modified Brierley and Fryirs (2005) framework

In summary, the portion of Findlay Creek within the subject lands was characterized by a single thread, straight, mixed load channel with a low to moderate gradient. Such systems are often characterized by low-moderate flow velocities and stream power with moderate-high relative stability (Schumm, 1977). According to the RGA score outlined in **Table 1**, the observed section of channel was in a potential state of transition or stress, due mainly in part to observations associated with systematic widening, as observed by fallen and leaning trees, exposed tree roots, large organic debris, and basal scour. The channel scored a 24.5 according to the RSAT, indicating the channel was in fair to good condition, with respect to corridor health. The limiting feature was channel stability, indicated by fallen trees, exposed roots, erodible bottom bank material, and a trapezoidal shaped channel. Application of the Downs' (1995) channel evolution model suggests that the channel was undergoing "enlarging". Wherein, there is generally consistent increase in channel width with erosion along both banks with observed young tree roots and tree falls.

We recognize that there are limitations to the RSAT and RGA techniques and that they only provide a snapshot in time of existing conditions. We have utilized these tools to be consistent with previous studies and supplement the additionally completed desktop and field-based assessments.

3.4 Detailed Geomorphological Assessment

A scoped detailed channel assessment was undertaken to supplement the topographic survey and reconnaissance-level assessments to provide a more complete characterization of bankfull channel geometry, flow and sediment characteristics. The assessment was completed along the portion of Findlay Creek within the subject lands and covered approximately 427 m of channel, which reflected the watercourse's natural condition within the Study Area.

Channel cross sections and a bed profile survey were completed by Stantec on April 17, 2026. The survey data collected by Stantec was used in the detailed geomorphological assessment and was reviewed alongside the scoped detailed assessment measurements and observations, completed by GEO Morphix. The bed profile was used to determine the channel gradient, which was analysed with the cross-sectional dimensions to calculate bankfull channel hydraulics. Furthermore, where applicable, a modified Wolman (1954) pebble count was performed at each transect to characterise the bed materials and to assess sediment transport sensitivity. A summary of measured and calculated values for the assessed reaches are provided in **Table 2.**

Table 2: Bankfull parameters of the reference channel

Channel parameter	FC-1a	FC-1b
Measured		
Average bankfull channel width (m)	4.51	4.97
Average bankfull channel depth (m)	0.74	0.70
Bankfull channel gradient (%)	0.11	0.67
D_{50} (mm)	<2	25.2
D_{84} (mm)	41.0	103.5
Manning's *n* — Roughness coefficient	0.035	0.035
Computed		
Bankfull discharge (m^3/s) [a]	2.64	6.43
Average bankfull velocity (m/s)	0.79	1.85
Unit-width stream power at bankfull discharge (W/m^2)	6.6	85.2
Stream power at bankfull discharge (W/m)	29.7	423.6
Shear stress at bankfull discharge (N/m^2)	8.32	46.12
Critical shear stress (N/m^2) [b]	1.46	18.33
Critical flow depth (m) Provisional	0.13	0.28
Flow competency for D_{50} (m/s) [c]	0.27	0.87
Flow competency for D_{84} (m/s) [c]	1.09	1.67

[a] Based on Manning's equation

[b] Based on Shields diagram from Miller et al. (1997)

[c] Based on Komar (1987)

The susceptibility (erodibility) of a bed or bank is governed by its composition and other variables such as steepness and type and density of vegetation or roots. Comparing the bed substrates critical shear and flow competencies with computed bankfull conditions, the in-channel materials (D_{50} and D_{84}) are susceptible to entrainment at bankfull capacity. Channel bank material generally consisted of a vegetated loam and/or cohesive clay till. For reference, the critical shear of a sandy loam is estimated by others to be around 1.68 N/m2 (Fischenich, 2001). Channel banks are therefore also vulnerable to erosion, as evidenced by the persistence of leaning trees and exposed tree roots throughout the channel. The detailed assessment findings support that the observed patterns of systematic channel widening are likely to persist.

4 Findlay Creek Natural Channel Design

4.1 Design Objectives

The proposed realignment of the portion of Findlay Creek within the subject lands provides an opportunity to replace the existing morphologically limited feature with a dynamically stable design. This realignment will allow the existing channel, previously impacted by urban development, to be restored to a system that will offer significant improvements to form and function per unit length. Findlay Creek will be restored to a single-thread channel with riffle-pool typology, with cross-sectional dimensions closer to a naturalized feature conveying similar flows.

The channel realignment and naturalization provide an opportunity for improved riparian conditions and a well-developed bankfull channel with morphological variability. Improvement in morphology and function will provide additional benefits to sediment balance, floodplain storage, vegetation communities and terrestrial habitat features, edge impacts, water balance, fish passage and water quality. From a habitat perspective, the watercourse contributes to seasonal habitat, organic inputs, and a more complex corridor system by providing elements with a wide range of hydroperiods and aquatic and terrestrial habitat elements. Online and offline wetlands constructed throughout the corridor will enhance terrestrial habitat by increasing diversity and providing a more natural floodplain form. They also provide functional benefits by storing and discharging water over longer attenuated periods. Additional terrestrial features are proposed within the corridor to increase habitat and promote wildlife diversity, including basking logs, rock piles, and raptor poles.

The primary objectives of the design are to:

- Reinstate a more natural physical form, including planform and instream characteristics
- Improve the channel function and promote interaction with its floodplain
- Improve water quality by extending detention of water through online and offline wetland features
- Improve water quality and temperature downstream
- Enhance aquatic habitat through the provision of a morphologically diverse channel with spatially varied flows
- Improve riparian habitat by installing woody plantings and dynamic floodplain features
- Mitigate potential hazards to the development as well as lands surrounding the development

The accompanying conceptual design figures in **Appendix B** provide additional details and a visual representation of the conceptual corridor and channel planform. A full set of detailed design drawings that provide additional details and direction for implementing the proposed channel restoration design will be provided at the detailed design phase.

4.2 Bankfull Channel

A riffle-pool system is proposed for the realigned channel, which will provide significant improvements to not only the channel, as it essentially replicates a natural system, but also to aquatic and semi-aquatic habitats. When it is assessed to be an appropriate channel type, a riffle-pool system offers numerous benefits, such as:

- Channel bed relief for flow variability
- Improve feature function and interaction with the floodplain
- Relatively quiescent flows in pool sections to provide refuge for fish during high flows
- In-channel energy dissipation
- Improve riparian habitat by installing woody plantings and floodplain features

Channel design dimensions are determined by bankfull discharge, as this represents what is generally referred to as the "channel-forming discharge" or the "dominant discharge". Several methods can be applied to select an appropriate bankfull discharge. Back calculation of discharge from a reference reach and support from hydrological modelling is usually the most appropriate. Given the significant historical channel modifications due to agricultural activities and anticipated hydrology changes likely to occur due to the proposed development, discharges based on hydrologic modelling were determined for the channel realignment. This discharge was then used to define channel bankfull geometries. The bankfull discharge used to size the channel was assumed to be equivalent to the modelled 1.25-year post-development flow return period. The 1.25-year flow was estimated at approximately two-thirds of the 2-year flow of 1.61 m^3/s for Reach FC-1, as provided by JFSA (2026). As such, the average bankfull discharge was defined as 1.07 m^3/s for both **Reach FC-1a** and **FC-1b**. Bankfull capacity for channels generally ranges from the 1- to 2-year return events.

Riffle and pool geometries, as well as anticipated bankfull conditions for both Upstream and Downstream design Reaches, are provided in **Table 3**. A simple Manning's approach was used to iteratively back-calculate bankfull dimensions for the proposed channel. Since the pool sections are designed to contain ineffective space, this model over-predicts the amount of discharge that they convey. However, the modelled values for the riffle sections give a better prediction of the channel capacity. The bankfull width and average depth of riffle and pool sections in the realigned **Reach FC-1a** range from 4.25 m to 4.70 m and 0.45 m to 0.60 m. In the realigned **Reach FC-1b**, the bankfull width and average bankfull depth of riffle and pool sections range from 3.15 m to 3.50 m and 0.30 m to 0.45 m. Design **Reach FC-1a** has a bankfull gradient of 0.11%, while the design **Reach FC-1b** has a bankfull gradient of 0.67%.

Table 3: Bankfull parameters for the designed channel

Channel parameter	Reach FC-1a		Reach FC-1b	
	Riffle††	Pool†	Riffle††	Pool†
Bankfull width (m)	4.25	4.70	3.15	3.50
Average bankfull depth (m)	0.34	0.41	0.24	0.31
Maximum bankfull depth (m)	0.45	0.60	0.30	0.45
Bankfull width-to-depth ratio	9.44	7.83	10.50	7.78
Channel gradient (%)	0.44	0.11	2.56	0.67
Bankfull gradient (%)	0.11		0.67	
Radius of curvature (m)‡	11		8	
Riffle-pool spacing (m)‡‡	46		24	
Manning's roughness coefficient, *n*	0.04	0.03	0.04	0.03
Mean bankfull velocity (m/s) *	0.74	0.54	1.40	1.09
Bankfull discharge (m^3/s) *	1.08	1.04	1.06	1.18
Discharge to accommodate (m^3/s)	1.07		1.07	
Tractive force at bankfull (N/m^2)	19	6	75	28
Stream power (W/m)	46	11	265	74
Unit stream power (W/m^2)	12	3	96	29
Froude Number (unitless)	0.40	0.27	0.92	0.63
Maximum grain size entrained (m) **	0.02	0.01	0.08	0.03
Mean grain size entrained **	0.02	0.00	0.06	0.02

† Based on bankfull gradient
†† Based on riffle gradient
‡ Based on Williams (1986)
‡‡ Based on Hey and Thorne (1986)
* Based on Manning's equation; as pools contain ineffective space, the velocity and discharge conveyed in them are not representative
** Based on Shields equation (Miller et al. (1977), assuming Shields parameter equals 0.06 (gravel)

After preliminary geometries were determined, the radius of curvature and riffle-pool spacing were calculated using relations from Williams (1986) and Hey and Thorne (1986). As discussed above once the planform parameters and bankfull geometries were determined the channel centreline was designed and geometries were finalized based on the final gradient.

4.3 Channel Planform

The initial channel planform layouts were created using the modelled radius of curvature value (*Rc*) as a guide. The radius of curvature (*Rc*) of meanders can be used to evaluate channel stability. For example, stable meanders typically exhibit larger *Rc* values as opposed to lower values that indicate increased channel bank erosion and avulsion. Bankfull width is often an appropriate indicator for this instability. Hickin and Nanson (1983) note that channel avulsions are common when meander *Rc* is approximately 1-2 times the channel bankfull width. For larger *Rc* (e.g., >5), the upstream limb of the meander will migrate more rapidly than the downstream limb (Hooke, 1975). Based on the above bankfull widths the radius of curvatures and feature spacing were determined.

Williams (1986) was used to derive values for the channel radius of curvature, using the following equation (Eq. 1):

$$Rc = 2.43 \times w$$ **Eq. 1**

where Rc is the radius of curvature and w is the average bankfull width.

Empirical models derived by Hey and Thorne (1986) were followed to determine riffle spacing. Hey and Thorne's (1986) modelled values are often applied in larger watercourses. As such, multiple methods (Eq. 2 – 4) were considered in order to provide a range of riffle spacing values. These are:

$$Z = 6.31 \times w$$ **Eq. 2**

$$Z = 9.1186 \times w^{0.8846}$$ **Eq. 3**

$$Z = 7.36 \times w^{0.896} \times S^{-0.03}$$ **Eq. 4**

where Z represents riffle spacing.

Stream power and unit stream power were calculated as a function of bankfull discharge and channel gradient (Eq. 5-6). Stream power values are important to determine the need for mitigating channel bank and bed erosion. Stream power is given by:

$$\Omega = \rho \times g \times d \times S$$ **Eq. 5**

where ρ is the density of water (kg/m^3), g is the acceleration due to gravity (m/s^2), and Q and S are discharge (m^3/s) and channel gradient, respectively.

Stream power per unit width (Eq. 6), is given by:

$$\omega = \frac{\Omega}{w}$$ **Eq. 6**

whereas before, Ω and ω are stream power and bankfull width, respectively.

In the development of a natural channel design, the length of the watercourse proposed to be realigned is typically replicated or exceeded to provide an overall gain in habitat. The combined existing length of both reaches proposed for realignment is approximately 415 m. This overall length includes the existing culvert between both reaches. The proposed realignment will have an overall length of 451 m. The realigned channel will be located within a 53 m wide naturalized channel corridor containing meadow habitat and other riparian and terrestrial features that will diversify habitat within the corridor.

The final channel planform was established through an iterative process. First, a cross-section with defined bankfull geometry was developed to calculate parameters for the planform (i.e., radius of curvature, riffle-pool spacing). The cross-section was then further refined, based on the final channel gradient. Hydraulic sizing for the proposed channel substrates will be completed at the detailed design phase.

4.4 Corridor Sizing

The meander belt width delineation supports overall corridor sizing requirements, particularly regarding an appropriate bottom width for a valley corridor. As part of the design, a modelling approach was used to review a range of potential meander belt widths for the proposed reaches. Meander belt widths were calculated using several empirical models for comparison purposes. The calculated bankfull channel dimensions were used to inform both the Williams (1986) and Ward et al. (2002) models outlined below.

JFSA (2026) provided the 2-year discharge, from which the 1.25-year discharge was derived, along with topographic information, which was used to determine the reach gradient for **Reaches FC-1a** and **FC-1b**. The proposed average bankfull channel width and cross-sectional area are 4.48 m and 1.68 m^2 in

Reach FC-1a, and 3.33 m and 0.91 m^2 in **Reach FC-1b**. **Table 4** provides a summary of parameters used in the Williams (1986) and Ward et al (2002) models.

Table 4: Parameters used in the meander belt width models

Channel parameter	Reach FC-1a	Reach FC-1b
Channel gradient (%)	0.11	0.64
1.25-yr flow discharge (m^3/s)	1.07	1.07
Average channel width (m)	4.48	3.33
Average channel depth (m)	0.38	0.28
Cross-sectional area (m^2)	1.68	0.91

The empirical relations from Williams (1986) were modified to include channel width, and applied using the bankfull channel dimensions such that:

$$B_w = (4.3{W_b}^{1.12} + W_b) \times 1.2 \qquad \textbf{Eq. 7}$$

$$B_w = (18A^{0.65} + W_b) \times 1.2 \qquad \textbf{Eq. 8}$$

where *Bw* is meander belt width (m), *A* is bankfull cross-sectional area (m^2), and W_b is bankfull channel width (m). An additional 20% buffer (factor of safety) was applied to the computed belt width values. This addresses issues of underprediction.

The Ward et al. (2002) bankfull width model was also used to determine a meander belt width (ft). The Ward et al. (2002) bankfull width model is derived from the Williams width relationship and corrects its tendency to underpredict channel width while incorporating a factor of safety into the resulting estimate, *Bw*:

$$B_w = \left(6W_b^{1.12}\right) \qquad \textbf{Eq. 9}$$

where again W_b is the average bankfull channel width (ft). The resulting value was then converted to the metric system (m). The resulting meander belt width estimates are provided in **Table 5.**

Table 5: Meander belt width estimates for the realigned channel

Reach	Meander Belt Width (m)			Recommended Meander Belt Width (m)	Provided Valley Bottom Width (m)
	Williams -Area (1986)*	Williams – Width (1986)*	Ward - Width (2002)**		
Reach FC-1a	35.61	33.01	37.06	36	24
Reach FC-1b	24.37	23.81	26.57	24	16.42 – 29.13

* Note: Addition of one bankfull width plus 20% factor of safety to belt width, Bw
**Note: Values used in modelling were in imperial units. Final MBW values have been converted to SI units

Regarding the delineation of hazards associated with channel migration, the Ontario Ministry of Natural Resources distinguishes between confined and unconfined systems. Unconfined systems feature poorly defined valleys or slopes that extend well beyond the area where the channel could realistically migrate. In these systems, the hazard is assumed to stem from channel migration, which involves identifying a meander belt width. Although the proposed meander belt width exceeds the corridor floor slightly, it still qualifies as an unconfined channel due to the low gradient and the corridor sidewalls being less than 1.5 m high. Therefore, even if the channel were to migrate towards the corridor toe, it would not pose additional risk to people or property. Furthermore, the meander belt width methodology and its application are consistent with the delineation of erosion hazards in Ontario.

The existing corridor, both upstream and downstream of the proposed realignment, has been altered and narrowed from its historical condition. The width of these modified sections has been documented through desktop and field observations, with the downstream section measuring approximately 30 m between Blais Road and the SWM facility, and the upstream section varying from 33 m to 38 m between adjacent backyard fences and the edge of residential streets. The total width of the proposed realigned corridor and its associated MBW fall within the range of the existing channel corridor, both upstream and downstream of the proposed corridor.

It should be noted that the meander belt widths are theoretical and given the limited energy and vegetation control in the proposed system, the channel is unlikely to migrate or adjust its planform within the bounds calculated. All meander belt width calculations are based on channels where instream energy is greater than the potential resistance of bank materials. As such, they overpredict the potential extent of meandering and erosion hazard. It is our opinion that these corridor arrangements address the theoretical meander belt widths and more than adequately address any potential erosion hazard.

It is important to note that the meander belt width assessment does not account for proposed stabilization measures, including bioengineering and strategic planting. These enhancements are intended to improve floodplain connectivity, reduce erosion potential, and reinforce the naturalized channel, ultimately limiting long-term lateral migration.

We recognize that the theoretical meander belt widths for the proposed channel conditions are slightly greater than the provided corridor bottom widths, in most cases, but highlight that the proposed corridor has slopes less than 1.5 m in height and have proposed shallow (10:1) side slopes for **Reach FC-1a** and moderate (5:1 to 3:1) side slopes for **Reach FC-1b**. As such, even if there were to be channel erosion it does not create additional risk to the corridor due to the low overall corridor height and shallow side slopes. Note that bioengineering of the channel banks is also proposed to limit the potential for erosion to occur.

We also note that the proposed channel realignment within Reach FC-1b will shift the channel to the west from its existing condition. As such, the proposed condition realignment will improve the erosion hazard, from its existing condition, on the City lands to the east, including the adjacent SWM Facility.

4.5 Corridor Wet Meadows

The realignment and restoration of both **Reaches FC-1a** and **FC-1b** will allow for the creation of offline and online wet meadows within the corridor valley bottom. These wet meadows will enhance ecological functions within the constructed corridor. The proposed wet meadows will enhance terrestrial habitat by increasing diversity and creating a more natural floodplain form. Wetlands also provide functional benefits such as short-term water retention, infiltration, evapotranspiration, and sediment banking. They are irregularly shaped to maximize the perimeter for a given area, which increases the potential for edge effects and increases habitat diversity. Submerged and dry mounds are proposed within the wetlands to increase habitat heterogeneity by providing a topographically complex bottom. The proposed corridor design includes approximately 0.13 ha (1345 m2) of offline and online wetlands within the corridor. The proposed wet meadows have an average depth of 0.7 m with deeper areas of up to 1.0 m provided for overwintering habitat.

The proposed wet meadows should be constructed as over-excavated depressions, which will be lined with a mix of soil and granular materials to provide both depressional and subsurface storage (within the interstitial space of the sediment and soil). The granular mix proposed within these features can provide future sediment sources into the channel if it migrates laterally. The granular mix will have substrate sizes similar to those proposed within the riffle channel features.

An aggressive landscape restoration plan is proposed around the corridor wet meadows to provide shading over the features. Live staking around the periphery will provide thermal mitigation through shade and will also provide a source of coarse organic matter. The incorporation of a native seed mix within the wet meadows will promote polishing of flows once the vegetation has established.

4.6 Habitat Features

Several habitat elements are incorporated into the conceptual design within the naturalized drainage corridor to improve riparian habitat and promote wildlife biodiversity. The habitat elements include basking logs, brush mattress, brush piles, overwintering pools, and rock piles. The proposed elements provide a variety of topographies and woody debris that maximize the potential for wildlife passage, forage, and residency. Further details and directions for implementation of the features described below will be shown on the design drawings prepared at the detailed design phase.

Basking logs consist of a mixture of hardwood and softwood species, placed in shallow areas of wet meadows and anchored with a mix of stone or limestone blocks. These logs are angled in a way that promotes turtle basking.

Brush piles consist of logs, snags and other wood debris placed in a way that forms a stable interconnected mound shaped like a pallet. The brush piles are also planted with native fruit-bearing vines, which provide foraging opportunities for wildlife. Brush piles are placed at various locations along the length of the floodplain.

Potential overwintering pools are proposed to provide critical habitat for resident fish. The overwintering pools are located within the tortuous meander pattern, which will increase scour and pool depth. The bankfull widths for the overwintering pools within **Reaches FC-1a** and **FC-1b** are 4.7 m and 3.5 m, with a maximum depth of 0.9m. This habitat feature will provide fish with potential refuge from freezing conditions in the winter and an ideal habitat during low flow periods and increase habitat heterogeneity within the channel.

Brush mattress is proposed along the outside meander bend of the tortuous meanders. This treatment consists of live brush cuttings installed parallel to the banks and tied with coir twine and stakes. The brush mattress will provide bank stability and improve aquatic habitat through shading and foraging opportunities.

Rock piles consist of stones of varying sizes piled up to create small mounds. These features provide hibernation habitat and cover from predators for various terrestrial species. The base of the piles is partially buried to prevent rock falls. Rock piles are installed at multiple locations along the corridor length within the buffer.

5 Natural Erosion Control

Newly constructed features can be vulnerable to erosion. This is particularly true before vegetation has been established along the channel banks. While low-flow events should not intensify erosion, the concern for erosion occurs when high flows or precipitation events occur during construction.

Immediately after construction, the outer banks of the meander bends (i.e., cutbanks) may experience relatively higher erosive flows, leading to meander bend migration. As such, all cutbanks are bioengineered for additional stability. A 100% biodegradable erosion control blanket, and live stakes are installed along the banks in the riffle and pool sections for immediate erosion protection. Over time, the blanket will biodegrade, while the live stakes establish in the immediate overbank areas to provide long-term soil stability.

For long-term stability, implementing planting plans within the corridor is recommended. This includes deep-rooting native grasses and other herbaceous species seeded along and within channel sections, prescription of flood-tolerant native shrub and tree species, and use of seed banks within the local soil. Shrubs should be planted close to the channel margins to maximize stabilization and channel cover benefit.

Potential erosion locations (i.e., along the outside meander bends, immediately downstream of wet meadow features, etc.) should be anticipated and reflected in the planting plans. Live staking and shrub stock should be used adjacent to the channel bank to provide immediate benefit and long-term infilling. If appropriate live staking methods are followed, this method should provide more significant benefits than simple potted or bare root shrub planting as there is potential for higher densities with live staking.

6 Design Implementation

6.1 Construction Timing

Based on resident fish species and their respective life cycles, in-stream work will be regulated by the fisheries warmwater timing window (July 15th to March 15th), unless otherwise directed by the Ministry of Natural Resources (MNR).

Vegetation removals associated with clearing, site access and staging should occur outside the key nesting season of migratory birds, as well as the active season of turtles and bats identified by The Ministry of the Environment, Conservation and Parks (MECP). The MECP (2023) defines the migratory bird nesting season as March 31st to August 31st each year. The active season for turtles is defined as April 1st to October 31st each year. The active period for endangered bats is defined as April 1st to September 30th each year. In combination, these requirements dictate that any vegetation clearing should be undertaken between November 1st and March 30th each year to avoid the active seasons of species at risk and nesting migratory birds. Should vegetation removals be required during these critical nesting and active seasons, a qualified biologist should inspect potential habitats to ensure they do not contain any species of concern. Note vegetation removals are not limited to cutting woody vegetation, but also applies to topsoil stripping and grubbing activities, due to ground-nesting bird species.

6.2 Best Management Practices

Instream construction should be carried out only during low-flow or dry conditions. Site inspection should be performed by an inspector with experience overseeing channel works, as this type of work differs considerably from engineering projects. An experienced inspector will be able to provide quick and appropriate response to issues that may arise and ensure that construction proceeds in accordance with the approved design and contract. Erosion and sediment control monitoring should be performed by a CAN-CISEC certified monitor.

The limits of construction will be delineated to prevent unanticipated impacts to natural surroundings, including trees and the watercourse. Flows shall be conveyed around the work area uninterrupted either through a temporary diversion channel or with a cofferdam and pump system, such that the channel can be constructed fully isolated from the active flow area.

All isolated work areas will be unwatered to perform work under dry conditions. If required, water from the work area will be pumped to a sediment filtration system located at least 30 m from the receiving creek and be allowed to naturally flow over a well-vegetation surface and ultimately return to the channel downstream of the work area. This will allow particles to settle before reaching the watercourse. The weather forecast will be monitored prior to construction to ensure favourable working days.

All materials and equipment will be stored and operated in such a manner that prevents any deleterious substances from entering the water. Vehicle and equipment refuelling and/or maintenance will be conducted away from the watercourse and be free of fluid leaks and externally cleaned/degreased to prevent the release of deleterious substances. Machinery should arrive on site in a clean condition (including free of mud/soil/dirt from other locations; including clean wheels/tires/tracks) and should be maintained free of fluid leaks. To reduce the spread of invasive species, equipment should be cleaned before being brought onsite and before leaving site. For guidance in this regard, please refer to the Clean Equipment Protocol for Industry available online: (https://www.ontarioinvasiveplants.ca/wp-content/uploads/2016/07/Clean-Equipment-Protocol_June2016_D3_WEB-1.pdf).

7 Post-construction Monitoring

A post-construction monitoring program is recommended to assess the performance of the implemented design. Monitoring observations can also be used to determine the need for remedial works. The following activities should be undertaken by a fluvial geomorphologist and completed on a seasonal basis (i.e., spring and fall), unless otherwise indicated, for a period of three years following the year of construction as most potential channel adjustments would occur in the first one to two years. The following tasks would be completed as part of the post-construction monitoring program:

- Collection of general observations of the channel works after construction and after the first large flooding event to identify any potential areas of erosion concern
- Completion of bi-annual visual inspections along the restored corridor to observe and document any areas of concern
- Collection of a monumented photographic record of site conditions during each visit
- Completion of a total station survey of the longitudinal profile and monumented cross sections following construction to serve as the as-built reference condition for use in comparing surveys completed in subsequent monitoring years
- Re-survey of the longitudinal profiles and monumented cross sections on an annual basis following construction
- Installation of erosion pins at monumented cross sections to be remeasured annually
- Characterization of bed material using a modified Wolman (1954) pebble count or bed sample, as appropriate, annually
- Completion of annual general vegetation surveys
- Preparation of year-end reporting summarizing construction activities (i.e., design implementation), and subsequent year-end reports for the duration of the monitoring period

Monitoring would commence immediately after construction, and sites would be reviewed annually to identify the system's natural variability. The monitoring period may be extended if concerns are identified during the 3-year monitoring period.

8 Summary

GEO Morphix Ltd. was retained to complete a fluvial geomorphology assessment and conceptual natural corridor design for a portion of Findlay Creek in support of a proposed development in the Community of Leitrim. The review of available background materials and field reconnaissance indicates that Findlay Creek has experienced historical corridor modifications and lacks connection to the floodplain.

Field reconnaissance included rapid and scoped detailed geomorphological assessments, along with a modified version of the Brierley and Fryirs (2005) River Styles Framework and the Downs (1995) model of channel evolution, to describe current conditions, guide erosion hazard delineation, and support the development of conceptual natural corridor design drawings. The existing state of Findlay Creek within the study area shows a single-thread, straight, mixed-load channel with a low to moderate gradient. The channel was considered to be in a potential state of transition, due mainly in part to observations associated with systematic widening. With respect to corridor health, the channel was in fair to good condition, with channel stability being the limiting feature.

The conceptual natural corridor designs for the portion of Findlay Creek within the subject lands support realigning and naturalizing these features. The design approach provides opportunities for significantly improved riparian and aquatic habitat conditions with increased floodplain storage and connectivity. The design also includes a well-developed bankfull channel with morphological variability. Improvement in morphology and function will provide additional benefits associated with sediment balance, floodplain storage, vegetation communities, terrestrial habitat features and water quality. The conceptual channel design was completed through an iterative process to ensure stability using previously developed relations of bankfull geometries, feature spacing and meander potential (i.e., meander belt width). Overall, the proposed design result in an increase in channel length, improvements to the conveyance of flow and sediment, increases in morphological and substrate variability and a more natural floodplain form when compared to existing conditions.

We trust this report meets your current requirements. Should you have any questions, please contact us.

Respectfully submitted,

Paul Villard Ph.D., P.Geo., CAN-CISEC, EP, CERP
Director, Principal Geomorphologist

Ben Miller, B. Sc., CAN-CISEC
Senior River Scientist, Practice Lead

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Appendix A:
Study Area

GEO MORPHIX®

Study Area

Findlay Creek

Ottawa, Ontario

Legend

Reach Break and ID

Watercourse

Study Area

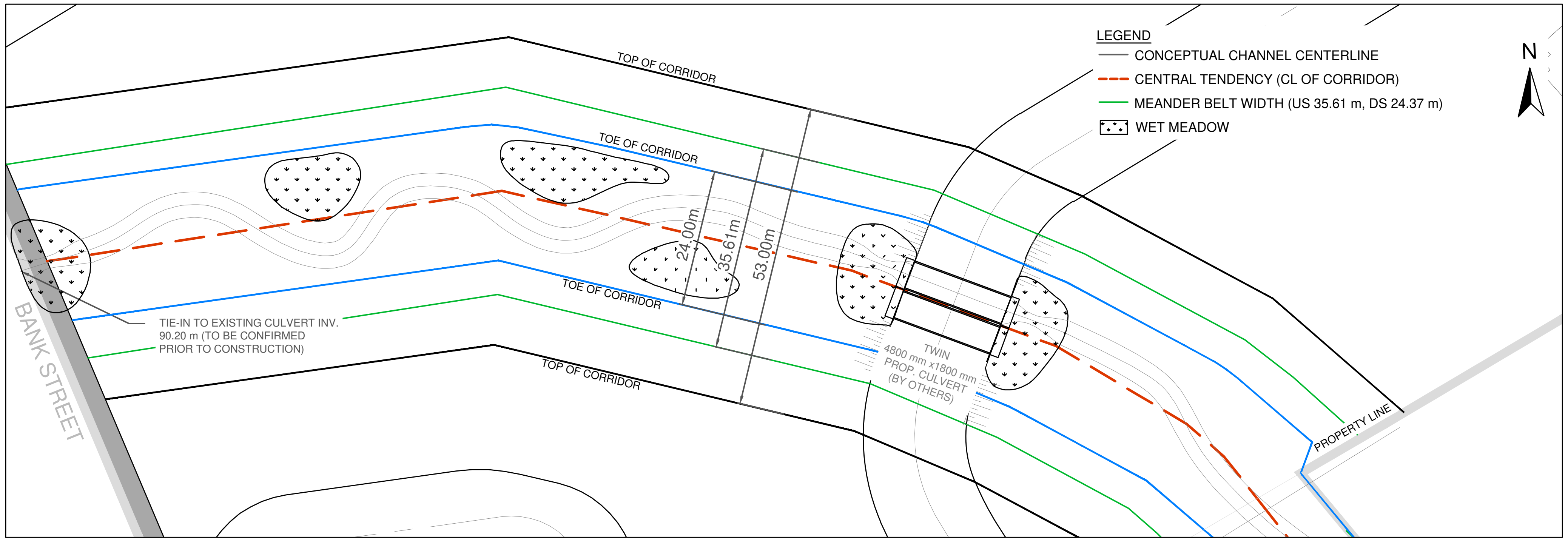
N

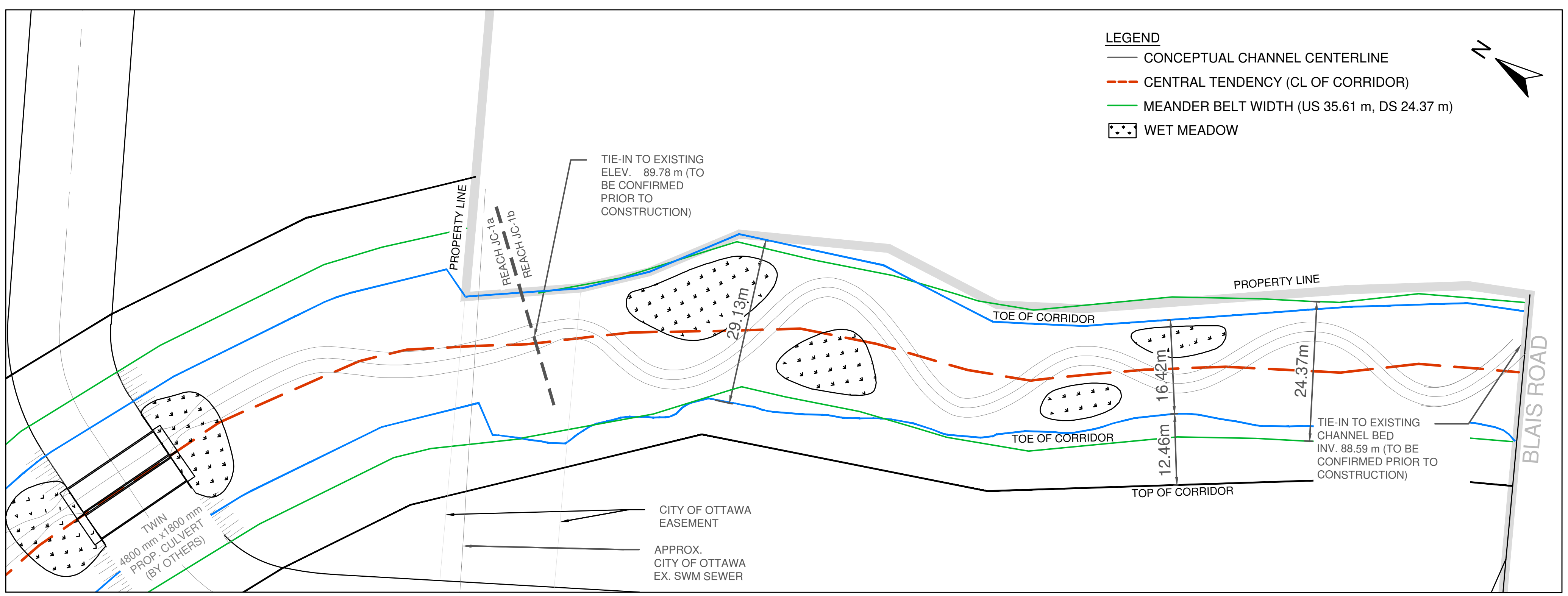
0 50 100

Meters

Imagery: MNR 2023. Watercourse: MNR, 2024.
Study Area: Caivan, 2026.
Print Date: June 2026. PN26021. Drawn By: M.O., B.Mi.

Appendix B:
Conceptual Design Figures

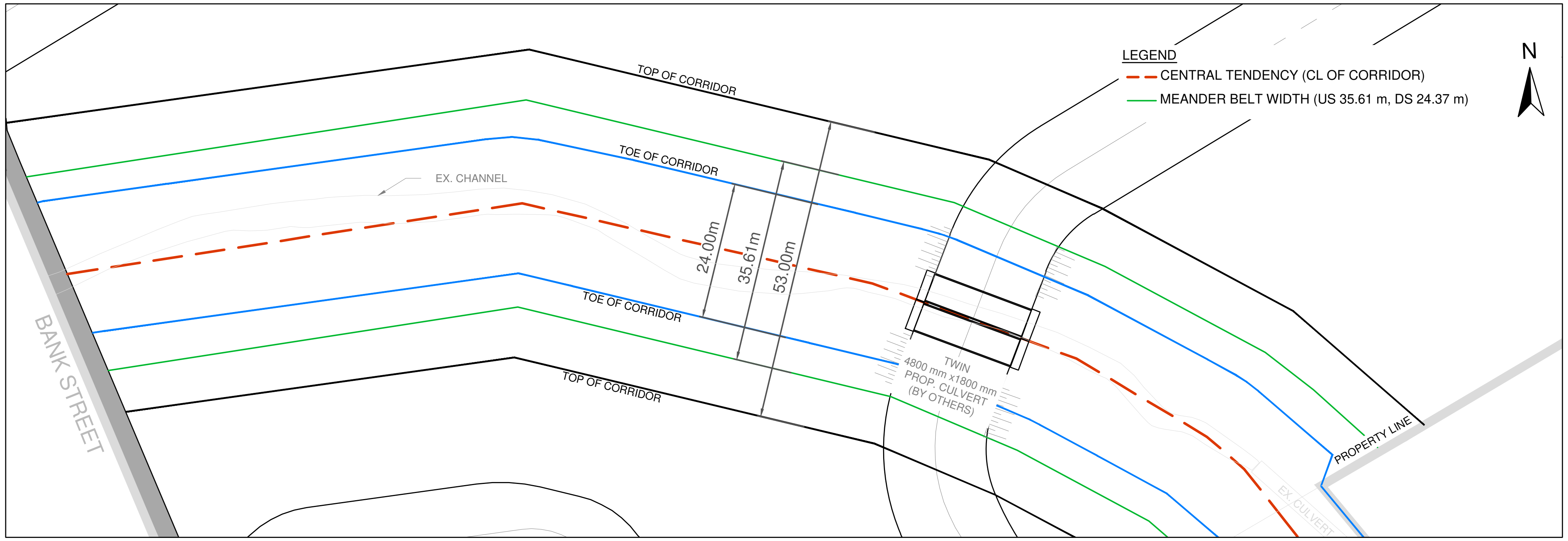


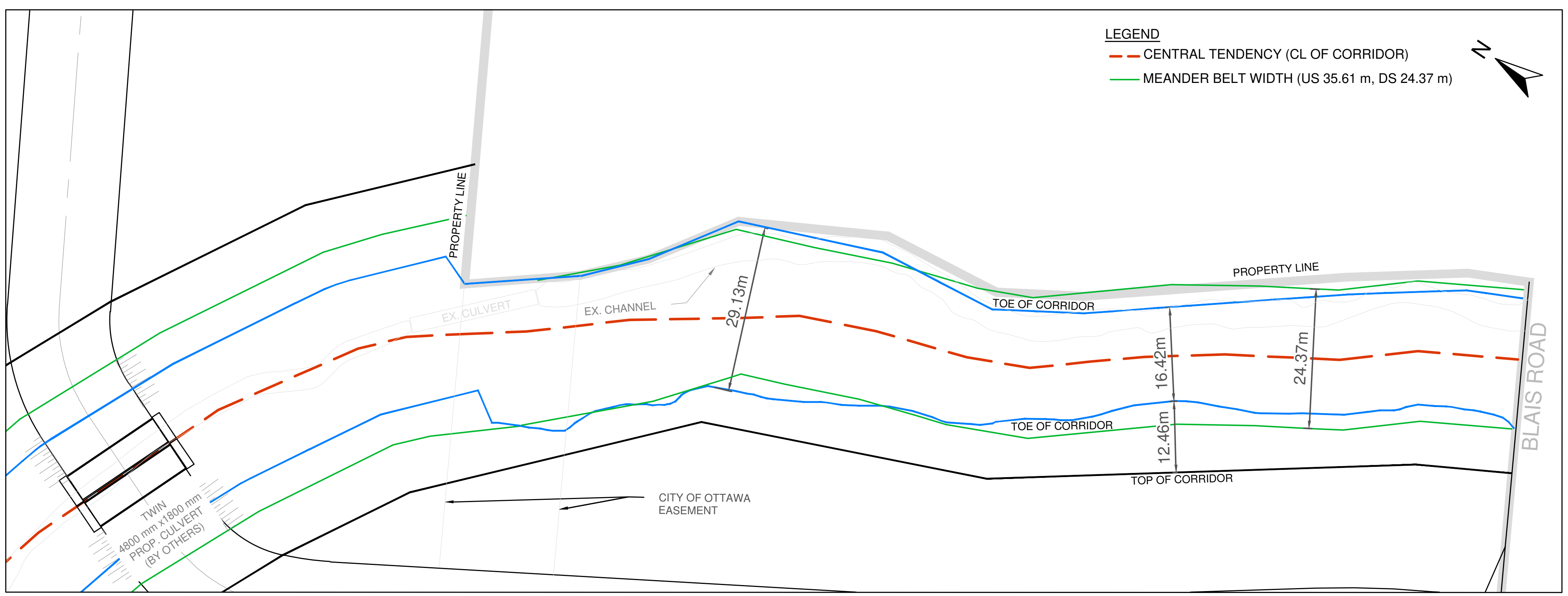


PLANFORM
NTS

SCALED FOR PLOT ON 'TABLOID'

DESIGNED BY: BMI	CHECKED BY: P.V.
DRAWN BY: QW	DATE: JULY 2026
NOT FOR CONSTRUCTION	GEO MORPHIX® 36 Main Street North, PO Box 205 Campbellville, Ontario L0P 1B0 T: 416.920.0926 www.geomorphix.com
4795 BANK STREET SUBDIVISION OTTAWA CAIVAN	
FINDLAY CREEK CONCEPTUAL CHANNEL DESIGN CONCEPTUAL CORRIDOR	
PROJECT No.: 26028	DRAWING No.: MBW-1
SCALE: AS NOTED	SHEET 1 OF 2



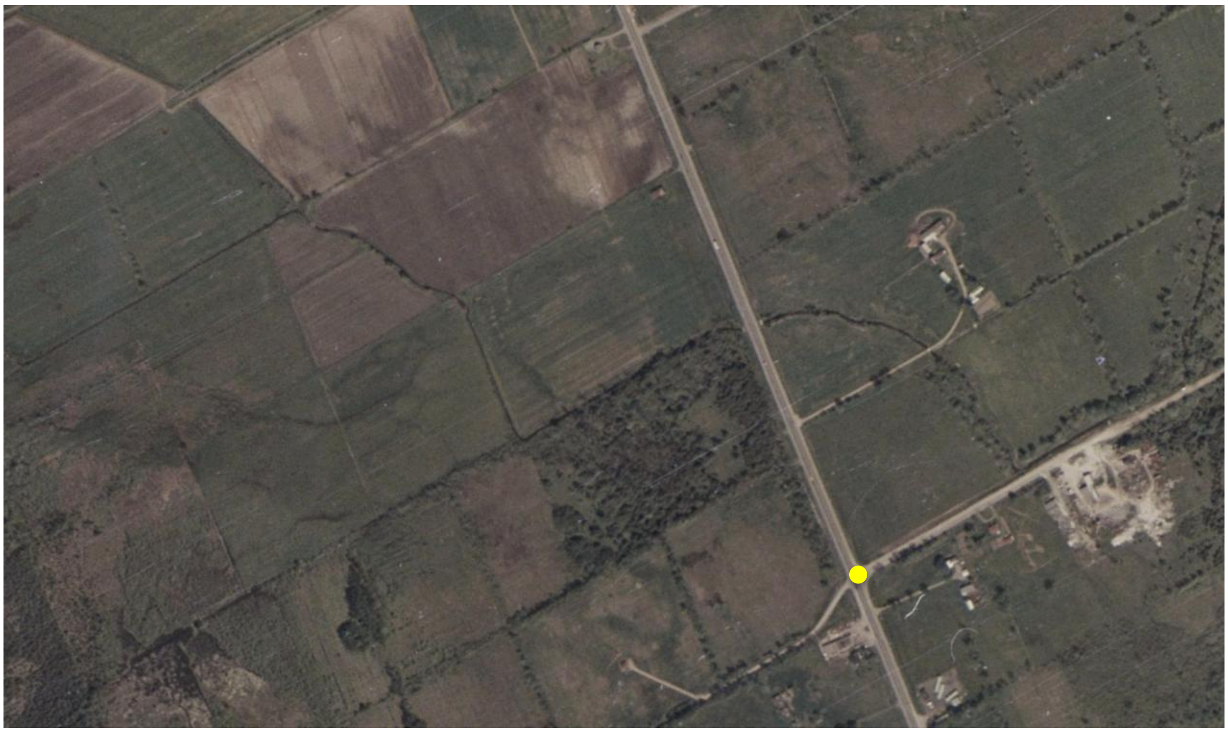


PLANFORM
NTS

SCALED FOR PLOT ON 'TABLOID'

DESIGNED BY: BMI	CHECKED BY: P.V.
DRAWN BY: QW	DATE: JULY 2026
NOT FOR CONSTRUCTION	GEO MORPHIX® 36 Main Street North, PO Box 205 Campbellville, Ontario L0P 1B0 T: 416.920.0926 www.geomorphix.com
4795 BANK STREET SUBDIVISION OTTAWA CAIVAN	
FINDLAY CREEK EXISTING CHANNEL CONCEPTUAL CORRIDOR	
PROJECT No.: 26028	DRAWING No.: MBW-2
SCALE: AS NOTED	SHEET 2 OF 2

Appendix C:
Historical Aerial Imagery



Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 1976
Scale: Digital Orthoimagery
Source: geoOttawa

Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 1991
Scale: Digital Orthoimagery
Source: geoOttawa

Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 2002
Scale: Digital Orthoimagery
Source: geoOttawa

Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 2005
Scale: Digital Orthoimagery
Source: geoOttawa

Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 2008
Scale: Digital Orthoimagery
Source: geoOttawa

Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 2011
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Source: geoOttawa

Location: Ottawa, ON
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Year: 2015
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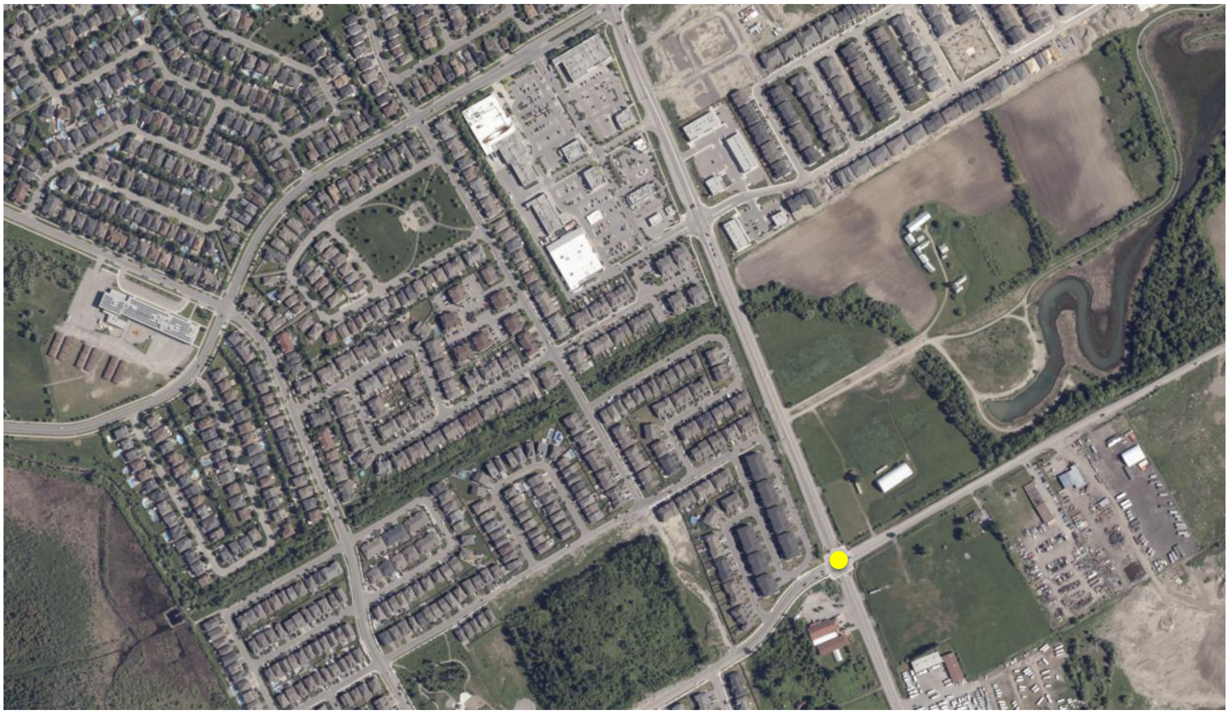
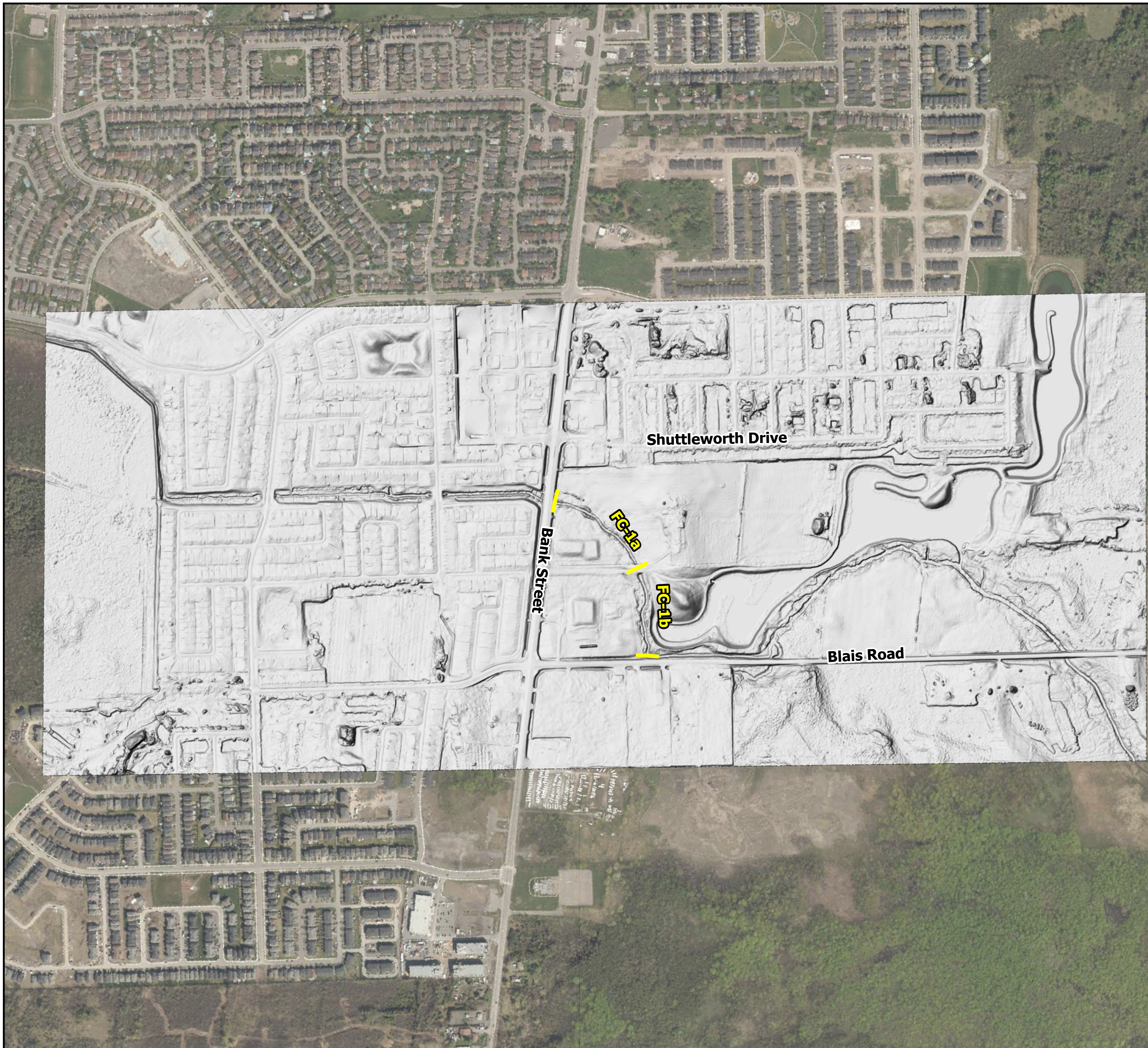
Source: geoOttawa



Location: Ottawa, ON
Yellow point: Bank Street and Blais Road
Year: 2022
Scale: Digital Orthoimagery
Source: geoOttawa

Appendix D:
Hillshade Map



GEO MORPHIX®

Hillshade

Findlay Creek

Ottawa, Ontario

Legend

Reach Break and ID

N

0 170 340

Meters

Hillshade:MNR, 2020.
Print Date: June 2026. PN26021. Drawn By: M.O., B.Mi.

Appendix E:
Photographic Record

Photo 1: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

View of the downstream extent of Findlay Creek within the subject lands. Riparian vegetation consisted primarily of trees and shrubs with moderate-good canopy cover.

Photo 2: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

The channel was partially confined and had a low sinuosity.
The channel was defined and had moderate to steep sloped banks.

Photo 3: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Leaning trees and woody debris jams were common throughout the watercourse.

Photo 4: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Bank erosion was observed along both banks for portions of the channel.

Photo 5: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Left bank

Banks consisted of clay, silt, rootlets, and sporadic boulders.
Exposed tree roots were observed within the banks throughout the channel.

Photo 6: Reach FC-1b
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Culvert at the upstream extent of Reach FC-1b. Rip rap was observed at the extent of the culvert, and more grasses and herbaceous material was present on the channel banks.

Photo 7: Reach FC-1a
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Rip rap bank armouring along both sides of the bank, and within the mouth of the culvert can be observed at the downstream extent of Reach FC-1a.

Photo 8: Reach FC-1a
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Bed substrate ranged from silt to boulders. While the substrate consisted mostly of gravel and cobble, large sporadic boulders and patches of fine sediments were found throughout the site

Photo 9: Reach FC-1a Findlay Creek, Ottawa, Ontario Photo Direction: Upstream		Large boulders were present throughout the reach along the banks. Treefalls and leaning trees were common. The channel was generally straight with low sinuosity.
Photo 10: Reach FC-1a Findlay Creek, Ottawa, Ontario Photo Direction: Upstream/Right bank		Bankfull heights ranged from 0.63 to 0.73 m. The top of bank heights for some sections of the channel were greater than 1.0m.

Photo 11: Reach FC-1a
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Multiple woody debris jams were observed, some causing backwatering upstream. Treefalls and leaning trees were common.

Photo 12: Reach FC-1a
Findlay Creek, Ottawa, Ontario
Photo Direction: Upstream

Photo of the Bank Street crossing at the upstream extent of Reach FC-1a. Note bank erosion along both sides of the channel.

Appendix F:
Field Sheets

GEO MORPHIX™

General Site Characteristics

Project Number: 26028

Date:	2026/04/22	**Stream:**	Findlay Creek
Time:	10:15	**Reach:**	
Weather:	Sunny, 12°C	**Location:**	Findlay Creek
Field Staff:	BM, EG	**Watershed/Subwatershed:**	Castor River

Features	**Monitoring**
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

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		
H9	Free fall	H9A	Dissipates below free fall

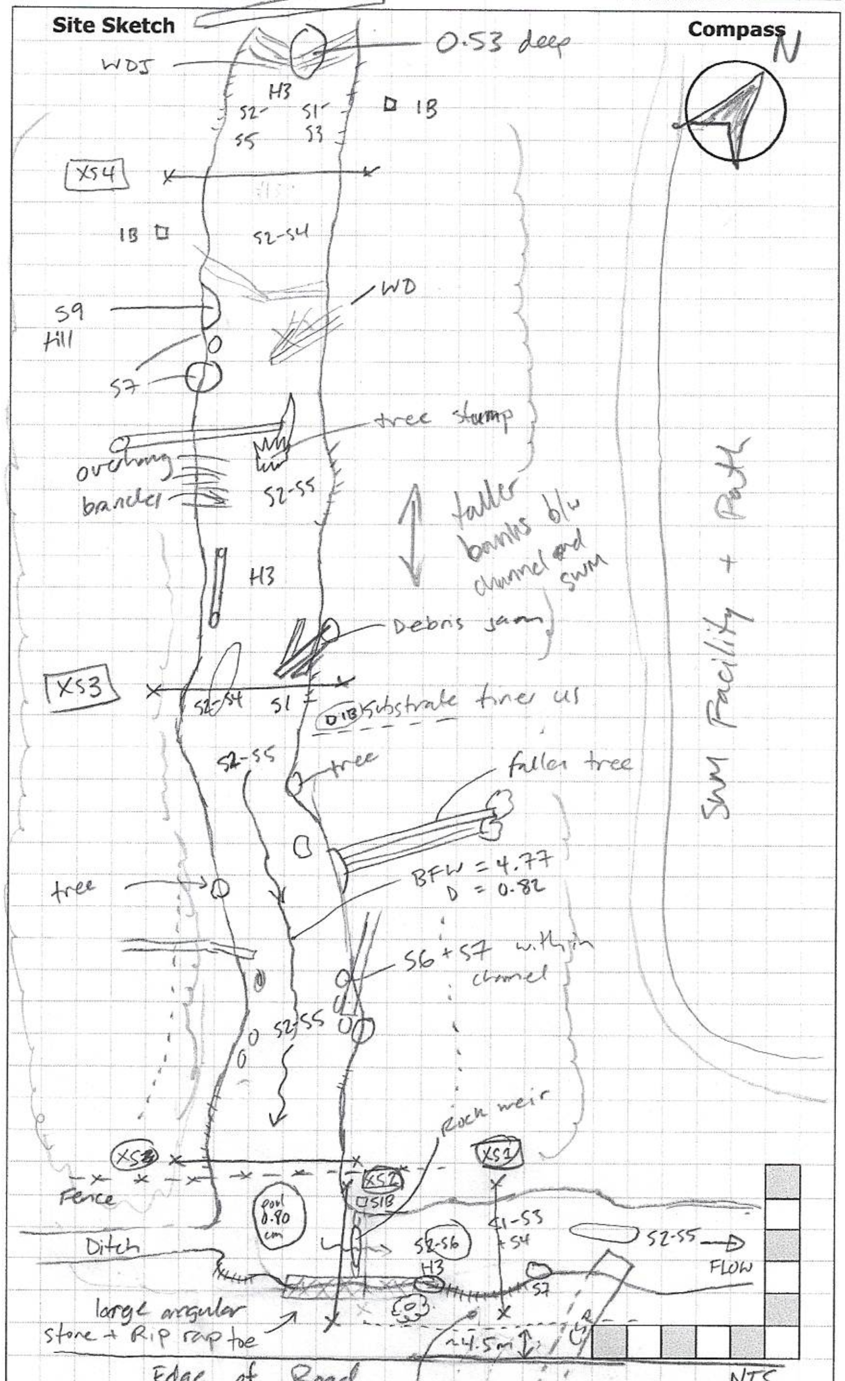
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch



Bank erosion

Photos:

Notes: generally straight, coarser materials DS
lots of leaning/fallen trees & bank erosion, WDJ frequent & causes changes in local sediment, LB b/w SWM generally taller & built up/berm

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

General Site Characteristics

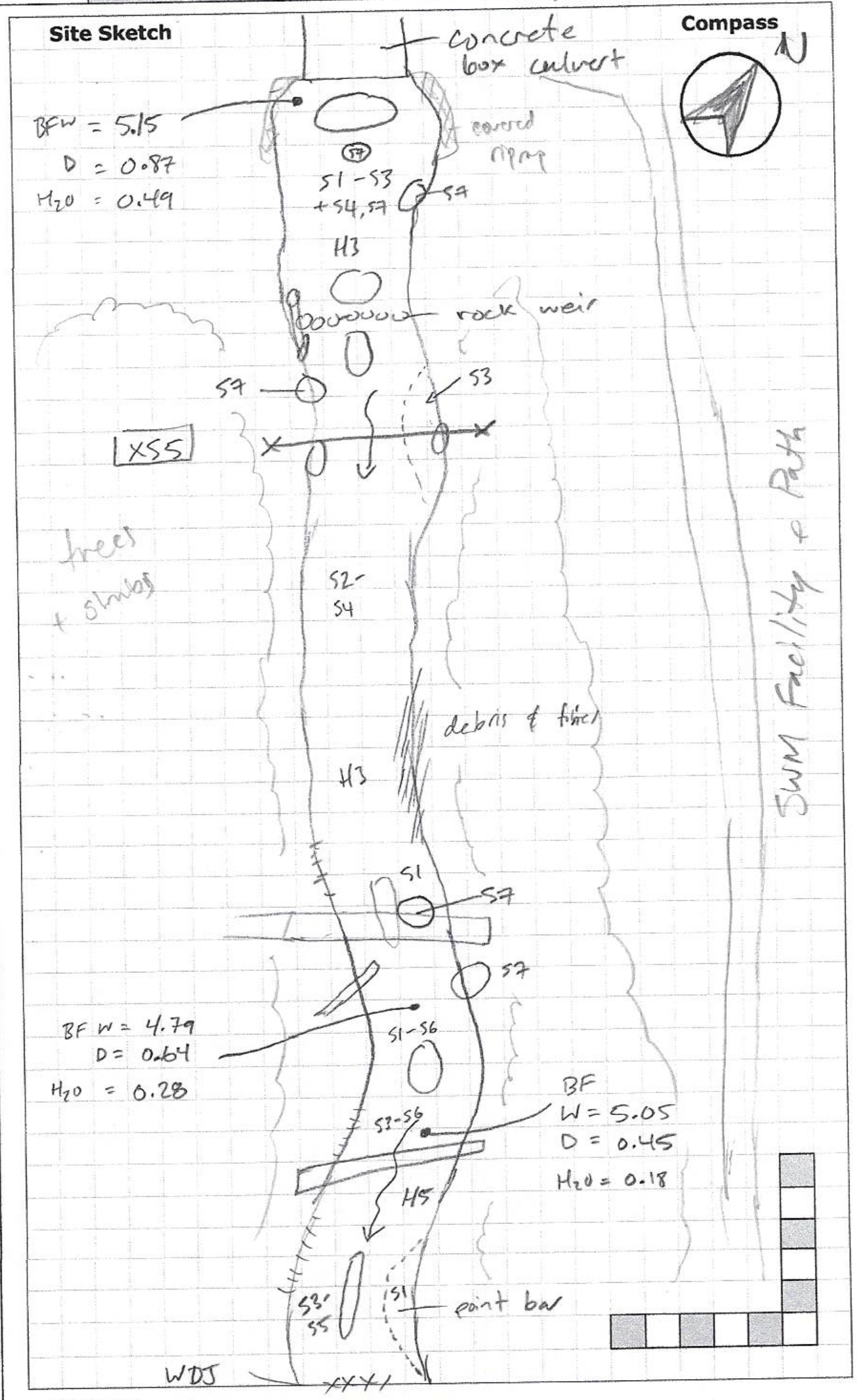
Project Number: 26028

Date:	2026/04/22	**Stream:**	Findlay Creek
Time:	11:45	**Reach:**	
Weather:	Sunny, 12°C	**Location:**	Findlay Creek
Field Staff:	BM, EG	**Watershed/Subwatershed:**	Castor River

Features	**Monitoring**
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

Site Sketch

Compass



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		
H9	Free fall	**H9A**	Dissipates below free fall

Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Photos:

Notes: more fines present further US + observed on banks, boulders scattered on bed + banks, banks armoured around culvert

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

General Site Characteristics

Project Number: 26028

Date:	2026/04/22	**Stream:**	Findlay Creek
Time:	13:00	**Reach:**	
Weather:	Sunny, 12°C	**Location:**	Findlay Creek
Field Staff:	BM, EG	**Watershed/Subwatershed:**	Castor River

Features	Monitoring
Reach break	Long-profile
Station location	Monumented XS
Cross-section	Monumented photo
Flow direction	Monumented photo direction
Riffle	Sediment sampling
Pool	Erosion pins
Sediment bar	Scour chains
Eroded bank/slope	**Additional Symbols**
Undercut bank	
Bank stabilization	
Leaning tree	
Fence	
Culvert/outfall	
Swamp/wetland	
Grasses	
Tree	
Instream log/tree	
Woody debris	
Beaver dam	
Vegetated island	

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		
H9	Free fall	H9A	Dissipates below free fall

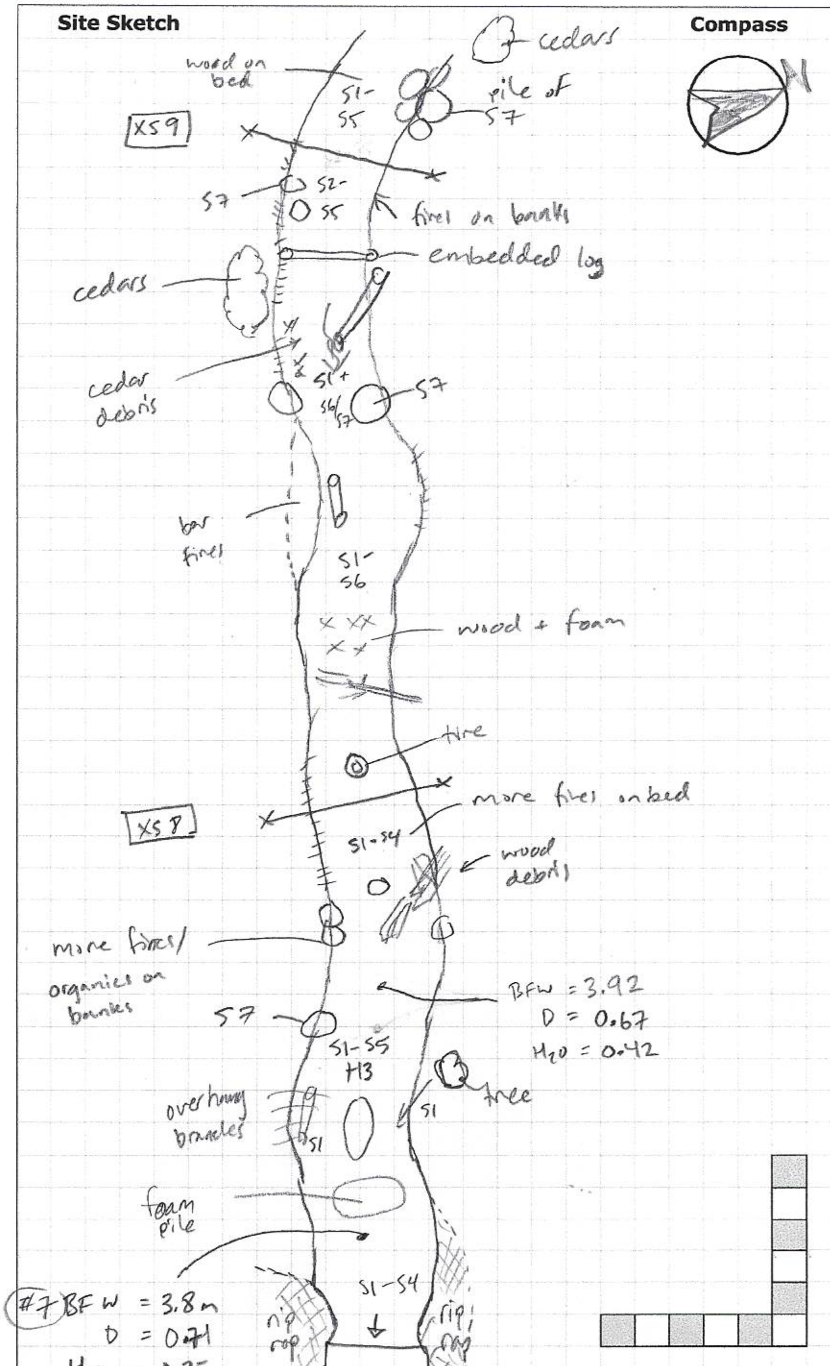
Substrate

S1	Silt	S6	Small boulder
S2	Sand	S7	Large boulder
S3	Gravel	S8	Bimodal
S4	Small cobble	S9	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	EP	Erosion pin
BS	Backsight	RB	Rebar
DS	Downstream	US	Upstream
WDJ	Woody debris jam	TR	Terrace
VWC	Valley wall contact	FC	Flood chute
BOS	Bottom of slope	FP	Flood plain
TOS	Top of slope	KP	Knick point

Site Sketch **Compass**



concrete box culvert

Photos:

Notes: More woody debris on bed + banks, generally finer materials but lots of large boulders

General Site Characteristics

Project Number: 26029

Date:	2026/04/22	**Stream:**	Findlay Creek
Time:	15:00	**Reach:**	
Weather:	Sunny, 17°C	**Location:**	Findlay Creek
Field Staff:	BM, EG	**Watershed/Subwatershed:**	Castor River

Features

- 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

Monitoring

- Long-profile
- Monumented XS
- Monumented photo
- Monumented photo direction
- Sediment sampling
- Erosion pins
- Scour chains

Additional Symbols

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		
H9	Free fall	**H9A**	Dissipates below free fall

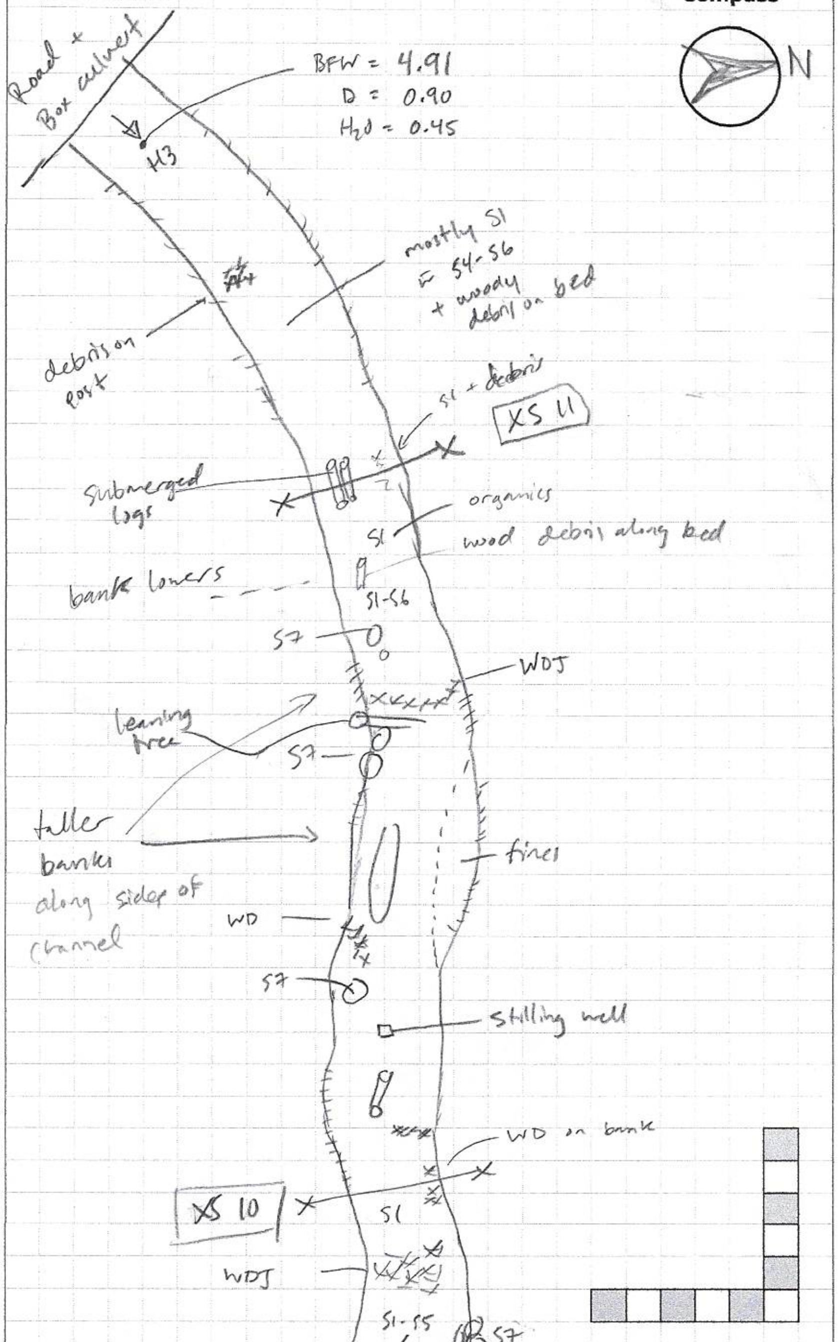
Substrate

S1	Silt	**S6**	Small boulder
S2	Sand	**S7**	Large boulder
S3	Gravel	**S8**	Bimodal
S4	Small cobble	**S9**	Bedrock/till
S5	Large cobble		

Other

BM	Benchmark	**EP**	Erosion pin
BS	Backsight	**RB**	Rebar
DS	Downstream	**US**	Upstream
WDJ	Woody debris jam	**TR**	Terrace
VWC	Valley wall contact	**FC**	Flood chute
BOS	Bottom of slope	**FP**	Flood plain
TOS	Top of slope	**KP**	Knick point

Site Sketch



Photos:

Notes: fines continue US

- Fill piles / berms observed along channel banks (not continuous) but taller than 'natural' sections
- bank erosion observed on both toes

Version #4
Last edited: 21/02/2023

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

GEO MORPHIX™

Reach Characteristics — Project Number: 26028

Date:	2026-04-22	**Field Staff:**	BM EG	**Watershed/Subwatershed:**	Castor River
Time:	16:00	**Stream:**	Findlay Creek	**UTM (Upstream):**	
Weather:	Sunny, 12°C	**Reach:**	FC-1a + FC-1b	**UTM (Downstream):**	

Land Use (Table 1): 2/3 **Valley Type** (Table 2): 3 **Channel Type** (Table 3): 6 **Channel Zone** (Table 4): 2 **Flow Type** (Table 5): 1 ☐ Evidence of Groundwater Location: NA Photo: ____

Riparian Vegetation

Dominant Type (Table 6): 1
Encroachment (Table 7): 2

Coverage	Channel Widths	Age (yrs)
☐ None	☒ 1 - 4	☐ Immature (<5)
☒ Fragmented	☒ 4 - 10	☒ Established (5-30)
☐ Continuous	☐ > 10	☐ Mature (>30)

Aquatic & Instream Vegetation

Type (Table 8): 6
Reach Coverage %: 15

Woody Debris	WD Density
☐ In Cutbank	☐ Low
☒ In Channel	☐ Mod
☐ Not Present	☒ High

WDJ/50m: 2

Water Quality

Odour (Table 16): 1
Turbidity (Table 17): 1

Channel Characteristics

Sinuosity Type (Table 9)	1	**Sinuosity Degree** (Table 10)	1
Gradient (Table 11)	1/2	**# of Channels** (Table 12)	1
Entrenchment (Table 13)	2	**Bank Failure** (Table 14)	1
Down's Model (Table 15)	E	**Bankfull Indicators** (Table 18)	5, 3
Sed Sorting (Table 20)	poor - moderate	**Sediment Transport Observed?**	☐ Yes ☒ No ☐ Not Visible
Transport Mode (Table 21)	/	**% of Bed Active**	0
Geomorphic Units (Table 22)	5, 6, 7	**Mass Movement** (Table 23)	/
Riffle-Pool Spacing (m):	/	**% Riffles:**	30

% Pools: 20

Bank Angle	Bank Erosion
☐ 0 – 30	☐ < 5%
☒ 30 – 60	☐ 5 – 30%
☒ 60 – 90	☒ 30 – 60%
☒ Undercut	☐ 60 – 100%

(Table 19)	Clay/Silt	Sand	Gravel	Cobble	Boulder	Parent	Rootlets
Bank	☒	☒	☒	☒	☒	☐	☐
Riffle	☐	☒	☒	☒	☐	☐	☐
Pool	☒	☒	☐	☐	☐	☐	☐
Bed (If no riffle-pool morphology)	☒	☒	☒	☒	☒	☒	☐

Bankfull Width (m)	4.77	5.05	3.92
Bankfull Depth (m)	0.82	0.45	0.67
Undercuts (m)	0.10	0.14	0.08
Pool Depth (m)	0.8	0.53	0.87
Riffle Length (m)	/	/ not measured	/

Wetted Width (m)	/	/ not measured	/
Wetted Depth (m)	0.18	0.28	0.42
Velocity (m/s)	0.44	0.063	0.62
Velocity Estimate Method	WB	WB	WB
Meander Amplitude (m)	/	/ not measured	/

Notes:

- mostly straight channel, some sinuosity
- riffle-pool sequence observed but not continuous
- minor undercuts observed but sporadic
- coarser bed materials DS w some embedment, more fines present US
- lots of WD on bed + banks causing localized sedimentation

Photos:

Rapid Stream Assessment Technique (RSAT) Summary

Category	Poor	Fair	Good	Excellent	Points
Channel Stability	0-2	3-5	6-8	9-11	4
Scour/Deposition	0-2	3-4	5-6	7-8	4.5
Instream Habitat	0-2	3-4	5-6	7-8	5
Water Quality	0-2	3-4	5-6	7-8	7
Riparian Conditions	0-1	2-3	4-5	6-7	4
Stream Health Score (0-42)	**Total Score** = 24.5	**Poor (<13)**	**Fair (13-24)**	**Good (25-34)**	**Excellent (>35)**
Limiting Feature	Channel stability, fallen trees, exposed root, erodable bank				

Version #5
Last edited: 22/07/2026

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

GEO MORPHIX™

Rapid Geomorphic Assessment   Project Number: 26028

Date:	2026-04-22	**Stream:**	FINDLAY CREEK
Time:	16:00	**Reach:**	FC-1a + FC1b
Weather:	Sunny 12°C	**Location:**	Leitrim
Field Staff:	BM EG	**Watershed/Subwatershed:**	Castor River

Process	No.	Geomorphological Indicator – Description	Present? Yes	Present? No	Factor Value
Evidence of Aggradation (AI)	1	Lobate bar		X	3/7
	2	Coarse materials in riffles embedded – partial in some locations	X		
	3	Siltation in pools	X		
	4	Medial bars		X	
	5	Accretion on point bars		X	
	6	Poor longitudinal sorting of bed materials	X		
	7	Deposition in the overbank zone		X	
		Sum of indices =	3	4	0.43
Evidence of Degradation (DI)	1	Exposed bridge footing(s) N/A no bridge on site	—	—	1/7
	2	Exposed sanitary / storm sewer / pipeline / etc.		X	
	3	Elevated storm sewer outfall(s) N/A not on site	—	—	
	4	Undermined gabion baskets / concrete aprons / etc. N/A not on site	—	—	
	5	Scour pools downstream of culverts / ~~storm sewer outlets~~	X		
	6	Cut face on bar forms		X	
	7	Head cutting due to knickpoint migration		X	
	8	Terrace cut through older bar material		X	
	9	Suspended armour layer visible in bank		X	
	10	Channel worn into undisturbed overburden / bedrock		X	
		Sum of indices =	1	6	0.14
Evidence of Widening (WI)	1	Fallen / leaning trees / fence posts / etc.	X		4/8
	2	Occurrence of large organic debris	X		
	3	Exposed tree roots	X		
	4	Basal scour on inside meander bends		X	
	5	Basal scour on both sides of channel through riffle	X		
	6	Outflanked gabion baskets / concrete walls / etc. N/A not on site	—	—	
	7	Length of basal scour >50% through subject reach		X	
	8	Exposed length of previously buried pipe / cable / etc.		X	
	9	Fracture lines along top of bank		X	
	10	Exposed building foundation N/A not on site	—	—	
		Sum of indices =	4	4	0.5
Evidence of Planimetric Form Adjustment (PI)	1	Formation of chute(s)		X	1/7
	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	X		
		Sum of indices =	1	7	0.14

Notes:

Stability Index (SI) = (AI+DI+WI+PI)/4 =		0.3025
In Regime	**In Transition/Stress**	**In Adjustment**
☐ **0.00 - 0.20**	☑ **0.21 - 0.40**	☐ **0.41**

Version #3
Last edited: 10/02/2023

Senior staff sign-off (if required): ________ Checked by: BM Completed by: EG