Mud Creek 2023 Catchment Report

Catchment Features	
Area	57.13 square kilometers 1.36% of the Rideau Valley watershed
Land Use	55.46% agriculture 10.13% settlement 13.28% forest 7.72% meadow 4.11% transportation 7.57% wetlands
Surficial Geology	48.88% clay 3.28% organic deposits 6% gravel 26.38% diamicton 15.46% sand
Watercourse Type	2023 thermal conditions warmwater to coolwater
Invasive Species	Fifteen invasive species were identified in 2023: bull thistle, common & glossy buckthorn, curly-leafed pondweed, Eurasian milfoil, European frogbit, flowering rush, garlic mustard, Himalayan balsam, honey suckle (non-native), Manitoba maple, purple loosestrife, rusty crayfish, wild parsnip and yellow iris.
Fish Community	Twenty-seven species have been observed from 2008 to 2023; game species include: black crappie, bluegill, brown bullhead, largemouth bass, pumpkinseed, redhorse sp., rock bass, walleye, white sucker, and yellow perch.

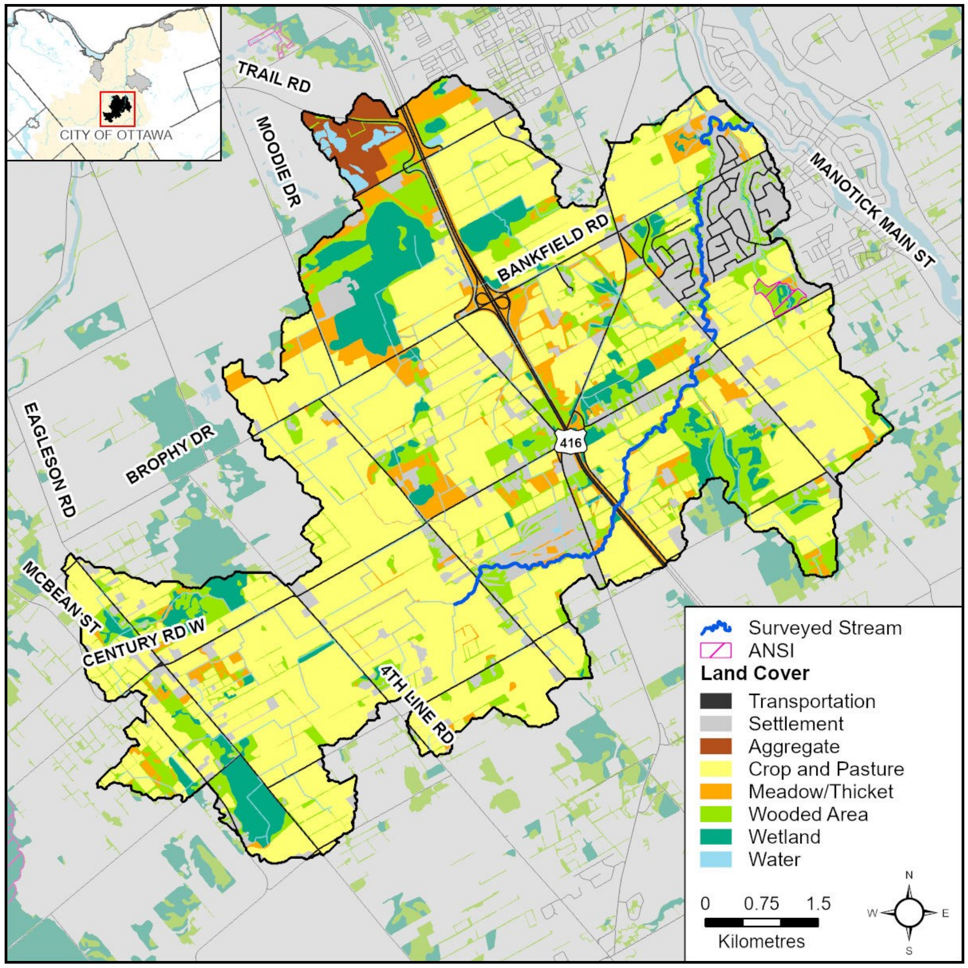


Figure 1 Land cover in the Mud Creek catchment

Woodlot Analysis

Size Category	Number of Woodlots	Percent of Woodlots
1 Hectare	149	58.89%
1 to <10 Ha	90	35.57%
10 to <30 Ha	13	5.14%
>30 Ha	1	0.4%
Total Cover	**253**	**100%**

Vegetation Cover

Type	Hectares	Percent of Cover
Wooded Areas:	**754**	**63.55%**
Hedgerow	91.15	7.68%
Plantation	35.49	2.99%
Regenerative	43.67	3.68%
Treed	583.7	49.20%
Wetlands*	**432.5**	**36.45%**
Total Cover	**1186.5**	**100%**

*Includes treed swamps

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 2023 collaborative.

Introduction

Mud Creek is a tributary of the Rideau River, located in the south end of the City of Ottawa. The mouth of Mud Creek is located just off of Rideau Valley Drive between Bankfield Road and Barnsdale Road. This creek is approximately 11 kilometers long with it's headwaters consisting of primarily agricultural drains. Mud creek was surveyed from the mouth to about 350 meters past 3rd Line Road.

The majority of Mud Creek is composed of permanent flow, with the geology of the creek predominately being marine clay and silt, with cobble and sand deposits. Ninety two percent of the surrounding land use is forests, therefore, making this creek a favourable habitat for wildlife such as fish, macroinvertebrates, birds, and other aquatic and terrestrial wildlife.

Mud Creek was previously surveyed in 2014 under the City Stream Watch program where 7.8 km of the creed was surveyed. In 2023, 105 sections (10.5km) were surveyed as a part of the City Stream Watch monitoring activities. The following is a summary of observations made by staff and volunteers along those 105 sections.

Mud Creek at the mouth.

Agricultural section of Mud Creek upstream of 3rd Line Road.

Mud 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 of 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 Mud Creek. Buffers greater than 30 meters were present along 47 percent of the left bank and 53 percent of the right bank. A 15 to 30 meter buffer was present along 28 percent of the left bank and 20 percent of the right bank. A five to 15 meter buffer was present along 23 percent of the left bank and 21 percent of the right bank. A five meter buffer or less was present along 13 percent of the left bank and 17 percent of the right bank. The buffer width evaluation on the sections surveyed of Mud Creek are below the recommended guidelines from Environment and Climate Change Canada.

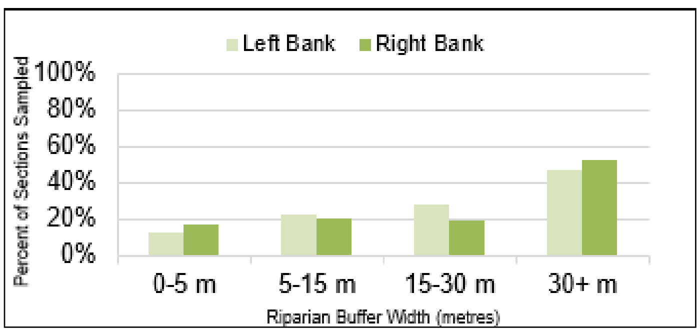


Figure 2 Vegetated buffer width along Mud Creek

Vegetated buffer greater than 30 meters in width along Mud Creek behind Gray Willow Place.

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.

Mud Creek surveyed the riparian vegetative communities to evaluate the riparian buffer alterations. The results concluded that there were predominately natural, accounting for 54 percent of sections being considered natural along the banks, 29 percent of sections considered altered, 10 percent of sections were considered as unaltered, and six percent of sections are considered highly altered .

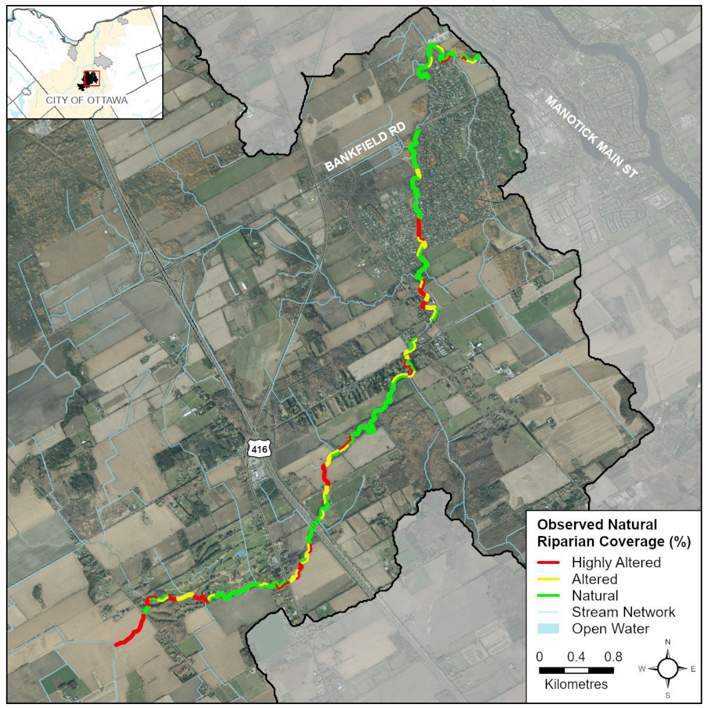


Figure 3 Riparian buffer alterations in Mud Creek.

Roadway infrastructure on Prince of Wales Drive along Mud 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 92 percent and 79 percent of the sections surveyed, being the most common land use observed. Wetlands were present in 30 percent of the surveyed areas, and meadow was present in 71 percent of sections.

Aside from the natural areas, the most common land use in the catchment was active agriculture with 66 percent of the sections containing husbandry properties. Infrastructure, such as roads, bridges and culverts were observed in 24 percent of sections, while commercial land use was observed in seven percent of sections. Residential land use was also fairly common; observed in 52 percent of sections. Recreational land use was present in 15 percent of sections.

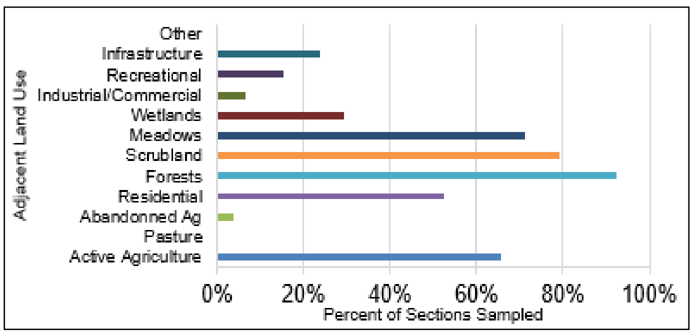


Figure 4 Adjacent land use 100 meters from each shoreline and percentage of presence along Mud Creek

Section along Mud Creek with forest, meadow and residential land uses near Carrison Drive.

Mud 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 105 sections surveyed in the Mud Creek catchment, with 10 percent of sections remaining without any human alteration. Of the areas surveyed, 54 percent of sections fell in the classification of natural. Natural sections had a riparian buffer greater than 15 meters in width and natural shorelines.

Twenty-nine percent of sections were classified as altered. They contained straightened sections and riparian buffers of five to 15 meters in width. Shoreline alterations included concrete bridges and metal culverts.

Six percent of the surveyed sections were highly altered. The riparian buffers were less than five meters in width and shoreline alterations, including rip rap and storm water outlets, were present. These sections were mostly found near road and highway infrastructure.

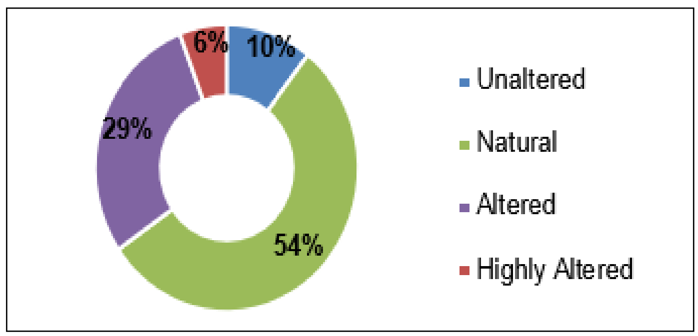


Figure 5 Anthropogenic alterations along Mud Creek

An altered section of Mud Creek near McManus Avenue.

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 significant erosion was observed across the surveyed portions. Bank instability was observed in 54 percent of the left bank and 52 percent of the right bank of the sections surveyed.

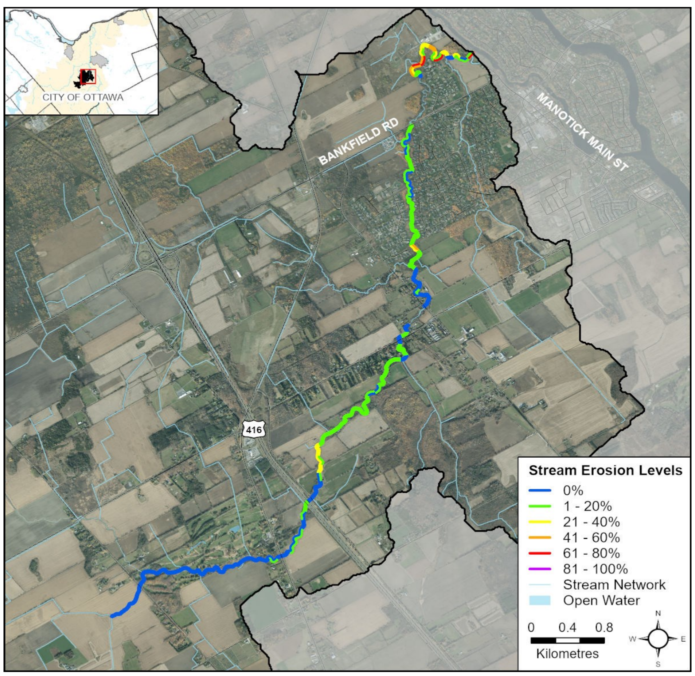


Figure 6 Erosion levels along Mud Creek

Bank erosion along Mud Creek near Rideau Valley Drive.

Undercut Stream Banks

Stream bank undercuts can provide excellent cover habitat for aquatic life, however excessive levels can be an indication of unstable shoreline conditions. Bank undercut was 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 Mud Creek. Along the left bank; 15 percent of sections had undercut banks; and the right bank had 10 percent of sections with undercut banks.

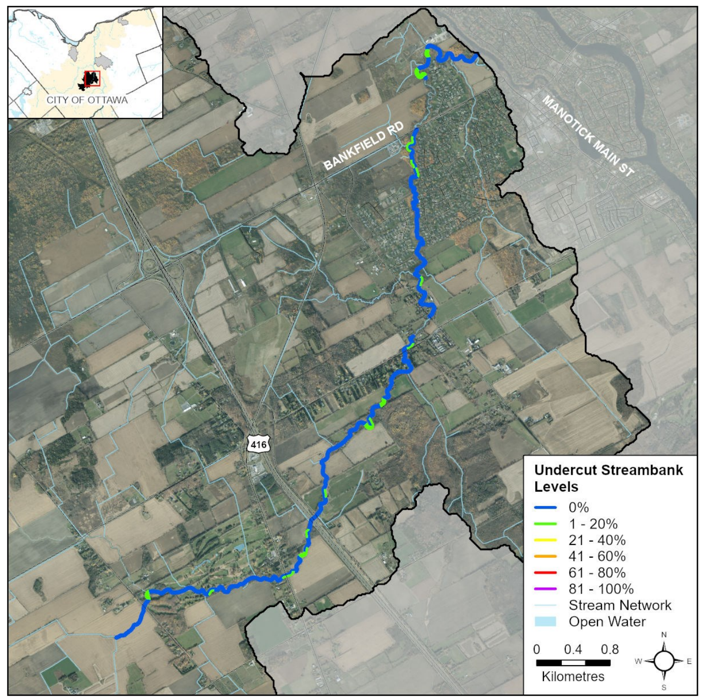


Figure 7 Undercut stream banks along Mud Creek

Undercut banks 600 m upstream of the mouth of Mud 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, 56 of them, had a shade cover of one to 20 percent, which was the highest shading level observed. Twenty-five sections had 21 to 40 percent shade cover. No cover was observed in four of the sections. Eight sections were observed to have shading between 41 to 60 percent and eight sections had between 61 to 80 percent shaded. Lastly, four sections were observed to have extreme shading coverage with a percentage ranging between 81 and 100.

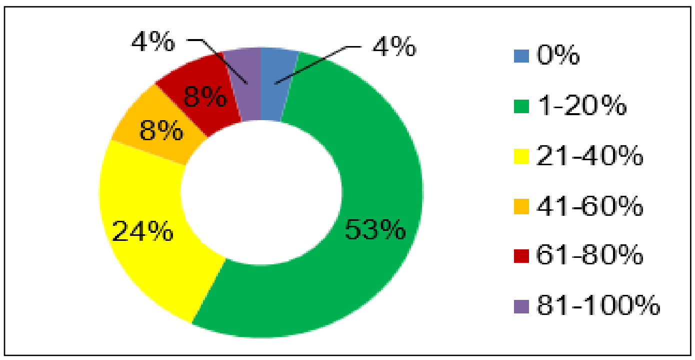


Figure 8 Stream shading along Mud Creek.

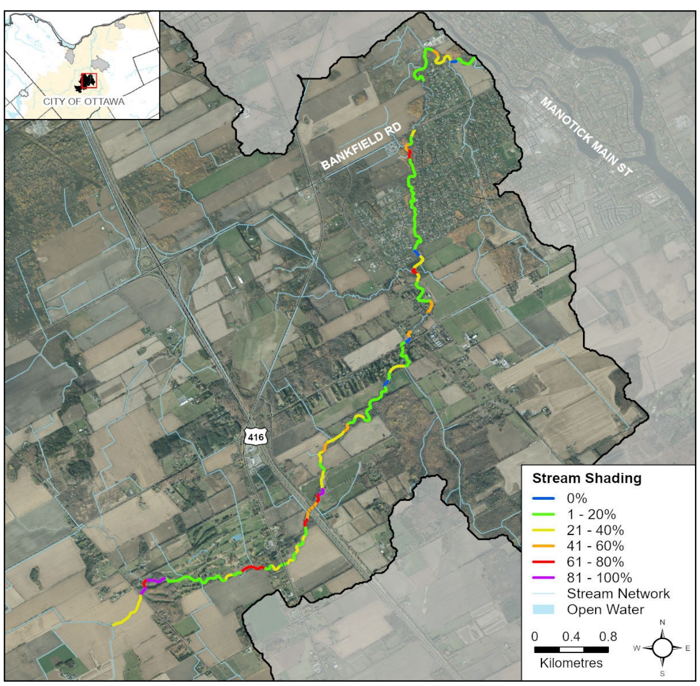


Figure 9 Stream shading along Mud Creek.

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

A mix of trees and plants comprised the majority of shading. Overhanging plants, mainly grasses and broad leaved emergent plants, were seen in 96 percent of both the left and right banks..

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 Mud Creek. Of the surveyed portions, 84 percent of the sections had overhanging trees and branches on the left bank, and 87 percent of the sections had overhanging trees on the right bank.

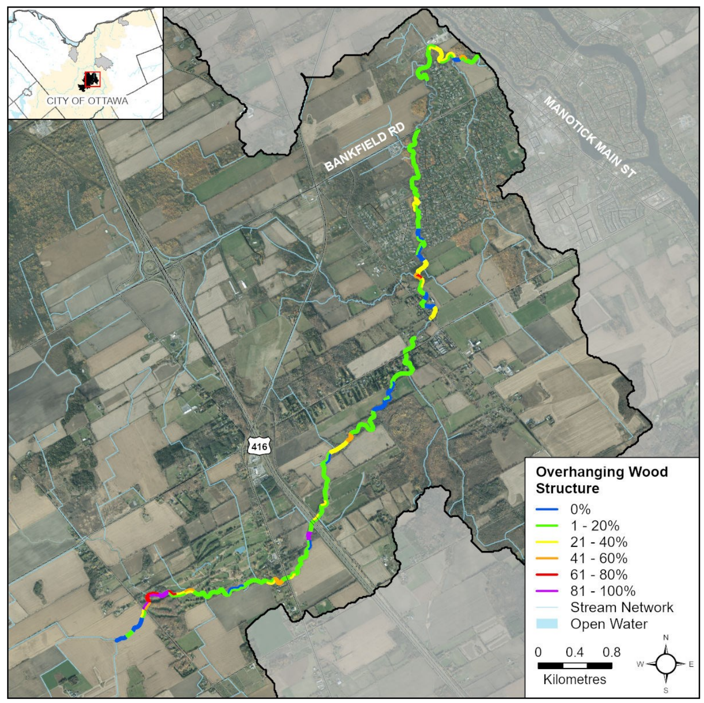


Figure 10 Overhanging trees and branches along Mud Creek.

Overhanging plants, such as grasses, contribute most of the shading along Mud Creek.

Mud Creek Instream Aquatic 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: two percent had no complexity; 24 percent had a score of one; 37 percent scored two; and 20 percent scored three. 17 percent of the sections surveyed scored four for habitat complexity.

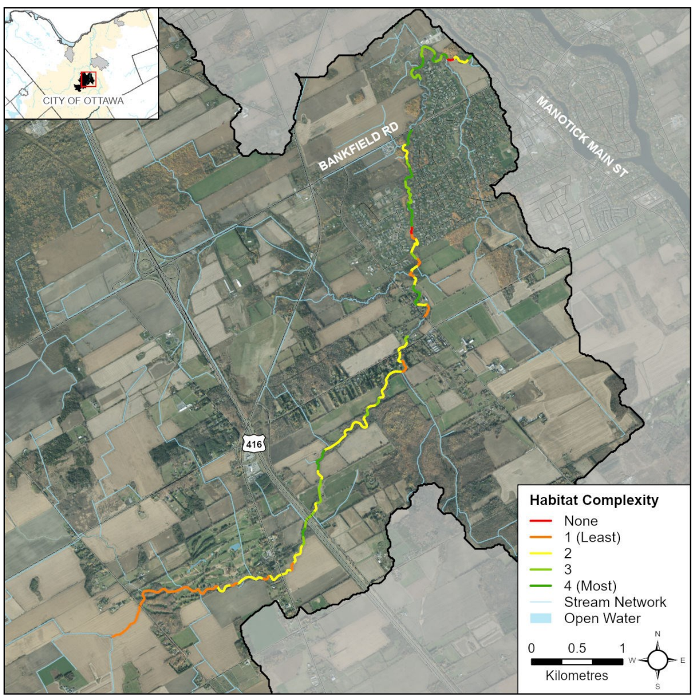


Figure 11 Instream habitat complexity along Mud Creek.

Section of Mud Creek with complex habitat features including boulders, gravel and woody debris.

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 Mud Creek was observed to be heterogenous in 54 percent of sections surveyed, and homogenous in the remaining 46 percent. Figure 12 shows the substrate types observed. It is a system dominated by clay, with 94 percent of sections containing this type of substrate. Most sections surveyed also contained silt. Other substrate types included sand, gravel, cobble and boulders.

Figure 13 shows the dominant substrate types along the creek. Clay and silt were the dominant substrate types in 48 percent of sections surveyed, cobble in two percent, and sand was dominant in one percent.

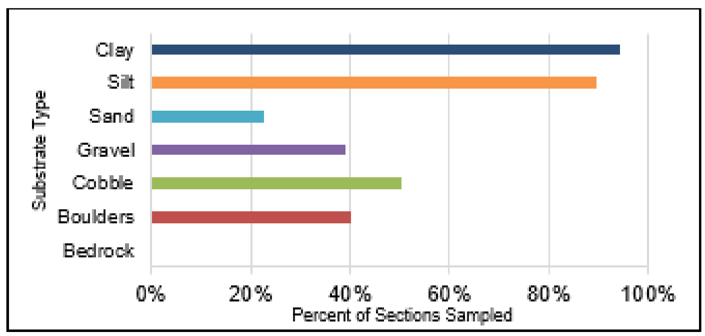


Figure 12 Instream substrate along Mud Creek.

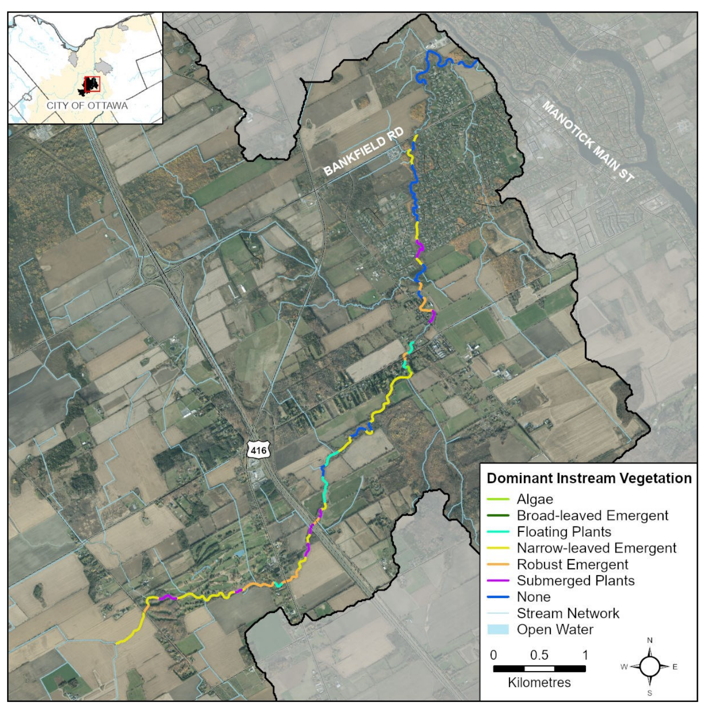


Figure 13 Dominant instream substrates along Mud Creek.

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 Mud Creek are mainly comprised of runs and pools, with limited riffle habitat. This morphology is common in municipal drains due to required drain maintenance. Seventy-three percent of sections contained pools, 10 percent of sections contained riffles and 97 percent contained runs. Figure 15 shows the locations of sections surveyed which contained riffle habitat and the extent of presence within each section.

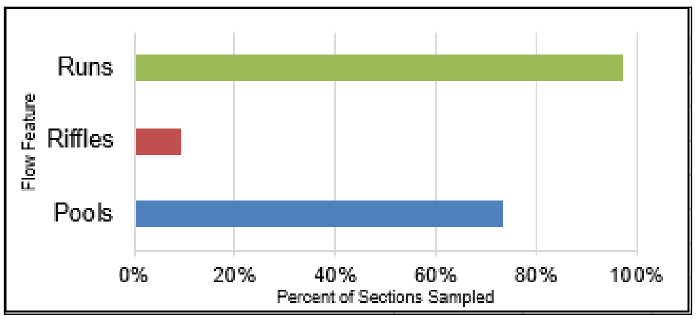


Figure 14 Instream morphology along Mud Creek.

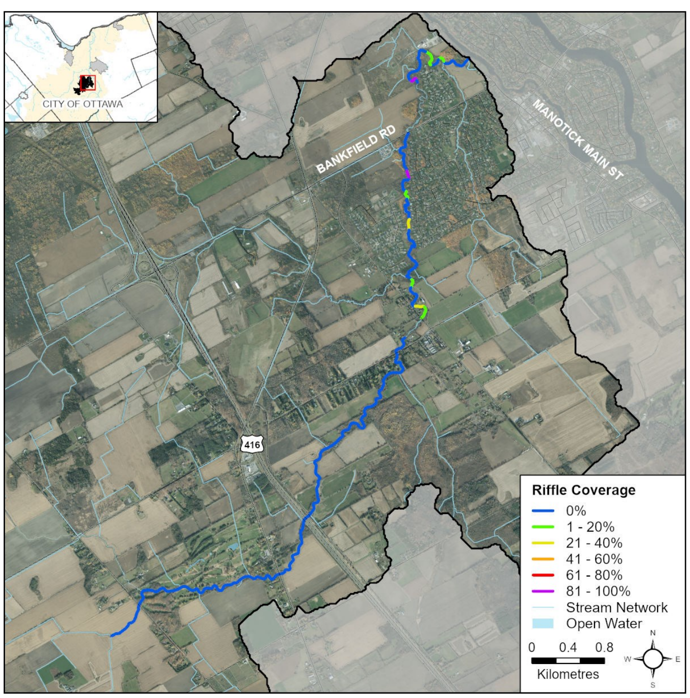


Figure 15 Riffle habitat locations along Mud Creek.

Instream Wood Structure

Figure 16 shows that Mud Creek had high levels of instream wood structure in the form of branches, trees, and beaver dams. Instream wood structure is important for fish and wildlife habitat, by providing refuge and feeding areas from the resulting shade. Excessive amounts can result in temporary seasonal migration barriers.

Instream wood structure found along Mud Creek are important for fish a wildlife habitat (above), some can become seasonal migration barriers (below).

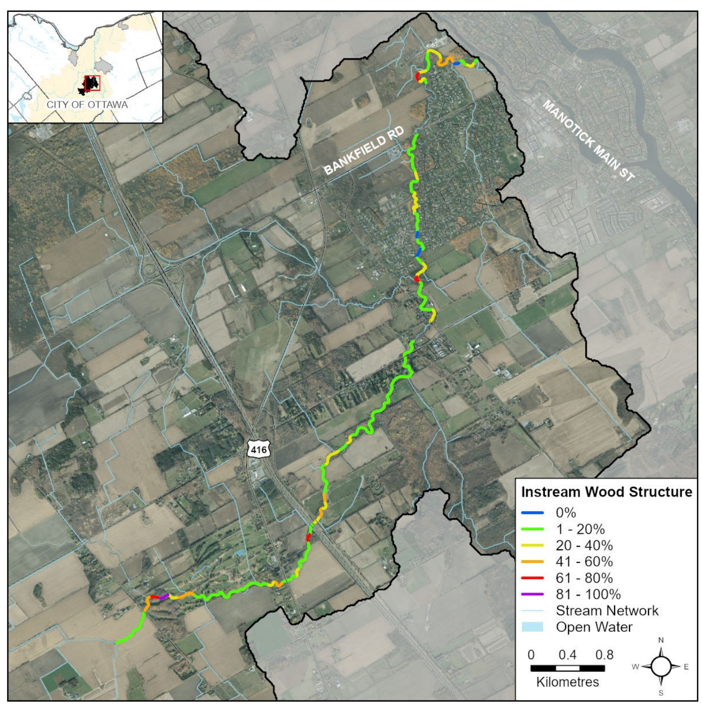


Figure 16 Instream wood structures along Mud Creek.

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 instream aquatic vegetation community structure along Mud Creek. Vegetation types included: narrow-leaved emergent vegetation in 90 percent of sections; free-floating in 80 percent of sections; submerged vegetation in 78 percent of sections; broad-leaved emergent in 67 percent of sections; algae in 48 percent; robust emergent in 33 percent; and floating plants in 19 percent of sections.

Figure 18 shows Mud Creeks dominant instream aquatic vegetation by geographical location.

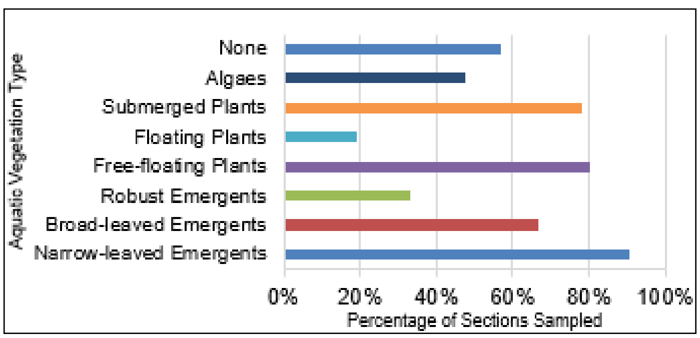


Figure 17 Aquatic vegetation presence along Mud Creek.

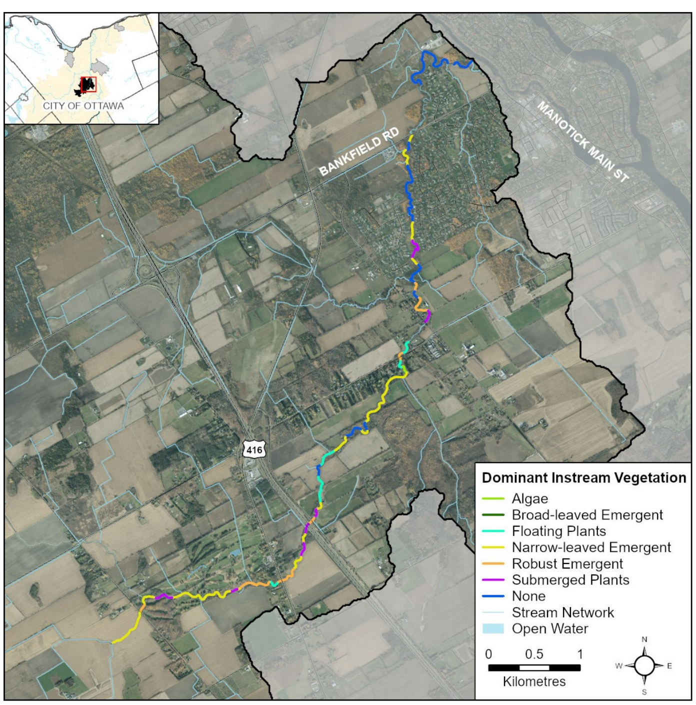


Figure 18 Dominant instream vegetation in Mud Creek.

Instream Vegetation Abundance

The abundance of instream vegetation is also crucial for aquatic ecosystem health. Lack of vegetation, 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. 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 this extensive mode of growth.

Abundance of vegetation is classified by the amount of vegetation present along each section. Levels of vegetation are categorized based on the extent of coverage of a section from none and sparse to an entire section choked with vegetation. As seen in Figure 19, fourteen percent of sections along Mud Creek had low levels of vegetation; 27 percent had normal vegetation; 81 percent had extensive vegetation and 65 percent had common vegetation. Rare abundance was observed in seven percent of sections surveyed and no vegetation was found along 57 percent of sections.

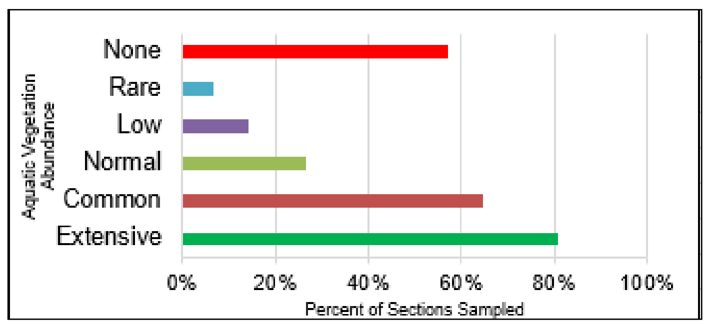


Figure 19 Instream vegetation abundance along Mud Creek.

Instream vegetation in Mud Creek showing sections of Mud Creek with low abundance (top left); common abundance (top right); normal abundance (bottom left); and extensive abundance of instream vegetation (bottom right).

Mud 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.

Invasive species that were observed in sections surveyed along Mud Creek, Figure 20 shows the diversity of species observed per section surveyed.

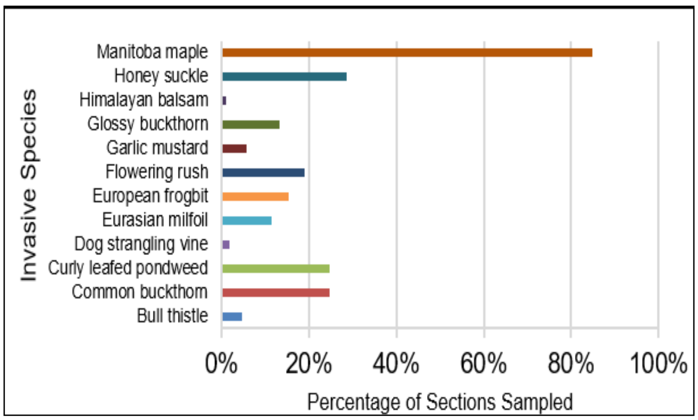
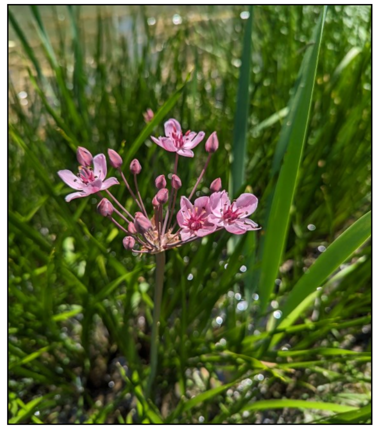


Figure 20 Invasive species diversity along Mud Creek.

The following are a list of species observed in 2023 in the surveyed portions of Mud Creek:

- bull thistle (*Cirsium vulgare)*
- common buckthorn (*Rhamnus cathartica*)
- curly-leaved pondweed (*Potamogeton crispus*)
- dog-Strangling vine (*Cynanchum rossicum*)
- Eurasian water-milfoil (*Myriophyllum spicatum*)
- European frog-bit (*Hydrocharis morsus-ranae*)
- flowering rush (*Butomus umbellatus*)
- garlic mustard (*Alliaria petiolate*)
- glossy buckthorn (*Rhamnus frangula*)
- Himalayan balsam (*Impatiens glandulifera*)
- non-native honeysuckles (*Lonicera spp.)*
- Manitoba maple (*Acer negundo*)
- poison/wild parsnip (*Pastinaca sativa*)
- purple loosestrife (*Lythrum salicaria*)
- rusty crayfish (*Faxonius rusticus*)
- yellow iris (*Iris pseudacorus*)




Invasive species observed along Mud Creek; flowering rush (left) and rusty crayfish (right)

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 Mud Creek. The levels of garbage found in the main portion of the stream were low, with 69 percent of sections surveyed containing no garbage. Garbage on the stream bottom was found in six percent of sections surveyed. Floating garbage was observed in 27 percent of sections surveyed.

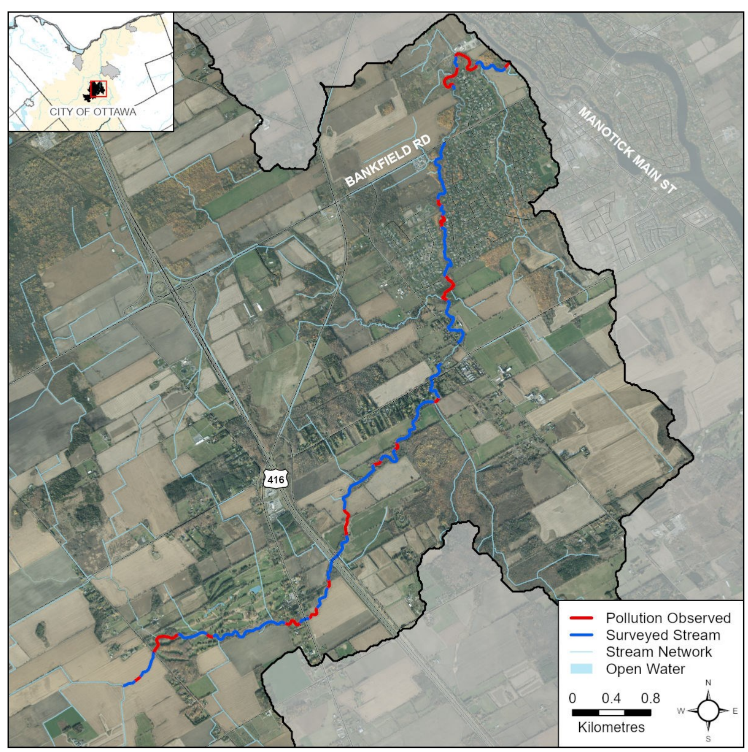


Figure 21 Pollution observed along Mud Creek.

Wildlife

The diversity of fish and wildlife populations can be an indicator of water quality and stream health (Table 1). Wildlife observations are noted during monitoring and survey activities; they do not represent an extensive evaluation of species presence in the Mud Creek catchment.

Fat mucket mussel (above) and a garter snake (below) are some of the different wildlife that were observed along Mud Creek

Painted turtle (above) and a green frog (below) found along

Table 1 Wildlife observations along Mud Creek

Birds	American goldfinch, American robin, American crow, black-capped chickadee, blue jay, common grackle, Eastern kingbird, Eastern phoebe, great blue heron, green heron, gold finch, hooded mergansers, house finch, killdeer, kingfisher, mallard, Northern cardinal, Northern flicker, pileated woodpecker, red-eyed vireo, song sparrow, red-winged blackbird, tree swallow, wood duck, yellow finch
Reptiles & Amphibians	American toad, garter snake, Northern green frog, Northern leopard frog, snapping turtle, tree frog, wood frog
Mammals	American beaver, chipmunks, deer tracks, raccoon tracks, black squirrel, Eastern gray squirrel, red squirrel
Aquatic Insects & Benthic Invertebrates	crayfish, dragonfly larvae, damselfly larvae, isopods, giant floater mussel, giant water bug, leeches, riffle beetles, snails, water boatmen, water striders, whirligig beetle
Other	black flies, bumblebees, butterflies, damselflies, deer flies, dragonflies, horsefly, mosquitoes, moths, spiders, snails

Green heron on a dead standing tree along Mud Creek (above) and a pair of hooded mergansers (below) observed in Mud Creek catchment during headwater surveys.

Mud 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.

Staff collecting water chemistry measurements with a multiparameter YSI probe

Dissolved Oxygen

Dissolved oxygen is essential for a healthy aquatic ecosystem, 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 Mud Creek. The dashed lines depicted represent the Canadian water quality guidelines. Most of the surveyed portions were found to have oxygen levels below the Canadian water quality guidelines. In 2023, dissolved oxygen levels did not meet the requirements to support aquatic life, with an average concentration of 5.66mg/L. However, saturation levels indicate that the water has stabilized at its estimated maximum. This is indicative of higher water temperatures and stagnant flows.

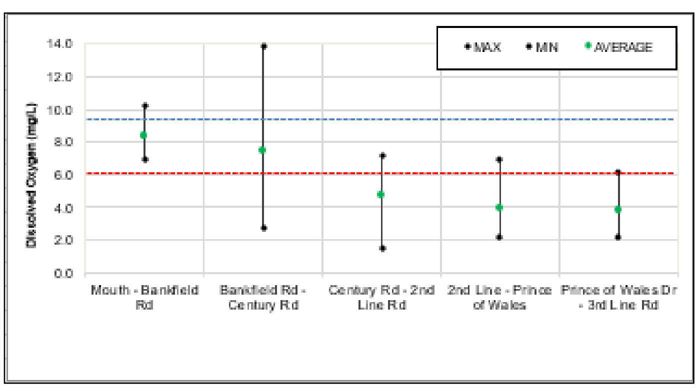


Figure 22 Dissolved oxygen ranges along surveyed sections of Mud Creek.

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 also have a profound effect. 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 Mud Creek. Overall, the average specific conductivity was 908.2 µS/cm. Conductivity levels are fairly consistent throughout the Mud Creek catchment, however, at Century Road there is moderately elevated levels which could be attributed to more inorganic materials in that area.

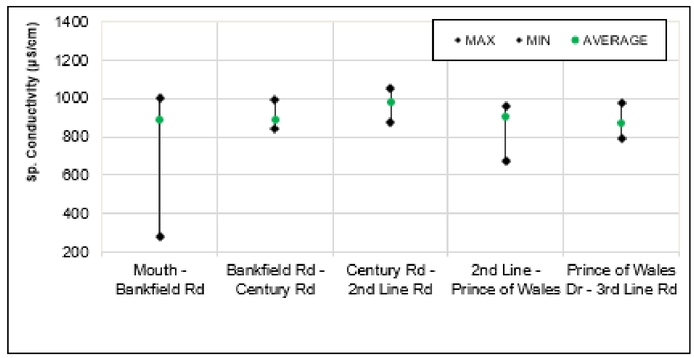


Figure 23 Specific Conductivity ranges along surveyed sections of Mud Creek.

pH

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

Figure 24 shows Mud Creek had mostly pH levels that meet the PWQO, depicted by the dashed lines. Average levels across the system were pH 7.66.

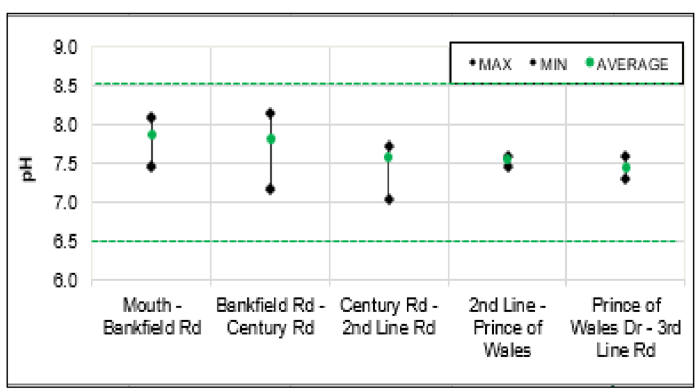


Figure 24 pH ranges along surveyed sections of Mud Creek.

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 Mud Creek between Century Road and HWY 416 with **impaired** oxygen conditions. (Dissolved oxygen levels of 1.44 mg/L and 16.1 % saturation)

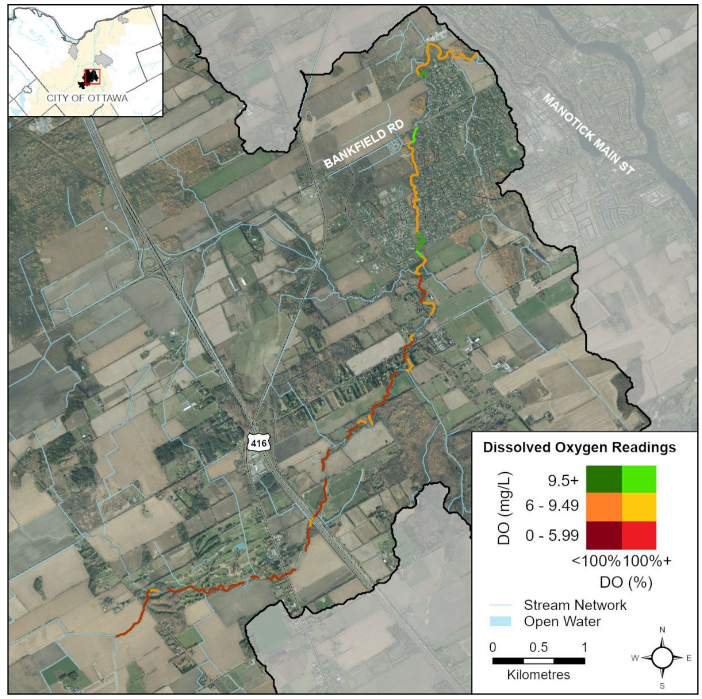


Figure 25 Bivariate assessment of dissolved oxygen concentration (mg/L) and saturation (%) along Mud Creek.

Figure 25 shows the oxygen conditions across the sections that were surveyed in 2023. Dissolved oxygen conditions in Mud Creek varied across the catchment and were shown to be sufficient to sustain warm-water biota in the downstream reaches of the system, particularly where the creek flows behind McManus Avenue and upstream of Bankfield Road. These sections were well shaded, which can help the creek maintain lower oxygen levels. Many sections had impaired oxygen conditions, shown in dark red. These areas were mainly agricultural, where the stream is straightened with minimal shading. An increase in shading conditions, through riparian planting of trees and shrubs could help cool stream temperatures and increase the levels of dissolved oxygen.

Section on Mud Creek near Bankfield Road with **optimal** oxygen conditions for warm-water biota (Dissolved oxygen levels of 13.83 mg/L and 115.3 % 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 as well as commercial and 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 Mud Creek (908.2 µS/cm) were above guidelines (500 µS/cm) used for the Canadian Environmental Performance Index (Environment Canada 2011).

Figure 26 shows relative specific conductivity levels in Mud Creek. Normal levels were maintained for most of the surveyed portions and moderately elevated conditions were observed approaching Bankfield Road. This area has some agricultural land use influences and road runoff. Both of these factors can contribute to elevated conductivity levels.

Section of Mud Creek near Bankfield Road with highly elevated levels of specific conductivity (above). Section of the Mud Creek near the mouth has lower than average specific conductivity levels (below).

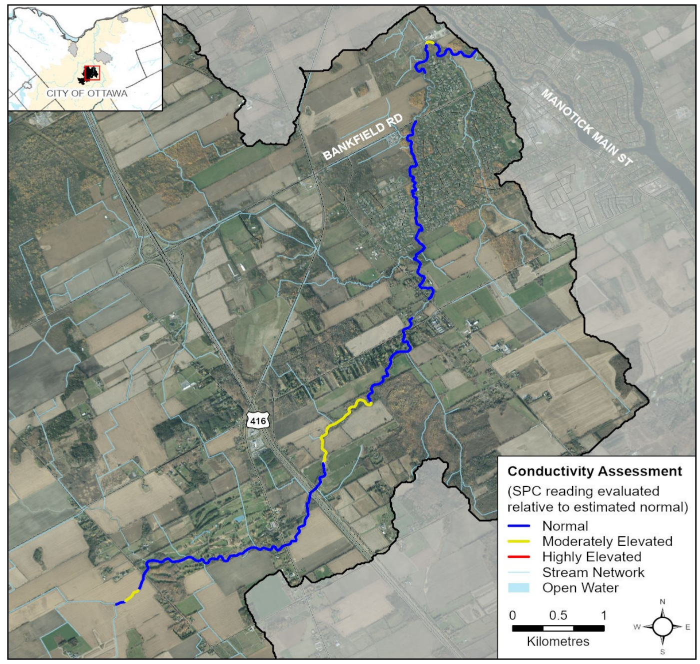


Figure 26 Relative specific conductivity levels along Mud Creek.

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, iron staining, significant temperature changes and rainbow mineral film.

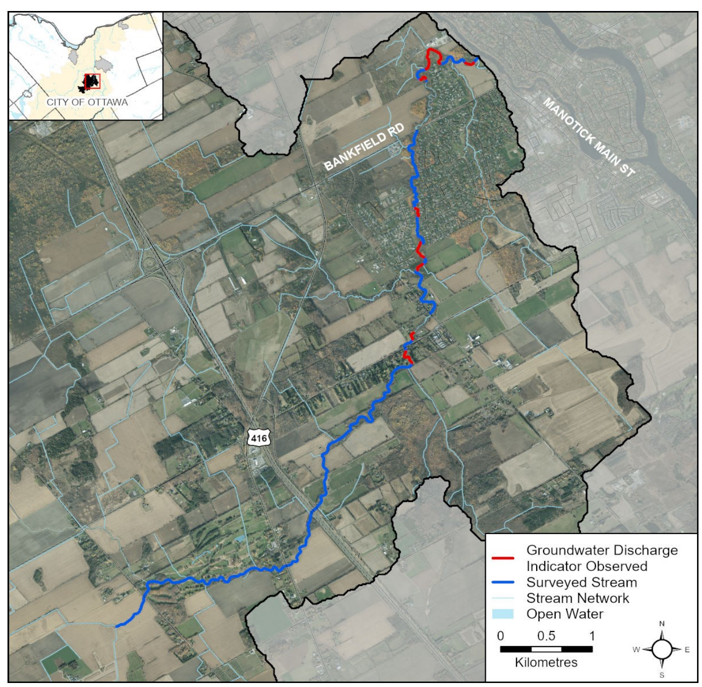


Figure 27 Groundwater indicators observed in the Mud Creek catchment.

Mud 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 Mud Creek, three temperature loggers were placed in April and retrieved in early November.

Figure 28 shows where thermal sampling sites were located. Due to instrument malfunction and a lost logger, only data from logger at Bankfield Road was fully retrieved. Analysis of data from one logger (using the Stoneman and Jones, 1996, method adapted by Chu et al., 2009), indicated Mud Creek was classified as **coolwater** at Bankfield Road in 2023. Figures 29 and 30 show a comparison of thermal conditions from 2014 to 2023. Fish species observed in that area have thermal preferences from cool to warm as indicated by Cocker at al. (2001).

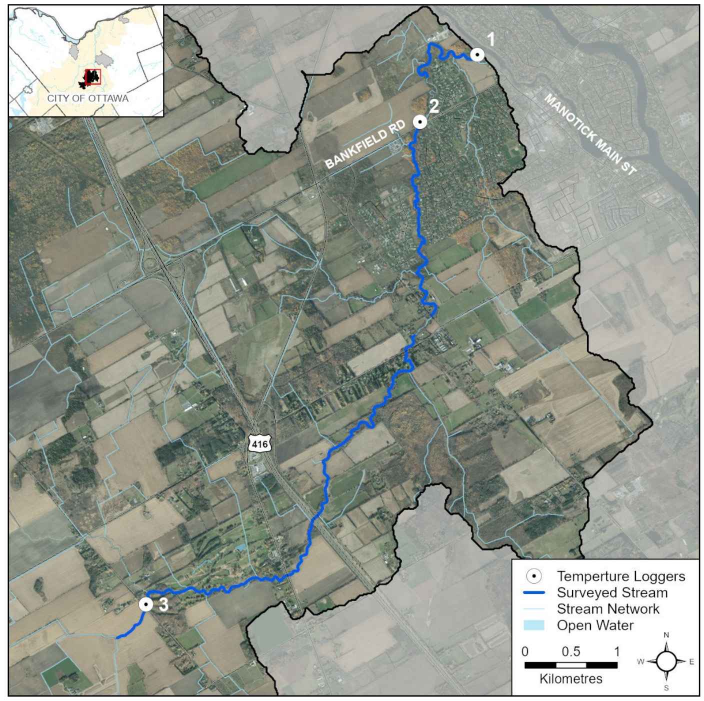


Figure 28 Temperature logger locations on Mud Creek.

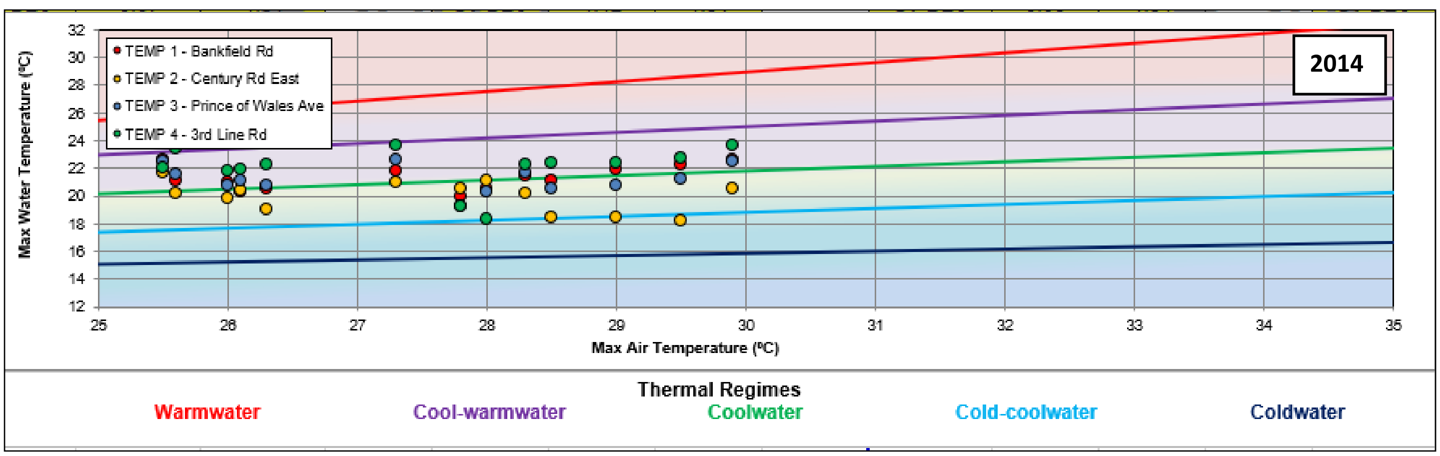


Figure 29 Thermal Classification for Mud Creek 2014, with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009):

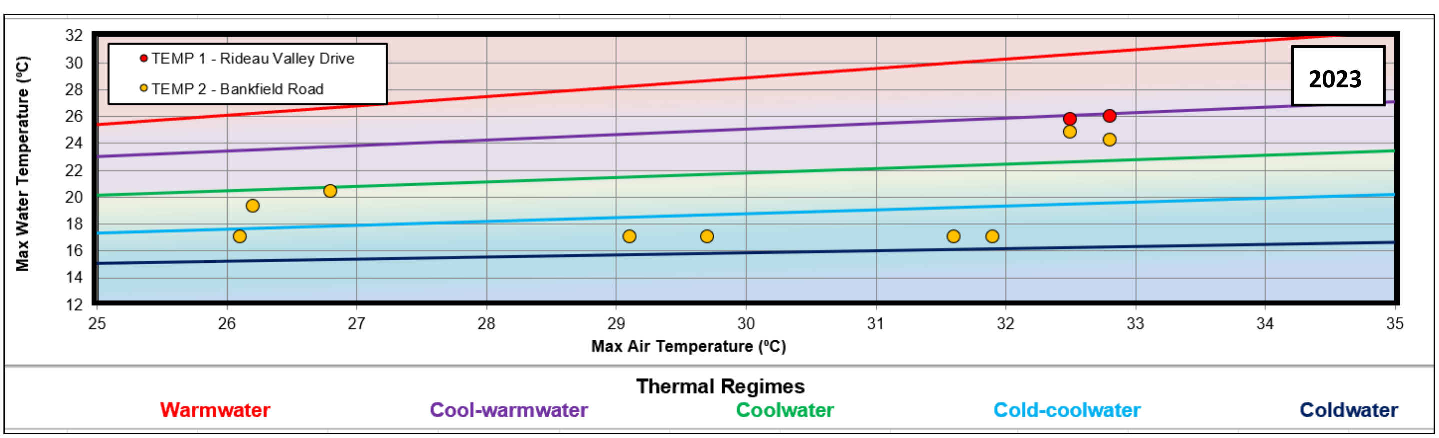


Figure 30 Thermal Classification for Mud Creek 2023, with the five thermal regimes adapted from Stoneman and Jones (1996) by Chu et al. (2009):

Mud Creek Fish Community

Fish Community Summary

Five fish sampling sites were evaluated between May and September 2023. Three site locations were sampled with the use of a backpack electrofishing unit, and two sites were sampled with a bag seine net.

Eighteen species were captured in 2023, they are listed in Table 2 along with their thermal classification preferences (Coker et al., 2001) and MNR species codes. Mud Creek had a mixed fish community ranging from cold 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 Mud Creek refer to page 23 of this report.

Table 2 Fish species observed in Mud Creek in 2023

Species	Thermal Class	MNR Species Code
blacknose dace *Rhinichthys atratulus*	**Cool**	BnDac
blacknose shiner *Notropis heterolepis*	**Cool/Warm**	BnShi
bluegill *Lepomis macrochirus*	**Warm**	Blueg
brook stickleback *Culaea inconstans*	**Cool**	BrSti
brown bullhead *Ameiurus nebulosus*	**Warm**	BrBul
carps and Minnows *Cyprinidae*	**Warm/Cold**	CA_MI
creek chub *Semotilus atromaculatus*	**Cool**	CrChu
common shiner *Luxilus cornutus*	**Cool**	CoShi
darter species *Etheostoma spp.*	**Cool**	EthSp
hornyhead chub *Semotilus atromaculatus*	**Cool**	HhChu
logperch *Percina bimaculata*	**Warm**	LogPe
longnose dace *Rhinichtys cataractae*	**Cool**	LnDac
mottled sculpin *Cottus bairdii*	**Cold**	MoScu
northern redbelly dace *Chrosomus eos*	**Cool**	NRDac
pumpkinseed *Lepomis gibbosus*	**Warm**	Pumpk
rock bass *Ambloplites rupestris*	**Cool-warm**	NRDac
smallmouth bass *Micropterus dolomieu*	**Cool**	SmBas
yellow perch *Perca flavescens*	**Cool**	YePer
Total Species		**18**

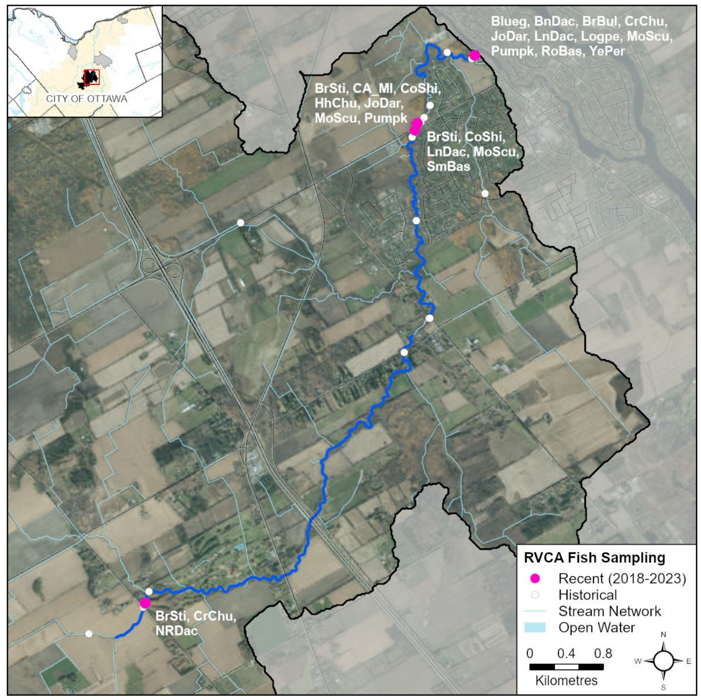
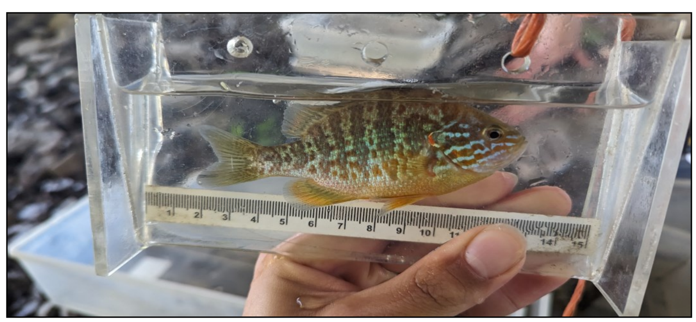


Figure 31 Mud Creek fish sampling locations in 2023



Pumpkinseed (above) and a yellow perch (below) observed in Mud 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 six migratory obstructions observed along the surveyed portions of Mud Creek. The location of the migratory obstructions observed during the surveyed portions of Mud Creek in 2023 are shown in Figure 32. Migratory obstructions were present in less than six percent of all sections of Mud Creek. All recorded obstructions were caused by debris dams.

Debris dam create fish migratory obstructions and loss of aquatic habitat and seasonal grounds for many fish species.

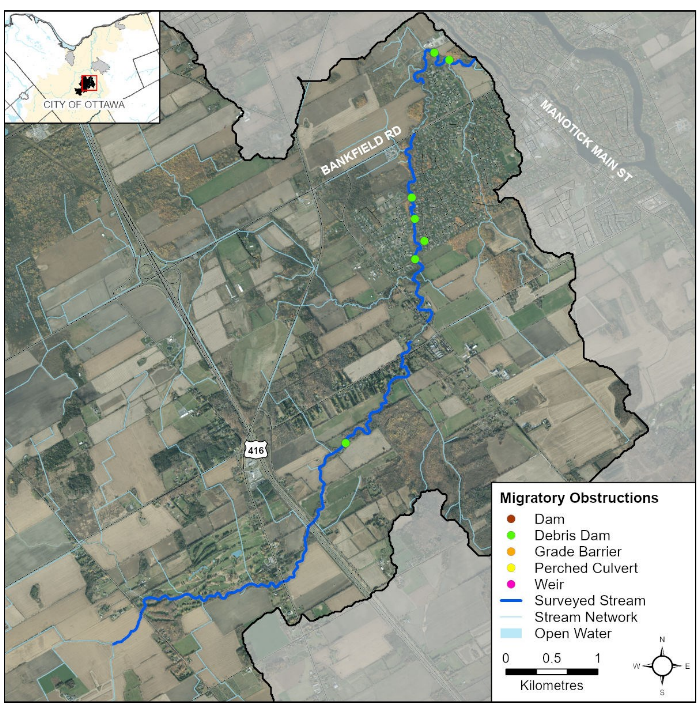


Figure 32 Locations of migratory obstructions along Mud Creek catchment

Beaver Dams

Beaver dams create natural changes in the environment. Some of the benefits include providing habitat for wildlife, flood control, and silt retention. Additional benefits come from bacterial decomposition of wood material used in the dams which removes excess nutrient and toxins. Beaver dams may be seasonal potential barriers to fish migration.

In 2023, a total of three beaver dams were identified on the surveyed portions of Mud Creek and are shown in Figure 33. Additionally, one beaver lodge was noted as well. Beavers prefer marsh-like environments, making Mud Creek a prime ecosystem with the tremendous amount of surrounding woodland.

An active beaver dam along Mud Creek.

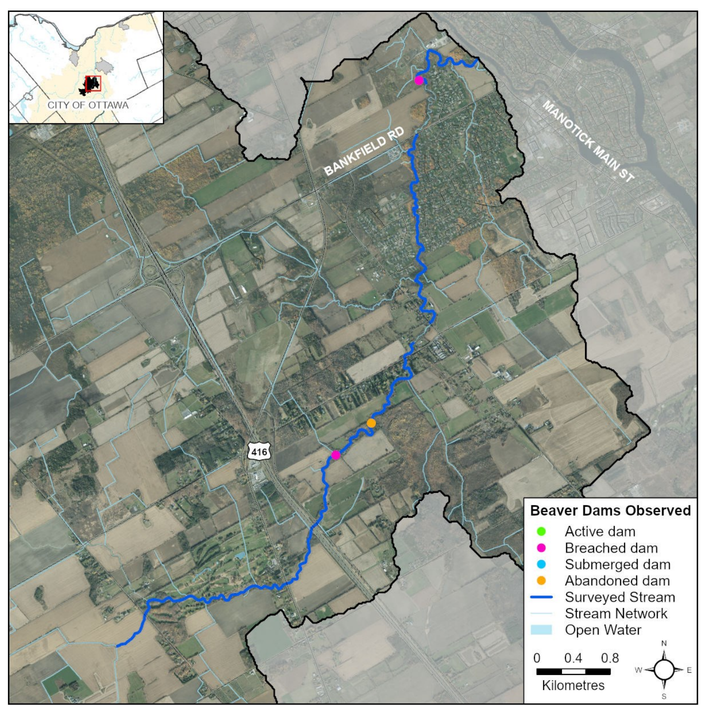


Figure 33 Locations of beaver dams along Mud Creek catchment

Headwater Drainage Feature Assessment

Headwater drainage features (HDF) represent the origin from which water enters a watershed. These are small depressions, stream and wetland features that capture flows from groundwater discharge, rain and snow melt water and transport it to larger streams and rivers. In their natural state, they provide (OSAP, 2017):

- flood mitigation as water storage capacity
- water purification and groundwater discharge
- seasonal and permanent habitat refuge for fish, including spawning and nursery areas
- wildlife migration corridors/breeding areas
- storage and conveyance of sediment, nutrients and food sources for fish and wildlife

Headwaters Sampling

RVCA is working with other Conservation Authorities and the Ministry of Natural Resources and Forestry to implement the protocol with the goal of providing standard datasets to support science development and monitoring of headwater drainage features.

Features were evaluated as per the Ontario Stream Assessment Protocol (OSAP, 2017). This protocol measures zero, first and second order headwater drainage features. It is a rapid assessment method characterizing the amount of water, sediment transport, and storage capacity within headwater drainage features. In 2023 a total of 57 HDF sites were assessed in the Mud Creek Catchment (Figure 34).

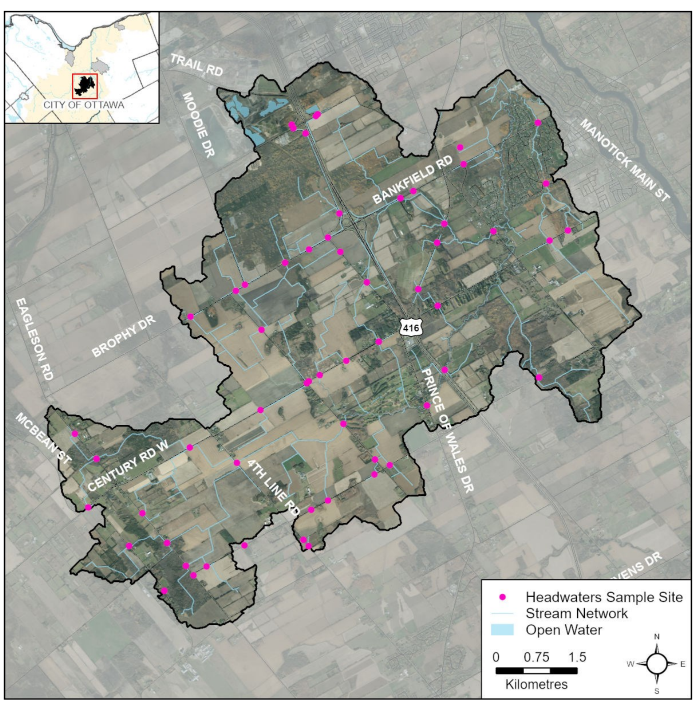


Figure 34 Location of headwater drainage feature sampling sites in the Mud Creek catchment

Feature Type

The headwater sampling protocol assesses the feature type in order to understand the function of each feature. The evaluation includes the following classifications: defined natural channel, channelized or constrained, multi-thread, no defined feature, tiled, wetland, swale, roadside ditch and pond outlet. By assessing the values associated with the headwater drainage features in the catchment area we can understand the ecosystem services that they provide to the watershed in the form of hydrology, sediment transport, and aquatic and terrestrial functions.

Figure 35 shows the feature type of the primary feature at the sampling locations. Channelized features were dominant, with 28 sites being observed. Fourteen road-side ditches, five natural features, and five undefined features were also sampled. The remaining features were wetlands, four of them, and one tiled feature.

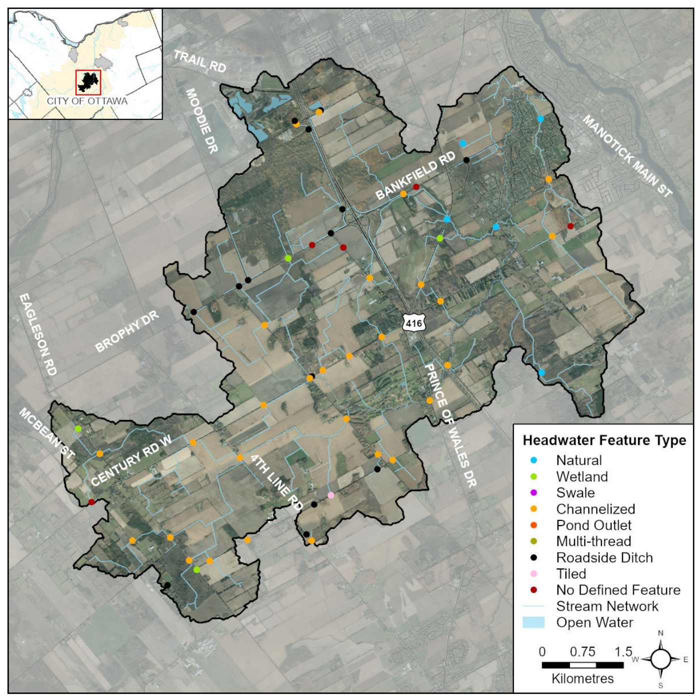


Figure 35 Map of Mud Creek catchment headwater drainage feature types

A natural channel headwater drainage feature near Bankfield Road within the Mud Creek catchment.

Headwater Feature Flow

Flow conditions in headwater features can be variable throughout the year in response to yearly seasonal weather conditions. This protocol targets features that are perennial or intermittent. Intermittent flow conditions are those where water typically flows at least six months of the year. Perennial systems flow year round. Sites were observed in the spring and summer; flow conditions were compared. Flow conditions in the Mud Creek catchment area are shown in Figure 36.

Intermittent headwater drainage feature with spring and summer conditions near Bankfield Road.

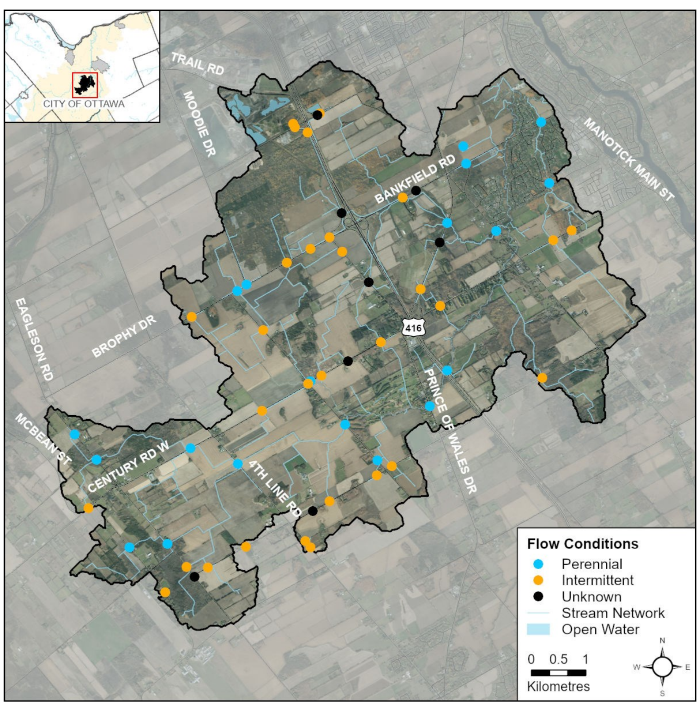


Figure 36 Headwater drainage feature flow conditions in the Mud Creek catchment

Feature Channel Modifications

Channel modifications can influence HDF conditions and function. Modifications that were of focus included dredging (and historical channel straightening), hardening (e.g. rip-rap, armourstone, gabion baskets) or on-line ponds.

Figure 37 shows channel modifications observed in Mud Creek headwater drainage features. Modifications in this catchment for its headwater drainage features are channel hardening with rip rap or gabion baskets.

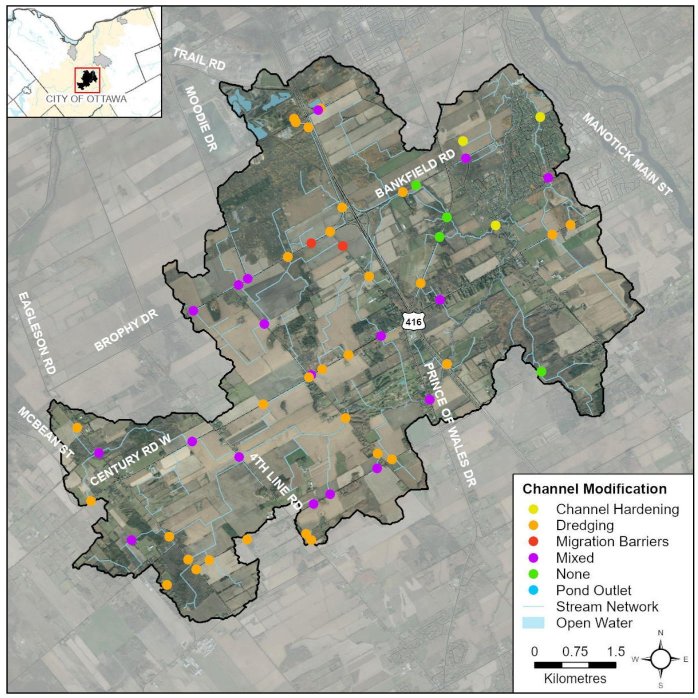


Figure 37 Headwater drainage feature channel modifications in the Mud Creek catchment

An example of historical channel straightening on a headwater drainage feature near Malakoff Road.

Headwater Feature Vegetation

Headwater feature vegetation evaluates the type of vegetation that is found within the drainage feature. The type of vegetation within the channel influences the aquatic and terrestrial ecosystem values that the feature provides. For some types of headwater features the vegetation within the feature plays an important role in flow, sediment movement and provides wildlife habitat. The following classifications are evaluated: none, lawn, wetland, meadow, scrubland and forest.

Figure 38 depicts the dominant vegetation observed at the sampled sites in the Mud Creek catchment. Twenty-three features were dominated by wetland vegetation. Thirteen features were dominated by meadow vegetation, five were dominated by cropped land, and two were dominated by lawn. The remaining 14 features had no vegetation in the spring, where flows and sediment transport are unmitigated by the lack of vegetation.

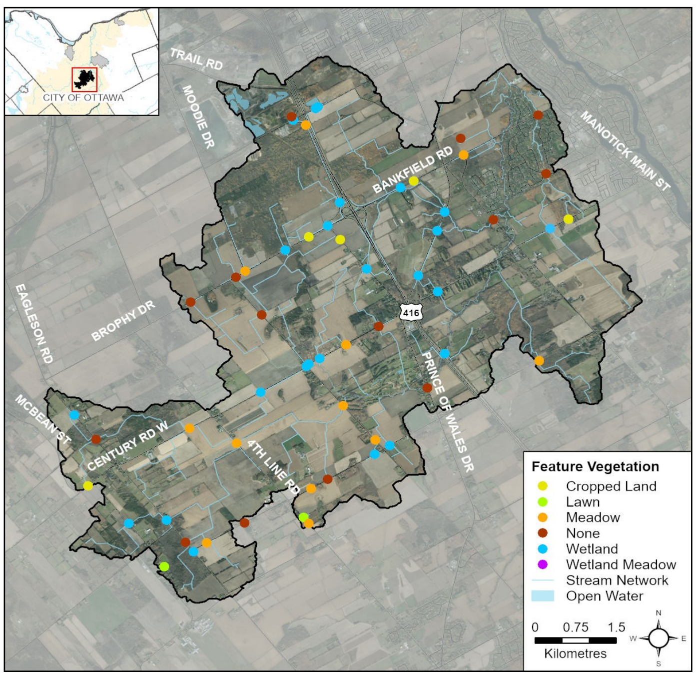


Figure 38 Headwater drainage in feature vegetation in the Mud Creek catchment

Headwater feature with no instream vegetation on Bankfield Road.

Headwater Feature Riparian Vegetation

Headwater riparian vegetation evaluates the type of vegetation that is found along the adjacent lands of a headwater drainage feature. The type of vegetation within the riparian corridor influences the aquatic and terrestrial ecosystem values that the feature provides to the watershed.

Figure 39 shows the types of riparian vegetation observed at the sampled headwater sites in the Mud Creek catchment. They are evaluated as natural or other. Natural accounts for 29 headwater sites, and other riparian zones account for 28 headwater sites, (which have anthropogenic influences from agricultural areas, residential areas as well as road infrastructure).

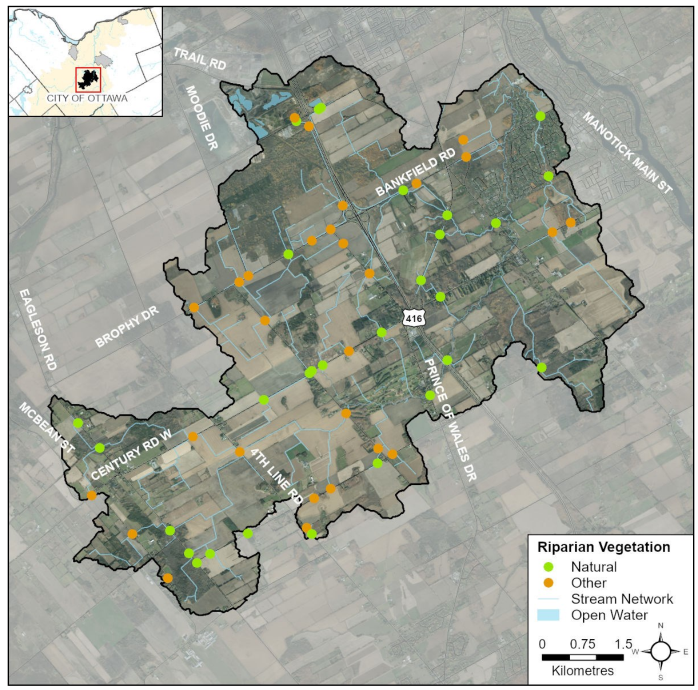


Figure 39 Riparian vegetation types along headwater drainage features in the Mud Creek catchment

Headwater drainage feature with natural meadow, scrubland and forest riparian vegetation near Prince of Wales Drive.

Headwater Feature Sediment Deposition

Assessing the amount of recent sediment deposition in a channel provides an index of the degree to which the feature could be transporting sediment downstream (OSAP, 2017). Sediment transport is a natural process, however, excessive sedimentation can be indicative of higher erosion than a natural system can accommodate. High sediment deposition can indicate the need for further assessment and potential implementation of best management practices.

From the features assessed, sediment deposition ranged from none to substantial. Twenty-three features had evidence of minimal deposition levels; 31 features had moderate amounts of deposition; two features had substantial; and one had no sediment deposition. Figure 40 shows the levels of sediment deposition observed in the catchment headwaters.

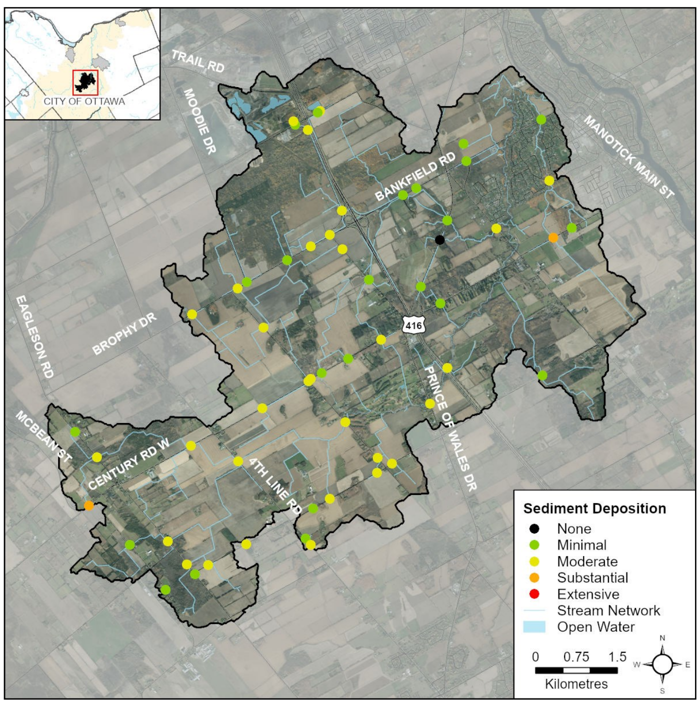


Figure 40 Headwater drainage feature sediment deposition in the Mud Creek catchment

Headwater Feature Upstream Roughness

Feature roughness is a relative measure of the amount of material within the feature that diffuses flows (OSAP, 2017). Materials on the channel bottom that provide roughness include vegetation, wood material as well as boulders and cobble substrates. Roughness can reduce erosion downstream of the feature, as well as providing important habitat to a variety of aquatic organisms, and producing food sources.

This parameter is categorized depending on the amount of roughness coverage in a channel: minimal (less than 10 %), moderate (10-40 %), high (40-60 %), and extreme (more than 60 %). In the Mud Creek catchment, 21 features were considered to have extreme roughness as shown in Figure 41. The remainder of the sites were evenly distributed between high (11), moderate (12), and minimal (13).

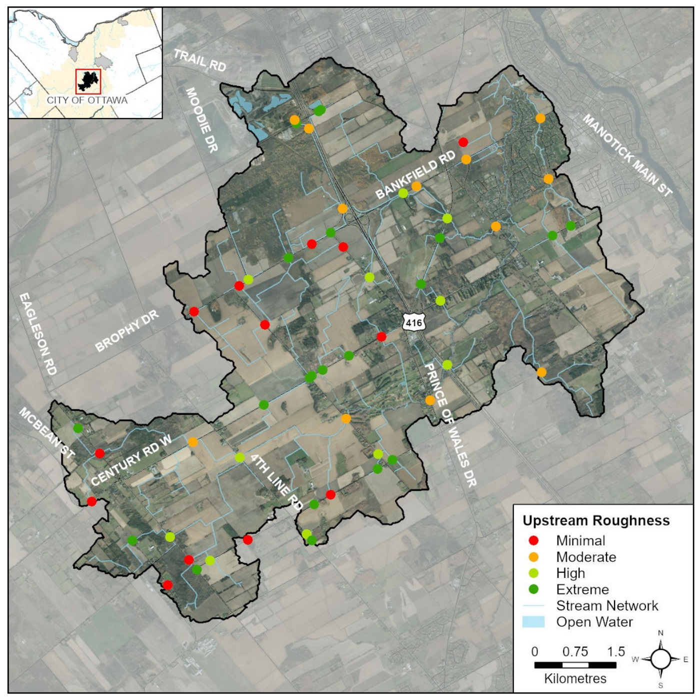


Figure 41 Headwater drainage feature roughness in the Mud Creek catchment

Substantial sediment deposition observed in a headwater drainage feature on Mud Creek.

Extreme roughness due to high presence of vegetation and coarse substrate that diffuse flow.

Stream Comparison Between 2008, 2014 and 2023

The following tables provide a comparison of observations on Mud Creek between the 2008, 2014 and 2023 survey years (RVCA 2008, RVCA 2014, RVCA 2023). Monitoring protocols since 2008 have been modified and enhanced, only certain data from that year can be compared to later years. 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 2008, 2014 and 2023.

Average pH decreased by 0.19 units from 2014 to 2023 and specific conductivity decreased from 2014 to 2023 by 100.77 µS/cm. These slight changes may reflect seasonal variability. Average dissolved oxygen levels were found to be lower by 2.5 milligrams per liter from 2014 to 2023. These changes can also be attributed to seasonal conditions and warmer temperatures which are conductive to the stream's ability to hold less oxygen.

Average summer water temperatures range from warmer water in 2023 (18°C) to cooler values in 2014 (17.7°C), with 0.3 degrees centigrade of variation, whereas in 2008 it was much cooler (14.3°C). 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 temperature loggers at Bankfield Road, the standardized stream temperature factors were calculated and summarized in Table 3 for 2008, 2014 and 2023. In 2008, standardized stream temperature was 0.91 for every degree of air temperature, 0.88 in 2014, and 0.78 in 2023. In all cycle years, Mud Creek was classified as cool water (methods from Chu et al., 2009) along Bankfield Road.

[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

Table 3 Water chemistry comparison (2008/2014/2023)

Water Chemistry (2008/2014/2023)				
Year	**Parameter**	**Unit**	**Average**	**STND Error**
2008	pH	-	7.85	± 0.37
2014	pH	-	7.85	± 0.17
2023	pH	-	7.66	± 0.02
2008	Sp. Conductivity	us/cm	807.0	± 40.9
2014	Sp. Conductivity	us/cm	835.9	± 24.3
2023	Sp. Conductivity	us/cm	908.2	± 8.86
2008	Dissolved Oxygen	mg/L	6.7	± 0.44
2014	Dissolved Oxygen	mg/L	8.4	± 0.20
2023	Dissolved Oxygen	mg/L	5.9	± 0.28
2008	Water Temperature	ºC	14.3	± 0.29
2014	Water Temperature	ºC	17.7	± 0.18
2023	Water Temperature	ºC	18.0	± 0.25
2008	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.91	± 0.16
2014	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.88	± 0.11
2023	Standardized Stream Temperature[1]	ºC Water / 1ºC Air	0.78	± 0.42

Stream Comparison Between 2008, 2014 and 2023

The following tables provide a comparison of observations on Mud Creek between the 2008, 2014 and 2023 survey years (RVCA 2008, RVCA 2014, RVCA 2023). Monitoring protocols since 2008 have been modified and enhanced, only certain data from that year can be compared to later years. This information is a comparative evaluation and doesn't represent the entirety of our assessment.

Instream Aquatic Vegetation

Table 4 shows increases in instream aquatic vegetation from 2008-2023. Narrow-leaved emergent plants (e.g. sedges), broad-leaved emergent plants (e.g. arrowheads), submerged plants (e.g. pondweed) and free-floating plants (e.g. frog-bit) were all shown to increase significantly from 2008-2023. Robust emergent plants (e.g. cattails), floating plants (e.g. duckweed) and algae increased continuously over the three cycle years.

Table 4 Instream aquatic vegetation (presence in % of sections) comparison between 2008-2023

Instream Vegetation	2008	2014	2023	+/-
narrow-leaved emergent plants	8%	33%	90%	▲
broad-leaved emergent plants	3%	9%	67%	▲
robust emergent plants	9%	12%	33%	▲
free-floating plants	6%	3%	80%	▲
floating plants	0%	4%	19%	▲
submerged plants	8%	21%	78%	▲
algae	15%	18%	48%	▲

Instream vegetation observed along Mud Creek

Invasive Species

The percentage of sections surveyed where invasive species were observed had a significant increase of 23 percent (Table 5). Almost all invasive species previously reported had an increase in the number of sections they were observed in. There are also several species that were not previously reported, including bull thistle, Eurasian milfoil, and non-native honey suckle.

Table 5 Invasive species presence (% of sections) observed in 2014 and 2023 (NR are Not Reported species)

Invasive Species	2014	2023	+/-
bull thistle	NR	5%	▲
common & glossy buckthorn	11%	38%	▲
curly-leaved pondweed	8%	25%	▲
Eurasian milfoil	NR	11%	▲
European frogbit	1%	15%	▲
flowering rush	35%	19%	▼
garlic mustard	1%	6%	▲
Himalayan balsam	1%	1%	-
honey suckle (non-native)	NR	29%	▲
Manitoba maple	36%	85%	▲
poison/wild parsnip	1%	32%	▲
purple loosestrife	50%	33%	▼
rusty crayfish	1%	NR	▼
yellow iris	NR	1%	▲
Total percent of sections invaded	**74%**	**97%**	▲

Pictured above are two invasive species; (left) is a Manitoba maple and (right) is curly-leaf pondweed. Both species were observed along Mud Creek in 2023.

Fish Community

Fish community sampling was carried out by the City Stream Watch program in 2008, 2014 and 2023 to evaluate fish community composition in Mud Creek (see Table 6). In total 27 species have been observed in Mud Creek. In 2008, 17 fish species were captured at seven sites between May and August; in 2014, 25 species were observed at eight sites; and 18 species were observed at five sites in 2023. The majority of species observed in 2023 had been captured in previous years, with the logperch as a new observation.

RVCA staff member with a redhorse sp. during fish community sampling on Mud Creek 2014.

Examples of fish species caught during all three sample years: mottled sculpin (above) and rock bass (below)

Table 6 Comparison of fish species caught between 2008-2023

Species	2008	2014	2023
black crappie *Pomoxis nigromaculants*		X	
blacknose dace *Rhinichthys atratulus*	X	X	X
blacknose shiner *Notropis heterolepis*	X	X	X
bluegill *Lepomis macrochirus*		X	X
bluntnose minnow *Pimephales notatus*	X	X	
brook stickleback *Culaea inconstans*	X	X	X
brown bullhead *Ameiurus nebulosus*		X	X
carps and minnows *Cyprinidae*	X	X	X
central mudminnow *Umbra limi*	X	X	
common shiner *Luxilus cornutus*	X	X	X
creek chub *Semotilus atromaculatus*	X	X	X
darter species *Etheostoma sp.*	X	X	X
fallfish *Semotilus corporalis*		X	
fathead minnow *Pimephales promelas*		X	
golden shiner *Notemigonus crysoleucas*	X	X	
hornyhead chub *Nocomis biguttatus*		X	X
largemouth bass *Micropterus salmoides*	X		
logperch *Percina caprodes*			X
longnose dace *Rhinichthys cataractae*	X	X	X
mottled sculpin *Cottus bairdi*	X	X	X
northern redbelly dace *Phoxinus eos*		X	X
pumpkinseed *Lepomis gibbosus*	X	X	X
redhorse sp. *Moxostoma sp.*		X	
rock bass *Ambloplites rupestris*	X	X	X
smallmouth bass *Micropterus dolomieu*			X
walleye *Stizostedion vitreum*		X	
white sucker *Catostomus commersoni*	X	X	
yellow perch *Perca flavescens*	X	X	X
Total Species 28	**18**	**25**	**18**

Monitoring and Restoration

Monitoring on Mud Creek

Table 7 highlights recent and past monitoring that has been done on Mud Creek by the Rideau Valley Conservation Authority's City Stream Watch program. Monitoring activities and efforts have changed over the years.

Table 7 City Stream Watch monitoring on Mud Creek

Accomplishment	Year	Description
City Stream Watch Stream Monitoring	2008	9.5 km of stream was surveyed
	2014	7.8 km of stream was surveyed
	2023	10.5 km of stream was surveyed
City Stream Watch Fish Sampling	2008	seven fish community sites were sampled
	2014	eight fish community sites were sampled
	2023	five fish community sites were sampled
City Stream Watch Thermal Classification	2008	three temperature probes were deployed from June to September
	2014	four temperature probes were deployed from June to September
	2023	three temperature probe was deployed from April to October
Headwater Drainage Feature Assessment	2014	36 headwater drainage feature sites were sampled in the Mud Creek catchment
	2023	59 headwater drainage feature sites were sampled in the Mud Creek catchment

RVCA staff assessing a headwater drainage feature in the Mud Creek catchment.

Potential Riparian Restoration Opportunities

Riparian restoration opportunities include potential enhancement through riparian planting and erosion control. Opportunities were identified along Mud Creek surveyed areas (Figure 42).

Riparian Planting

Various riparian areas of Mud Creek can benefit from planting to increase plant diversity and shading. Many sections had riparian buffers of low plant diversity. Additional planting would increase shading, enhance wildlife habitat, prevent soil erosion and mitigate negative impacts from runoff and anthropogenic input.

Area of Mud Creek near Rideau Valley Drive that would benefit from riparian planting

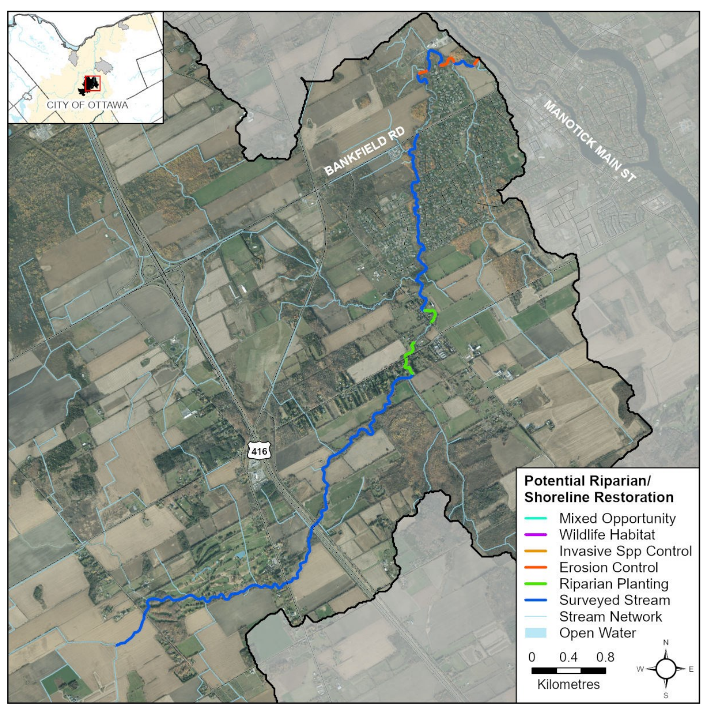


Figure 42 Potential riparian/shoreline restoration opportunities along Mud Creek

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For more information on the 2023 City Stream Watch Program and the volunteer activities, please refer to the City Stream Watch 2023 Summary Report:

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

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