Cardinal Creek

2022 Catchment Report

Catchment Features	
Area	34.76 square kilometres 0.82% of the Rideau Valley watershed
Land Use	48.2% agriculture 9.5% forest 9.1% meadow 8.3% rural 19.8% urban 0.1% waterbody 5.1% wetlands
Surficial Geology	77.0% clay 6.4% diamicton 0.5% gravel 1.7% organic deposits 13.3% Paleozoic bedrock 1.1% sand
Thermal Regime	Warmwater
Invasive Species	Fourteen invasive species were identified in 2022: bull thistle, common buckthorn, curly-leaved pondweed, dog strangling vine, European frog-bit, flowering rush, glossy buckthorn, goldfish, Manitoba maple, non-native honeysuckle, non-native *Phragmites*, purple loosestrife, rusty crayfish and wild parsnip
Fish Community	Thirty nine fish species have been observed from 2003 to 2022; game fish species include: black crappie, bluegill, brook trout, brown and yellow bullhead, channel catfish, largemouth bass, longnose gar, muskellunge, northern pike, pumpkinseed, rock bass, sauger, shorthead and silver redhorse, walleye, white sucker and yellow perch

Wetland Cover
4.3% are unevaluated wetlands
0.8% are evaluated wetlands

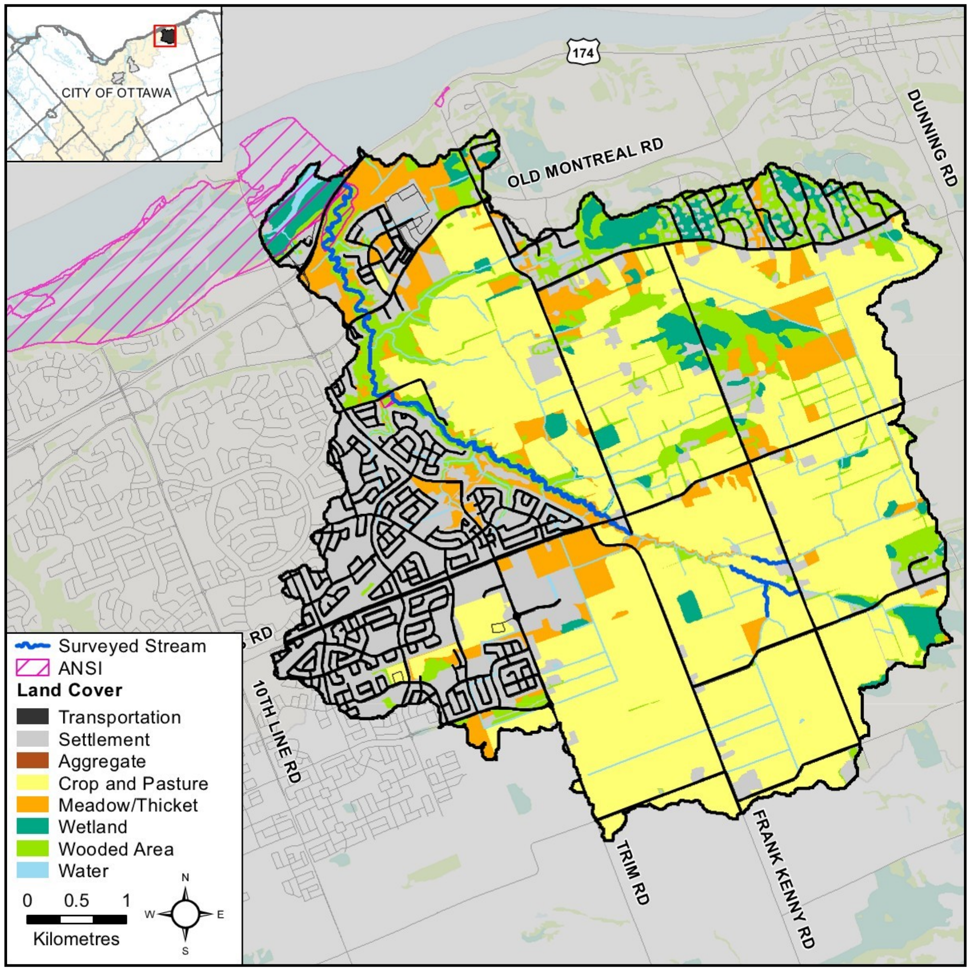


Figure 1 Land cover in the Cardinal Creek catchment

Vegetation Cover		
Type	**Hectares**	**Percent of Cover**
Wooded Areas:	**328.91**	**64.9%**
Hedgerow	29.72	5.9%
Plantation	0.66	0.1%
Treed	298.53	58.9%
Wetlands*	**178.16**	**35.1%**
Total Cover	**507.07**	**100%**

*Includes treed swamps

Woodlot Analysis		
Size Category	**Number of Woodlots**	**Percent of Woodlots**
<1 Hectare	97	65.5%
1 to <10 Ha	46	31.1%
10 to <30 Ha	3	2.0%
>30 Ha	2	1.4%
Total Cover	**148**	**100%**

The Rideau Valley Conservation Authority in partnership with the City of Ottawa, National Capital Commission, Ottawa Flyfishers Society, Canadian Forces Ottawa Fish and Game Club, Ottawa Stewardship Council, Rideau Roundtable, South Nation Conservation and Mississippi Valley Conservation Authority form the City Stream Watch 2022 collaborative.

Introduction

Cardinal Creek is a tributary of the Ottawa River that is approximately eight kilometers long, not including the tributaries that flow into the creek, and drains 35 square kilometers of land. The creek flows in a north-western direction, beginning in the headwaters near Frank Kenny Road and Innes Road, flowing across Watters Road and Old Montreal Road then emptying into the Ottawa River by Highway 174. The land use in the headwaters of the catchment south of Innes Road is primarily agricultural, with several municipal drains flowing into the creek. Downstream from the agricultural areas, the creek flows through residential areas and into an online stormwater management facility that outlets into a karst feature and continues to flow north of Watters Road (RVCA, 2008). At this point the creek flows into an underground cave system and surfaces into a waterfall system. Cardinal Creek is an important ecological area containing two provincially significant Areas of Natural and Scientific Interest (ANSI) one of them being the Cardinal Creek Karst, an earth science ANSI near Watters Road (OMNRF, 2023). The second provincially significant designated area is located where the creek flows into the Ottawa River, known as the Petrie Island provincially significant wetland (OMNRF, 2023).

Since the previous City Stream Watch Cardinal Creek Report, which was completed in 2014, the new community known as Cardinal Creek Village has commenced development. A wetland restoration feature has been created within the floodplain of Cardinal Creek in association with that development.

In 2022, 77 sections (7.7 km) of the main stem of Cardinal Creek and two of its tributaries were surveyed as part of the City Stream Watch monitoring activities. The following is a summary of observations made by staff and volunteers along those surveys.

Section of Cardinal Creek near the confluence with the Ottawa River.

Cardinal Creek Overbank Zone

Riparian Buffer Width Evaluation

The riparian buffer is the adjacent land area surrounding a stream or river. Naturally vegetated buffers are important to protect the health of streams and watersheds. Natural shorelines provide buffering capacity for contaminants and nutrients that would otherwise run off freely into aquatic systems. Well established shoreline plant communities will hold soil particles in place, preventing erosion, and will also provide the stream with shading and cover. Environment and Climate Change Canada recommends a guideline of 30 meters of natural vegetation on both sides of the stream for at least 75 percent of the stream length (Environment Canada, 2013).

Figure 2 demonstrates buffer conditions along the left and right banks of the surveyed sections of Cardinal Creek. Buffers greater than 30 meters were present along 67 percent of the left bank and 71 percent of the right bank. A 15 to 30 meter buffer was present along 17 percent of the left bank and 18 percent of the right bank. A 5 to 15 meter buffer was present along 14 percent of the left bank and 11 percent of the right bank. A five meter buffer or less was present along 2 percent of the left bank only. The buffer width evaluation on the sections surveyed of Cardinal creek fall below recommended guidelines.

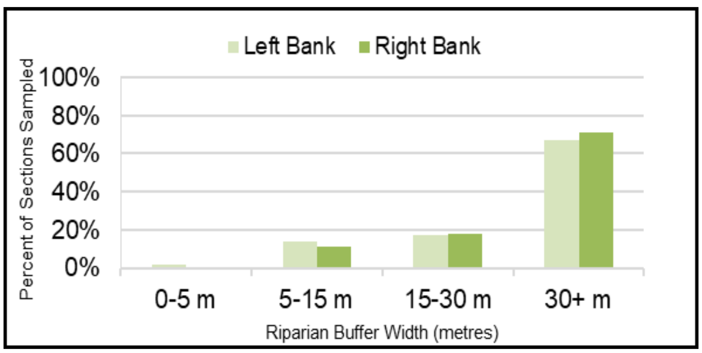


Figure 2 Vegetated buffer width along Cardinal Creek and two tributaries of Cardinal Creek.

Vegetated buffer greater than 30 meters in width along Cardinal Creek upstream Highway 174.

Riparian Buffer Alterations

Alterations within the riparian buffer were assessed within three distinct shoreline zones (0-5 m, 5-15 m, 15-30 m), and evaluated based on the dominant vegetative community and/or land cover type. The evaluation of anthropogenic alterations to the natural riparian cover are shown in Figure 3.

Cardinal Creek surveyed riparian zones were primarily natural, with 86 percent of the right bank and 84 percent of the left bank having dominant natural riparian vegetative communities. Alterations to the riparian buffer accounted for five percent of the right and left banks; highly altered conditions were observed on nine percent of the right bank and ten percent of the left bank. These alterations were associated with infrastructure including roadways and residential land uses.

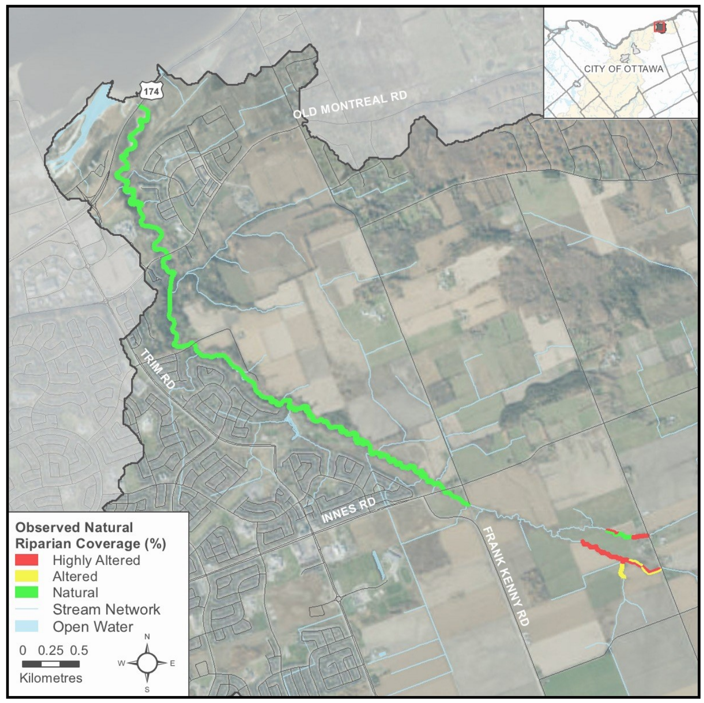


Figure 3 Riparian buffer alterations on Cardinal Creek and two tributaries of Cardinal Creek.

Roadway infrastructure on Watters Road along Cardinal Creek.

Adjacent Land Use

Surrounding land use is considered from the beginning to the end of the survey section (100 m) and up to 100 meters on each side of the creek. Land use outside of this area is not considered for the surveys but is nonetheless part of the subwatershed and will influence the creek. Figure 4 shows the percent of surveyed sections that contain each type of land use.

Forest and scrubland were present in 70 percent and 55 percent of the sections surveyed, being two of the most common land use observed. Wetlands were present in 62 percent of the surveyed areas, and meadow was present in 42 percent of sections.

Aside from the natural areas, the most common land use in the catchment was active agriculture, in 17 percent of sections surveyed. Additionally, abandoned agricultural lands were observed in three percent of sections and pastures were present in 14 percent of sections. Four percent of land use was residential and three percent was attributed to recreational uses, such as walking trails and parks. The other land use observed in six percent of sections was infrastructure, which included the highway, roads and bridges.

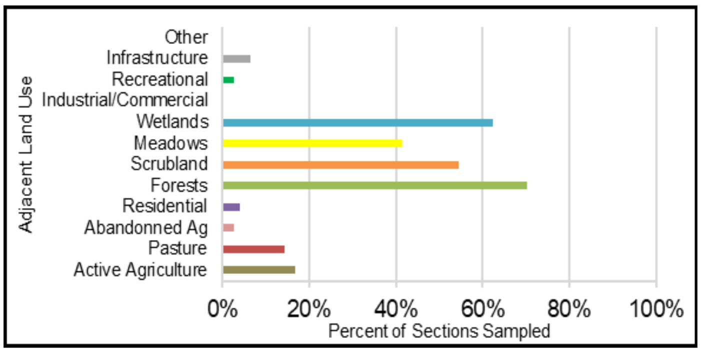


Figure 4 Adjacent land use 100 meters from each shoreline and percentage of presence along Cardinal Creek and two tributaries of Cardinal Creek.

Section along Cardinal Creek near Highway 174 with mix land uses including natural forest, scrubland, meadow and urban infrastructure.

Cardinal Creek Shoreline Zone

Anthropogenic Alterations

Stream alterations were classified based on specific functional criteria associated with potential human influences on the riparian buffer, shoreline state, flow conditions and channel structure.

Figure 5 shows the level of anthropogenic alterations for the 77 sections surveyed in the Cardinal Creek catchment, with 34 sections remaining without any human alteration. Of the areas surveyed, 41 sections fell in the classification of natural. Natural sections had a riparian buffer greater than 15 meters in width and naturally vegetated shorelines.

Two of the surveyed sections were highly altered. The riparian buffers were less than five meters in width in some areas. Two sections were highly altered, containing long road overpasses and reduced riparian buffers.

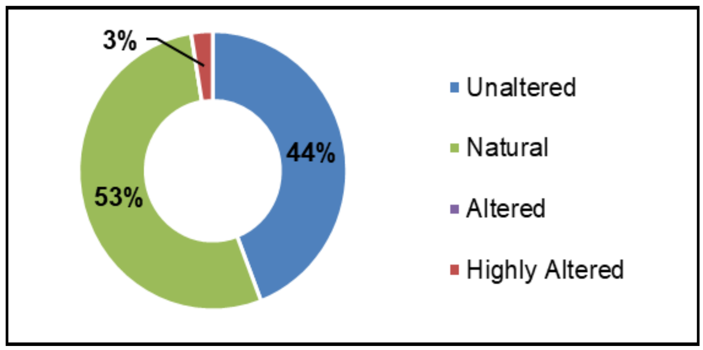


Figure 5 Anthropogenic alterations along Cardinal Creek Cardinal Creek and two tributaries of Cardinal Creek.

Unaltered section of Cardinal Creek with large riparian buffers near Old Montreal Road (above); and a highly altered area with a concrete over pass on Cox County Road (below).

Erosion

Stream erosion is the process by which water erodes and transports sediments, resulting in dynamic flows and diverse habitat conditions. Excessive erosion can result in drastic environmental changes, as habitat conditions, water quality and aquatic life are all negatively affected. Bank stability was assessed as the extent of each section with "unstable" shoreline conditions. These conditions are defined by the presence of significant exposed soils/roots, minimal bank vegetation, undercutting, slumping or scour and potential failed erosion measures (rip rap, gabion baskets, etc.).

Figure 6 shows the location of erosion that was observed across the surveyed portions. Bank instability was observed in 48 percent of the left bank and 51 percent of the right bank of the sections surveyed.

Undercut Stream Banks

A stream bank undercut is a bank that rises vertically or overhangs the stream or creek. Stream bank undercuts can provide excellent cover/shelter habitat for aquatic organisms including fish and benthic invertebrates. However, excessive or deep undercuts can be an indication of unstable shoreline conditions and may result in bank failure or collapse. Bank undercuts were assessed as the extent of each surveyed section with overhanging bank cover present.

Figure 7 shows where undercut banks were present and to what extent each section contained them in Cardinal Creek. Along the left bank, 57 percent of sections had undercut banks; while the right bank had 55 percent of sections with undercut banks.

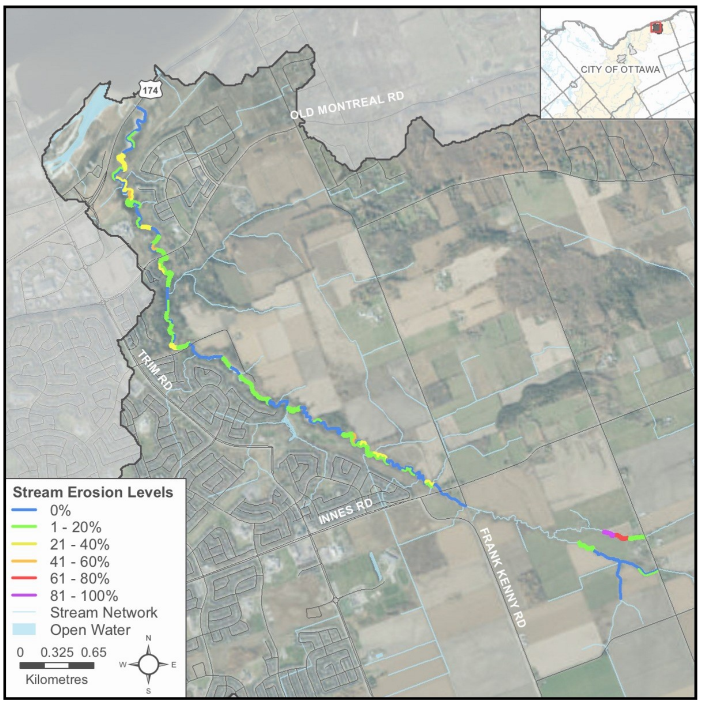


Figure 6 Erosion levels along Cardinal Creek and two tributaries of Cardinal Creek.

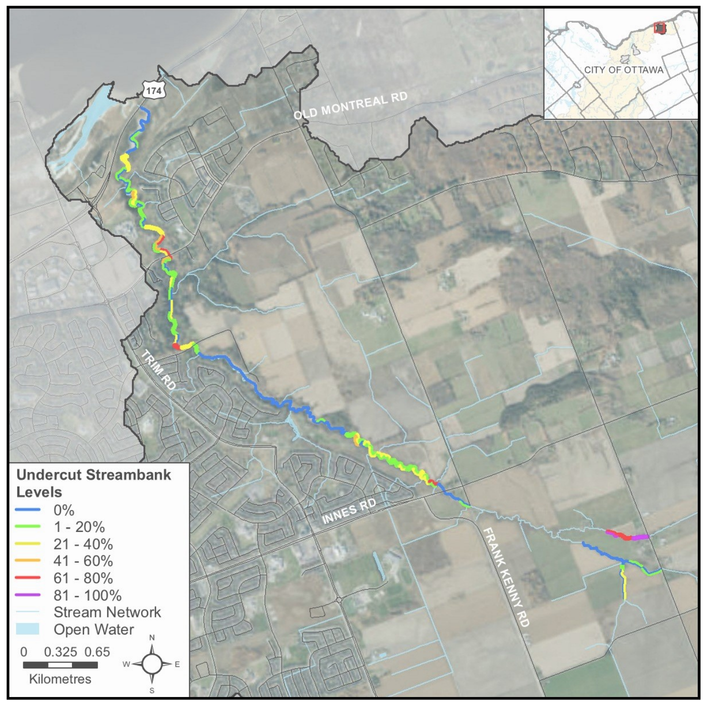


Figure 7 Undercut stream banks along Cardinal Creek and two tributaries of Cardinal Creek.

Bank erosion exposing tree roots, creating instability for trees along the right bank of Cardinal Creek.

Undercut right banks near Caprihani Way along Cardinal Creek.

Stream Shading

Grasses, shrubs and trees all contribute towards shading a stream. Shade is important in moderating stream temperature, contributing to food supply and helping with nutrient reduction within a stream. Stream cover is assessed as the total coverage area in each section that is shaded by overhanging trees/grasses and tree canopy, at greater than one meter above the water surface.

Figure 8 shows the percentage of sections surveyed with various levels of stream shading. The majority of sections, 23 of them, had a shade cover of one to 20 percent. The highest shading levels observed of 81 to 100 percent was present in three sections; 15 sections had a high level of shading of 61 to 80 percent. Five sections had shading levels between 41 to 60 percent and 14 sections had levels between 21 to 40 percent. Seventeen sections had no shading at all.

Figure 9 shows the distribution of these shading levels as a percentage of sections surveyed along Cardinal Creek.

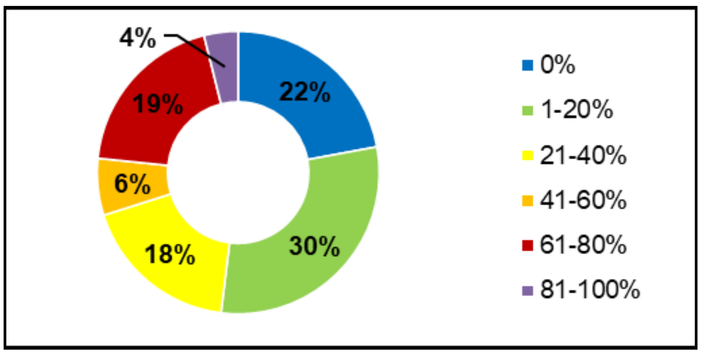


Figure 8 Stream shading levels along Cardinal Creek and two tributaries of Cardinal Creek.

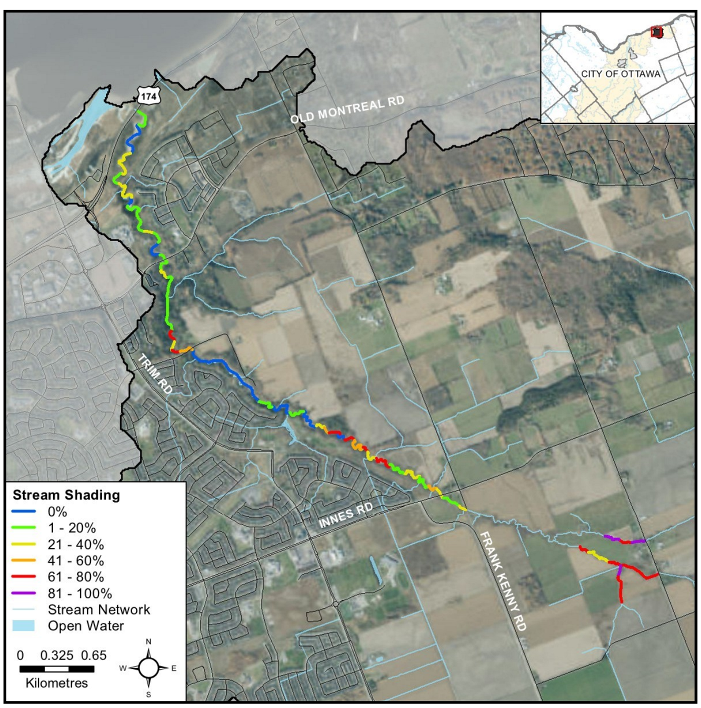


Figure 9 Stream shading along Cardinal Creek and two tributaries of Cardinal Creek.

A mix of trees and plants comprised the majority of shading. Overhanging plants, mainly grasses, robust and broad leaved emergent plants, were seen in 62 percent of the left bank and 60 percent of the right bank.

Overhanging Trees and Branches

Trees and branches that are less than one meter from the surface of the water are defined as overhanging. Overhanging branches and trees provide a food source, nutrients and shade which helps to moderate instream water temperatures.

Figure 10 shows the presence and percentage within each section of overhanging trees and branches that were observed along Cardinal Creek. A total of 70 percent of the left bank, and 53 percent of the right bank of the sections had overhanging trees and branches.

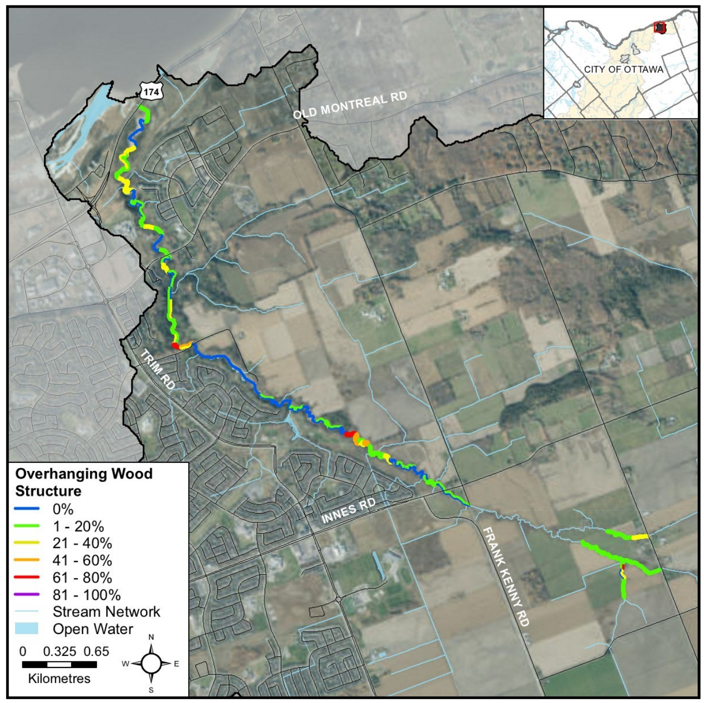
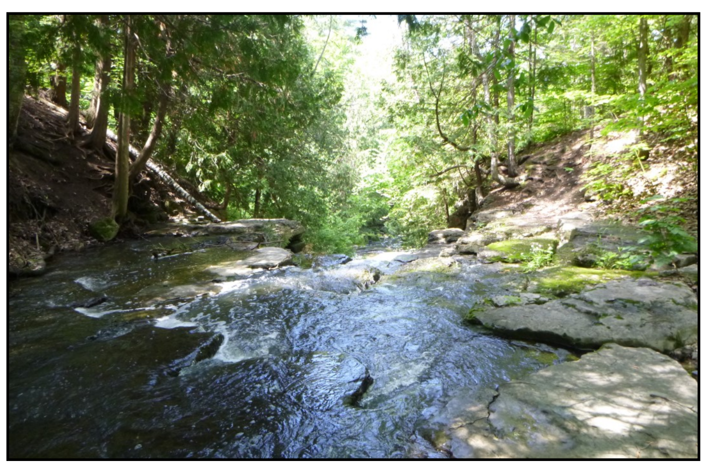


Figure 10 Overhanging trees and branches along Cardinal Creek and two tributaries of Cardinal Creek.



Overhanging trees and shrubs providing shade and cooling stream temperatures along Cardinal Creek.

Cardinal Creek Instream Habitat

Habitat Complexity

Habitat complexity is a measure of the diversity of habitat types and features within a stream. Streams with high habitat complexity support a greater variety of species niches, and therefore contribute to greater diversity. Factors such as substrate, morphologic conditions (pools, riffles) and cover material (vegetation, wood structure, etc.) all provide crucial habitat to aquatic life. Habitat complexity is assessed based on the presence of boulder, cobble and gravel substrates, as well as the presence of instream wood structure. A higher score shows greater complexity where a variety of species can be supported. Figure 11 shows habitat complexity of the sections surveyed: 25 percent had no complexity; 35 percent had a score of one; 13 percent scored two; 19 percent scored three; and eight percent scored four for habitat complexity.

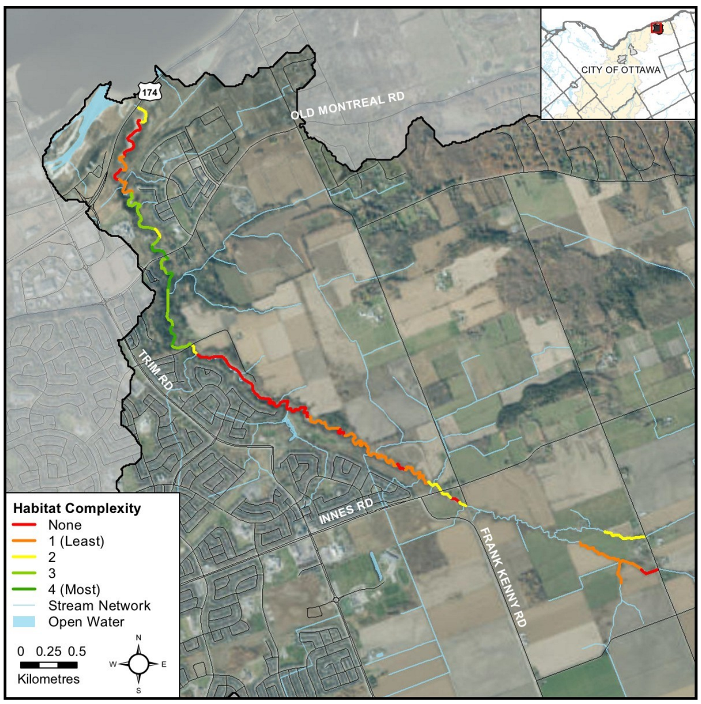


Figure 11 Instream habitat complexity along Cardinal Creek and two tributaries of Cardinal Creek.

Section of Cardinal Creek with complex habitat features including boulders, cobble, gravel and instream wood structure.

Instream Substrate

Diverse substrate is important for fish and benthic invertebrate habitat because some species have specific substrate requirements and for example will only reproduce on certain types of substrate. The absence of diverse substrate types may limit the diversity of species within a stream.

Substrate complexity along Cardinal Creek was observed to be fairly homogenous in 75 percent of sections surveyed, and heterogenous in the remaining 25 percent. Figure 12 shows the substrate types observed. It is a system dominated by silt and clay, with 74 percent of sections containing silt and 62 percent with clay. Over a quarter of the sections surveyed also contained gravel and cobble. Other substrate types included sand, boulders and bedrock.

Figure 13 shows the dominant substrate types along the creek. From the assessed areas the dominant substrate type was silt in 43 percent of sections surveyed, followed by clay in 35 percent, and cobble was third dominant in 17 percent of sections surveyed.

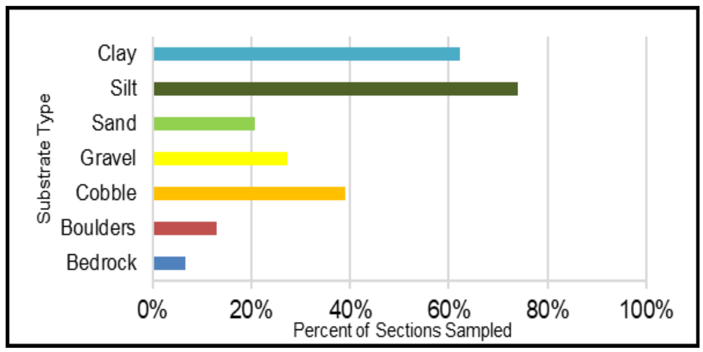


Figure 12 Instream substrate along Cardinal Creek and two tributaries of Cardinal Creek.

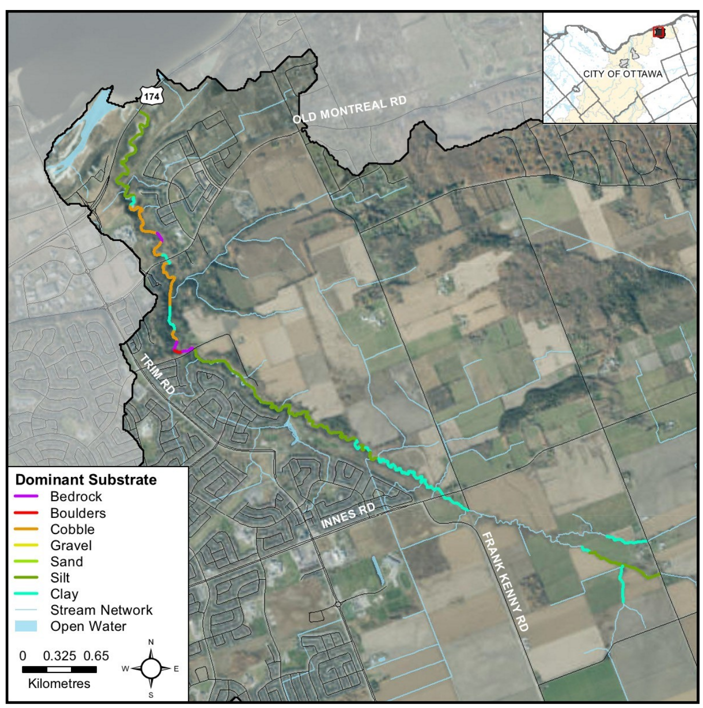


Figure 13 Dominant instream substrates along Cardinal Creek and two tributaries of Cardinal Creek.

Instream Morphology

Pools and riffles are important habitat features for aquatic life. Riffles are fast flowing areas characterized by agitation and overturn of the water surface. Riffles thereby play a crucial role in contributing to dissolved oxygen conditions and directly support spawning for some fish species. They are also areas that support increased benthic invertebrate populations which are an important food source for many aquatic species. Pools are characterized by minimal flows, with relatively deep water and winter and summer refuge habitat for aquatic species. Runs are moderately shallow, with unagitated surfaces of water and areas where the thalweg (deepest part of the channel) is in the center of the channel.

Figure 14 shows that the surveyed portions of Cardinal Creek have a high diversity of morphological conditions, suitable for a variety of aquatic species and life stages; 90 percent of sections contained pools, 29 percent of sections contained riffles and 100 percent contained runs.

Figure 15 shows the locations of sections surveyed which contained riffle habitat.

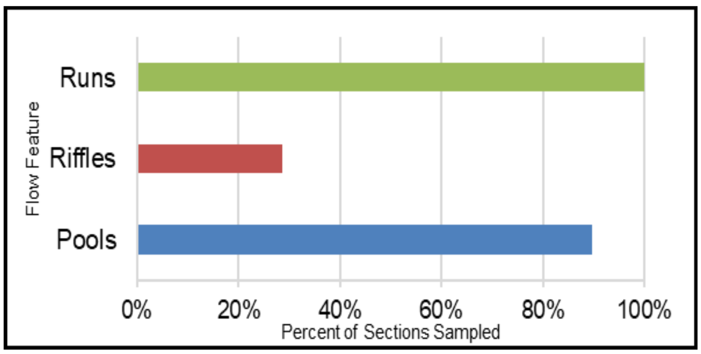


Figure 14 Instream morphology along Cardinal Creek and two tributaries of Cardinal Creek.

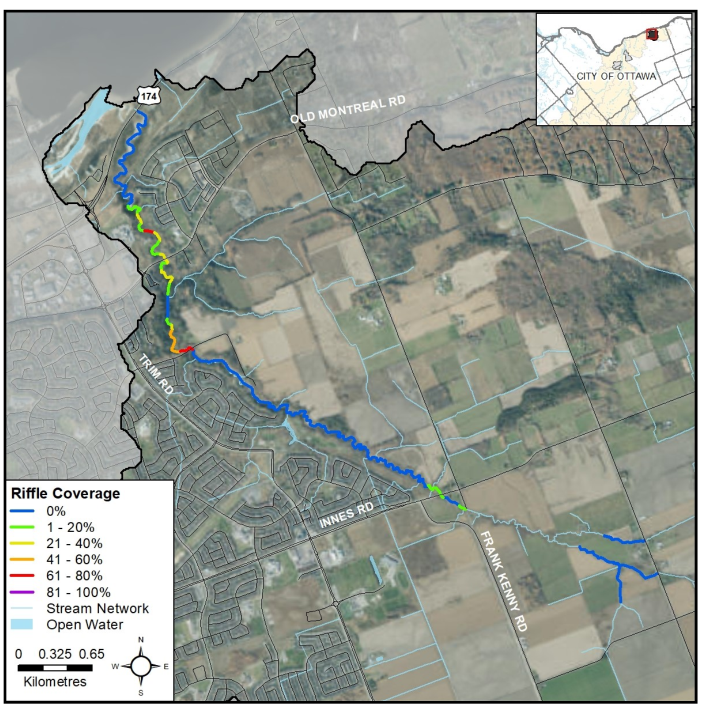


Figure 15 Riffle habitat locations along Cardinal Creek and two tributaries of Cardinal Creek.

Instream Wood Structure

Figure 16 shows that a large portion of Cardinal Creek had moderate levels of instream wood structure in the form of branches and trees. Instream wood structure is important for fish and wildlife habitat, by providing refuge and feeding areas. Excessive amounts can result in temporary seasonal migration barriers. The May 2022 wind storm resulted in a number of trees being downed into Cardinal Creek (RVCA, 2022).

Instream wood structures found along Cardinal Creek are important for fish and wildlife habitat (above), some can become seasonal migration barriers (below).

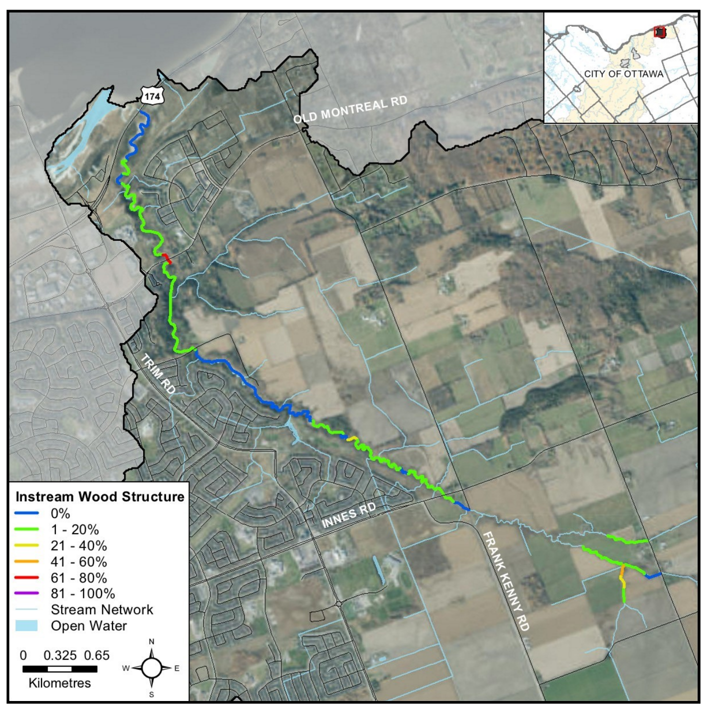


Figure 16 Instream wood structures along Cardinal Creek and two tributaries of Cardinal Creek.

Instream Aquatic Vegetation Type

Instream vegetation is a key component of aquatic ecosystems. It promotes stream health by:

- Providing riparian and instream habitat;
- Maintaining water quality by erosion control, nutrient cycling, and pollutant absorption;
- Stabilizing flows and reducing shoreline erosion;
- Contributing dissolved oxygen via photosynthesis;
- Moderating temperatures through shading.

Figure 17 shows the aquatic vegetation community structure along Cardinal Creek. Vegetation types included: narrow-leaved emergent vegetation in 65 sections; submerged vegetation in 39 sections; algae in 37 sections; broad leaved emergent plants in 24 sections; and robust emergent plants in 21 sections; floating plants in 11 sections; and free-floating plants in one section. There were 34 sections which had areas where no vegetation was present. Figure 18 shows the diversity of the dominant instream aquatic vegetation type by section.

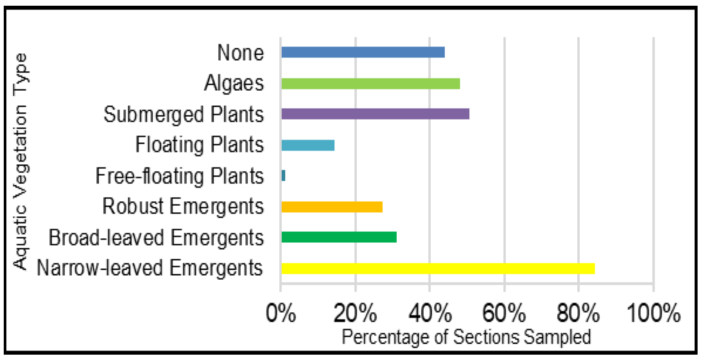


Figure 17 Aquatic vegetation presence along Cardinal Creek and two tributaries of Cardinal Creek.

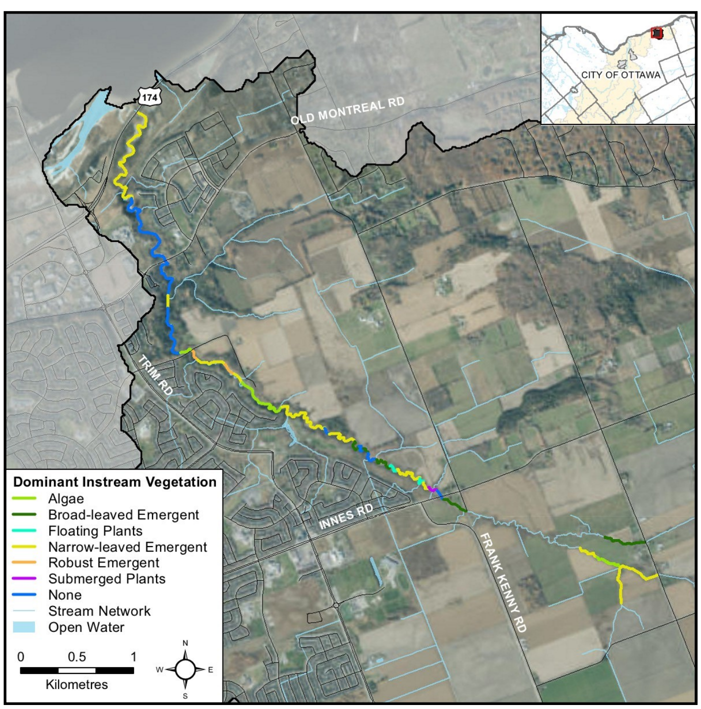


Figure 18 Dominant instream vegetation in Cardinal Creek and two tributaries of Cardinal Creek.

Instream Vegetation Abundance

The abundance of instream vegetation is also crucial for aquatic ecosystem health. Lack, and rare or low abundances can impair the ability of plants to contribute adequately to dissolved oxygen, provide habitat, and remove nutrients and contaminants. Extensive amounts of vegetation can also have negative impacts by lowering dissolved oxygen levels during decomposition. It can act as a physical barrier for humans and wildlife, and it can lead to a reduction in plant diversity. Invasive species in particular tend to have extensive growth.

Abundance of vegetation is classified by the amount of vegetation present along each section. The level of vegetation is categorized based on the extent of its presence in a section, from none or sparse, to parts being choked. As seen in Figure 19, 45 percent of sections along Cardinal Creek had no vegetation in part and 23 percent had rare abundance. Low levels of vegetation abundance were observed in 23 percent of sections and normal levels in 22 percent. Common levels were recorded in 44 percent of sections and extensive levels were in 25 percent of sections.

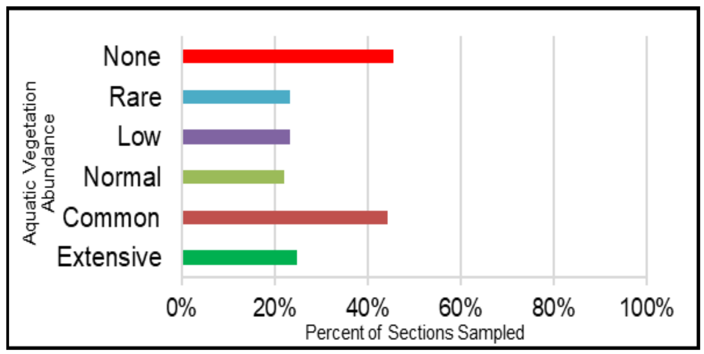


Figure 19 Instream vegetation abundance along Cardinal Creek and two tributaries of Cardinal Creek.

Broad-leaved emergent, narrow-leaved emergent, submerged vegetation and algae observed along Cardinal Creek.

Cardinal Creek Stream Health

Invasive Species

Invasive species are harmful to the environment, the economy and our society. They have high reproduction, quick establishment of dense colonies, tolerate a variety of environmental conditions and lack natural predators. They can have major implications on stream health and reduce species diversity (OMNR 2012). They can be difficult to eradicate, however it is important to continue to research, monitor and manage them. Figure 20 shows the diversity of species observed per section surveyed.

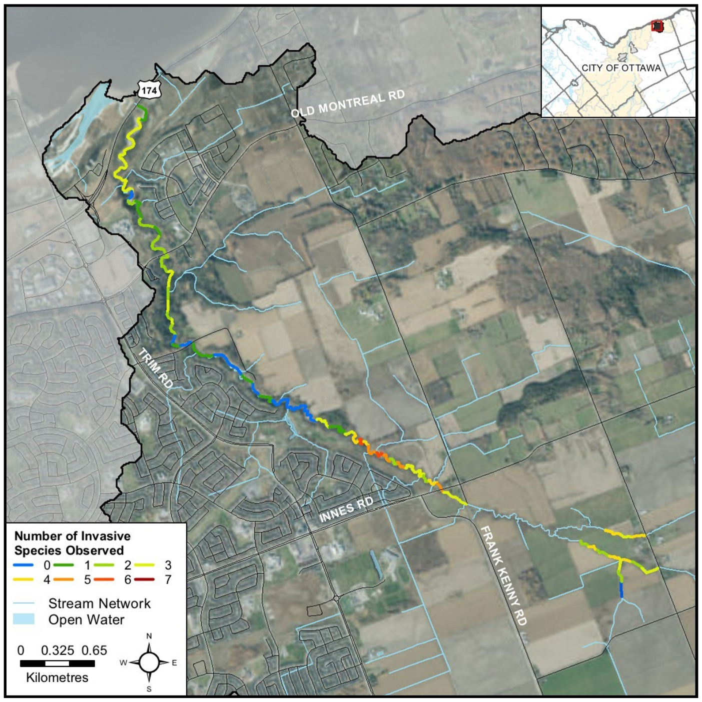


Figure 20 Invasive species diversity along Cardinal Creek and two tributaries of Cardinal Creek.

The following invasive species were observed in the surveyed portions of Cardinal Creek in 2022:

- bull thistle (*Cirsium vulgare*)
- common buckthorn (*Rhamnus cathartica*)
- curly-leaved pondweed (*Potamogeton crispus*)
- Dog strangling vine (*Cynanchum rossicum & nigrum*)
- European frog-bit (*Hydrocharis morsus-ranae*)
- flowering rush (*Botomus umbrellatus*)
- glossy buckthorn (*Rhamnus frangula*)
- goldfish (*Carassius auratus*)
- non-native honeysuckles (*Lonicera spp.)*
- Manitoba maple (*Acer negundo*)
- non-native *Phragmites* (*Phragmites australis*)
- poison/wild parsnip (*Pastinaca sativa*)
- purple loosestrife (*Lythrum salicaria*)
- rusty crayfish (*Orconectes rusticus*)

European frog-bit observed for the first time along the storm-water management pond in Cardinal Creek in 2022.

To report and find information about invasive species visit:

http://www.invadingspecies.com

Managed by the Ontario Federation of Anglers and Hunters.

Pollution

Figure 21 shows where pollution was observed along Cardinal Creek. The levels of garbage found in the main portion of the stream were moderate, with 47 percent of sections surveyed containing no garbage. Floating garbage was found within 38 percent of the surveyed sections. Garbage on the stream bottom was found in 18 percent of sections surveyed. Other garbage such as tires and disposable masks was observed in eight percent of sections.

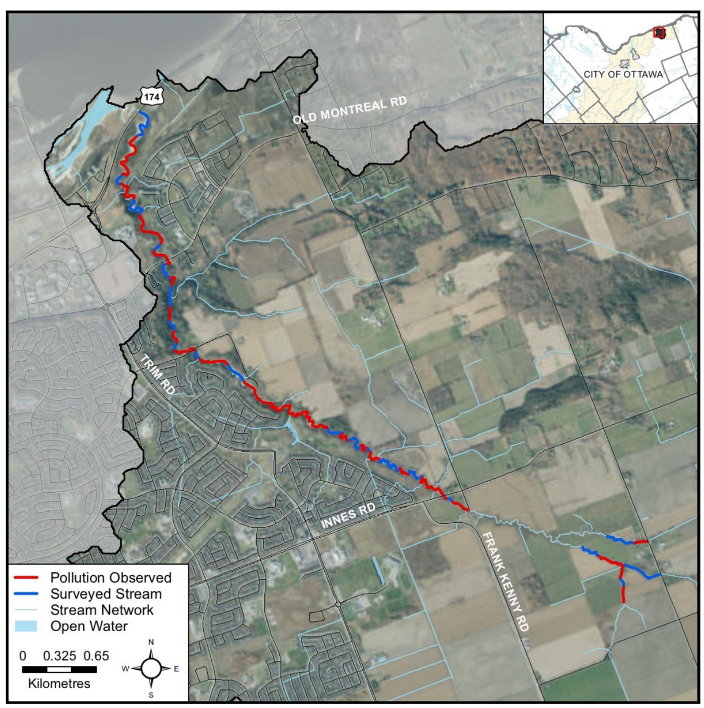


Figure 21 Pollution observed along Cardinal Creek and two tributaries of Cardinal Creek.

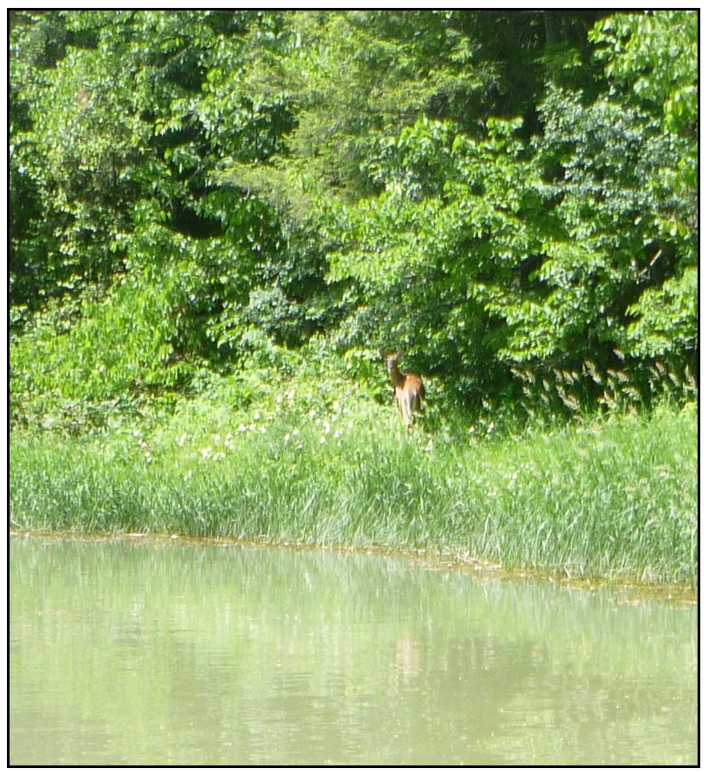
Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and stream health. Wildlife observations were noted during monitoring and survey activities; they do not represent an extensive evaluation of species presence in the Cardinal Creek catchment (Table 1). It is noteworthy to highlight species at risk observed, the monarch butterfly (*Danaus plexippus*) and the snapping turtle (*Chelydra serpentina).*

Green frog, *Rana clamitans*, (above) and a tadpole (below) were amphibians observed along Cardinal Creek.

Table 1 Wildlife observations along Cardinal Creek in 2022

Birds	American Crow, American goldfinch, American redstart, blue jay, broad-winged hawk, Cooper's hawk, common grackle, common yellowthroat, eastern phoebe, great blue heron, grey catbird, killdeer, mallard, northern cardinal, northern flicker, red-winged blackbird, sparrows, swallows, thrushes. Woodpeckers, yellow warbler
Reptiles & Amphibians	green frog, northern leopard frog, snakes, snapping turtle, tadpoles, wood frog
Mammals	American beaver, Canada otter, muskrat, raccoon tracks, squirrels, white-tailed deer
Aquatic Insects & Benthic Invertebrates	craneflies, damselflies, dragonflies, mayfly larvae, snails, whirligig beetle, water striders
Other	bumblebees, butterflies, cabbage white, deer flies, grasshoppers, monarch, mosquitoes, moths, spiders, snails, viceroy



White tailed deer (*Odocoileus virgininanus*) observed along the shoreline of Cardinal Creek.

Cardinal Creek Water Chemistry

Water Chemistry Assessment

Water chemistry collection is done at the start and end of each 100 meter section with a multiparameter YSI probe. The parameters monitored are: air and water temperature, pH, conductivity, dissolved oxygen concentration and saturation.

Volunteers collecting water chemistry measurements with a multiparameter probe.

Dissolved Oxygen

Dissolved oxygen is essential for a healthy aquatic ecosystem, as fish and other aquatic organisms need oxygen to survive. The level of oxygen required is dependent on the particular species and life stage. The lowest acceptable concentration for the early and other life stages according to the Canadian water quality guidelines for the protection of aquatic life are: 6.0 milligrams per liter in warm-water biota and 9.5 milligrams per liter for cold-water biota (CCME 1999).

Figure 22 shows the concentration levels found in the surveyed portions of Cardinal Creek. The two dashed lines depict the Canadian water quality guidelines. Dissolved oxygen levels that are sufficient to support warm-water aquatic life were found in the majority of sections, from the karst areas to the confluence with the Ottawa River (Coyote Trail Park to the mouth). Oxygen levels below the Canadian water quality guidelines were also observed in the upper reaches (Coyote Trail Park to O'Toole Road). Adequate levels of dissolved oxygen were observed in the sections that are classified as agricultural drains, in the headwater reaches, including the two branches. Average concentration levels across the system were 7.4 mg/L.

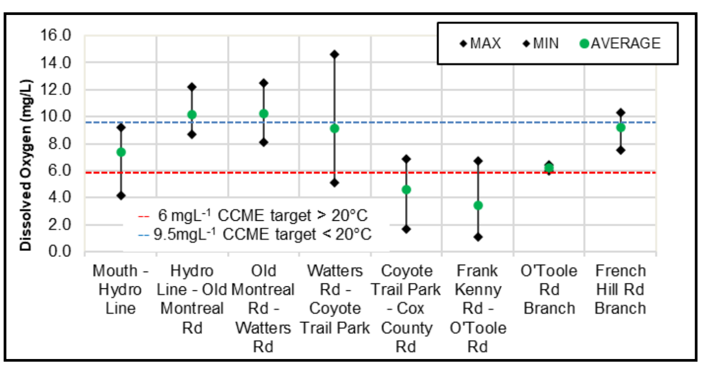


Figure 22 Dissolved oxygen ranges along surveyed sections of Cardinal Creek and two tributaries of Cardinal Creek.

Conductivity

Conductivity is a measure of water's capacity to conduct electrical flow. This capacity is dictated by the presence of conductive ions that originate from inorganic materials and dissolved salts. Water conductivity in natural environments is typically dictated by the geology of the area, however anthropogenic inputs can also have a profound effect. Currently there is no existing guideline for stream conductivity levels, however conductivity measurements outside of normal range across a system are good indicators of anthropogenic inputs including unmitigated discharges and storm water input.

Figure 23 shows specific conductivity levels in Cardinal Creek. The average level is depicted by the dashed line (863 µS/cm). Conductivity levels are lower in areas downstream of Montreal Road. Higher levels were observed in the sections closer to stormwater management facilities and agricultural areas (Watters Road to O'Toole Road).

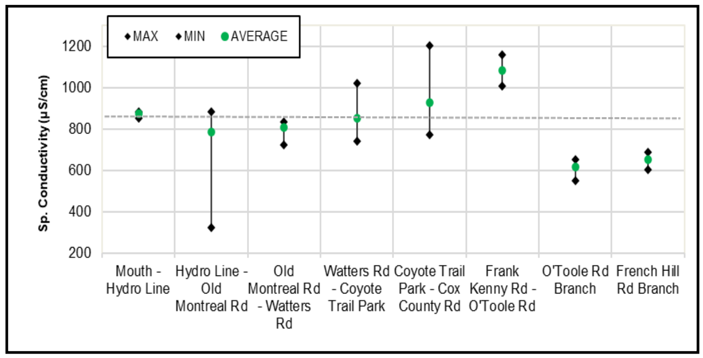


Figure 23 Specific Conductivity ranges along surveyed sections of Cardinal Creek and two tributaries of Cardinal Creek.

pH

pH is a measure of alkalinity or acidity. This parameter is influenced by the geology of the system but it can also be influenced by anthropogenic inputs. For pH the provincial water quality objective (PWQO) recommends a range of 6.5 to 8.5 to protect aquatic life (MOEE 1994).

Figure 24 shows Cardinal Creek had pH levels that meet the PWQO, depicted by the dashed lines. The average levels across the system was pH 7.77.

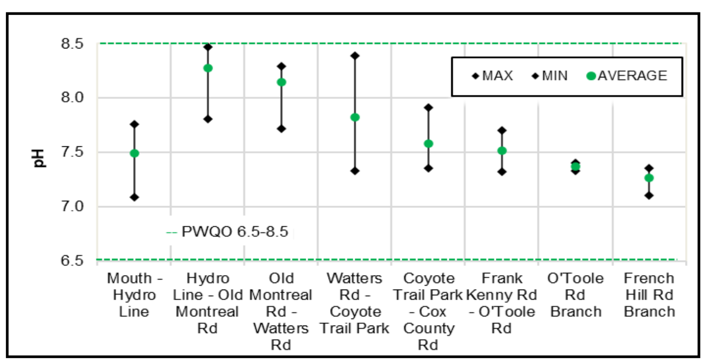


Figure 24 pH ranges along surveyed sections of Cardinal Creek and two tributaries of Cardinal Creek.

Oxygen Saturation (%)

Oxygen saturation is measured as the ratio of dissolved oxygen relative to the maximum amount of oxygen that will dissolve based on the temperature and atmospheric pressure. Well oxygenated water will stabilize at or above 100 percent saturation, however the presence of decaying matter/pollutants can drastically reduce these levels. Oxygen input through photosynthesis has the potential to increase saturation above 100 percent to a maximum of 500 percent, depending on the productivity level of the environment. In order to represent the relationship between concentration and saturation, the measured values have been summarized into 6 classes:

1) <100% Saturation / <6.0 mg/L Concentration

Oxygen concentration and saturation are not sufficient to support aquatic life and may represent impairment.

2) >100% Saturation / <6.0 mg/L Concentration

Oxygen concentration is not sufficient to support aquatic life, however saturation levels indicate that the water has stabilized at its estimated maximum. This is indicative of higher water temperatures and stagnant flows.

3) <100% Saturation / 6.0—9.5 mg/L Concentration

Oxygen concentration is sufficient to support warm-water biota, however depletion factors are likely present and are limiting maximum saturation.

4) >100% Saturation / 6.0—9.5 mg/L Concentration

Oxygen concentration and saturation levels are optimal for warm-water biota.

5) <100% Saturation / >9.5 mg/L Concentration

Oxygen concentration is sufficient to support cold-water biota, however depletion factors are likely present and are limiting maximum saturation.

6) >100% Saturation / >9.5 mg/L Concentration

Oxygen concentration and saturation levels are optimal for warm and cold-water biota.

Section on Cardinal Creek near Innes Road with **impaired** oxygen conditions (Dissolved oxygen levels of 5.18 mg/L and 63.7 % saturation).

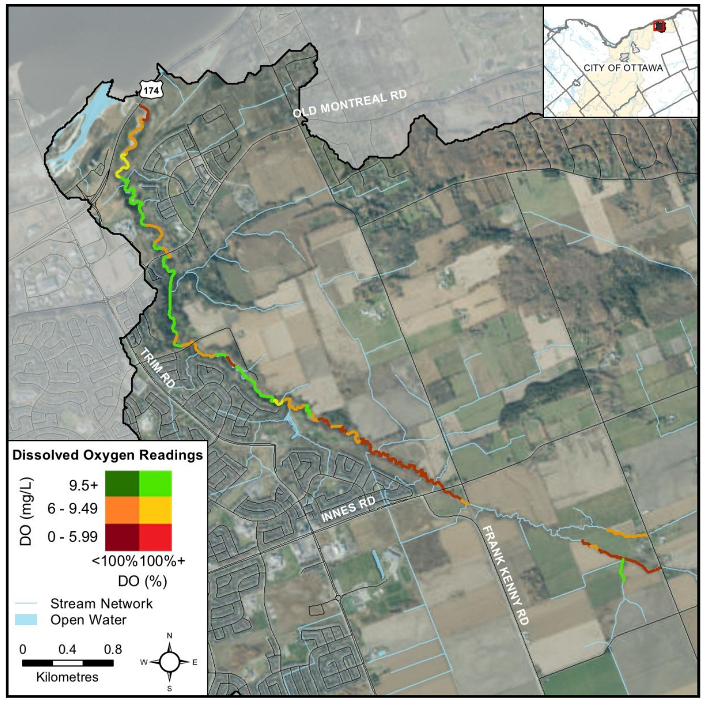


Figure 25 Bivariate assessment of dissolved oxygen concentration (mg/L) and saturation (%) along Cardinal Creek and two tributaries of Cardinal Creek.

Figure 25 shows the oxygen conditions across the areas that were surveyed in 2022. Dissolved oxygen conditions in Cardinal Creek were sufficient to sustain cold-water and warm-water biota in areas from Caprihani Way to the confluence with the Ottawa River. Sections shown in dark red, had significant levels of impairment both in concentration and percent saturation. The areas north of Innes Road had wetland features that have naturally lower oxygen levels. The largest influence of oxygen levels is the agricultural land use of the surrounding areas. Systems that are dominated by agricultural land use can have higher nutrient loading on the system which can generate increased algae levels that have the effect of depleting oxygen in the system. There were some areas with higher concentrations and saturation conditions in the headwater reaches. Various fish species were observed in these sections, even though the average conditions are low in oxygen, there were refuge areas in the system. To mitigate this issue it is recommended that efforts focus on increasing riparian vegetation by planting trees and shrubs in the headwaters, which can help cool the system and reduce the amount of nutrients from entering the tributaries.

Section on Cardinal Creek near Anderson Road with **optimal** oxygen conditions for warm-water biota (Dissolved oxygen levels of 12.5 mg/L and 130.0 % saturation).

Specific Conductivity Assessment

Specific conductivity (SPC) is a standardized measure of electrical conductance, collected at or corrected to a water temperature of 25°C. SPC is directly related to the concentration of ions in water, and is influenced by the area geology and anthropogenic input as it contributes to the presence of dissolved salts, alkalis, chlorides, sulfides and carbonate compounds. The higher the concentration of these compounds, the higher the conductivity. Common sources of elevated conductivity include stormwater, agricultural inputs and commercial or industrial effluents.

In order to summarize the conditions observed, levels were evaluated as either normal, moderately elevated or highly elevated. These categories are defined by the amount of variation (standard deviation) at each section compared to the system's average.

Average levels of specific conductivity measured in the surveyed portions of Cardinal Creek (826.6 µS/cm) exceeded guidelines (500 µS/cm) used for the Canadian Environmental Performance Index (Environment Canada 2011).

Figure 26 shows relative specific conductivity levels in Cardinal Creek. Normal levels were maintained for most of the surveyed portions. Moderately elevated conditions were observed approaching Innes Road and the headwater reaches. This area has agricultural land use influences and road runoff, contributing to ion loading to the system.

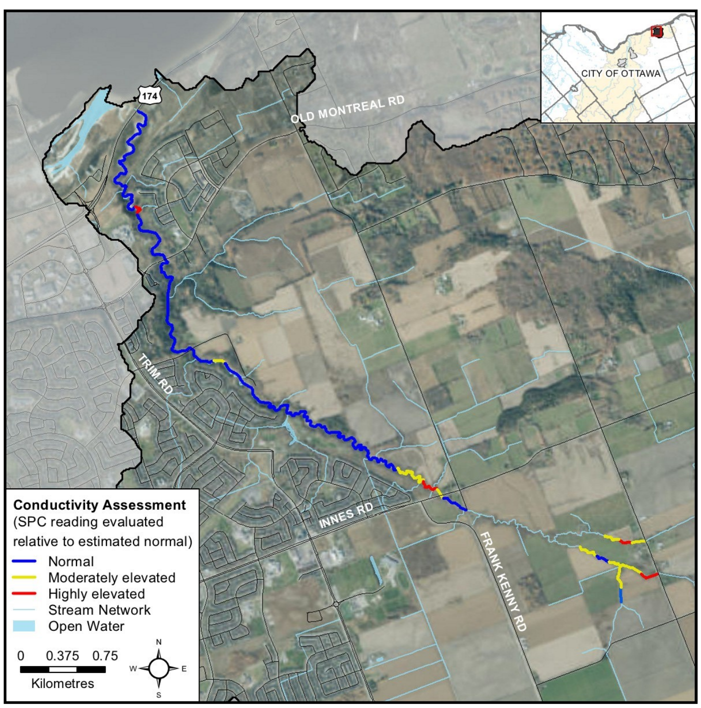


Figure 26 Relative specific conductivity levels along Cardinal Creek and two tributaries of Cardinal Creek.

Groundwater

Groundwater discharge areas can influence stream temperature, contribute nutrients, and provide important stream habitat for fish and other biota. During stream surveys, indicators of groundwater discharge were noted when observed (Figure 27). Indicators included: springs/ seeps, watercress, iron staining, significant temperature changes and rainbow mineral film.

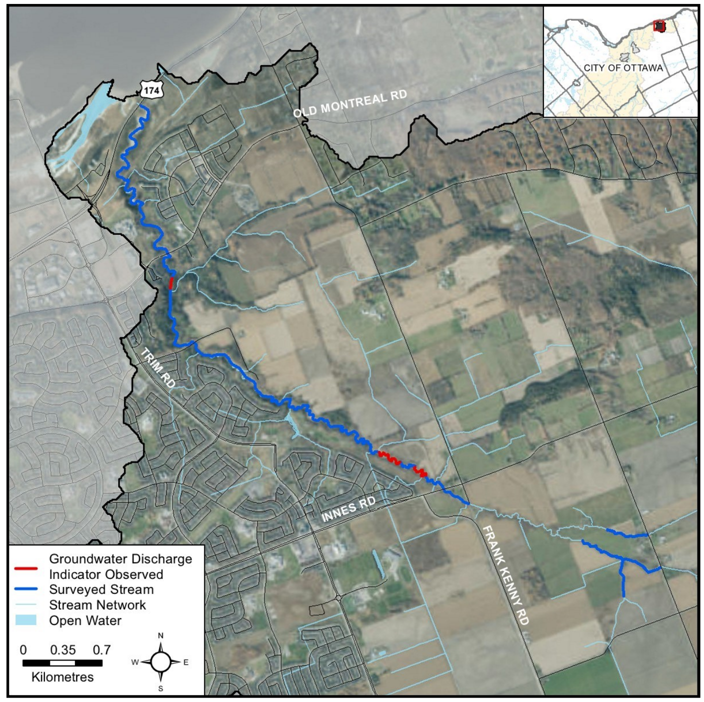


Figure 27 Groundwater indicators observed along Cardinal Creek and two tributaries of Cardinal Creek.

Section of Cardinal Creek where a groundwater seep was observed with visible iron staining.

Cardinal Creek Thermal Classification

Thermal Classification

Instream water temperatures are influenced by various factors including season, time of day, precipitation, storm water run off, springs, tributaries, drains, discharge pipes, stream shading from riparian vegetation and artificial shade created by infrastructure. To monitor water temperatures in Cardinal Creek, three temperature loggers were placed in early June and retrieved at the end of September.

Figure 28 shows where thermal sampling sites were located. One additional instrument was lost and data is missing at a fourth location not depicted. Analysis of data from three loggers (using the Stoneman and Jones, 1996, method adapted by Chu et al., 2009), indicate Cardinal Creek is classified as a **warm-water** system. Figures 29 and 30 show a comparison of thermal conditions from 2014 and 2022. The system appears to be shifting to a warmer thermal regime classification, may be due to different site locations of thermal loggers.

Fish species observed in the monitored areas have thermal preferences from cool to warm as indicated by Coker et al. (2001).

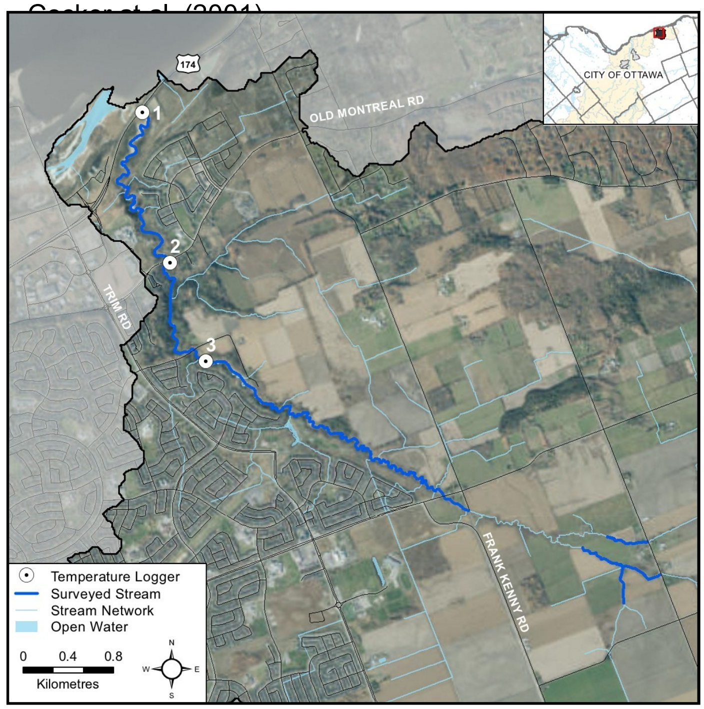


Figure 28 Temperature logger locations on Cardinal Creek.

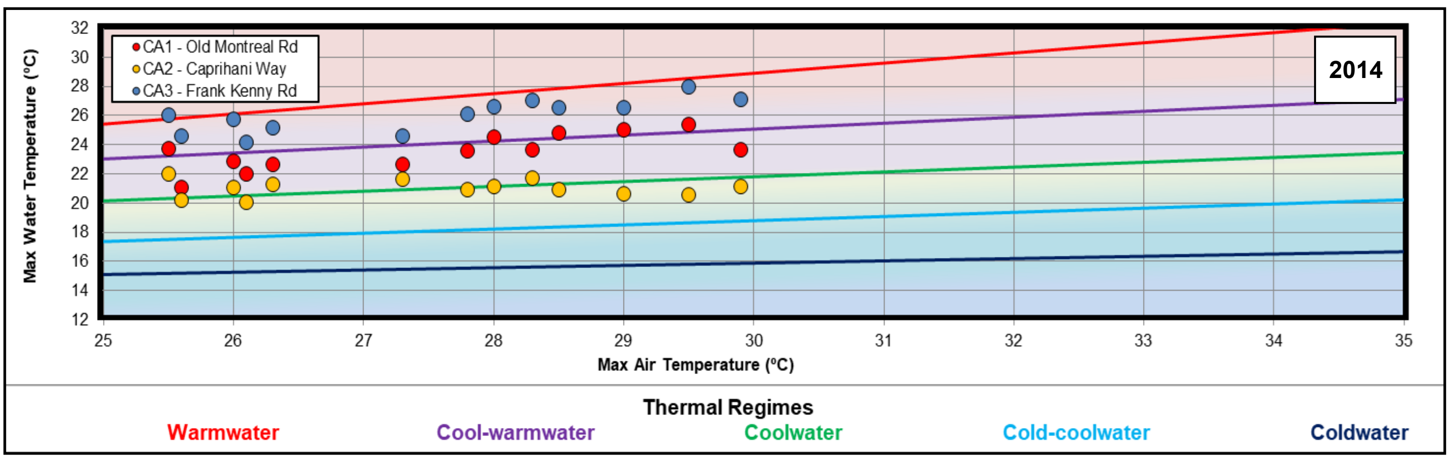


Figure 29 Thermal Classification for Cardinal Creek with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009): conditions range from **cool-warm water** (CA1 and CA2) to the **warmater** (CA3) category for Cardinal Creek in **2014.**

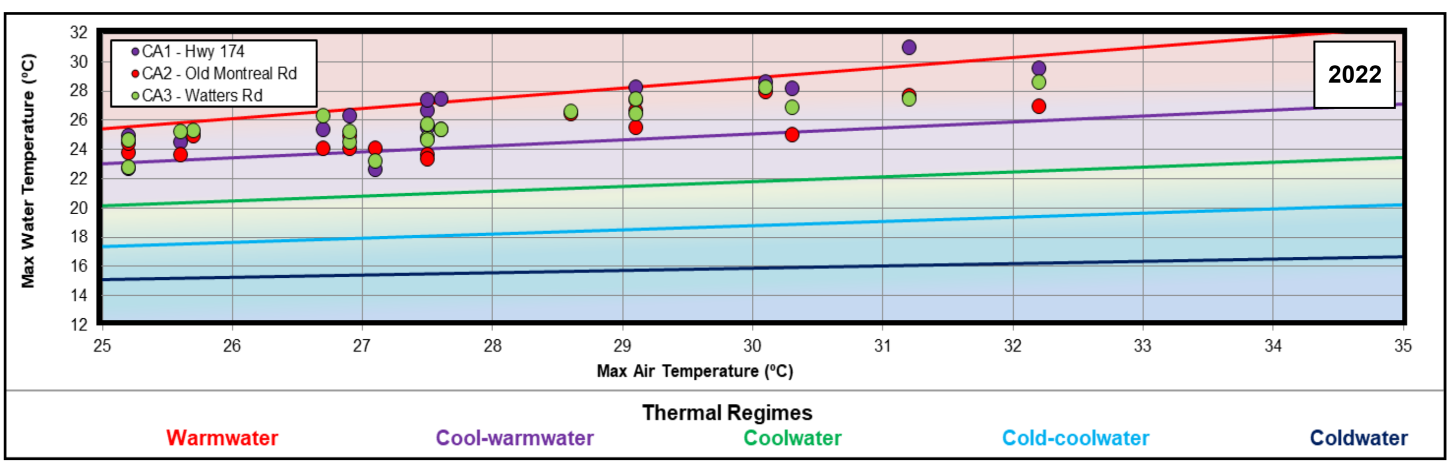


Figure 30 Thermal Classification for Cardinal Creek with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009): conditions are in the **warm water** category for Cardinal Creek in **2022.**

Cardinal Creek Fish Community

Fish Community Summary

Three fish sampling sites were evaluated between May and July 2022. Two site locations were sampled with the use of a backpack electrofishing unit, and two sites were sampled with a bag seine net.

Fourteen species were captured in 2022, they are listed in Table 2 along with their thermal classification preferences (Coker et al., 2001) and MNR species codes. Cardinal Creek had a mixed fish community ranging from cold-cool to warm water species.
The sampling locations where these species were observed, as well as RVCA historical sites, are depicted in Figure 31. The codes used in the figure are the MNR species codes provided in Table 2. For comparisons across sampling years and a complete list of RVCA historical fish records from Cardinal Creek refer to page 19 of this report.

Table 2 Fish species observed in Cardinal Creek in 2022.

Species	Thermal Class	MNR Species Code
Bluegill *Lepomis microchirus*	**Warm**	Blueg
Bluntnose minnow *Pimephales notatus*	**Warm**	BnMin
Brook stickleback *Culaea inconstans*	**Cool**	BrSti
Brown bullhead *Ameiurus nebulosus*	**Warm**	BrBul
Carps and minnows unidentified species	**Cool to Warm**	CA_MI
Central mudminnow *Umbra limi*	**Cool**	CeMud
Common shiner *Luxilus cornutus*	**Cool**	CoShi
Creek chub *Semotilus atromaculatus*	**Cool**	CrChu
Darter species *Etheostoma spp.*	**Cool**	EthSp
Fathead minnow *Pimephales promelas*	**Warm**	FhMin
Longnose dace *Rhinichtys cataractae*	**Cool**	LnDac
Pumpkinseed *Lepomis gibbosus*	**Warm**	Pumpk
Rock bass *Ambloplites rupestris*	**Cool**	RoBas
White sucker *Catostomus commersonii*	**Cool**	WhSuc
Yellow perch *Perca flavescens*	**Cool**	YePer
Total Species		**14**

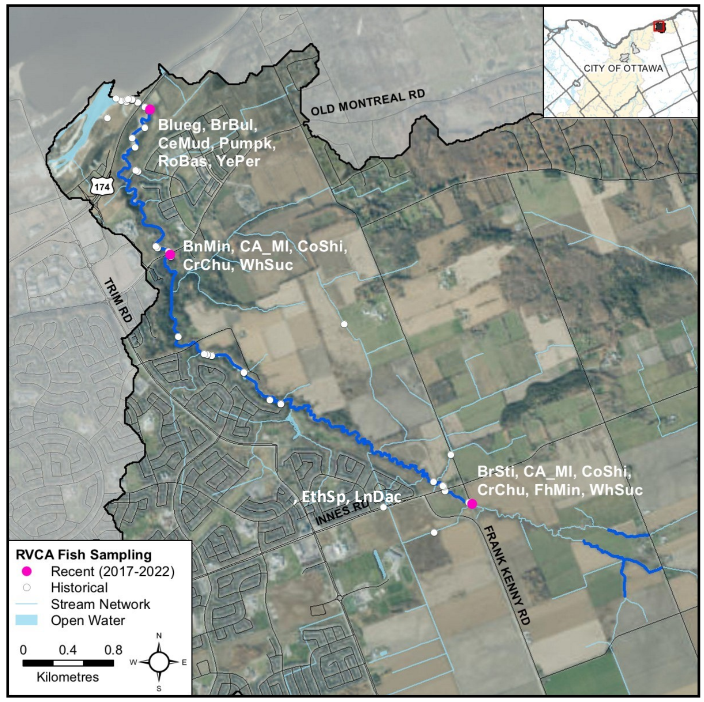


Figure 31 Cardinal Creek fish sampling locations (historical in white, 2022 in pink) and fish species observations from 2022.

Fish community sampling by electrofishing in Cardinal Creek.

Bluegill. *Lepomis microchirus*, (above) and a yellow perch, *Perca flavescens*, (below) observed in Cardinal Creek.

Migratory Obstructions

It is important to know locations of migratory obstructions because these can prevent fish from accessing important spawning and rearing habitat. Migratory obstructions can be natural or manmade, and they can be permanent or seasonal.

There were migratory obstructions observed along the surveyed portions of Cardinal Creek. The migratory obstructions observed during stream surveys in 2022 are shown in Figure 32. Most were grade barriers, which are naturally occurring. There was also a weir structure associated with the online stormwater management facility.

Natural waterfalls create grade barriers which result in upstream fish passage obstructions, however fish populations adapt to these natural conditions.

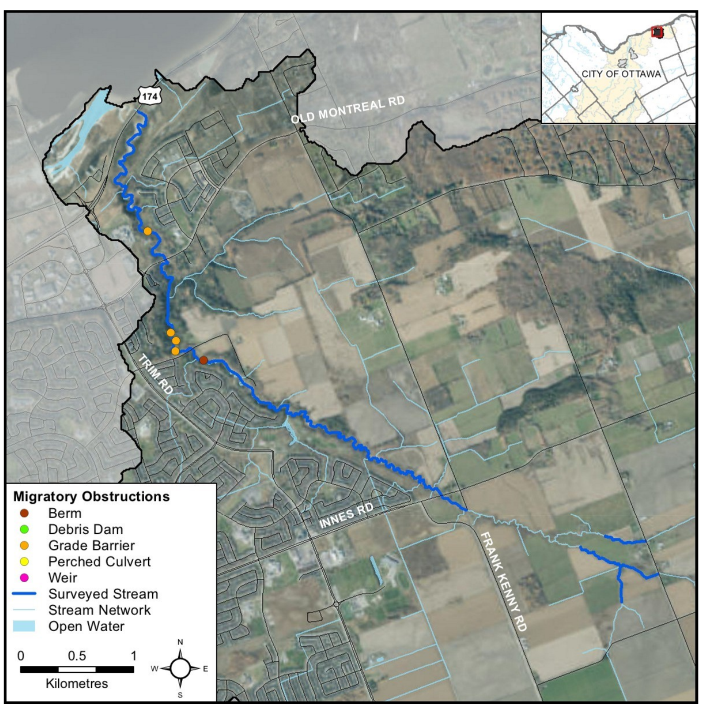


Figure 32 Locations of migratory obstructions along Cardinal Creek and two tributaries of Cardinal Creek.

Beaver Dams

Beaver dams create natural changes in the environment. Some of the benefits include providing habitat for fish and wildlife, flood control, baseflow during low water conditions and sediment retention. Additional benefits come from bacterial decomposition of wood material used in the dams which removes excess nutrient and toxins. Beaver dams can in certain circumstances result in seasonal barriers to fish migration. They can also put important infrastructure at risk upstream of the dam location. If this is an issue, there are dam flow device options that can be considered and potentially implemented that balance the risks to infrastructure while supporting the ecosystem created by the dam.

In 2022 three beaver dams were identified on the surveyed portions of Cardinal Creek and are shown in Figure 33. One was abandoned, one was active and the last was breached.

An active beaver dam along Cardinal Creek upstream of Innes Road.

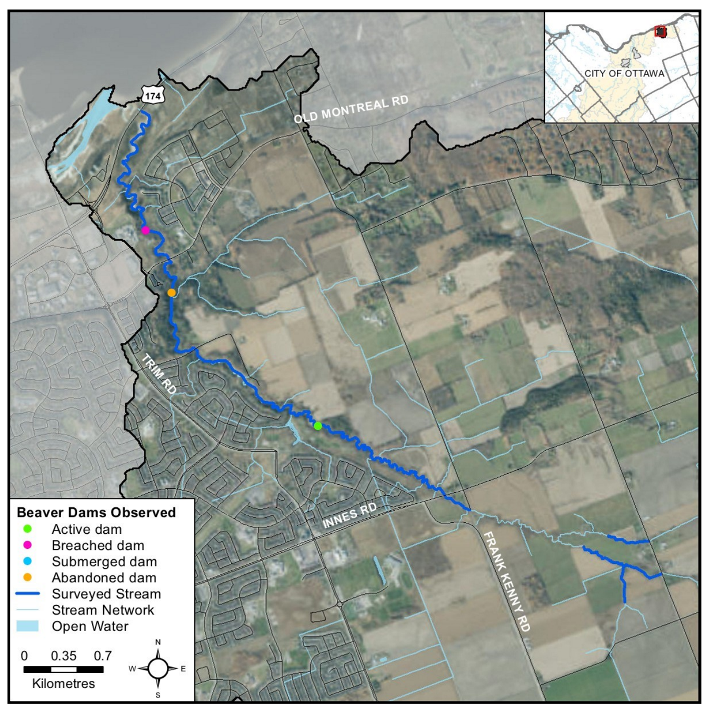


Figure 33 Locations of beaver dams along Cardinal Creek and two tributaries of Cardinal Creek.

Stream Comparison Between 2003, 2008, 2014 and 2022

The following tables provide a comparison of observations on Cardinal Creek between the 2003, 2008, 2014 and 2022 survey years (RVCA, 2003; RVCA, 2008; RVCA, 2014). Monitoring protocols since 2003 have been modified and enhanced, so only certain data from previous years can be compared to later years. In order to accurately represent current and historical information, the data was only compared for those sections surveyed in all years presented. This information is a comparative evaluation and doesn't represent the entirety of our assessment.

Water Chemistry

Water chemistry parameters are collected throughout all the sections surveyed in the stream. This criteria reflects the conditions and changes in the environment. Variation in these conditions can be attributed to environmental and ecological changes. Some can be in part due to natural variability within the system from various weather, seasonal, and annual conditions. Table 3 shows a comparison of these water chemistry parameters between 2014 and 2022, as well as certain indicators from 2008.

Average pH decreased by 0.16 units from 2014 to 2022 and specific conductivity increased from 2014 by 26.1 µS/cm. These slight changes may reflect seasonal variability. Average dissolved oxygen levels were found to be lower by 1.7 milligrams per liter from 2014 to 2022. These changes can also be attributed to seasonal conditions and cooler temperatures which are conducive to the stream's ability to hold more oxygen.

Average summer water temperatures range from warmer water in 2022 (20.1°C) to cooler values in 2014 (18.0°C) and in 2008 (15.8°C), with 4.3 degrees centigrade of variation. In 2022 warmer temperatures were observed than in previous reporting years, this may be due in part to different sampling windows, however there does appear to be a shift in thermal regime from coolwarm to warmwater. Observations from 2008 were made from June to late September, in 2014 from June to early September, whereas observations in 2022 were made from late June to early August.

Table 3 Water chemistry comparison (2008, 2014 and 2022).

Water Chemistry (2008, 2014 and 2022)				
Year	**Parameter**	**Unit**	**Average**	**STND Error**
2014	pH	-	7.93	± 0.03
2022	pH	-	7.77	± 0.04
2014	Sp. Conductivity	us/cm	800.5	± 24.6
2022	Sp. Conductivity	us/cm	826.6	± 16.7
2014	Dissolved Oxygen	mg/L	9.1	± 0.3
2022	Dissolved Oxygen	mg/L	7.4	± 0.4
2008	Water Temperature	ºC	15.8	± 0.3
2014	Water Temperature	ºC	18.0	± 0.3
2022	Water Temperature	ºC	20.1	± 0.3
2008	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.71	± 0.76
2014	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.85	± 0.14
2022	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.93	± 0.18

[1] ***Standardized Stream Temperature:*** Temperature data is collected via logger and standardized based on the following conditions:

- Daily maximum air temperatures must exceed 24.5 ºC;
- No precipitation for 3 days preceding measurement;
- Measurements to be taken between 4:00PM - 6:00PM;
- Water temperature points collected from July 1st - September 10th;
- Logger must be deployed in flowing waters.

Aside from these general temperature observations, loggers provide a detailed recording of stream thermal conditions. Standardized stream temperature assessments account for climatic factors including air temperatures and precipitation. With the data collected from three temperature loggers each survey year, standardized stream temperature factors were calculated and summarized in Table 3. This factor has variability, 0.22 for every degree of air temperature from 2008 to 2022. This is likely due to many of the sites being different across sampling years, due to equipment loss, with Old Montreal Road being the only location replicated all three years. From 2014 to 2022, parts of Cardinal Creek at Old Montreal Road changed classification from cool-warm to warmwater (methods from Chu et al., 2009).

Invasive Species

The percentage of sections surveyed where invasive species were observed remained the same, 84 to 85 percent (Table 4). All invasive species previously reported had variability in the number of sections they were observed in, likely due to missing sightings during observations. There are also several species that were not previously reported, including bull thistle, dog-strangling vine, goldfish, non native honeysuckle, and non native *Phragmites*.

Table 4 Invasive species presence (% of sections) observed in 2014 and 2022 (NR are Not Reported species).

Invasive Species	2014	2022	+/-
Bull thistle	NR	1%	▲
Common and glossy buckthorn	5%	47%	▲
Curly-leaved pondweed	31%	17%	▼
Dog strangling vine	NR	3%	▲
European frogbit	NR	1%	▲
Flowering rush	11%	1%	▼
Goldfish	NR	1%	▲
Honeysuckle (non-native)	NR	3%	▲
Japanese knotweed	1%	NR	▼
Manitoba maple	34%	43%	▲
Phragmites (non-native)	NR	6%	▲
Poison/wild parsnip	18%	31%	▼
Purple loosestrife	57%	32%	▼
Rusty crayfish	1%	1%	-
Total percent of sections invaded	**85%**	**84%**	**▼**

Pollution

Garbage accumulation on Cardinal Creek was found to have increase from 2003 to 2022. In 2022 the polluted sections contained garbage such as plastics, packaging, cardboard, Styrofoam, beverage containers, disposable masks, old farming equipment, an old bike, car parts and tires. Table 5 shows pollution levels in all three monitoring years.

Table 5 Pollution levels (presence in % of sections surveyed) comparison between 2008, 2014 and 2022.

Pollution/Garbage	2008	2014	2022	+/-
Floating garbage	28%	30%	38%	▲
Garbage on stream bottom	22%	23%	18%	▼
Oil or gas trails	1%	0%	0%	▼
Unusual coloration on stream bed	1%	0%	0%	▼
Other	0%	5%	8%	▲
Total polluted sections	**47%**	**49%**	**53%**	▲

Garbage dumping of scrap metal on Cardinal Creek.

Instream Aquatic Vegetation

Table 6 shows decreases in instream aquatic vegetation from 2014 and 2022. Narrow-leaved emergent plants (e.g. sedges) had an increase in presence across sections. Broad leaved emergent plants (e.g. arrowhead), free floating plants (e.g. duckweed) and floating plants (e.g. water lilies) had substantial declines, appearing in less than half the sections between the two periods. Submerged plants (e.g. pondweed), robust emergent plants (e.g. cattails) and algae were present in comparable abundance in both survey years. Between the two cycle years there has been a decline in overall vegetation abundance and in particular an increase in sections with no vegetation.

Table 6 Instream aquatic vegetation (presence in % of sections) comparison between 2014 and 2022.

Instream Vegetation	2014	2022	+/-
Narrow-leaved emergent plants	78%	84%	▲
Broad-leaved emergent plants	57%	31%	▼
Robust emergent plants	28%	27%	▼
Free-floating plants	11%	1%	▼
Floating plants	30%	14%	▼
Submerged plants	55%	51%	▼
Algae	57%	48%	▼
None	11%	44%	▲

Arrowhead (above) is an example of a broad-leaved emergent plant and algae (below) which was observed in over half the surveyed sections of Cardinal creek.

Fish Community

Fish sampling was carried out by the City Stream Watch program in 2003, 2014 and 2022 to evaluate fish community composition in Cardinal Creek; in 2010 observations were made under the American eel, species at risk, surveys (see Table 7). In total 39 fish species have been observed in Cardinal Creek. In 2003, seven fish species were captured at one site by seining. In 2008, 16 species were observed in six sites by eight seine netting sessions. In 2010, 13 species were observed in two sites by boat electrofishing. In 2014, 30 species were caught in seven sites through the use of a backpack electrofisher one time, four seine netting sessions, five fyke net locations and in passive observation. In 2022, 14 species were observed in three sites by three electrofishing sessions and additional seining at one location. Sample locations in 2022 were revisited historical sites.

All the species observed in 2022 had been captured in previous years. Noteworthy species observations across the years include the longnose gar, the cold water brook trout near the confluence with the Ottawa River, as well as the North American species of the Esocid family.

Table 7 Comparison of fish species caught between 2003-2022.

Species	2003	2008	2010	2014	2022
Black crappie *Pomoxis nigromaculatus*			X	X	
Blackchin shiner *Notropis heterodon*		X			
Bluegill *Lepomis microchirus*			X	X	X
Bluntnose minnow *Pimephales notatus*		X		X	X
Brassy minnow *Hybognathus hankinsoni*				X	
Brook silverside *labidesthes sicculus*			X		
Brook stickleback *Culaea inconstans*	X	X		X	X
Brook trout *Salvenilus fontinalis*				X	
Brown bullhead *Ameiurus nebulosus*	X		X	X	X
Carps and minnows unidentified species		X		X	X
Central mudminnow *Umbra limi*				X	X
Channel catfish *Ictalurus punctatus*				X	
Common carp *Cyprinus carpio*			X		
Common shiner *Luxilus cornutus*	X	X	X	X	X
Creek chub *Semotilus atromaculatus*	X	X		X	X
Emerald shiner *Notropis atherinoides*		X	X		
Darter species *Etheostoma spp.*		X		X	X
Species (continued)	**2003**	**2008**	**2010**	**2014**	**2022**
Fallfish *Semotilus corporalis*				X	
Fathead minnow *Pimephales promelas*		X		X	X
Golden shiner *Notemigonus crysoleucas*		X	X	X	
Largemouth bass *Microterus salmoides*			X	X	
Logperch *Percina caprodes*		X	X		
Longnose dace *Rhinichtys cataractae*	X			X	X
Longnose gar *Lepisosteus osseus*				X	
Muskellunge *Esox masquinongy*				X	
Northern pearl dace *Margariscus nachtriebi*				X	
Northern pike *Esox Lucius*		X			
Northern redbelly dace *Chrosomus eos*				X	
Pumpkinseed *Lempois gibbosus*			X	X	X
Rock bass *Ambloplites rupestris*				X	X
Sauger *Sander canadensis*				X	
Shorthead redhorse *Moxostoma macrolepidotum*				X	
Silver lamprey *Ichthyomyzon unicuspis*				X	
Silver redhorse *Moxostoma anisurum*			X	X	
Spottail shiner *Notropis hudsonius*	X	X			
Troutperch *Percopsis omiscomaycus*		X			
Walleye *Sander vitreus*			X	X	
White sucker *Catostomus commersonii*	X	X		X	X
Yellow bullhead *Ameiurus natalis*		X			
Yellow perch *Perca flavescens*		X		X	X
Total Species 39	**7**	**16**	**13**	**30**	**14**

Longnose gar observed swimming along Cardinal Creek in 2014.

Monitoring and Restoration

Monitoring on Cardinal Creek

Table 8 highlights recent and past monitoring that has been completed on Cardinal Creek by the Rideau Valley Conservation Authority's City Stream Watch program. Monitoring activities and efforts have changed over the years.

Table 8 City Stream Watch monitoring on Cardinal Creek.

Accomplishment	Year	Description
City Stream Watch Stream Monitoring	2003	5.1 km of stream was surveyed
	2008	7.4 km of stream was surveyed
	2014	7.4 km of stream was surveyed
	2022	7.7 km of stream was surveyed
City Stream Watch Fish Sampling	2003	One fish community site was sampled
	2008	Six fish community sites were sampled
	2014	Seven fish community sites were sampled
	2022	Three fish community sites were sampled
City Stream Watch Thermal Classification	2008	Three temperature probes were deployed from May to September
	2014	Two temperature probes were deployed from May to September
	2022	Three temperature probes were deployed from June to September
Headwater Drainage Feature Assessment	2014	Six headwater drainage feature sites were sampled in the catchment (included main stem of Cardinal Creek)
City Stream Watch Shoreline Naturalization	2008	In partnership with the Cardinal Creek Community Association 295 trees and shrubs were planted

Area of Cardinal Creek east of O'Toole Road that would benefit from riparian planting (above) and headwater reaches that would benefit from erosion control measures (below).

Potential Riparian Restoration Opportunities

Riparian restoration opportunities include potential enhancement through riparian planting and erosion control. Opportunities were identified along Cardinal Creek surveyed areas (Figure 34).

Riparian Planting

Various riparian areas of Cardinal Creek and its headwater reaches can benefit from tree and shrub planting to increase plant diversity. Additional planting would increase shading, enhance wildlife habitat, prevent soil erosion and mitigate negative impacts from runoff and anthropogenic input.

Erosion Control

Certain headwater reaches of Cardinal Creek catchment would benefit from erosion control measures to stabilize banks. Bioengineering methods such as installation of fascines, brush mattresses, soil wrapping and livestaking of shrubs are some methods to prevent further erosion.

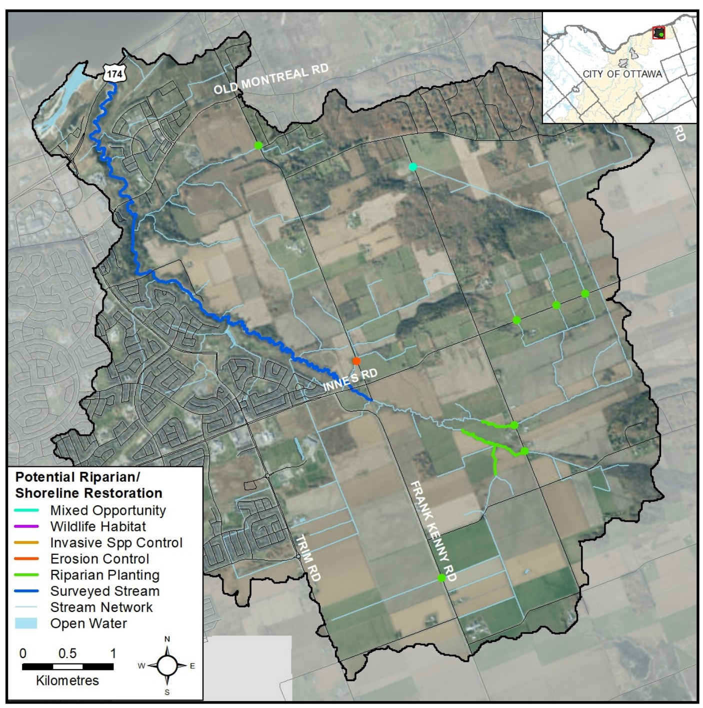
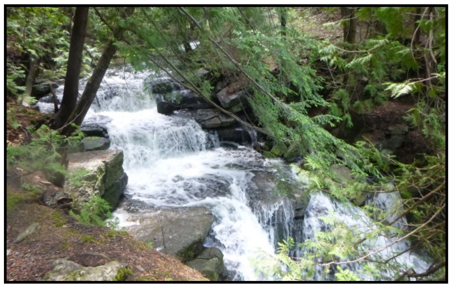


Figure 34 Potential riparian/shoreline restoration opportunities along Cardinal Creek, two tributaries of Cardinal Creek and its headwater reaches.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For more information on the 2022 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2022 Summary Report:

https://www.rvca.ca/rvca-publications/city-stream-watch-reports

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