# 147 Langstaff Drive, Carp, Ontario

## Fluvial Geomorphological and Erosion Hazard Assessment

Prepared for:
Inverness Homes
69 Moore Street
Richmond ON K0A 2Z0

October 23, 2019
PN19072

GEO MORPHIX
Geomorphology
Earth Science
Observations

| | |
|---|---|
| Report Prepared by: | GEO Morphix Ltd.<br>36 Main Street North<br>PO Box 205<br>Campbellville, ON L0P 1B0 |
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| Prepared by: | Melisa Kopan, M.Sc., Ben Miller, B.Sc., CAN-CISEC and Suzanne St. Onge, M.Sc. |
| Approved by: | Paul Villard, Ph.D., P.Geo., CAN-CISEC, EP, CERP |
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## Appendices

# 1 Introduction

GEO Morphix was retained by Inverness Homes to complete a fluvial geomorphological and erosion hazard assessment for a proposed development located at 147 Langstaff Drive in the community of Carp, Ontario. The subject lands are approximately 8.12 ha in area and bounded by Langstaff Drive to the north, Carp Road and existing residences to the south and east, and existing residential and commercial/industrial development to the west. A tributary of the Carp River flows in a generally north to south orientation through the central portion of the subject lands. A second tributary flows immediately west of the subject lands. Existing land uses consist of vacant greenfield and natural areas associated with the Carp River tributaries.

The City of Ottawa, as part of the pre-application consultation, requested the completion of a Fluvial Geomorphology Report. The following activities have been completed in support of our assessment:

- Review available background reports and mapping (e.g., watershed/subwatershed reporting, geology, and topography) related to channel form and function and controlling factors related to fluvial geomorphology
- Delineate watercourse reaches through a desktop assessment
- Complete rapid geomorphological assessments on a reach basis to document channel conditions and verify the desktop assessment
- Document any areas of significant erosion and locations of valley wall contacts/valley wall systems
- Collect instream measurements of bankfull channel dimensions and characterize bed and bank material composition and structure
- Delineate limits of the erosion hazard on a reach basis using field observations and historical aerial photography
- Prepare recommendations for the two proposed trail crossings over the central tributary to ensure that natural hazards are addressed from a fluvial geomorphological perspective

This report summarizes the results of our desktop and field-based assessment. It identifies site constraints from a fluvial geomorphological perspective and should be considered in conjunction with studies being completed by other disciplines in support of the proposed development.

# 2 Background Review and Desktop Assessment

## 2.1 Geology and Physiography

Geology and physiography act as constraints to channel development and tendency. These factors determine the nature and quantity of the availability and type of sediment. Secondary variables that affect the channel include land use and riparian vegetation. These factors are explored as they not only offer insight into existing conditions, but also potential changes that could be expected in the future as they relate to a proposed activity.

The subject lands are located within the Ottawa Valley Clay Plains physiographic region and Clay Plains physiographic landform. Areas north (upstream) of the subject lands are located within the Shallow Till and Rock Ridges physiographic landform (Chapman and Putnam, 1984 and 2007). Based on published surficial geology mapping, the majority of the subject lands contain coarse-textured glaciomarine deposits of sand, gravel, minor silt and clay. The north tip of the subject

lands and areas north of Langstaff Drive contain fine-textured glacio-marine deposits of silt and clay, minor sand and gravel that are massive to well laminated (OGS, 2010).

Available mapping is generally consistent with boreholes recovered by Paterson Group (2008) in support of a previous geotechnical study. Six boreholes were advanced to a maximum depth of 18.9 m. Borehole logs showed that subsurface conditions consisted of topsoil overlying a thin silty sand layer, which was underlain by a stiff silty clay deposit, and then a silty sand deposit.

## 2.2 Site History

A series of historical aerial photographs were reviewed to determine changes to the channel and surrounding land use/cover. This information, in part, provides an understanding of the historical factors that have contributed to current channel morphodynamics. Aerial photographs from 1945, 1964, 1966, 1967, 1975, 1978, and 1989 from the National Air Photo Library (NAPL), imagery available online through the GEO Ottawa web mapping application, and recent satellite imagery from Google Earth Pro were reviewed. Refer to **Appendix A** for copies of select imagery obtained from the National Air Photo Library.

In 1946, agriculture and rural land uses were predominant. Outbuildings/agricultural facilities were visible adjacent to the top of the bank of the central tributary near what is now Langstaff Drive and near the downstream extent of the central tributary. The defined valleys were apparent, but the watercourse was not clearly visible in the imagery. Natural riparian vegetation had been removed from the upstream portion of the central tributary, likely to facilitate agricultural uses, while the western tributary that flows adjacent to the subject lands retained natural vegetation in the immediate riparian zone. A large natural area was present upstream, which coincides with Precambrian bedrock based on published surficial geology mapping (OGS, 2010).

There were limited changes to land use and land cover by 1966, with areas within the subject lands under active cultivation; however, rural residential development had expanded westward along Donald B Munro Drive. In 1967, a large industrial/commercial facility was constructed northwest of the subject lands, west of what is now Langstaff Drive, but was set well back from the central tributary.

In 1975, the subject lands remained under active cultivation, while lands to the east and west were converted from agriculture to relatively small residential subdivisions. An access road was constructed over the western most tributary immediately adjacent to the subject lands, likely to facilitate access to agricultural fields.

By 1989, residential subdivisions had begun to encroach on the central tributary north of what is now Langstaff Road, and commercial/industrial development had expanded to the immediate west. The crossing visible in the 1975 imagery along the western tributary was no longer present, likely due to expansion of the local road network west of the subject lands. Portions of the central tributary north of the subject lands also appeared to have been straightened or modified to accommodate residential development, with landscaped rear yards of several residences abutting the central tributary upstream of the subject lands. Between 1975 and 1989, headwaters of the western tributary appeared to be straightened to follow property boundaries or enclosed in storm sewers. These channel modifications likely resulted in limited/reduced natural channel form upstream of the subject lands, as well as potentially more rapid run-off to receiving features due to increases in impervious surfaces.

By 2004, the current alignment of Langstaff Drive had been constructed and residential development had expanded further in the upstream extents of both the central and western tributaries. An online stormwater management facility and access road were recently constructed

immediately upstream of the subject lands on the north side of Langstaff Road. In addition, an access road and watercourse crossing were apparent at the upstream extent of the central tributary within the subject lands, approximately 110 m downstream of Langstaff Drive. A second access to the central tributary was visible amongst the trees in the lower third of the central tributary. The purpose of these two crossings was unclear based on the aerial photograph record but it is inferred that they may provide a stormwater management function. There was limited change between 2004 and 2018, with the exception of the construction of additional residences on the west side of the central tributary upstream of Langstaff Drive.

# 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

Reach delineation follows scientifically defensible methodology proposed by Montgomery and Buffington (1997), Richards et al. (1997), and the Toronto and Region Conservation Authority (2004) as well as others. A single reach, **CR-1**, was delineated along the central tributary that bisects the subject lands. Reaches **CR-2** and **CR-2a** were delineated along the tributary to the immediate west. Due to site access limitations, only approximately 50 m of **Reach CR-2** was assessed in the field. Refer to **Appendix B** for the location and extent of each reach.

## 3.2 General Reach Observations

Field investigations were completed on July 10 and September 4, 2019, and included the following:

- Completion of reach-scale habitat sketch maps based on Newson and Newson (2000) outlining channel substrate, flow patterns, geomorphological units (e.g., riffle, run, pool), and riparian vegetation
- Descriptions of riparian conditions
- Estimates of bankfull channel dimensions
- Determination of 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, and channel disturbances such as crossing structures

These observations and measurements are summarized below. The descriptions are supplemented and supported with representative photographs, which are included in **Appendix**

**C**. Field sheets, including reach summaries, habitat sketch maps and rapid assessments, are provided in **Appendix D**.

Reach **CR-1** was a single thread, irregularly meandering channel within a transfer zone. The riparian zone was continuous and consisted of established trees (5-30 years), shrubs, grasses and herbaceous species, and was approximately 4-10 channel widths. The reach had a perennial flow regime and was moderately entrenched. Evidence of groundwater inputs (i.e., iron staining) was observed within the reach. Riffle-pool spacing was approximately 10 m, with riffle lengths ranging between 2 and 5 m. Riffle substrates consisted of sand, gravel and cobble and pool substrates consisted of clay/silt and sand. Bank materials consisted of clay, silt, sand and rootlets. There was minimal undercutting, with the highest measured undercut being 0.05 m.

Average bankfull channel width and depth were approximately 3.0 m and 0.4 m, respectively. Average wetted width and depth were 0.61 m and 0.19 m, respectively. Bank angles ranged from 0-90°. The upstream portion of **Reach CR-1** was extensively encroached with vegetation and was situated within a partially confined valley with minimal woody debris. Meander amplitude was measured in the upstream portion of the reach to be approximately 3.9 m. The downstream portion of the reach flowed through a forest within a confined valley and minimal vegetation encroachment. The channel became less defined and had multiple valley wall contacts and a few slumps. There was more woody debris present in the downstream portion of the reach relative to the upstream portion.

Based on the extent assessed, **Reach CR-2** was a single thread, irregularly meandering channel flowing through a confined valley. The riparian zone was continuous and consisted mainly of established trees (5-30 years) and herbaceous species and was approximately 4-10 channel widths. The reach has an intermittent to perennial flow regime and had low entrenchment. No true riffle-pool sequences were present but spacing between geomorphic units was approximately 6 m, with riffle lengths ranging between 1 and 2 m. Riffle substrates consisted mainly of sand, gravel and small cobbles and pool substrates consisted of clay/silt and sand. Bank angles ranged from 30-90° and materials consisted of clay/silt, sand and rootlets.

Average bankfull channel width and depth were 2.3 m and 0.25 m, respectively. At the time of the assessment, average wetted width and depth were 0.93 m and 0.04 m, respectively. The valley corridor had a bottom width of approximately 4-5 m and minimal bank erosion was observed even though the channel was in contact with the left valley wall for a significant portion of the reach. One larger eroded bank was present near the downstream extent assessed and was approximately two metres in height and 5 metres in length.

## 3.3 Rapid Assessments

Channel instability was objectively quantified through the application of the Ontario Ministry of the Environment's (2003) Rapid Geomorphic Assessment (RGA). Observations were quantified using an index that identifies channel sensitivity based on evidence of aggradation, degradation, channel widening, and planimetric adjustment. The index produces values that indicate whether a channel is stable/in regime (score <0.20), stressed/transitional (score 0.21-0.40), or adjusting (score >0.41).

The Rapid Stream Assessment Technique (RSAT) was also employed to provide a broader view of the system as it considers the ecological function 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.

Reaches **CR-1** and **CR-2** were also classified according to a modified Downs (1995) Channel Evolution Model. The Downs Model describes successional stages of a channel as a result of a perturbation, namely hydromodification. Understanding the current stage of the system is beneficial as this allows one to predict how the channel will continue to evolve or respond to an alteration to the system. The results of these assessments are summarized below in **Table 1**.

For Reach **CR-1**, an RGA score of 0.19 was assigned, indicating the reach was in regime. The dominant geomorphological indicator was evidence of widening, shown by occurrences of large organic debris and exposed roots. **Reach CR-1** had an RSAT score of 32.5, or good. There was no definitive limiting factor, as the reach scored 'good' in all categories. The reach was given a Downs classification of 'M' for lateral migration.

For **Reach CR-2**, an RGA score of 0.24 was assigned, indicating the reach was in transition/stress. The dominant geomorphological indicator was evidence of aggradation, evidenced by siltation in pools, medial bars, accretion on point bars, and deposition in the overbank zone. Reach **CR-2** had an RSAT score of 30, or good. The limiting factor was physical instream habitat due to the few shallow pools and small riffle substrate sizes present. The reach was given a Downs classification of 'M' for lateral migration.

### Table 1: Summary of rapid assessment results

| Reach | RGA (MOE, 2003) | | | RSAT (Galli, 1996) | | | Downs Channel Evolution Model (1995) |
|---|---|---|---|---|---|---|---|
| | Score | Condition | Dominant Systematic Adjustment | Score | Condition | Limiting Feature(s) | |
| **CR-1** | 0.19 | In Regime | Widening | 32.5 | Good | N/A | M – lateral migration |
| **CR-2*** | 0.24 | In Transition | Evidence of Aggradation | 30 | Good | Physical Instream Habitat | M – lateral migration |

***** ~50 m of reach assessed due to the feature being located on private property

## 4 Erosion Hazard Delineation

Most watercourses in southern Ontario have a natural tendency to develop and maintain a meandering planform, provided there are no spatial constraints. A meander belt width or erosion hazard assessment estimates the lateral extent that a meandering channel has historically occupied and will likely occupy in the future. This assessment is therefore useful for determining the potential hazard to proposed activities in the vicinity of a stream.

When defining the meander belt width for a creek system, the TRCA (2004) and MNR (2002) protocols treat unconfined and confined systems differently. Unconfined systems are those with poorly defined valleys or slopes well-outside where the channel could realistically migrate. Confined systems are those where the watercourse is contained within a defined valley, where valley wall contact is possible.

Based on our desktop review and field observations, the Carp River tributaries within and adjacent to the subject lands are confined systems. Notably, channel migration rates could not be measured due to the presence of trees along the tributary corridors, the size of the features, and the resolution of available aerial photography. The MNR (2002) provides recommendations for an appropriate toe erosion allowance based on evidence of erosion, channel bank composition and bankfull channel width. As noted previously, the channel banks were composed of clay, silt and

sand, and the average bankfull channel widths were estimated to be approximately 3.0 m and 2.3 m along the central and western tributaries, respectively. MNR (2002) guidelines indicate that for channels with no active erosion, a bankfull channel width of less than 5 m and banks composed of soft/firm cohesive soils, a 1-2 m toe erosion allowance should be applied. As Reach **CR-1** contained limited evidence of erosion, had an average bankfull width of 3.0 m, with bank materials consisting of clay, silt and sand, an erosion setback of 2 m is appropriate. A toe erosion allowance of 1 m is recommended for Reach **CR-2**, as it has an intermittent to perennial flow regime, an average bankfull width of 2.3 m and bank materials consisting of clay, silt and sand. These values should be considered in conjunction with the geotechnical study, prepared under separate cover by the Patterson Group Inc.

# 5 Recommendations for Proposed Crossings

Two pedestrian crossings are proposed in Reach **CR-1** where concrete culverts are currently located. At this time, it is uncertain as to whether the existing concrete culverts will be maintained or replaced. At the time of our assessment, no erosion concerns were documented in vicinity of either culvert. Should the culverts be replaced, we recommend the new structures consider the following from a fluvial geomorphic perspective:

- Replacement structures should be open bottom or embedded a minimum of 0.3 m
- Where possible, avoid the need for channel armouring or adjustment
- Address potential channel migration
- Maintain flow velocities and sediment transport processes for frequent storm events
- Be located at a straight section of channel
- Cross the channel at a perpendicular angle
- Be located at a reasonably stable length of channel

The above recommendations are consistent with crossing guidelines developed by Greater Golden Horseshoe Conservation Authorities such as Toronto and Region Conservation Authority (TRCA) and Credit Valley Conservation (CVC). The TRCA (2015) recommends that crossing structures span the meander belt width, where feasible, or, at minimum, the 100-year erosion limit to avoid the migration of the channel into the crossing structure within the next 100 years. The TRCA guidelines also allow smaller crossing structures that accommodate relatively small, stable watercourses provided that they consider physical channel characteristics (e.g., alignment, width and depth) and fluvial processes (e.g., erosion and scour).

# 6 Summary

GEO Morphix was retained to complete a fluvial geomorphological assessment of two tributaries of the Carp River located within and adjacent to the property located at 147 Langstaff Drive, Ottawa. The desktop assessment included a review of available reporting, and surficial geology and topographic mapping, as well as reach delineation. A historical assessment was also completed using imagery available from the National Air Photo Library, the GEO Ottawa web mapping application and Google Earth Pro.

The desktop assessment was confirmed through the completion of reach-based rapid field reconnaissance on July 10 and September 4, 2019. Reach **CR-1**, along the central tributary, consisted of a confined channel and was evaluated to be in regime, with an RGA score of 0.19. The dominant systematic adjustment was evidence of widening. This reach had an RSAT score of 32.5, or good. Due to site access limitations, only approximately 50 m of Reach **CR-2** was assessed. This reach was also confined and assigned an RGA score of 0.24, indicating it was in

transition/stress. The RSAT resulted in a score of 30, or good. The dominant systematic adjustment was evidence of aggradation. Both reaches were assigned a score of 'M' for lateral migration. Overall, although the channels were in contact with the valley walls at multiple locations, there was minor evidence of erosion along each tributary.

Where channel systems are confined, the erosion hazard can be defined using the 100-year erosion limit or through the selection of an appropriate toe erosion allowance based on MNR (2002) guidelines. For this study, channel migration rates could not be measured due to the presence of trees along the tributary corridors, the relatively small size of the features, and the resolution of available aerial photography. Therefore, toe erosion allowances were determined following Table 3 of the MNR (2002) guideline document. A 2 m toe erosion allowance was determined for Reach **CR-1** and a 1 m toe erosion allowance of 1 m was determined for Reach **CR-2**. These values should be considered in conjunction with the geotechnical study, prepared under separate cover by the Patterson Group Inc.

We trust this report meets your requirements at this time. Should you have any questions please contact the undersigned.

Respectfully submitted,

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

Suzanne St. Onge, M.Sc.
Senior Environmental Scientist

# 7 References


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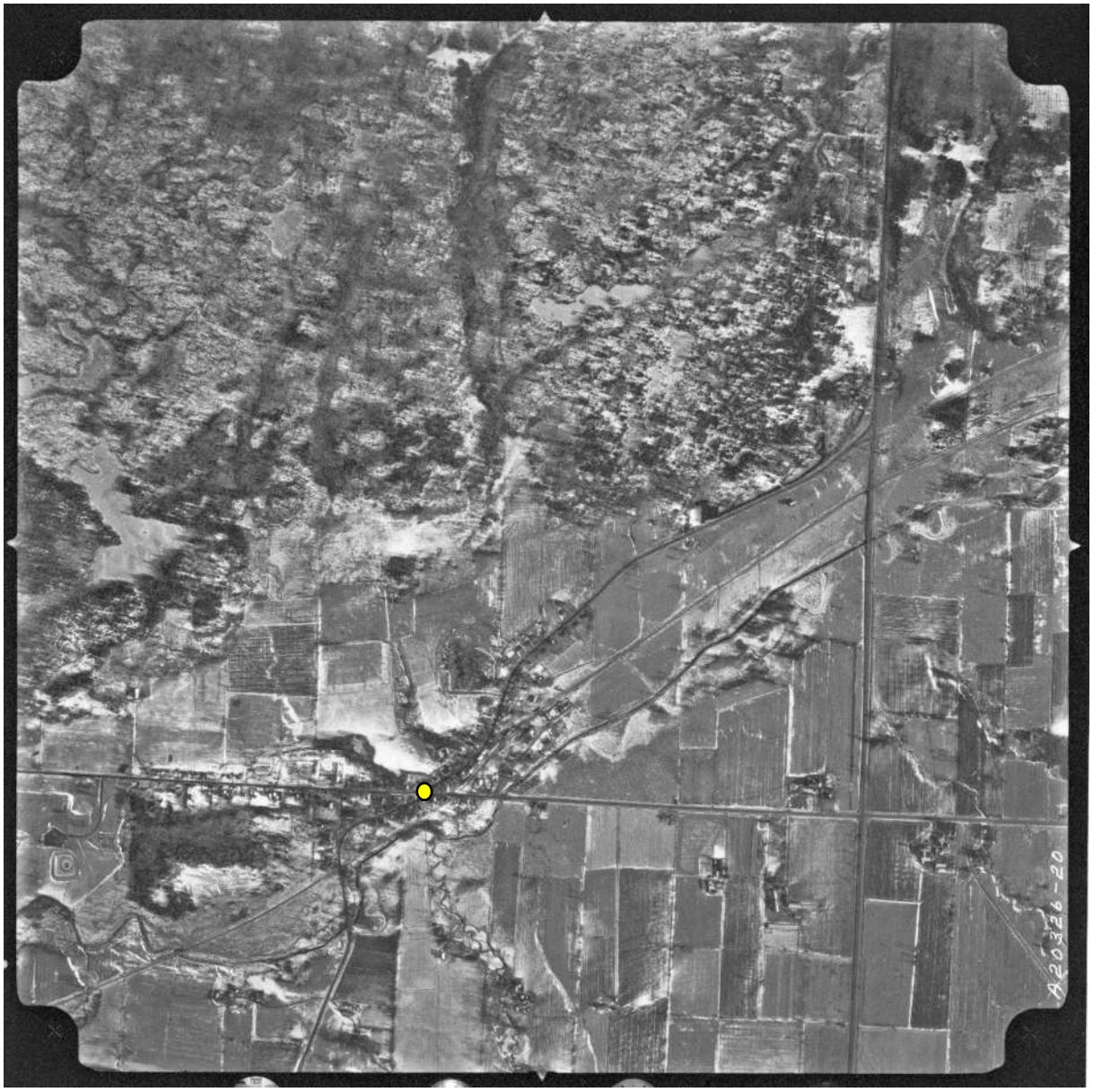
# Appendix A
# Historical Aerial Photographs


**Location:** Intersection of Carp Road and Donald B. Munro Drive (yellow dot)
**Year:** 1946
**Scale:** 1:15,000
**Source:** National Air Photo Library


**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 1966
**Scale:** 1:6,000
**Source:** National Air Photo Library




**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 1966
**Scale:** 1:15,000
**Source:** National Air Photo Library

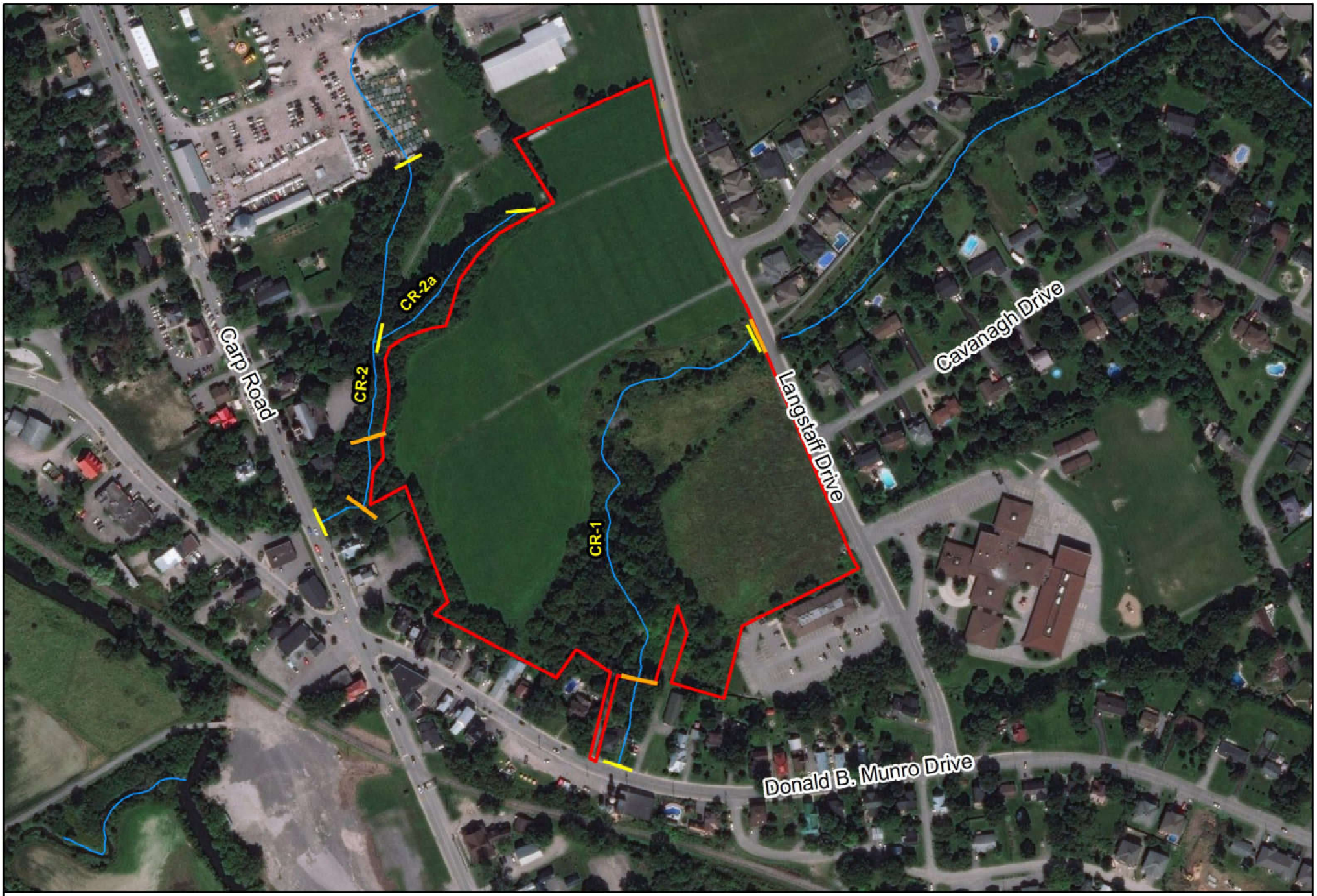

**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 1975
**Scale:** 1:15,000
**Source:** National Air Photo Library


**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 1989
**Scale:** 1:25,000
**Source:** National Air Photo Library

**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 2004
**Scale:** Not applicable
**Source:** Google Earth pro

**Location:** Intersection of Carp Road and Donald B. Munro Drive
**Year:** 2014
**Scale:** Not applicable
**Source:** Google Earth pro

# Appendix B
# Reach Delineation




**Legend**

Reach Break and ID

Watercourse

Extent Assessed

Subject Lands

# Inverness Homes

## 147 Langstaff Drive

Reach Delineation

N

0 25 50 100

Metres

GEO MORPHIX

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Imagery: December, 2016.
Watercourse: City of Ottawa, 2019. Reach Break and Extent Assessed: GEO Morphix Ltd., 2019.
Subject Lands: Inverness Homes, 2019.
Print Date: September 2019. PN19072. Drawn By: W.B., S.S.

# Appendix C
# Photographic Record

| | |
|---|---|
| Photo 1<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | View of the reach downstream of Langstaff Drive. The channel was heavily encroached with vegetation at the upstream extent and was partially confined. Yellow arrow indicates flow direction. |
| Photo 2<br>Tributary of Carp River: View Upstream<br>Reach CR-1 |  |
| | View of the culvert conveying flows under Langstaff Drive. |

| | |
|---|---|
| Photo 3<br>Tributary of Carp River: View Upstream<br>Reach CR-1 |  |
| | Stormwater outlet that discharged into the reach from Langstaff Drive. This outlet was located on the north side of the channel and flowed over small cobbles towards the reach. |
| Photo 4<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | An approximately 0.15 m knickpoint created by roots in the channel bed. There was a pool downstream of this location. |

| | |
|---|---|
| Photo 5<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | The reach was extensively encroached with vegetation and contained well-developed riffle-pool sequences at the upstream extent. |
| Photo 6<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | Riprap stabilization on top of a concrete culvert in the upper third of the reach. Note the channel remained extensively encroached with vegetation and flowed through a confined valley. No erosion was observed in vicinity of the crossing. |

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| Photo 7<br>Tributary of Carp River: View Downstream/Left Bank<br>Reach CR-1 |  |
| | The reach entered a forested area with signs of slumping. Note the valley wall contact in this image. |
| Photo 8<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | Within the forested section, the channel was less defined with multiple areas of woody debris. |

| | |
|---|---|
| Photo 9<br>Tributary of Carp River: View Upstream<br>Reach CR-1 |  |
| | Woody debris within the forested section of the channel. Note the valley wall contact circled in red. |
| Photo 10<br>Tributary of Carp River: View Downstream<br>Reach CR-1 |  |
| | Concrete culvert located in the lower third of the reach. Rip rap stabilization was observed on top of the culvert. No erosion was observed in vicinity of the crossing. |

| | |
|---|---|
| Photo 11<br>Tributary of Carp River: View Downstream<br>Reach CR-2 |  |
| | Downstream extent of the reach at Carp Road, where the tributary flowed into a 0.90 m diameter concrete pipe. |
| Photo 12<br>Tributary of Carp River: View Downstream<br>Reach CR-2 |  |
| | Downstream extent of assessed portion of reach. Channel flowed within a forested and confined valley. Bed material consisted mainly of silt, sand, and gravel. |

| | |
|---|---|
| Photo 13<br>Tributary of Carp River: View Upstream<br>Reach CR-2 |  |
| | Eroded outside bank with a moderately dense root network.<br>Several woody debris jams were present throughout the reach. |
| Photo 14<br>Tributary of Carp River: View Upstream<br>Reach CR-2 |  |
| | Channel flowed along the toe of slope of the left bank for most of the extent assessed.<br>Minor bank erosion was present and several fallen trees were observed. |

| | |
|---|---|
| Photo 15<br>Tributary of Carp River: View Upstream<br>Reach CR-2 |  |
| | Upstream extent of assessed portion of reach. Flows entered the site through a compromised corrugated steel pipe that appeared to be overtopped during larger flow events. |
| Photo 16<br>Tributary of Carp River: View Upstream<br>Reach CR-2 |  |
| | View of left valley wall that had little evidence of active erosion. |

Photo 17
Tributary of Carp River: View Downstream
Reach CR-2

View of right valley wall and channel corridor.
Right valley wall was more densely vegetated.

# Appendix D
# Field Assessment Sheets

GEO MORPHIX
Geomorphology Earth Science Observations

## General Site Characteristics

**Project Code:** PN 19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | sunny 25°C | **Location:** | Langstaff Rd |
| **Field Staff:** | MK | **Watershed/Subwatershed:** | carp river trib |

**Features**
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

**Flow Type**

| | |
|---|---|
| **H1** | Standing 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 |

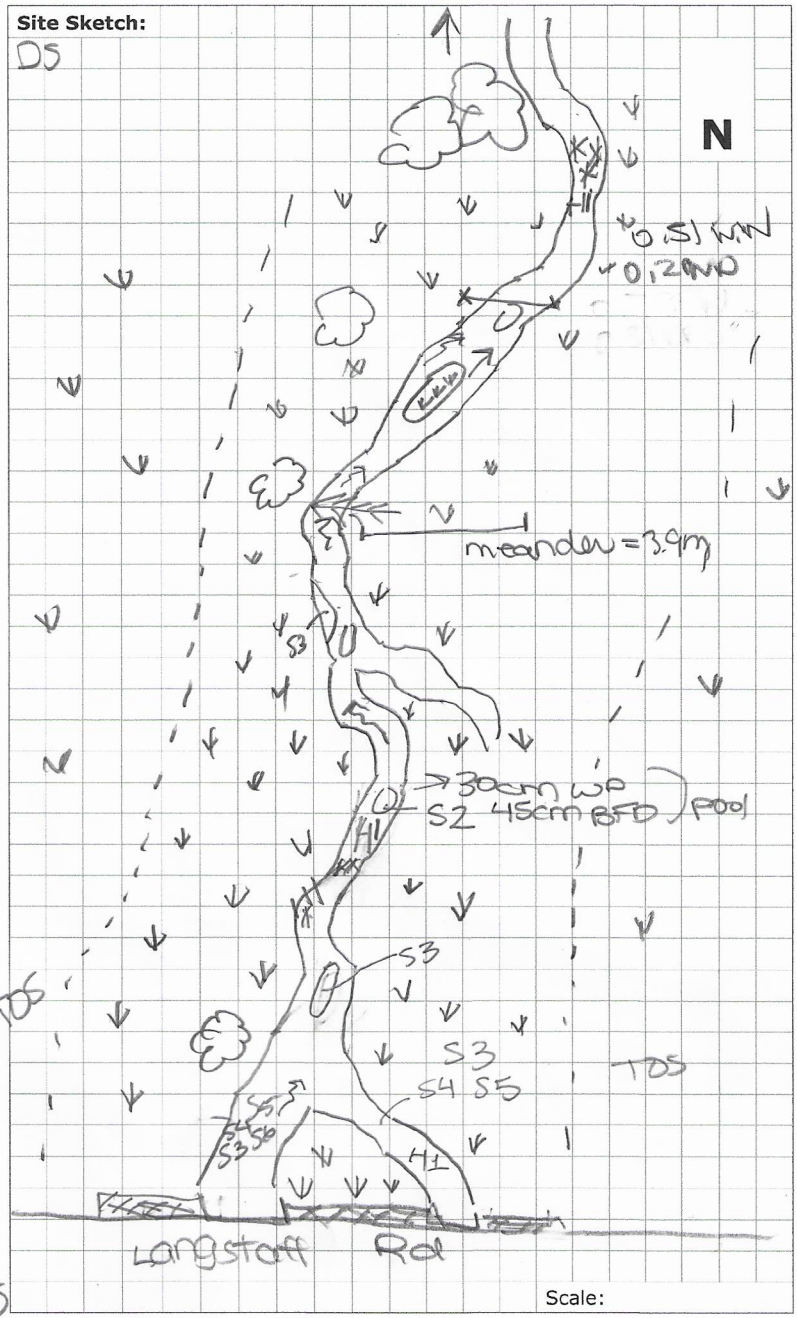
**Substrate**

| | | | |
|---|---|---|---|
| **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:**




Additional Notes: encroached
riffle length ~2m-5m



Completed by: MK/RL Checked by: R

GEO MORPHIX
Geomorphology Earth Science Observations

## General Site Characteristics

**Project Code:** PN 19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | sunny 25°C | **Location:** | Langstaff Rd |
| **Field Staff:** | MK | **Watershed/Subwatershed:** | carp river TT16 |

**Features**

- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

**Flow Type**

| | |
|---|---|
| **H1** | Standing 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 |

**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:**


Additional Notes:



Completed by: MK Checked by: RJ

GEO MORPHIX
Geomorphology Earth Science Observations

## General Site Characteristics

**Project Code:** PN 19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | Sunny 28°C | **Location:** | Langstaff Rd |
| **Field Staff:** | MK | **Watershed/Subwatershed:** | Carp River Trib |

**Features**
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

**Flow Type**

| | |
|---|---|
| **H1** | Standing 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 |

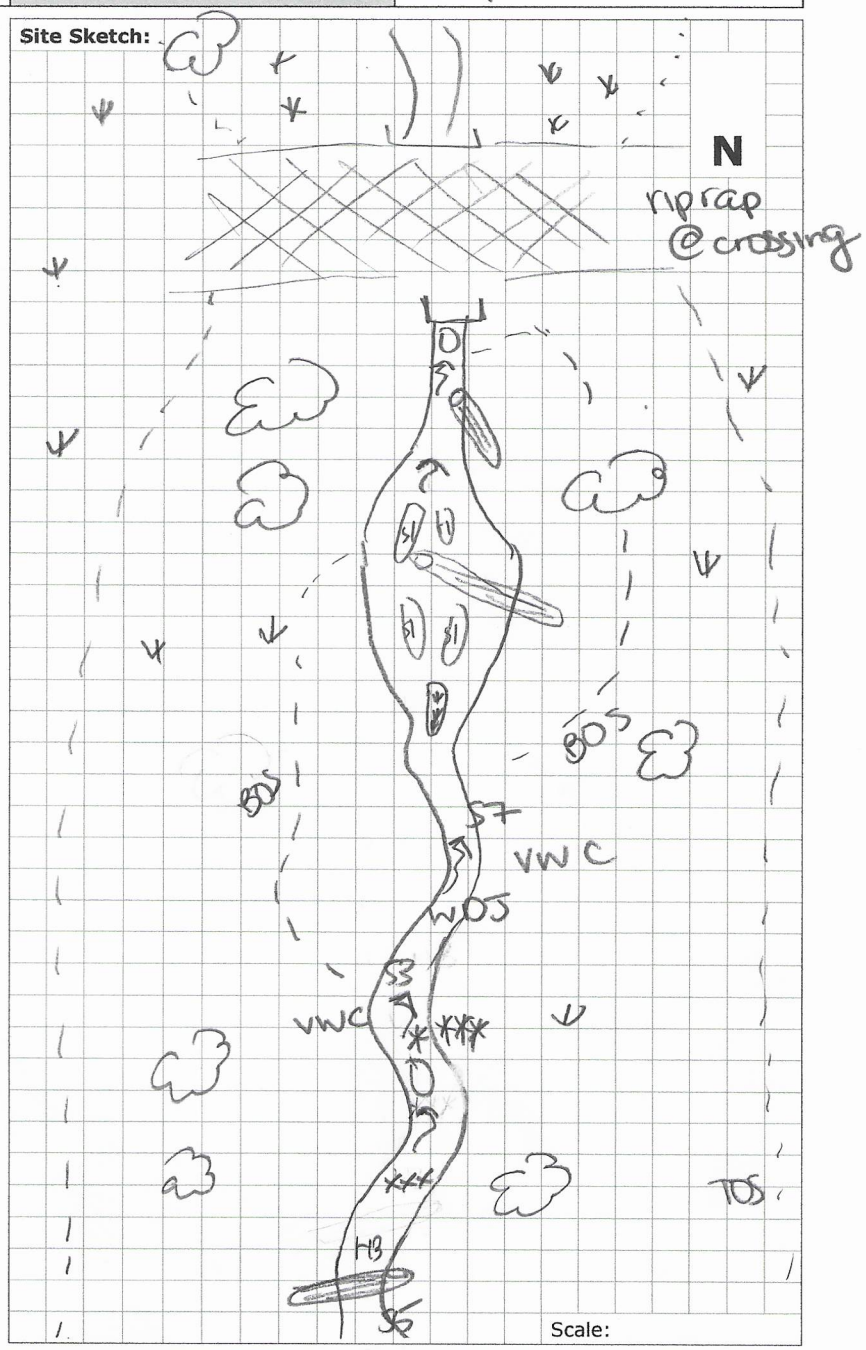
**Substrate**

| | | | |
|---|---|---|---|
| **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:**




Scale:

Additional Notes:



Completed by: MK Checked by: RL

GEO MORPHIX
Geomorphology Earth Science Observations

## Reach Characteristics

**Project Code:** PN 19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | sunny 25°C | **Location:** | Langstaff Rd |
| **Field Staff:** | MK | **Watershed/Subwatershed:** | Carp River (Trib) |
| **UTM (Upstream)** | | **UTM (Downstream)** | |

**Land Use** (Table 1): 1,3,7 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 7 | **Channel Zone** (Table 4): 2 | **Flow Type** (Table 5): 1 | ☑ Groundwater | Evidence: ironstaining

### Riparian Vegetation

**Dominant Type:** (Table 6) 1,2,3,4
Species: _____

**Coverage:** ☐ None ☐ Fragmented ☒ Continuous

**Channel widths:** ☐ 1-4 ☒ 4-10 ☐ > 10

**Age Class (yrs):** ☐ Immature (<5) ☒ Established (5-30) ☐ Mature (>30)

**Encroachment:** (Table 7) 2-4

### Aquatic/Instream Vegetation

**Type** (Table8): ⁄ | **Coverage of Reach (%):** 0

**Woody Debris:** ☑ Present in Cutbank ☑ Present in Channel ☐ Not Present

**Density of WD:** ☒ Low ☒ Moderate ☐ High

WDJ/50m: 1

### Water Quality

**Odour** (Table 16): 1

**Turbidity** (Table 17): 1

### Channel Characteristics

**Sinuosity (Type)** (Table 9): 2 | **Sinuosity (Degree)** (Table 10): 2 | **Gradient** (Table 11): 2 | **Number of Channels** (Table 12): 1

**Entrenchment** (Table 13): 2 | **Type of Bank Failure** (Table 14): 2,6 | **Downs's Classification** (Table 15): M

| | Clay/Silt | Sand | Gravel | Cobble | Boulder | Parent | Rootlets |
|---|---|---|---|---|---|---|---|
| **Riffle Substrate** | ☐ | ☒ | ☒ | ☒ | ☐ | ☐ | ☐ |
| **Pool Substrate** | ☒ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Bank Material** | ☒ | ☒ | ☐ | ☐ | ☐ | ☐ | ☒ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bankfull Width (m)** RU | ~3.0 | ~3.0 | ~3.0 | **Wetted Width (m)** | 0.51 | 0.63 | 0.7 |
| **Bankfull Depth (m)** RU | ~0.4 | ~0.4 | ~0.4 | **Wetted Depth (m)** | 0.2 | 0.15 | 0.23 |

**Riffle/Pool Spacing (m):** 10m | **% Riffles:** 50 | **% Pools:** 50 | **Meander Amplitude:** 3.9

**Pool Depth (m):** WD 300cm BF 450cm | **Riffle Length (m):** 2-5m | **Undercuts (m):** 5cm

**Velocity (m/s):** ⁄ ⁄ ⁄ **Wiffle ball / ADV / Estimated**

**Bank Angle**
☒ 0 – 30
☒ 30 – 60
☒ 60 – 90
☐ Undercut

**Bank Erosion**
☐ < 5%
☒ 5 – 30%
☐ 30 – 60%
☐ 60 – 100%

**Notes:** minimal undercutting - multiple wdj - culverts connecting LB & RB TDS @ 2 sites

**Comments:** US portion - heavily encroached (low WDJ)
DS portion - more WDJ, minimally encroached

Completed by: MK/RJ Checked by: RJ

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**Rapid Geomorphic Assessment** **Project Code:** PN19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | sunny 25°C | **Watershed/Subwatershed:** | Carp river trib |
| **Field Staff:** | MK | **Location:** | Langstaff Rd |

| Process | No. | Geomorphological Indicator: Description | Present? Yes | Present? No | Factor Value |
|---|---|---|---|---|---|
| Evidence of Aggradation (AI) | 1 | Lobate bar | | / | 1/7 |
| | 2 | Coarse materials in riffles embedded | | / | |
| | 3 | Siltation in pools | | / | |
| | 4 | Medial bars | | / | |
| | 5 | Accretion on point bars | / | | |
| | 6 | Poor longitudinal sorting of bed materials | | / | |
| | 7 | Deposition in the overbank zone | | / | |
| | | Sum of indices = | 1 | 6 | 0.14 |
| Evidence of Degradation (DI) | 1 | Exposed bridge footing(s) | NA | | 1/10 |
| | 2 | Exposed sanitary / storm sewer / pipeline / etc. | NA | | |
| | 3 | Elevated storm sewer outfall(s) | | / | |
| | 4 | Undermined gabion baskets / concrete aprons / etc. | | / | |
| | 5 | Scour pools downstream of culverts / storm sewer outlets | | / | |
| | 6 | Cut face on bar forms | | / | |
| | 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 | / | | |
| | | Sum of indices = | 1 | 9 | 0.13 |
| Evidence of Widening (WI) | 1 | Fallen / leaning trees / fence posts / etc. | / | | 3/9 |
| | 2 | Occurrence of large organic debris | / | | |
| | 3 | Exposed tree roots | / | | |
| | 4 | Basal scour on inside meander bends | | / | |
| | 5 | Basal scour on both sides of channel through riffle | | / | |
| | 6 | Outflanked gabion baskets / concrete walls / etc. | | / | |
| | 7 | Length of basal scour >50% through subject reach | | / | |
| | 8 | Exposed length of previously buried pipe / cable / etc. | | / | |
| | 9 | Fracture lines along top of bank | | / | |
| | 10 | Exposed building foundation | NA | | |
| | | Sum of indices = | 3 | 6 | 0.33 |
| Evidence of Planimetric Form Adjustment (PI) | 1 | Formation of chute(s) | | / | 1/7 |
| | 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 = | 1 | 6 | 0.14 |

Additional notes:

**Stability Index (SI) = (AI+DI+WI+PI)/4 =** 0.19

| Condition | In Regime | In Transition/Stress | In Adjustment |
|---|---|---|---|
| SI score = | ☑ 0.00 - 0.20 | ☐ 0.21 - 0.40 | ☐ 0.41 |

Completed by: MK Checked by: RJ

## Rapid Stream Assessment Technique

**Project Code:** PN 19072

| | | | |
|---|---|---|---|
| **Date:** | July 10, 2019 | **Stream/Reach:** | CR-1 |
| **Weather:** | sunny 25°C | **Location:** | Langstaff Rd |
| **Field Staff:** | MK | **Watershed/Subwatershed:** | Carp River trib |

| Evaluation Category | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Channel Stability | • < 50% of bank network stable<br>• Recent bank sloughing, slumping or failure frequently observed | • 50-70% of bank network stable<br>• Recent signs of bank sloughing, slumping or failure fairly common | • 71-80% of bank network stable<br>• Infrequent signs of bank sloughing, slumping or failure | • > 80% of bank network stable<br>• No evidence of bank sloughing, slumping or failure |
| | • Stream bend areas highly unstable<br>• Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)<br>• Bank overhang > 0.8-1.0 m | • Stream bend areas unstable<br>• Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas)<br>• Bank overhang 0.8-0.9m | • Stream bend areas stable<br>• Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas)<br>• Bank overhang 0.6-0.8 m | • Stream bend areas very stable<br>• Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas)<br>• Bank overhang < 0.6 m |
| | • Young exposed tree roots abundant<br>• > 6 recent large tree falls per stream mile | • Young exposed tree roots common<br>• 4-5 recent large tree falls per stream mile | • Exposed tree roots predominantly old and large, smaller young roots scarce<br>• 2-3 recent large tree falls per stream mile | • Exposed tree roots old, large and woody<br>• Generally 0-1 recent large tree falls per stream mile |
| | • Bottom 1/3 of bank is highly erodible material<br>• Plant/soil matrix severely compromised | • Bottom 1/3 of bank is generally highly erodible material<br>• Plant/soil matrix compromised | • Bottom 1/3 of bank is generally highly resistant plant/soil 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 | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 ☐ 5 | ☐ 6 ☐ 7 ☑ 8 | ☐ 9 ☐ 10 ☐ 11 |
| Channel Scouring/ Sediment Deposition | • > 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) |
| | • Few, if any, deep pools<br>• Pool substrate composition >81% sand-silt | • Low to moderate number of deep pools<br>• Pool substrate composition 60-80% sand-silt | • Moderate number of deep pools<br>• Pool substrate composition 30-59% sand-silt | • High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas)<br>• Pool substrate composition <30% sand-silt |
| | • Streambed streak marks and/or "banana"-shaped sediment deposits common | • Streambed streak marks and/or "banana"-shaped sediment deposits common | • Streambed streak marks and/or "banana"-shaped sediment deposits uncommon | • Streambed streak marks and/or "banana"-shaped sediment deposits absent |
| | • Fresh, large sand deposits very common in channel<br>• Moderate to heavy sand deposition along major portion of overbank area | • Fresh, large sand deposits common in channel<br>• Small localized areas of fresh sand deposits along top of low banks | • Fresh, large sand deposits uncommon in channel<br>• Small localized areas of fresh sand deposits along top of low banks | • Fresh, large sand deposits rare or absent from channel<br>• 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 bars small and stable, well-vegetated and/or armoured with little or no fresh sand | • Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand |
| Point range | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 | ☐ 5 ☑ 6 | ☐ 7 ☐ 8 |

| Date: | July 10 2019 | Reach: | CR-1 | Project Code: | PN 19072 |
|---|---|---|---|---|---|

| Evaluation Category | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Physical Instream Habitat | • 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.<br>• 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<br>• Relatively diverse velocity and depth of flow | • Riffles, runs and pool habitat present<br>• Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) |
| | • Riffle substrate composition: predominantly gravel with high amount of sand<br>• < 5% cobble | • Riffle substrate composition: predominantly small cobble, gravel and sand<br>• 5-24% cobble | • Riffle substrate composition: good mix of gravel, cobble, and rubble material<br>• 25-49% cobble | • Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand<br>• > 50% cobble |
| | • 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 | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 | ☐ 5 ☒ 6 | ☐ 7 ☐ 8 |
| Water Quality | • 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<br>• TDS: > 150 mg/L | • Grey colour<br>• TDS: 101-150 mg/L | • Slightly grey colour<br>• TDS: 50-100 mg/L | • Clear flow<br>• 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 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 | ☐ 5 ☐ 6 | ☒ 7 ☐ 8 |
| 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 ☒ 5 5.5 | ☒ 6 ☐ 7 |

| Total overall score (0–42) = 32.5 | Poor (<13) | Fair (13-24) | Good (25-34) | Excellent (>35) |
|---|---|---|---|---|

Completed by: MK Checked by: RE

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## General Site Characteristics

**Project Code:** 19072

| | | | |
|---|---|---|---|
| **Date:** | 09-04-2019 | **Stream/Reach:** | CR-2 |
| **Weather:** | cloudy 20°C | **Location:** | 3754 Carp Rd |
| **Field Staff:** | BM AS | **Watershed/Subwatershed:** | Carp River |

**Features**
- Reach break
- Cross-section
- Flow direction
- Riffle
- Pool
- Medial bar
- Eroded bank
- Undercut bank
- Rip rap/stabilization/gabion
- Leaning tree
- Fence
- Culvert/outfall
- Swamp/wetland
- Grasses
- Tree
- Instream log/tree
- Woody debris
- Station location
- Vegetated island

**Flow Type**

| | |
|---|---|
| **H1** | Standing 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 |

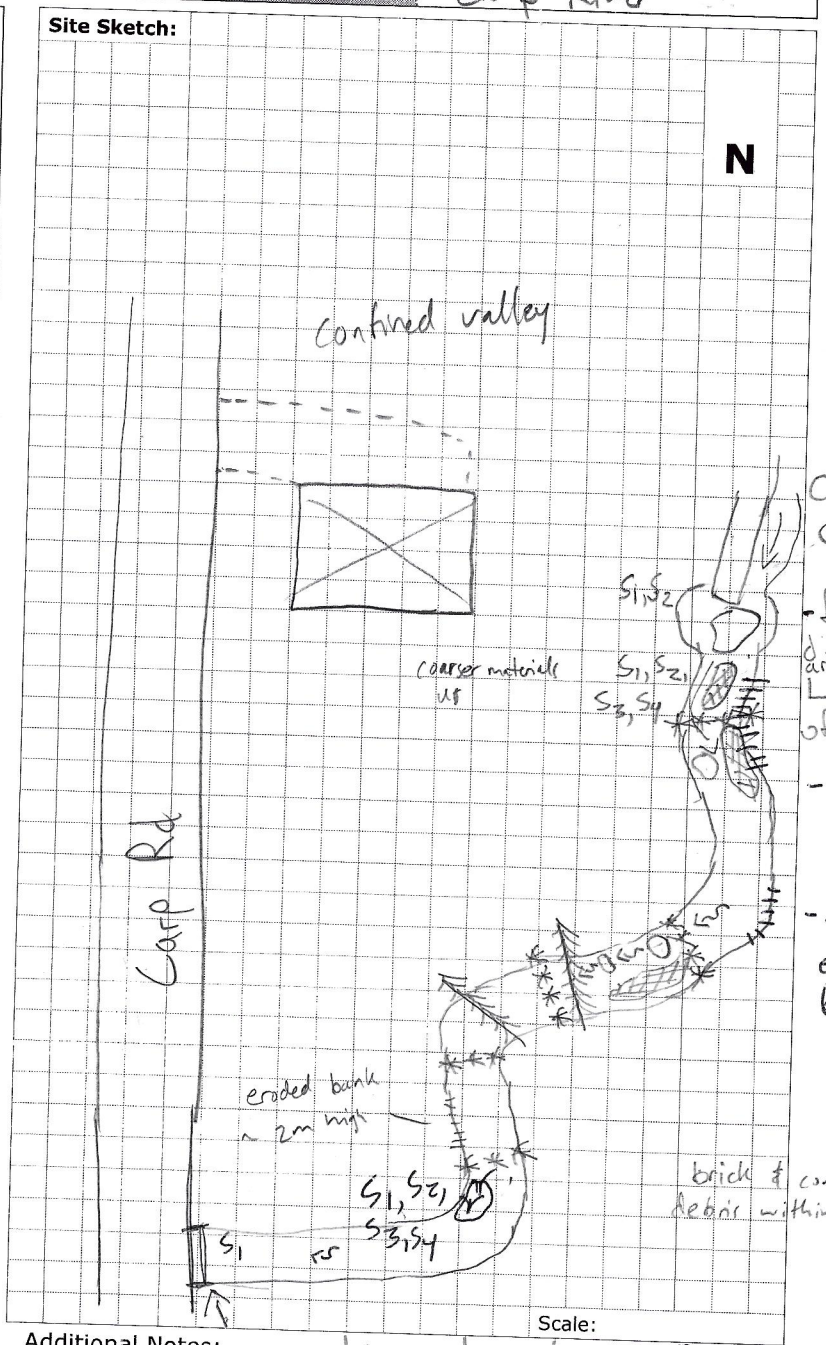
**Substrate**

| | | | |
|---|---|---|---|
| **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:**




Additional Notes: concrete culvert ~0.80m
-0.90 m

→ only had access to ~ 50m of channel

Completed by: TR Checked by: _____

## Reach Characteristics

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**Project Code:** 19072

| | | | |
|---|---|---|---|
| **Date:** | 2019-09-04 | **Stream/Reach:** | CR-2 |
| **Weather:** | Cloudy 20°C | **Location:** | 3754 Carp Rd. |
| **Field Staff:** | TR BM² | **Watershed/Subwatershed:** | Carp River |
| **UTM (Upstream)** | | **UTM (Downstream)** | |

**Land Use** (Table 1): 1/7 | **Valley Type** (Table 2): 2 | **Channel Type** (Table 3): 12 | **Channel Zone** (Table 4): 2/3 | **Flow Type** (Table 5): 1/2 | ☐ Groundwater | Evidence: _____

### Riparian Vegetation

**Dominant Type:** (Table 6): 1,4 | Species: _____

**Coverage:**
- ☐ None
- ☐ Fragmented
- ☒ Continuous

**Channel widths**
- ☐ 1-4
- ☒ 4-10
- ☐ > 10

**Age Class (yrs):**
- ☒ Immature (<5)
- ☒ Established (5-30)
- ☐ Mature (>30)

**Encroachment:** (Table 7): 2

### Aquatic/Instream Vegetation

**Type** (Table8): N/A | Coverage of Reach (%): /

**Woody Debris**
- ☒ Present in Cutbank
- ☒ Present in Channel
- ☐ Not Present

**Density of WD:**
- ☒ Low
- ☐ Moderate
- ☐ High

WDJ/50m: 2

### Water Quality

**Odour** (Table 16): 1

**Turbidity** (Table 17): 1

### Channel Characteristics

**Sinuosity (Type)** (Table 9): 2

**Sinuosity (Degree)** (Table 10): 2

**Gradient** (Table 11): 2

**Number of Channels** (Table 12): 1

**Entrenchment** (Table 13): 1

**Type of Bank Failure** (Table 14): 1

**Downs's Classification** (Table 15): M

| | Clay/Silt | Sand | Gravel | Cobble | Boulder | Parent | Rootlets |
|---|---|---|---|---|---|---|---|
| **Riffle Substrate** | ☒ | ☒ | ☒ | ☒ | ☐ | ☐ | ☐ |
| **Pool Substrate** | ☒ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **Bank Material** | ☒ | ☒ | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Bankfull Width (m)** | 2.1 | 2.2 | 2.7 | **Wetted Width (m)** | 0.92 | 1.1 | 0.77 |
| **Bankfull Depth (m)** | 0.20 | 0.25 | 0.30 | **Wetted Depth (m)** | 0.04 | 0.03 | 0.05 |

**Riffle/Pool Spacing (m):** ~6m | **% Riffles:** / | **% Pools:** / | **Meander Amplitude:** /

**Pool Depth (m):** 0.23 | **Riffle Length (m):** 1.6 | **Undercuts (m):** /

**Velocity (m/s):** _____ | **Wiffle ball / ADV / Estimated**

**Comments:** no true riffle pool sequences

**Bank Angle**
- ☐ 0 – 30
- ☒ 30 – 60
- ☒ 60 – 90
- ☐ Undercut

**Bank Erosion**
- ☐ < 5%
- ☒ 5 – 30%
- ☐ 30 – 60%
- ☐ 60 – 100%

**Notes:**
- some exposed tree roots
- more bank erosion at US extent but largest eroded bank at DS extent

Corridor → ~4 m from toe of slope to toe of slope

Completed by: TR | Checked by: _____

GEO | MORPHIX

## Rapid Geomorphic Assessment

**Project Code:** 19044

| | | | |
|---|---|---|---|
| **Date:** | 2019-09-04 | **Stream/Reach:** | CR-2 |
| **Weather:** | Cloudy 20°C | **Watershed/Subwatershed:** | Carp River |
| **Field Staff:** | TR BM2 | **Location:** | 3754 Carp Road |

| Process | No. | Geomorphological Indicator: Description | Present? Yes | Present? No | Factor Value |
|---|---|---|---|---|---|
| Evidence of Aggradation (AI) | 1 | Lobate bar | | X | 4/7 |
| | 2 | Coarse materials in riffles embedded | | 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 | |
| | | | X | | |
| | | Sum of indices = | 4 | 3 | 0.57 |
| Evidence of Degradation (DI) | 1 | Exposed bridge footing(s) | | N/A | 0/6 |
| | 2 | Exposed sanitary / storm sewer / pipeline / etc. | | N/A | |
| | 3 | Elevated storm sewer outfall(s) | | N/A | |
| | 4 | Undermined gabion baskets / concrete aprons / etc. | | N/A | |
| | 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 = | 0 | 6 | 0 |
| Evidence of Widening (WI) | 1 | Fallen / leaning trees / fence posts / etc. | X | | 3/8 |
| | 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 | |
| | 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 = | 3 | 8 | 0.38 |
| Evidence of Planimetric Form Adjustment (PI) | 1 | Formation of chute(s) | | X | 0/6 |
| | 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 = | 0 | 6 | 0 |

Additional notes:

**Stability Index (SI) = (AI+DI+WI+PI)/4 =** 0.24

| Condition | In Regime | In Transition/Stress | In Adjustment |
|---|---|---|---|
| SI score = | ☐ 0.00 - 0.20 | ☒ 0.21 - 0.40 | ☐ 0.41 |

Completed by: TR Checked by: _____

## Rapid Stream Assessment Technique

**Project Code:** 19072

| | | | |
|---|---|---|---|
| **Date:** | 2019-09-04 | **Stream/Reach:** | CR-2 |
| **Weather:** | Cloudy 20°C | **Location:** | 3754 Carp Road |
| **Field Staff:** | TR BM2 | **Watershed/Subwatershed:** | Carp River |

| Evaluation Category | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Channel Stability | • < 50% of bank network stable<br>• Recent bank sloughing, slumping or failure frequently observed | • 50-70% of bank network stable<br>• Recent signs of bank sloughing, slumping or failure fairly common | • 71-80% of bank network stable<br>• Infrequent signs of bank sloughing, slumping or failure | • > 80% of bank network stable<br>• No evidence of bank sloughing, slumping or failure |
| | • Stream bend areas highly unstable<br>• Outer bank height 1.2 m above stream bank (2.1 m above stream bank for large mainstem areas)<br>• Bank overhang > 0.8-1.0 m | • Stream bend areas unstable<br>• Outer bank height 0.9-1.2 m above stream bank (1.5-2.1 m above stream bank for large mainstem areas)<br>• Bank overhang 0.8-0.9m | • Stream bend areas stable<br>• Outer bank height 0.6-0.9 m above stream bank (1.2-1.5 m above stream bank for large mainstem areas)<br>• Bank overhang 0.6-0.8 m | • Stream bend areas very stable<br>• Height < 0.6 m above stream (< 1.2 m above stream bank for large mainstem areas)<br>• Bank overhang < 0.6 m |
| | • Young exposed tree roots abundant<br>• > 6 recent large tree falls per stream mile | • Young exposed tree roots common<br>• 4-5 recent large tree falls per stream mile | • Exposed tree roots predominantly old and large, smaller young roots scarce<br>• 2-3 recent large tree falls per stream mile | • Exposed tree roots old, large and woody<br>• Generally 0-1 recent large tree falls per stream mile |
| | • Bottom 1/3 of bank is highly erodible material<br>• Plant/soil matrix severely compromised | • Bottom 1/3 of bank is generally highly erodible material<br>• Plant/soil matrix compromised | • Bottom 1/3 of bank is generally highly resistant plant/soil 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 | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 ☐ 5 | ☐ 6 ☐ 7 ☒ 8 | ☐ 9 ☐ 10 ☐ 11 |
| Channel Scouring/ Sediment Deposition | • > 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) |
| | • Few, if any, deep pools<br>• Pool substrate composition >81% sand-silt | • Low to moderate number of deep pools<br>• Pool substrate composition 60-80% sand-silt | • Moderate number of deep pools<br>• Pool substrate composition 30-59% sand-silt | • High number of deep pools (> 61 cm deep) (> 122 cm deep for large mainstem areas)<br>• Pool substrate composition <30% sand-silt |
| | • Streambed streak marks and/or "banana"-shaped sediment deposits common | • Streambed streak marks and/or "banana"-shaped sediment deposits common | • Streambed streak marks and/or "banana"-shaped sediment deposits uncommon | • Streambed streak marks and/or "banana"-shaped sediment deposits absent |
| | • Fresh, large sand deposits very common in channel<br>• Moderate to heavy sand deposition along major portion of overbank area | • Fresh, large sand deposits common in channel<br>• Small localized areas of fresh sand deposits along top of low banks | • Fresh, large sand deposits uncommon in channel<br>• Small localized areas of fresh sand deposits along top of low banks | • Fresh, large sand deposits rare or absent from channel<br>• 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 bars small and stable, well-vegetated and/or armoured with little or no fresh sand | • Point bars few, small and stable, well-vegetated and/or armoured with little or no fresh sand |
| Point range | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 | ☐ 5 ☒ 6 | ☐ 7 ☐ 8 |

| Date: | 2019-09-04 | Reach: | CR-2 | Project Code: | 19072 |
|---|---|---|---|---|---|

| Evaluation Category | Poor | Fair | Good | Excellent |
|---|---|---|---|---|
| Physical Instream Habitat | • 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.<br>• 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<br>• Relatively diverse velocity and depth of flow | • Riffles, runs and pool habitat present<br>• Diverse velocity and depth of flow present (i.e., slow, fast, shallow and deep water) |
| | • Riffle substrate composition: predominantly gravel with high amount of sand<br>• < 5% cobble | • Riffle substrate composition: predominantly small cobble, gravel and sand<br>• 5-24% cobble | • Riffle substrate composition: good mix of gravel, cobble, and rubble material<br>• 25-49% cobble | • Riffle substrate composition: cobble, gravel, rubble, boulder mix with little sand<br>• > 50% cobble |
| | • 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 |
| Point range | ☐ 0 ☐ 1 ☐ 2 | ☐ 3 ☒ 4 | ☐ 5 ☐ 6 | ☐ 7 ☐ 8 |
| Water Quality | • 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<br>• TDS: > 150 mg/L | • Grey colour<br>• TDS: 101-150 mg/L | • Slightly grey colour<br>• TDS: 50-100 mg/L | • Clear flow<br>• 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 ☐ 1 ☐ 2 | ☐ 3 ☐ 4 | ☐ 5 ☐ 6 | ☒ 7 ☐ 8 |
| 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 ☒ 5 | ☐ 6 ☐ 7 |

| Total overall score (0–42) = 30 | Poor (<13) | Fair (13-24) | Good (25-34) | Excellent (>35) |
|---|---|---|---|---|

Completed by: TR Checked by: _____